



BAGS

Engineering the Future, Today!

TARS: A Futuristic Integration of Smart Technology

Design, and User-Centric Innovation in Smart Bag"

Design Process

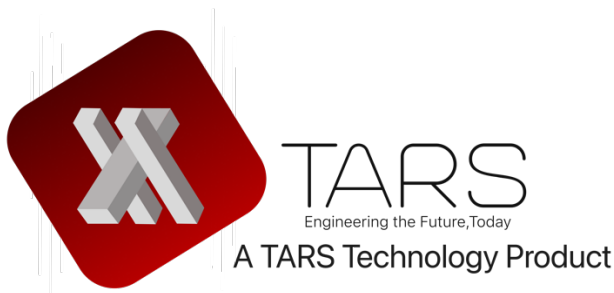


TARS Back Bag: A Futuristic Integration of Smart Technology

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About the Project

The objective of this project is to design a smart bag for modern traveler and tech enthusiasts, integrating features that **enhance convenience, security, and organisation**. By addressing common pain points through user feedback and competitor analysis, the goal is to create a product that meets customer needs and stands out in the competitive market.



Preface



The conceptualization of the TARS Smart Bag is deeply inspired by the clever robot "TARS" from Christopher Nolan's *Interstellar*, a character that epitomizes adaptability, intelligence, and transformative capability. This symbolic foundation informs our corporation's overarching challenge: to integrate superior technological innovation with normal functionality, thereby developing shrewd, anticipatory client products that align with the evolving needs of modern life. The TARS Smart Bag is anticipated now not merely as a travel accent, but as a dynamic, wise accomplice. Through the incorporation of consumer-centric synthetic intelligence, biometric protection capabilities, sustainable substances, and intuitive automation, the TARS Smart Bag addresses vital current journey demanding situations, consisting of inefficiencies in power control, constrained storage optimization, and heightened protection and luxury requirements. This quantity chronicles the complete developmental trajectory of the TARS Smart Bag from preliminary ideation and conceptual layout to technological execution and market deployment. It includes an in depth exploration of research methodologies, market evaluation, product engineering, and ergonomic considerations. In doing so, it offers a practical and theoretical framework for the improvement of sustainable, human-targeted clever technologies. In essence, the TARS initiative aspires to embody the traits of its namesake, positioning itself as a STAR dedicated to shaping a wiser, safer, and extra interconnected worldwide network

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TARS Company Hierarchy

A well-defined **organizational structure** enables **efficient product development, research, and market expansion**. Below is the **hierarchy of TARS**, showcasing key roles and responsibilities.

Technical Project Manager-Lead
Drives innovation and oversees the Development of TARS products



Mr. Jagathguru Pazhanivel

CEO-Technical Project Manager: Oversees technical projects with a focus towards timely completion and company goal alignment, oversees engineering teams, directs the development, and verifies technical viability.

Sales & Marketing Manager
Develops branding, sales, and marketing strategies.



Ms. Poojith Mandla

Sales and Marketing Manager: Develops and executes sales plans to achieve revenue objectives. Develops marketing strategies, manages the customer base, and expands the marketplace.

Quality Engineer Manager
Ensures top-notch material and product quality.



Ms. Yazhini Rajakumar

Quality Manager: Establishes and maintains quality standards for products and procedures. Carries out audits, enforces compliance, and encourages continuous improvement.

Supply Chain Manager
Manages procurement and logistics.



Mr. Fregin Sherofer

Supply Chain Manager: Responsible for procurement, inventory management, and logistics. Ensures smooth supply chain operations for the production and delivery needs.

Production Manager
Oversees manufacturing and quality control.



Mr. Anbucheliyan, Sadha Aravindh

Production Manager: Oversees the production process with timely and quality production. Oversees employees, equipment, and process improvement for increased productivity.

Operations Manager
Optimises workflow and resource management.



Mr. Nijanthan

Operation Manager: Coordinates daily business operations and organizes operations. Ensures departmental coordination for productivity and efficiency.

Chapter 1

1.1. TARS: Smart Lifestyle Solution Innovation



1.1.1. What is TARS?

In Christopher Nolan's film *Interstellar*, the robots TARS and CASE serve as advanced artificial intelligences (Özkural, 2018) designed to assist humans in space exploration. Here's a breakdown of their technological theory and design. (Wikipedia Fandom)

TARS and CASE possess a distinctive, monolithic modular design which can be unfolded and refolded in various shapes for various tasks and environments. Their versatility enhances their utility, enabling them to perform a range of operations ranging from heavy lifting to navigation. With highly sophisticated artificial intelligence, the robots possess high-level cognitive functions such as the ability to understand complex human emotions, solve problems, and alter their personality with varying levels of humor and sociability. Their ability to learn through experience and alter behavior makes

The movie explores the strong bond between humans and robots, with TARS being a loyal friend and a central member in times of crisis. Their mobility and physical strength enable them to travel through rugged terrain, carry heavy loads, and perform spacecraft maintenance, while their onboard sensors provide critical environment data for orientation and decision-making. Thematically,

them great friends for astronauts in uncertain environments. With the capability to communicate with humans in natural language, TARS and CASE can communicate with humans intuitively, evoking a sense of reliability and trust.



Figure 1 Doctor Brand with TARS in Miller Plan

the movie addresses ethical issues between AI autonomy and control by humans, raising the query of how much autonomy should be granted to robots while maintaining the safety of humans. Based in real-world AI research and robotics, TARS and CASE take inspiration from concepts in machine learning, cognitive computing, and human-robot interaction, evoking a sense of cinematic reality in

accordance with real-world technology. “Ultimately, the robots symbolize the integration of sophisticated technology with the ingenuity of humans, creating a bridge between the abilities of humans and the great unknown of the universe while exploring deeper themes of reliability, friendship, and the future of artificial intelligence”.

1.1.2. How TARS as an Inspiration?

TARS: A Paradigm of Flexibility, Wisdom, and Change in Technological Advance

The sophisticated humanoid artificial intelligence in *Interstellar*, TARS, is the inspiration for our company in its most basic sense, with the qualities of flexibility, intelligence, and transformation at its essence. The intellectual connection between TARS, the artificial intelligence, and TARS, the company, reflects the shared vision of the seamless integration of technology with dynamic environments, intelligent user interaction, and multi-function utility.

User-Centric AI: anticipatory AI-based solutions

TARS, in the film, engages with humans in a very human-like manner, demonstrating highly developed anticipatory ability in the absence of direct instruction. This is the foundational concept of our technology innovation. The AI-enabled offerings in TARS products leverage intuitive automation by using advanced machine learning algorithms to anticipate user behavior and act in response. These offerings extend to smart security systems, automated organization, and dynamic charging systems, each of which seeks to make the user experience more convenient through anticipatory intelligence.

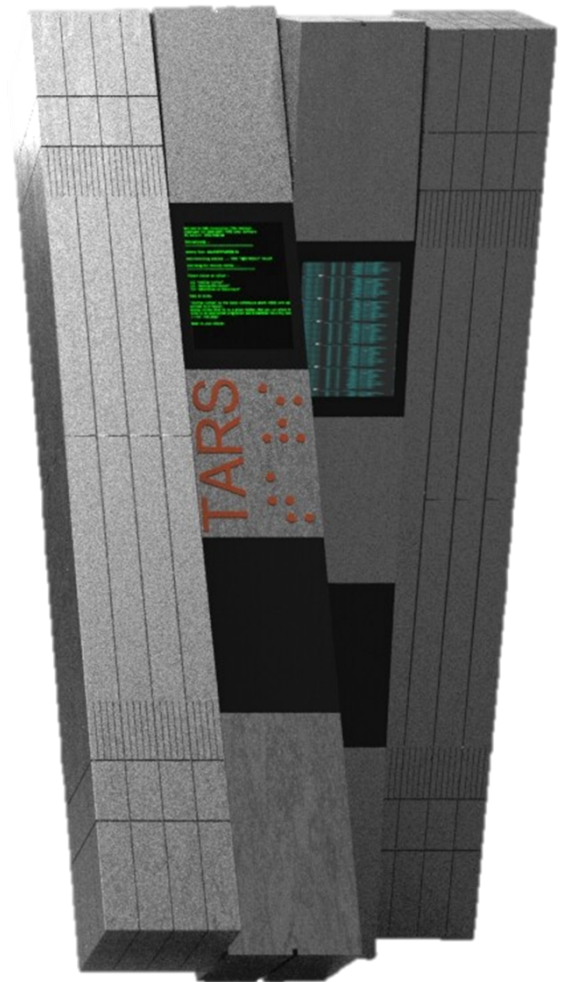


Figure 2 TARS Robot Portrait Image

Symbolism and Meaning: TARS as the Technological STAR

TARS, short for Interstellar AI but inspired by "STAR," is a force behind technological innovation. Like how stars power galaxies, TARS is dedicated to powering industries with smart, adaptive, and multi-functional technology. We seek to design AI-driven, eco-friendly, and human-centered products that deliver increased security, convenience, and connection. Beyond being a business, TARS is a force behind a smarter, more secure, and more connected world.

Our Mission: Smarter Solutions for a Smarter World

At TARS, we're dedicated to closing the gap between technology and daily life. With sustainable design and artificial intelligence-driven innovation, we create products that enhance security, optimize efficiency, and offer an improved user experience. This mission is a commitment to not only design intelligent products but also to make them intuitive,

sustainable, and completely integrated into the lifestyles of today. All the TARS products seek to simplify life, make it safer, and more efficient.

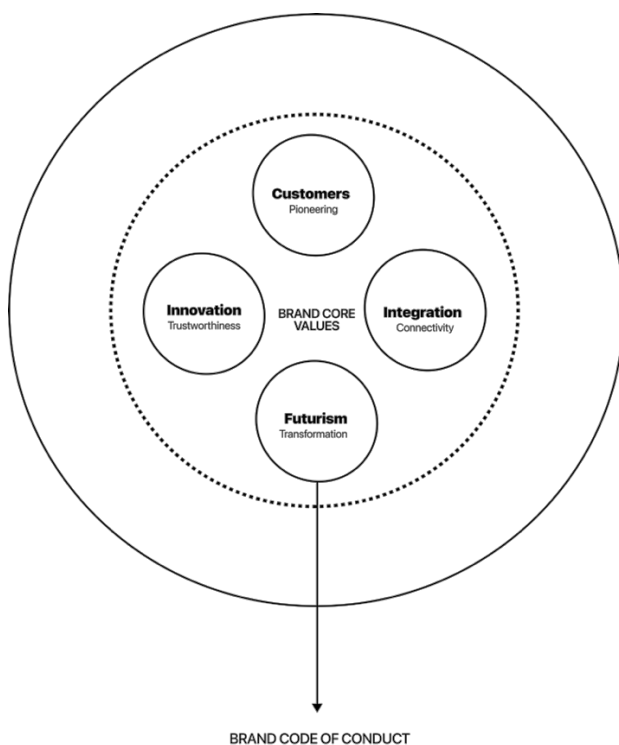


Figure 3 Brand Core Values

Our Vision: To shape the future of smart consumer technology.

TARS is aiming to position itself as a global intelligent consumer electronics leader by harnessing the power of artificial intelligence, Internet of Things (IoT), and environmentally friendly materials. The aim is to develop products that: Enhance security with the latest protection features, facilitate improved connectivity with intelligent automation, utilize environmentally friendly material and energy-efficient technology to support sustainability. By weaving together these elements, TARS is reimagining consumer

electronics ones that not only lead the way but also do so responsibly and forward-looking.

Rationale for Selecting the Smart Bag as the Initial Product:

Selecting the Smart Bag as the initial product is strategically aligned with the principles of flexibility, intelligence, and change. With the prevailing era of rapid technological change and increased mobility, travelers, students, and working professionals are confronted with problems such as battery limits, security threats, organizational inefficiencies, and carrier restrictions. A critical review of existing luggage solutions reveals that none are satisfactorily addressing the shared problems.

During our initial brainstorm session, company stakeholders brainstormed various ideas for the first product. Among them was the idea proposed by *Mr. Fregin Sherofer*, the Supply Chain Manager for TARS. He emphasized the company's need to launch a commercially viable product with broad appeal within the market, and the strategic decision was made to target a bag as the first product. Apart from this, results from extensive user research validated the selection through the affirmation that a Smart Bag would adequately meet the consumers' needs. We therefore agreed on the product as the "TARS Bag", promoting it as a cutting-edge and very useful solution for broad-scale customer acceptance.

Chapter 2

2.1. Problem Statement

2.1.1. Market gaps and challenges in smart bag design: A research-based approach:4.2

The contemporary market for smart bags is plagued by numerous shortcomings that adversely affect user experience, particularly in terms of flexibility, safety, and convenience during travel. Smart bags, despite continued technological advancements, cannot yet fully meet the requirements of frequent travellers, business travellers, and university students. A systematic review of existing publications, supplemented by a limited study with users, reveals four primary shortcomings in the design of smart bags: battery and charging, safety, inadequate storage and organization, and less-than-ideal ergonomics and durability. Our user study, in which we gathered information through questionnaires and interviews, also corroborates these findings, with real-life frustrations and unmet promises among consumers.

2.1.2. Batteries and Charging Restrictions:5.2.5

The most significant challenge with smart bags is adherence by airlines to battery regulations. Smart bags incorporate non-removable lithium-ion batteries, which most airlines ban for safety reasons related to fires(IATA, 2025). As a result, passengers are inconvenienced by having to remove or dispose of batteries before boarding. Smart luggage with removable lithium-ion batteries is still okay for travel so long as the battery can be quickly and easily removed. When checking the bag, you'll be required to remove the battery. If you choose to carry on your luggage, the battery can remain in place as long as the suitcase is stored in an overhead bin. If the luggage needs to go into the cargo hold

for any reason, you'll have to remove the battery and keep it in the cabin.(Jerri Ledford, 2023)

2.1.3. Security and Theft Problems:

Security and Theft Problems: An Overview

One of the most prevalent types of theft continues to be the theft of bags in public areas, particularly in bars and where high foot traffic is encountered. London bag theft entails a lot of security risks and frequently applied thief methods. Poor bag positioning, poorly educated members of the security staff, and insufficient safe storage in public areas are some of the risk-increasing elements. This paper discusses the primary bag snatching threats, trends of victim behaviour, and potential technology solutions to aid security.

In the UK alone, more than 1700 people were victims to pickpocketing every day in 2012 (JACK DOYLE FOR THE DAILY MAIL, 2012) and every minute there is a new victim of bag theft and bag theft is a serious problem in China as well (Gamman & Thorpe).

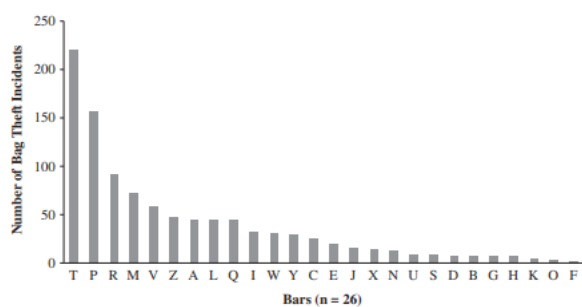


Figure 4 Distribution of recorded bag theft incidents across 26 bars of the same chain in central London, 2005 – 2006 (n = 1023) from the study of (Sidebottom & Bowers, 2009a)

2.1.4. Key Findings on Theft Risks

The Concentration of Theft Incidents

The prevalence of bag robbery is not randomly dispersed in public locations; rather, thefts are surprisingly concentrated in a few areas. A few locations account for a disproportionately high proportion of mentioned theft. Within the places, a few spaces together with flooring and chairs are riskier due to the fact that they provide a smooth

factor of entry for thieves to access abandoned goods.(Sidebottom & Bowers, 2009b)

Several methods are generally employed with the aid of thieves to execute bag thefts. These encompass:

Unattended Bags: More than 1/2 of the mentioned bag robbery incidents arise while people depart their luggage unattended, exposing them to theft.

Distraction Techniques: Criminals use distraction strategies, which includes distracting the sufferer or people surrounding them with talk, whilst a person else steals the bag without word.

"Dipping" or Pickpocketing: In different cases, as opposed to stealing an entire bag, robbers thief items along with wallets, credit playing cards, and phones without the victim's initial cognizance of the intrusion.

2.1.5. Items Most Frequently Stolen

The most stolen items include:

- Handbags, wallets and credit cards, which are particularly attractive to thieves due to their financial value.
- Mobile phone, because they have both monetary and personal data importance.
- Cash, which is inaccessible and easy to use.
- Identification documents, such as passport and driver's license, whose theft creates concern about unauthorized access to fraud and personal information.

2.1.6. Challenges in Theft Prevention

Despite the superiority of bag thefts, many public venues offer minimum security measures to mitigate risks. Some of the number one demanding situations in theft prevention include:

- **Lack of Secure Storage Facilities:** Many establishments fail to offer customers with stable garage answers, including bag hooks, lockers, or anti-theft clips,

leaving them with constrained alternatives for shielding their property.

- **Limited Public Awareness Campaigns:** Theft prevention efforts are similarly hindered by way of a loss of public recognition projects. Few venues put in force signage or instructional applications to inform customers of security risks and first-class practices for shielding their possessions.
- **Auto-Locking Zippers:** Biometric or cell phone-controlled locking mechanisms to prevent unauthorized access to the bag's contents.

3. Storage and Organizational Challenges

Storage Challenges in Smart Bags

Smart luggage, in spite of their technological improvements, face numerous demanding situations in making sure efficient garage and object control. One of the number one issues is item forgetfulness, wherein customers regularly forget to pack Essential gadgets, in particular the ones needed on the last minute. This oversight can result in incomplete garage, affecting the capability of the bag in everyday use. Additionally, item elimination and repacking pose enormous challenges. Items which might be taken out for cleaning, protection, or use at domestic might not be back to the bag, main to missing necessities when they're wished.

Another problem is non-ordinary item control. Occasionally required objects, which includes raincoats or specialised system, are often forgotten because of their irregular usage. Since these items aren't a part of each day recurring, users may also overlook their necessity till a scenario arises in which they may be wanted. Furthermore, restricted storage focus in conventional baggage exacerbates these problems. Conventional bags do no longer provide any indication of lacking items, making it difficult for users to verify the completeness in their saved belongings. This lack of actual-time remarks can result in customers discovering lacking items simplest once they want them, inflicting inconvenience and inefficiency.(Park & Zimmerman)

Organizational Challenges in Smart Bags

Beyond storage troubles, organizational challenges further impact the practicality of clever bags. One such assignment is ambiguity in packing obligations. In families or shared utilization scenarios, there may be confusion regarding who is chargeable for packing the bag (Yousaf & Mubashir).

Moreover, bag misplacement is a frequent problem. Smart bags may be forgotten in distinct places, which include some other vehicle or an occasion venue, causing inconvenience and capability lack of vital objects. Similarly, overpacking and duplication get up when users upload extra gadgets as opposed to attempting to find current ones. This ends in muddle, decreased bag performance, and pointless weight. Finally, object intake and depletion create similarly organizational difficulties (Park & Zimmerman). Consumable gadgets, such as snacks, sunscreen, or coins, may be used without replenishment. This can bring about unexpected shortages, leaving customers unprepared for sure situations. The loss of an automated monitoring or alert machine for such items exacerbates this challenge, making it hard to keep a most fulfilling inventory inside the bag. These demanding situations spotlight the need for revolutionary solutions in clever bag era, including automated inventory monitoring, actual-time notifications, and wise enterprise structures to beautify person convenience and efficiency.

4. Problems in Ergonomics and Durability

The majority of existing smart bags are heavy and uncomfortable, leading to physical strain after long periods. Problems in Ergonomics and Durability in Product Design

Ergonomic Issues in Product Design

Ergonomic deficiencies in product design continue to pose considerable challenges, mainly regarding accessibility and person comfort. According to Mohamed and Al-Shamrani (2023) in Ergonomic design of smart bags: (عبدالباسط, & الشمرانی 2020)(Volume 6, Issue 26), an important problem in ergonomic product layout is the insufficient

incorporation of accessibility capabilities within smart designs. Ineffective implementation of these capabilities can result in pain, diminished functionality, and decrease adoption rates among users. This highlights the need for designers to integrate ergonomic ideas efficaciously to beautify consumer revel in and value.

Furthermore, findings from *the 2nd International Conference on Ergonomics, Safety, and Health (ICESH) & the seventh ErgoCamp 2023* (Fauziyah et al.) emphasize the evolving nature of ergonomic interventions in response to technological improvements. The look at underscores that several ergonomic troubles stem from the insufficient integration of design with digital tools, adversely impacting both comfort and productivity. As generation maintains to develop, ergonomic designs have to adapt to new virtual landscapes to make sure top-rated user interaction and efficiency.

Durability Challenges in Ergonomic Products:5.2.2

In addition to ergonomic concerns, durability stays an essential assignment within the development of ergonomic merchandise. Research published in (عبدالباسط, & الشمرانی 2020)(Volume 6, Issue 26) identifies key durability problems in smart bags and wearable era, which include insufficient waterproofing, high manufacturing prices, and constrained washability. These elements appreciably impact the long-time period usability of such products, in the end influencing consumer delight and adoption charges.

Similarly, a have a look at in (Gutierrez et al., 2017) examines the ergonomic layout of emergency baggage (Go-Bags) for faculty kids, revealing that sturdiness concerns often rise up because of suboptimal fabric choice and fallacious weight distribution. These deficiencies make a contribution to speedy wear and tear, thereby diminishing the practical lifespan of those merchandise. Addressing those sturdiness troubles necessitates a more complete method to fabric engineering and structural integrity, ensuring that ergonomic products can withstand extended and extensive use.

2.2. Research Objective

2.2.1. Major goals for Tars Smart Bag

TARS focus on the inclusion of advanced technology to identify the user's requirements, address the market gaps and develop a versatile, travel -friendly smart bags for smart bags. The purpose of this study is to understand the needs of passengers, students and professionals by conducting survey and interviews to identify general challenges such as battery life boundaries, safety concerns, disabled storage organization and airline travel restrictions. Additionally, research will analyze the smart goods market by evaluating existing brands like Samsonite, **Nomatic**, **Tzwall** and **Nordace** to assess opportunities for its strength, weaknesses and potential innovation. Consumer expectations, pricing strategies and sales trends will be examined to determine the competitive status.

A major aspect of this study involves developing technical and functional enhancement, including a removable, airline-influence battery system, AI-driven safety facilities such as fingerprint authentication, GPS tracking and RFID-blocking technology, Face ID unlock, App Integration and solar charge as well as modular storage solutions for better organization. Material research will focus on identifying light, water-resistant and impact resistant components to increase durability by discovering permanent options to reduce environmental impact. In addition, the purpose of the study is to install a cost-effective and scalable manufacturing model by optimizing quality control, supply chain efficiency and regulatory compliance.

2.3. Scope of Study

The developed landscape of smart goods has introduced many innovative features to increase facilities, safety and stability for modern travelers. The study focuses on the integration of state -of -

the -art technologies such as state -of -the -art battery systems, artificial intelligence (AI) -drained security measures and environmentally friendly materials in smart goods design. The objective is to assess the impact of these technological progresses on travel efficiency, safety, ergonomics and user experience. This chapter defines the product focus, major technical aspects and target audiences, establishing the foundation for the comprehensive evaluation of the smart goods industry.

2.3.1. Product Focus

Smart baggage has emerged as a transformative answer that carries digital connectivity, real-time tracking, biometric protection, and sustainable design concepts. The middle awareness of this looks at is on technologically more suitable luggage that caters to diverse visitor desires, along with enterprise specialists, students, digital nomads, and environmentally aware customers. The look at also emphasizes the position of airline-compliant modular battery structures, which give advanced journey performance without violating aviation regulations.

Enhancing Travel Efficiency with Modular, Airline-Compliant Battery Systems

The International Air Transport Association describes clever baggage as baggage that contains incorporated lithium batteries, cars, energy banks, Global Positioning System (GPS), Bluetooth, Radio-Frequency Identification (RFID), Wi-Fi, or GSM technology.(Wang et al., 2025)

Improving Security thru AI-Driven Fingerprint Locks and GPS Tracking

The smart bag is designed with assist of the modern-day generation for fixing the dropping luggage problems. The bag is operating on Bluetooth interacting with a report controller, GPS / GSM modules, RFID cards, Ultrasound sensors, energy unit, load mobile, fingerprint, and so forth.(Khadija Abdullah Salim Al Jabri et al., 2023a)

3.Optimizing Ergonomics with Lightweight, Durable, and Weather-Resistant Materials

The green sensor structures evolved from degradable substances may also help mitigate some of the principal environmental troubles via decreasing digital waste (Hosseini et al., 2021)

4. Integrating Face ID and App Integration Features

This innovative bag incorporates a variety of Internet of Things (IoT) functions that decorate person experience, convenience, and security. At its middle, the Smart IoT Bag is equipped with embedded sensors and connectivity modules, enabling it to acquire real-time records approximately its surroundings and the gadgets it

includes.(Khadija Abdullah Salim Al Jabri et al., 2023a)

5. Implementing Solar Power Charging for Remote Locations

Some smart baggage integrates flexible sun panels into the exterior of the bag. These panels convert sunlight into power to rate inner batteries or without delay price gadgets.(Wang et al., 2025)

6. Utilizing Eco-Friendly and Durable Materials

The green sensor systems developed from degradable substances could also assist mitigate some of the foremost environmental issues with the aid of decreasing electronic waste.(Hosseini et al., 2021)

2.3.2. Target Audience

The smart luggage industry caters to a diverse range of users, each with specific needs and preferences. This study categorizes the target audience as follows:

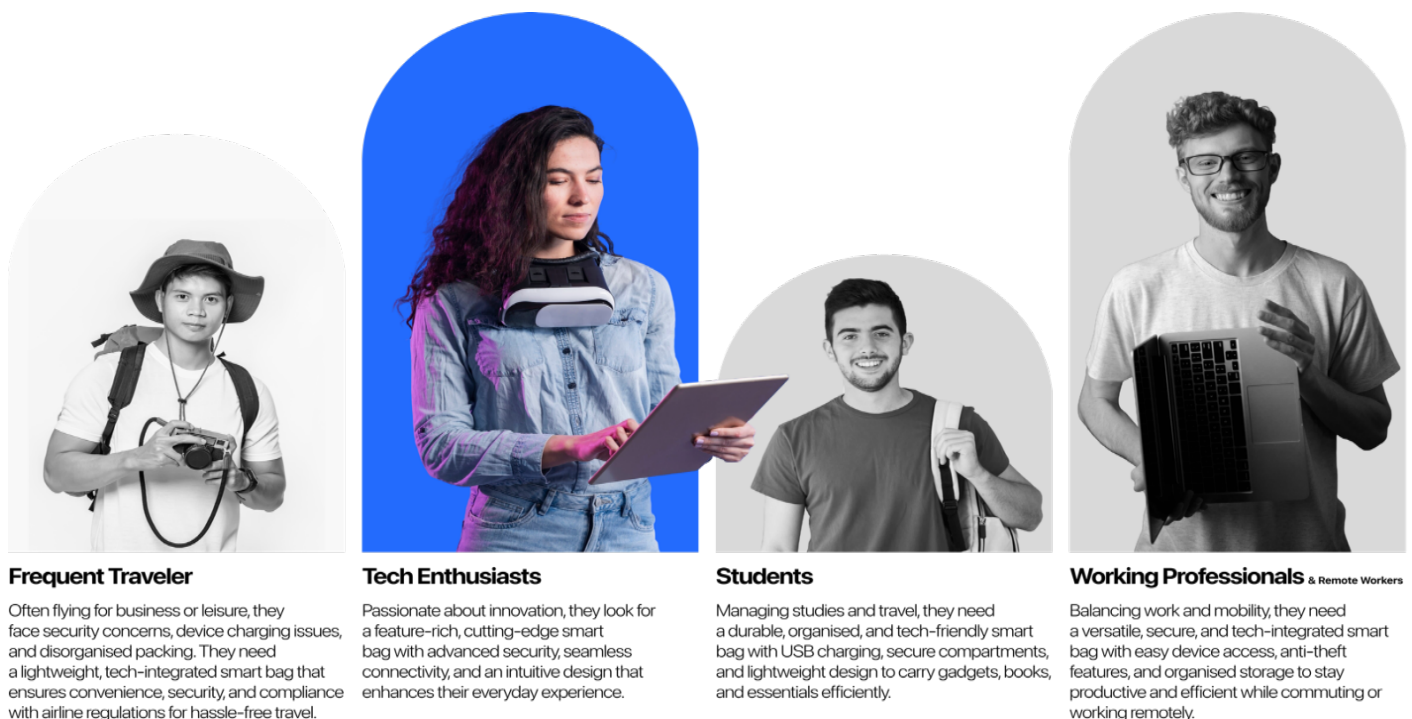


Figure 5 TARS Core Target Audiences based on the user research

Addressing the Needs of Business Professionals and Frequent Travelers:

Business vacationers require baggage that complements convenience and performance.

Features which include IoT-enabled weight dimension, biometric protection, and cellular app integration streamline their travel (Farooq et al., 2021).Smart bags refers to suitcases and luggage ready with advanced technological capabilities

including GPS tracking, integrated scales, USB charging ports, and far-flung locking systems, designed to enhance convenience, safety, and connectivity for Business Travelers.

Students and young professionals catering:

This innovative bag contains the Internet of Things (IOT) features that enhance user experience, convenience and safety. At its core, the smart IOT is equipped with an embedded sensor and connectivity module, which enables it to collect real -time data about its surroundings and items

present in it.(Khadija Abdullah Salim Al Jabri et al., 2023a; Market Research Intellect, 2024).

Appealing to Tech-Savvy Users and Digital Nomads:

This demographic value state -of -the -art technology, e.g., smart lock, Bluetooth integration, and real -time tracking and built the ability to charge equipment using power banks or solar panels attracts the tech enthusiastic.(Khadija Abdullah Salim Al Jabri et al., 2023a)

Chapter 3

3.1. Smart Bag Technology

3.1.1. What is Smart Bag?

A Smart product is a user friendly and multitasking product. This era is a smart product era - our mobiles, watches, televisions and many more products are becoming smarter with technology advancement and novel ideas. So, what exactly does our paper aim at? We propose an innovative Smart backpack that automatically travels the distance according to the user's choice and with other innovative features. Many people especially youngsters and office workers travel by their bicycles on roads with backpacks. After proper modification in such bags, we can add a substitute for reflectors of bicycles which are mostly not maintained properly by people to increase their safety. A common issue is inconvenience in locating items inside backpacks especially in areas with low light. Our paper aims to bring a solution to this issue. Also, rather than using a portable mobile charger, it would be better if we have a charging slot in our backpacks. Anyone would not want to carry their bag from one place to another but move on its own. This concept is implemented in our smart bag. To top the list, we have introduced an obstacle detection system in our smart backpack which detects and halts at any obstacle placed in its

path and waits for the user to resume its motion. We believe this smart backpack is the prime solution to help us in our day-to-day lives. WORKING PRINCIPLE (Hampshire culture Trust)

3.1.2. Evolution of Bags

The historical development of the backpacks reflects a broader growth in educational appliances and student's needs, which marks their changes up to multicolour, sophisticated from simple accounting units. Originally, students used basic leather or cloth straps to transport their books. In the old days, the bag was made from the skin of the animals, and the leather was later hidden. The bag was worn in a style that defines the type of cross bag to wear diagonally in the chest or attached to the belt (Aishwariya, 2018).Over time, this approach provided the way for the use of canvas or leather bag which represented a slight increase in the form of convenience and utility. In 1967, a decisive turning point emerged with the outbreak of light nylon backpacks of Outdoor Gear Companies as Gerry Outdoor and Jansport JanSport the world's largest backpack maker (by ABC News, 2009) created their own lightweight nylon daypacks around this same time, designs that eventually evolved into the student backpacks we know today. While these backpacks were originally designed for hikers, they quickly found a service among students. This growth in popularity inspired manufacturers to adapt their products to a better educational environment (*When Were Backpacks Invented? | Who Invented Modern Backpacks?*

2022). In the 1980s, backpacks were indispensable for students and were well installed as a standard product on school transmission lists. The innovation inspired by cultural changes and technological advances continued in recent decades. Which is often decorated with popular media characters, which transform a backpack into personal expression. In the digital age, the role of backpack is defined again. Modern design emphasizes smooth and compact shapes, including laptops and dedicated rooms to mobile devices. In addition, some companies are looking for alternatives that the goal is to completely change the traditional backpacks. This progress shows how backpacks have continuously adapted to meet changed demands, and eventually serve education, culture and students as a symbol of widespread lifestyle changes.(Elizabeth King, 2016)



Figure 6 History of the back bag 3,300 B.C to 2022 AD

3.1.3. Rise of Specialized Bag

The global bag has experienced significant expansion through the increasing demand for versatile, functional and environmental durable carrying solutions in the market. Previously considered only as storage accessories, the bag has

3.1.4. Innovation as a management Process

The innovation ideas explored on this literature evaluate have been directly carried out to the development of the TARS Smart Bag. Utilizing innovation control techniques, we converted person troubles into solution-pushed design features which includes removable batteries, clever monitoring, and modular compartments. The challenge followed a technopreneur ship-pushed version, blending technical know-how with entrepreneurial strategies, making sure each product relevance and market viability. The Business Model Canvas guided our technique to defining value propositions, client segmentation, key resources, and sales streams. Overall, the frameworks and innovation concepts mentioned

developed technically unified, fashion-conscious items that complete various tasks in travel, professional, retail and individual domains. The shift of this example is driven by innovations in the Physical Vijayan, changing customers' preferences that emphasize both utility and aesthetics, and the wider pace of global stability movement. Estimates suggest that the global bag market will rise from \$ 45.8 billion in 2025 to \$ 63.5 billion by 2035, representing an annual growth rate (CAGR) of about 3.7%. This expected growth most increases consumer interest in smart storage techniques, biodegradable materials and multifunctional bag designs. The most popular category contains crossbody bags and smart backpacks, which are gaining traction due to their ergonomic design and compatibility with modern technical lifestyle. Recent technological advances have played a key role in re -shaping the industry. These include radio-frequency identification (RFID) TS GS, anti-stolen mechanisms, artificial intelligence (AI)-Divine trend forecasts, blockchain-enabled transparency in supply chains and biodegradable materials such as plant-based fabrics and racial plastic. Such innovations not only enhance the functional and aesthetic appeal of bag products but also place manufacturers as forward thinking and durability oriented.(future market insights.com)

right here played an essential role in remodelling the TARS Smart Bag from concept to a scalable, functional, and market-equipped product.

The term innovation is closely related to newness (Johannessen et al., 2001). New products, new services, new production methods, new markets, new sources of supply, and new organizational structures are all examples of innovative activities. The process of commercializing a recently developed product or practice has been defined as innovation (Luc Soete et al., 1997). There are three types of innovation: product innovation, process innovation, and market innovation. Product innovation provides the clearest way to generate income. Process innovation provides a way to maintain and improve quality and to save costs. Market innovation is concerned with increasing the

mix of target markets and how the selected market is best served. Its purpose is to identify new or better potential markets and new or better ways to serve target markets (Johne, 1999).

Innovation management encapsulates the management of the entire innovation process from the idea formation stage through the product or process development/adaptation to market launch or initiation. Innovation management includes strategic and operational issues. According to (Carlos Santos Silva et al., 2012), the new product development process can be divided into three stages: generating ideas, technical development, and commercialization. Innovation management is complex and risky. Innovation is concerned with various knowledge sectors such as the creation of new ideas and concepts, model design and development, industrial development, R&D, business process redesign, marketing, Etc. Management of technological innovation is one of the challenges faced by management executives today is one of the most demanding to solve. The management of technological innovation involves all aspects of the company where the development and use of technological innovation allow the company to achieve its targets (Elias G. Carayannis et al., 2015) Innovation management usually occurs in several recognizable stages. Invention, the main central phase is preceded by a combination of dissatisfaction with the status quo (inside the company) and inspiration from others (usually outside the company). The invention is then followed by a validation process inside and outside the company (Birkinshaw & Mol, 2006)

3.1.5. Innovation systems

Innovation systems is a tool for analysing innovation processes and influencing them, without the strong restriction of innovation policy to market failures that characterizes the mainstream approach (Soete et al., 2021). According to (Elias G. Carayannis et al., 2015) One of the main types of relationships in an innovation system involves the transfer or acquisition of technology, either through markets or through non-commercial interactions. Innovation is not just an isolated act of learning by

a company or other entity; innovation is integrated into a larger system that fuels innovation and enables the innovation process to run smoothly. Therefore, the innovation system includes all the main actors and institutions that contribute to the creation, development, diffusion and use of innovation, as well as the interconnection and interaction between all these actors and institutions.

3.1.6. Technopreneurship

Technopreneurship is the innovative application of technical science and knowledge individually or by people who create and manage businesses and take financial risks to achieve their goals and perspectives. Engineers have high technical skills, but engineers do not have high skills in business and entrepreneurial thinking. (Prodan, 2007). According to (Byers et al.), technopreneurship is a business leadership style. Including identifying highly technological economic opportunities with high capacity for growth, gathering resources such as expertise and capital, rapid growth, and great risk management through decision-making skills. Technology-based businesses take advantage of significant advances in science and engineering to provide customers with better products and services. There are clear roles, opportunities, and challenges for entrepreneurs worldwide to accelerate and influence economic growth and take advantage of the Digital Divide through business initiatives in the private sector. Innovations related to moving resources to areas with higher yields. Therefore, knowledge and knowledge-based entrepreneurship will be the primary driver of innovation in the twenty-first century through real/virtual and global/local infrastructure such as a network of incubators (Elias G. Carayannis et al., 2015). Technopreneurship is vital for a business because it can provide added value in buying and selling products, services, and information to be more effective. The goal of technopreneurship is to commercialization innovations developed by academic scientists through patents, licenses, creation of start-ups, and university-industry partnerships (Grimaldi et al., 2011).

3.1.7. Business Model Canvas^{1.1}

Business Model Canvas (BMC) describes the rationale of how an organization creates, delivers, and captures value. The business model canvas can best be explained by the nine basic building blocks that show the logic of how the company intends to

make money. The nine blocks cover four main areas of business: customers, offerings, infrastructure, and financial viability. A business model is like a blueprint for a strategy to be implemented through organizational structures, processes, and systems (Siyanbola et al., 2011a).

Chapter 4

4.1. Research Methodology

Research Methodology is a study where data collection, analysis and interpretation are carried out in a way where it has a method and structure. This research process has exact measure of the data and this data does not include personal opinions and others can trust the results and can reproduce the data. And for better understanding we use mixed, qualitative, and quantitative methods. This is one of the key research techniques. Data collection methods include experiments, case studies, interviews, surveys, and more. There are two types of sampling techniques: probability (random, stratified) and non-probability (convenience, purposive). Machine learning models, coding, theme analysis, and statistical testing are examples of data analysis techniques. Ethical considerations include maintaining confidentiality, obtaining informed consent, and reporting objectively.

4.1.1. User Research & Data Collection:

Survey Design and Implementation:

We conducted a survey using google forms, from this we understood what customers want or expecting, what concerns they have and what do they prefer the most.

Survey Objectives:

From this we can understand what user is expecting in respect of features such as security, durability and technology integration. We check the common issues where people are facing with the current travel bags and from that we can modify our bag

according to people needs, also considering the material preferences and sustainability.

Survey structure:

We made some structured questions which include things like age group, occupation and travel frequency and collected information from people like which brand they prefer ,what are the common issues they are facing, what kind of bags they need. And some of the interesting smart features we have are anti-theft safeguards, USB charging, Biometric security, GPS monitoring and app integration.

Participants and Distribution of the Survey:

We shared the survey through mail, WhatsApp groups ,LinkedIn, Instagram and Facebook to increase audience and to get more results and we got more than 100 responses in three days. We basically collected from potential users which include students, professionals, travellers ,people who frequently use backpacks for travelling.

Important Findings from the Survey: The answers offered insightful information about consumer demands and industry trends. Among the main conclusions are: For instance, people in the age group of 35-44 and under 18 face no water proof protection issue. Users complain that their existing bags are not durable enough. Participants are willing to pay more for a smart bag with cutting-edge security features. from the survey's insights we understood the Important stages of our project, such as material selection, product design validation, and competitor benchmarking,. We were able to prioritize features that users value most, compare our smart bag to other brands, and select materials that improve sustainability and durability.

The integration of biometric locks will be our primary focus if the majority of respondents Favor fingerprint security over traditional locks. We can guarantee a high-capacity power bank integration if USB charging is a highly requested feature. and for theft control most of the users, mainly travellers and working professionals need GPS tracking. Followed by Insights from our User research.

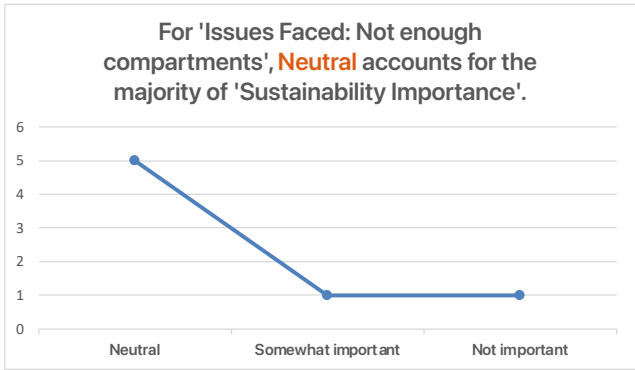


Figure 7 Space Concern Trend

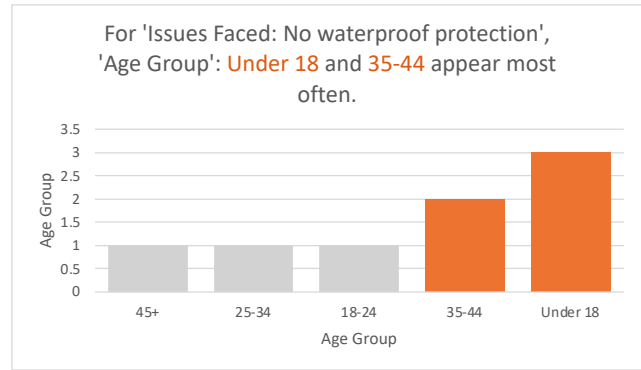


Figure 8 Age Group Trend

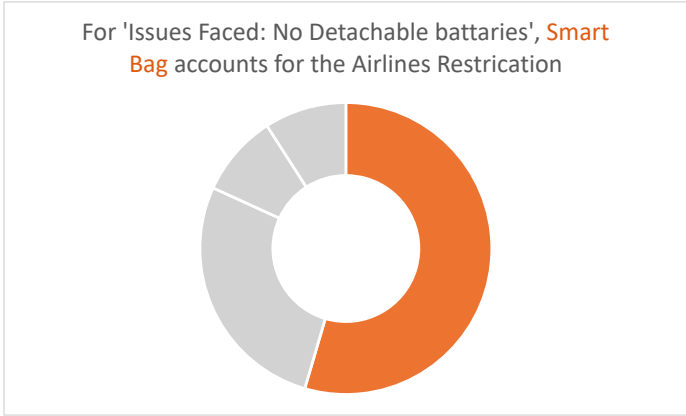


Figure 9 Air Line Restriction Trend

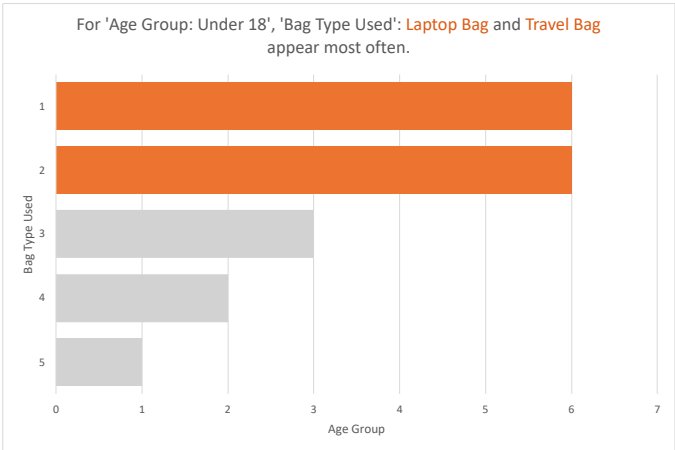


Figure 10 Core Use

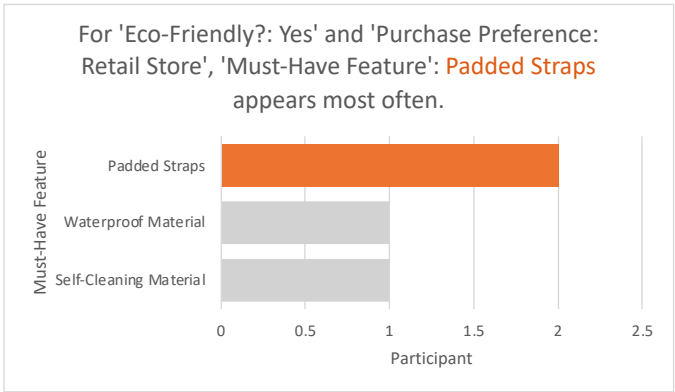


Figure 11Eco Friendly Concern Trend

Our User analysis of person issues reveals a clear hierarchy in perceived importance concerning backpack features. The least vast difficulty among users is "Airline Restrictions (Battery Removal)," registering at only 20%. This suggests that airline-associated barriers are not an essential issue for most customers. "Battery Life," marked at 30%, indicates a moderate level of challenge, reflecting a few attention for power availability however now not as a pinnacle precedence.

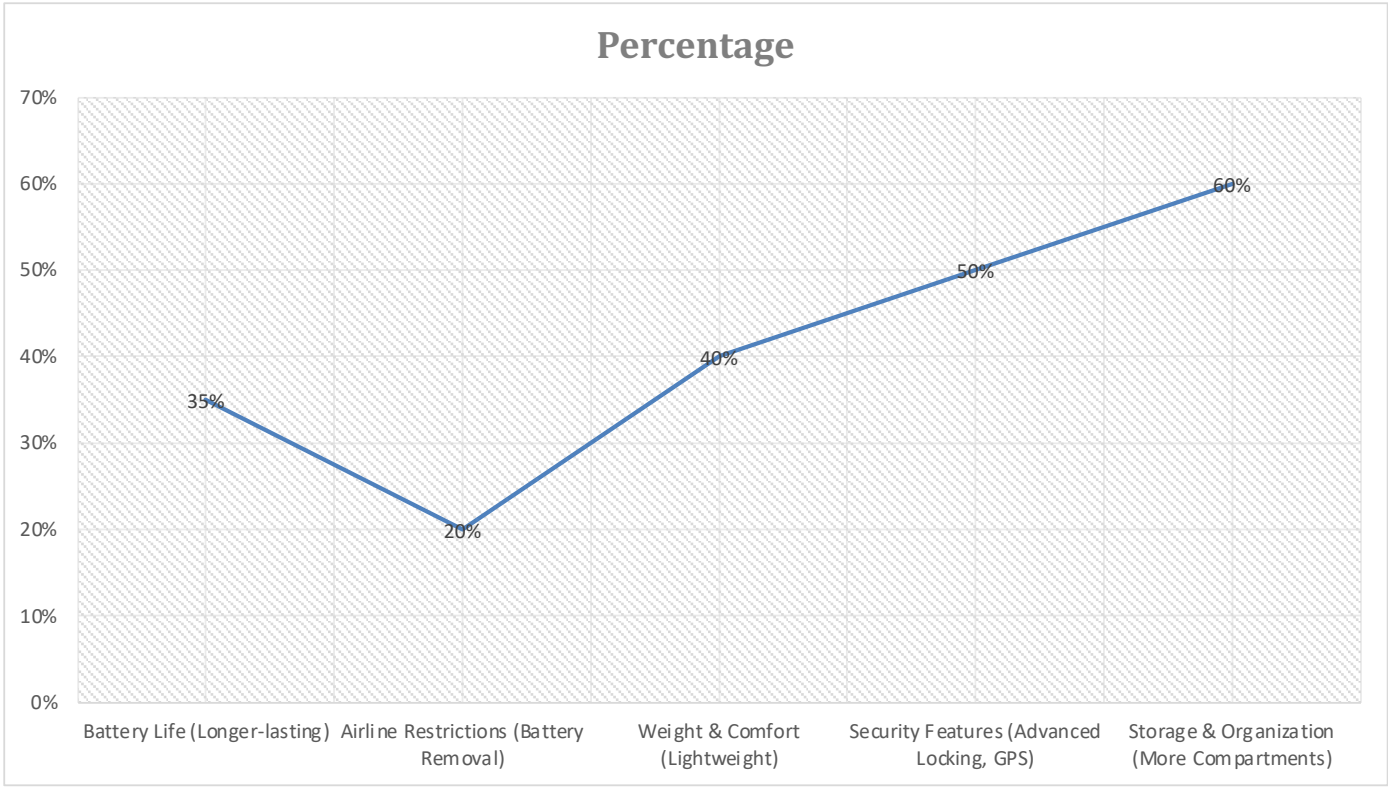


Figure 12 Overall Trendline Representation User Survey by TARS

The facts demonstrates a revolutionary boom in consumer priorities, beginning with "Weight & Comfort" at 40%, observed by "Security Features" at 50%, and culminating in "Storage & Organization" at 60%. This ascending trend means that practical aspects which includes ease of carrying and green compartmentalization, along the safeguarding of personal assets, are more vital to customers than power capacity or compliance with travel regulations. Therefore, the emphasis on usability and protection highlights a consumer preference for purposeful layout over technical or regulatory constraints.

User Research Pain Points & Solutions

	Pain Point Category	Pain Points Summary	Sample User Responses	Actionable Solutions
1	Airline Restrictions & Battery Removal	Battery removal due to airline rules is inconvenient; confusion around policies	"I had to remove my smart bag's battery at the airport..."	Design modular, airline-compliant removable batteries
2	Battery Life & Charging Concerns	Short battery life; unreliable charging ports	"Built-in battery doesn't last long enough..."	Use long-lasting batteries; provide replaceable USB ports
3	Security & Theft Protection	Weak locks and tracking; users request fingerprint & GPS	"Tracking didn't help locate my lost bag..."	Add fingerprint locks, GPS, and anti-theft mechanisms
4	Durability & Weight Issues	Heavy weight; hardware wears out (zippers, wheels, handles)	"Zippers and handles wore out in six months..."	Use lighter, durable materials for longer lifespan
5	Storage & Organization Problems	Poor access design; battery takes space; needs gadget-safe compartments	"Battery compartment limits space; poor laptop fit..."	Redesign compartments for tech-friendly, efficient storage

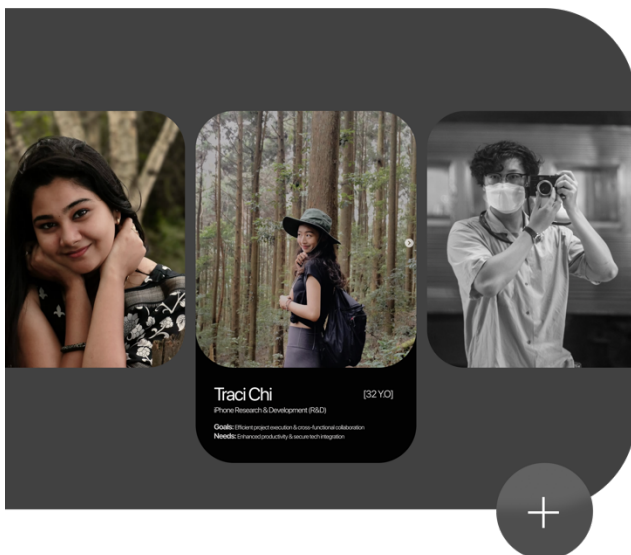
Figure 13 Insights from the User Interview (Major Responses)

User Persona of Smart Bag Tech

A person character is a fictional, special representation of your ideal user or purchaser, based on real records and studies. It consists of information like their demographics, conduct patterns, desires, needs, challenges, and motivations. User personas assist designers and builders understand who they are building for, which will create more person-focused merchandise and reports.

User Persona

The Smart Bag Tech project caters to Apple's iPhone R&D professionals, **offering security, tech integration, and ergonomic design**. With features like biometric locks, wireless charging, and RFID organization, it enhances **mobility and productivity** for their fast-paced work and frequent travel.



Debbieyh Hu BOM Engineer at Apple's

Background

Debbieyh Hu, a BOM Engineer at Apple's iPhone R&D in China, specialises in product structures, material sourcing, and change control, ensuring alignment with Apple's engineering and supply strategies.

Goals and Need

Debbie needs a smart bag with durable materials, ample storage, and airline-approved battery integration for hassle-free travel. She seeks enhanced security features like GPS tracking and biometric locks. Her goal is to find a stylish yet functional bag that supports her busy lifestyle.

4.2. Competitor Benchmarking (RCM Framework):

Competitor benchmarking is important for the research to know the benefits and drawbacks of the smart bags that are currently available in the market. We take a look at the very popular companies such as Samsonite, Nomad, Tzowla, and Nordace and we can able to identify key areas for the improvement and product innovation.

We compared competitors in detailed using the following criteria:

Discover Phase

Competitor Analysis is a crucial step in understanding market trends, evaluating existing smart bag solutions, and identifying gaps in material quality, security, battery life, and usability. This analysis helps refine our product strategy to create a superior, user-centric design.

Quantitative Research Competitor Analysis

			
Samsonite	Nomatic	Tzowla	Nordace
4.4 ★	4.5 ★	4.6 ★	4.3 ★

Features				
Material Quality	✓	✓	✓	✓
Weight (Lightweight Design)	✓	✗	✓	✓
Durability (Wear & Tear Resistance)	✓	✓	✓	✗
Water Resistance	✓	✓	✗	✓
Storage Compartments	✓	✗	✓	✓
TSA-Approved Lock	✗	✓	✓	✗
GPS Tracking	✓	✗	✓	✓
USB Charging Port	✓	✓	✓	✗
Ergonomic Design	✓	✓	✓	✓
Warranty & Customer Support	✓	✓	✗	✓

Importance of Benchmarking for Product Improvement:

By comparing our smart bag with Well-Known brands, we were able to:

Identify gaps in the market, Recognize what users value most, such as lightweight designs and security features. Make sure our product offers better value at a competitive price. We improve our product design by taking note of current shortcomings in competitors(e.g., weak zippers, battery overheating issues).Through this

benchmarking process, we were able to create a user-focused smart bag that offers exceptional innovation, security, and sustainability in addition to meeting industry standards. Gathering comprehensive annual sales and market data for the specified companies **Samsonite, Nomatic, Tzowla, Nordace, and Matein** is challenging due to varying levels of public disclosure. Among these, **Samsonite** is a publicly traded company that provides detailed financial reports, while the others are private entities with limited publicly available financial information.

Samsonite's financial performance is well-documented. According to Statista, the company's total revenue from 2007 to 2023 is available, with the latest data indicating that in 2023, Samsonite generated approximately 3.7 billion U.S. dollars in net sales. Additionally, Samsonite's net sales by brand from 2013 to 2023 are detailed, showing that in 2023, the American Tourister brand generated over 650 million U.S. dollars, making it the third-largest brand after Samsonite and Tumi. Regional sales data is also available, with North America contributing 1.27 billion U.S. dollars to Samsonite's revenue in 2023. We can understand a smart bag features, technical implementation a product development of a competitor smart bag company called Nomad from the research(*nomad sb*) Statistics and Data Resource: (www.statista.com)

Smart Bag Market Outlook (2024 to 2034)

Revenue from the global smart bag market is estimated to reach US\$ 3.97 billion in 2024 and achieve a value of US\$ 10.58 billion by the end of 2034. This latest research study by skilled analysts at Fact.MR states that worldwide demand is projected to rise at a noteworthy CAGR of 10.4% from 2024 to 2034.

Demand for smart bags with convenience and security features, such as GPS tracking, USB charging, smart locks, and others is increasing at a double-digit growth rate due to rising international travel, both for business and enjoyment. These features are valued by travelers as they allow them to stay connected and protect their stuff while traveling.

Another key factor that is positively influencing sales growth is the incorporation of technologies, including RFID, Bluetooth, and the Internet of

Things into smart bags. Sales are increasing because these features give consumers more convenience and protection, such as automated compartment organizing, real-time tracking, theft warnings, and others.

The North American region is projected to account for 31.4% of the worldwide market share in 2024 because of a high number of tech-savvy individuals. More people in the United States widely adopt products that are related to technology and these factors are also pushing sales of smart bags in North America. Other than this, strong e-Commerce infrastructure, particularly in the United States is further contributing to market expansion.

Based on material type, the revenue from ballistic nylon-based smart bags is analyzed to reach US\$ 935.55 million in 2024. Sales of smart bags made from this material are high in comparison with others because of their exceptional durability, resilience to deterioration, and water-repellent qualities.

By product, the demand for smart backpacks is projected to reach a worth of US\$ 5.73 billion by the end of 2034, up from 2.1 billion in 2024. Sales of smart backpacks are high in comparison with other products because of their adaptability and usefulness for several users, such as professionals, students, and tourists.

Report Attribute:(Tejas Chaudhary)

Report Attribute	Detail
Smart Bag Market Size (2024E)	US\$ 3.97 Billion
Forecasted Market Value (2034F)	US\$ 10.58 Billion
Global Market Growth Rate (2024 to 2034)	10.4% CAGR
North America Market Share (2024E)	31.4 Billion
East Asia Market Value (2024E)	US\$ 1.11 Billion
South Asia & Pacific Market Growth Rate (2024 to 2034)	15.1% CAGR
Trolley Smart Bags Segment Value (2034F)	US\$ 2.45 Billion
Brand Outlets Segment Value (2034F)	US\$ 2.82 Billion

4.3. KANO Model of TARS Bag:

The KANO Model affords a structured framework for categorizing product functions in step with their impact on customer delight (represented on the Y-axis as Customer Delight) and the corresponding degree of attempt or funding required for implementation (represented at the X-axis as Investment/Functionality). This model enables product teams to strategically determine how individual features have an effect on user notion and universal pleasure.

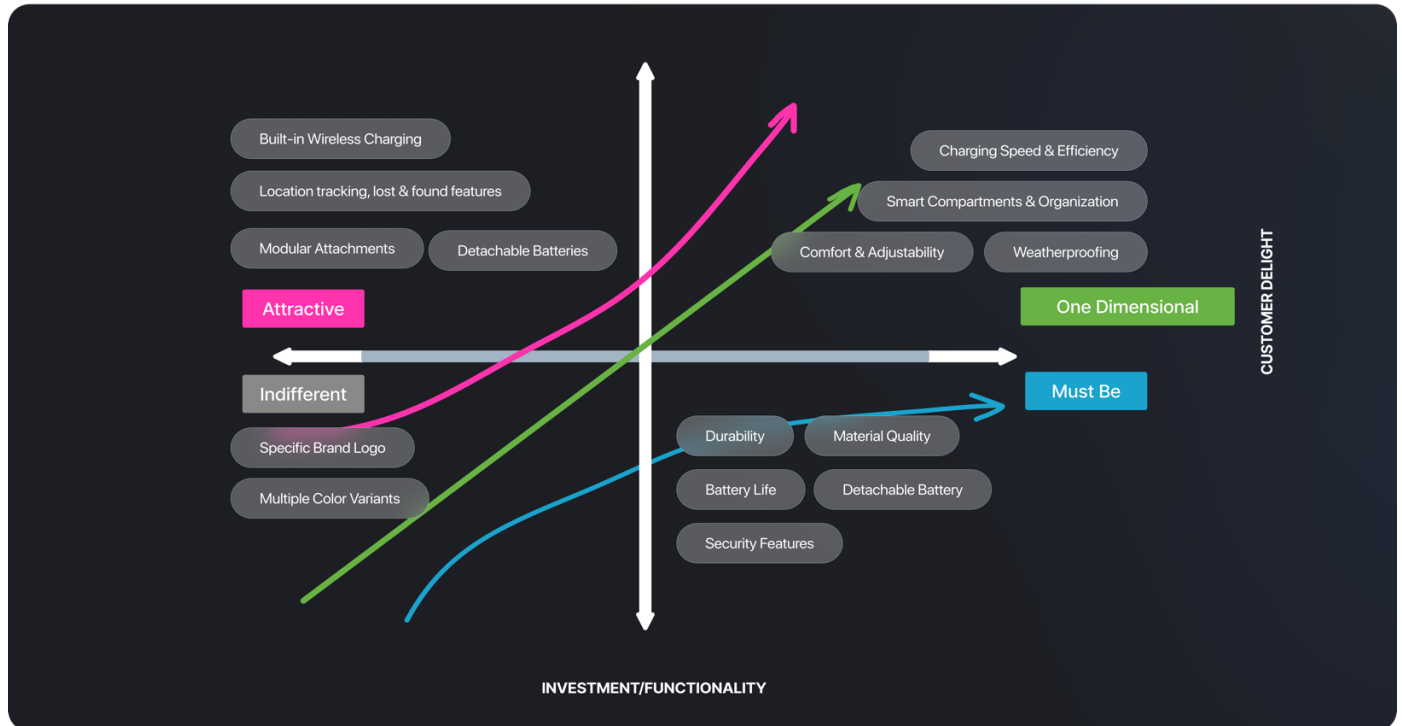


Figure 14 KANO Model Projection of User Research of TARS

Within this framework, capabilities are typically categorised into 4 primary categories:

Must-Be (Basic) Features: These are the foundational attributes that customers inherently count on. Their presence does not increase satisfaction, but their absence results in significant dissatisfaction. Ensuring these functions are correctly addressed is critical to keeping baseline consumer contentment.

One-Dimensional (Performance) Features: These functions show off a linear dating with satisfaction higher functionality or better performance immediately correlates with elevated customer pride. As such, they are perfect candidates for prioritization whilst aiming to beautify the product's price proposition.

Attractive (Delighters) Features: These are surprising or novel capabilities which could

drastically elevate consumer delight while gift, although their absence does no longer cause dissatisfaction. Investing in those features can create meaningful differentiation and foster more potent person engagement.

Indifferent Features: These functions neither make contributions to nor detract from patron satisfaction. As such, their development ought to be evaluated seriously in terms of value-effectiveness and strategic relevance, as they'll provide restricted return on investment.

In summary, product teams should prioritize the development of One-Dimensional and Attractive features to enhance competitive differentiation and user delight. At the same time, Must-Be features must be ensured to prevent dissatisfaction. The inclusion of Indifferent features should be carefully weighed against resource constraints, as their impact on user experience may be negligible.

Chapter 5

5.1. Pre-Production & Design Development

5.1.1. Technological Entrepreneurship Development

The concept of Tars smart bags was powered by a well-defined purpose: to develop a solution for a next generation that integrates intelligent technologies with ergonomic functionality and durable design principles. Inspired by AI Tars from the film *Interstellar*, the design crosses the traditional role of a backpack as a passive storage tool. Instead, it is imagined as an adaptive and responsible personal assistant, which is capable of developing according to the needs of the dynamic lifestyle of its users. This includes, but is not limited to students, professionals and frequent passengers. Tars smart bags thus symbolizes a convergence of innovation, utility and environmental consciousness, aimed at re-defining relationships between users and their everyday objects.

Initial Ideation:

Problem identification and formation

The ideology process originated from the crucial backpacks and a durable user challenge associated with travel bags. The main issues known include insufficient internal organization for both digital and analogue materials, inadequate power infrastructure for charging multiple devices during transport, absence of real-time security methods, physical discomfort during expanded use and unaffected nature of working materials. In addition, airline restrictions on smart bags equipped with non-removable lithium-ion batteries have emerged as a significant concern. These rules raise limitations on travellers and highlight the importance of designing battery-integrated systems compatible with international aviation safety standards.

These user-cantered challenges created a central design question:

“What if a bag could think, adapt, and respond to its user’s needs—just like TARS?”

The provocation re-imagined the traditional bag more than a passive storage solution, instead proposed an intelligent, interactive system capable of sensing, interpreting and responding to its environment and user's intentions. This refreshing served as the foundation for the imaginary development of the next pay-generation travel bag that is not only functional, but also respondent and adaptive.

Functional Themes and Core Ideals

The conceptual framework become structured round 3 middle pillars:

Intelligence: Integration of embedded sensors and microcontrollers to facilitate actual-time environmental sensing and adaptive responses, thereby transforming the bag into a semi-autonomous clever gadget.

Ergonomics: Application of biomechanical concepts to ensure a design that promotes consumer consolation throughout a number of usage contexts, together with day by day commuting and extended travel.

Sustainability: Commitment to the use of renewable, light-weight, and ethically sourced substances, aligning with broader environmental and social responsibility desires.

These thematic pillars furnished a strategic basis for the following design exploration, making sure that technological innovation was balanced with human-focused layout and ecological stewardship, at the same time as additionally accounting for regulatory compliance in international tour scenarios.

5.1.2. Brainstorming Sessions

Structure and Participation

A series of interdisciplinary brainstorming workshops were carried out over 3 iterative stages,

involving collaborative participation from key practical stakeholders. The periods blanketed:

Marketing Manager, accountable for competitor evaluation, patron segmentation, and prioritization of capabilities based on market demand.

Operations Manager, who assessed the feasibility of workflow integration, consumer interaction consistency, and general scalability of proposed capabilities.

Product Designer (the author), tasked with cloth selection, ergonomic issues, and the improvement of a modular and adaptive product structure.

Supply Chain Manager, who evaluated the provision of essential components, sourcing viability, and logistical implications.

Production Manager, focused on the manufacturability of proposed solutions, assessing factors consisting of meeting complexity, price-efficiency, and manufacturing timelines.

The workshops adopted principles from Design Thinking and Lean UX methodologies, with an emphasis on consumer empathy, rapid ideation, iterative prototyping, and remarks integration to

inform design selections. **Techniques Employed**

:To structure ideation and assessment techniques, the following techniques were utilized:

Mind-Mapping: Central design subject matters together with protection, strength management, travel compliance, and ergonomics have been extended into targeted and actionable function sets.

SWOT Analysis: Existing smart baggage products have been benchmarked to perceive marketplace gaps in terms of feature richness, value structures, and degrees of person satisfaction.

Persona Development: Representative consumer personas comprising a college scholar, a corporate govt who regularly travels, and a virtual nomad have been built to manual empathetic layout and accommodate various consumer desires.

Sketching and Rapid Prototyping: Preliminary visualizations have been created to conceptualize the internal format of modular cubicles, attachment mechanisms, and sensor placement strategies.

Key Outcomes of the Brainstorming Process: The interdisciplinary collaboration yielded several substantial design outcomes:

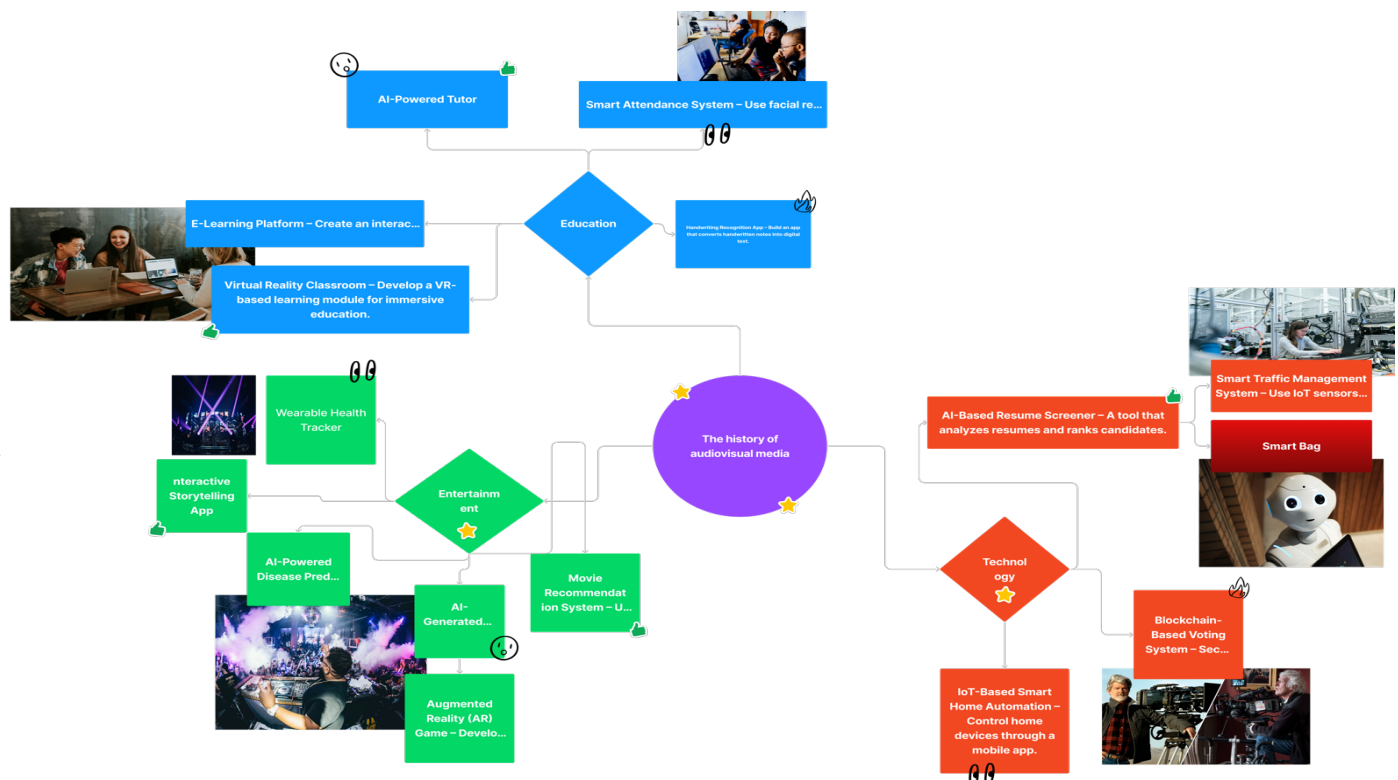


Figure 15 Brainstorm Session Outcomes Mind Map

The integration of modular booths, permitting users to reconfigure or detach unique sections primarily based on private or situational desires. The design of detachable smart modules (e.g., battery packs, GPS chips) to make sure regulatory compliance with air travel guidelines. The incorporation of biometric protection mechanisms, along with fingerprint sensors and facial reputation (Face ID) capability. Exploration of power-harvesting answers, such as sun panel-included fabric, to help sustainable and off-grid energy needs. Development of a committed cell application, enabling functionalities such as actual-time monitoring, battery popularity updates, and customizable indicators for user convenience.

5.1.3. Feasibility Steady

This step is essential for the development of technological entrepreneurship and should be taken seriously. In the feasibility study, the analysis and interpretation of all the fundamental issues related to the project, the environment, and all available alternatives are examined (Siyanbola et al., 2011b). According to Persistence Market Research, the trend of preferring and adopting smart devices in the market is expected to boost the global smart backpacks market in terms of value. This trend, as a result, is expected to be a vital driver of the global smart backpack market. Besides these, an increase in the awareness and participation of end-users in outdoor activities & sports across the globe has also encouraged the adoption of smart backpacks. It is expected to continue boosting the market during the forecast period. However, the high cost of smart backpacks is expected to be a major factor challenging the adoption of the same. Thus, the primary restraining factor for the global smart backpack market.

This research does not discuss the feasibility study comprehensively. The feasibility study is carried out only by calculating the cost structure, and revenue streams explained more fully on the business model canvas.

5.1.4. Data Collection

Data series is finished the usage of the Google Search Engine through typing in keywords related

to the technology being developed, that's a smart backpack. This includes phrases together with “smart backpack capabilities,” “IoT journey bag,” “anti-theft backpack with GPS,” and “biometric clever bag.” From this, a number of assets were analysed which includes product descriptions, consumer opinions, and technology blogs to recognize the contemporary tendencies, function gaps, and patron expectations in the clever backpack marketplace. Meanwhile, in accumulating information at the smart backpack evolved by using the author, user interviews and surveys had been conducted. Interviews have been achieved with decided on users representing the target marketplace segments (students, specialists, and frequent tourists) to collect insights on their reports with conventional backpacks and their expectations of a clever backpack. These interviews explored person pain factors along with battery lifestyles, organisation, protection, and journey convenience. In addition to interviews, researchers performed randomized on line questionnaires the usage of social media systems, specifically Instagram and WhatsApp corporations, to attain a much broader respondent base. The questionnaire focused on evaluating interest in functions evolved for the clever backpack product such as biometric locks, detachable battery modules, and GPS monitoring—and gauging how customers might respond to the mixing of those technologies of their daily workouts. The information gathered from interviews and questionnaires were in addition analysed the usage of the KANO version to categorize the capabilities primarily based on user pride (must-have, overall performance-primarily based, or attractive). Findings from this evaluation have been then used to support the function selection and prioritization within the TARS Smart Bag prototype.

5.2. Material Selection and Engineering

5.2.1. Recycled polyester (rPET)

Recycled polyester (rPET) is polyester material made by melting down used plastics (like PET

bottles) and re-spinning them into new fibers (Weavabel, 2024). His sustainable system maintains plastic waste out of landfills and oceans, giving materials a second existence (Weavabel, 2024), whilst using a ways fewer sources – its manufacturing can require ~59% much less electricity than virgin polyester. Despite its green starting place, recycled polyester keeps the excessive overall performance of conventional polyester (IKEA): it's robust, flexible and sturdy, and can be engineered to be water- and weather-resistant for travel use (HEATHER SEELY, 2024). It's an earth-friendly but tough-carrying preference for smart tour bags that should endure heavy use, and it complies fully with product and journey requirements many recycled-poly fabric are GRS (Global Recycled Standard) licensed (Dagne Dover), and the finished fabric meets rigorous industry satisfactory and safety requirements much like traditional substances (Naguib & Zhang, 2018)

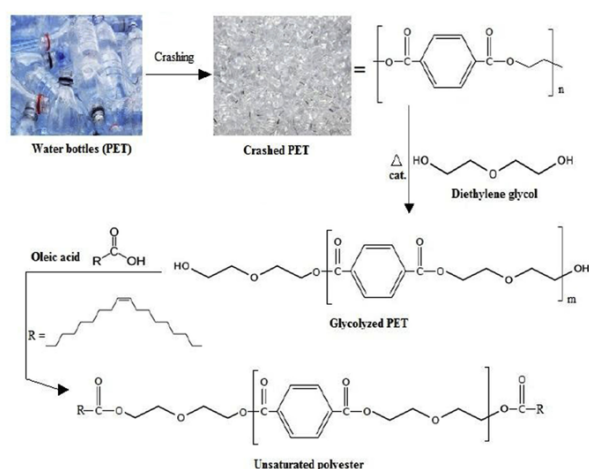


Figure 16 Preparation of ecological polyester using PET waste and oleic acid (Naguib & Zhang, 2018)

5.2.2. Durability Testing of Recycled Polyester for Smart Bags

Modern travel luggage is subject to considerable mechanical and environmental stress during transit, necessitating the use of materials that offer superior durability and resilience. Recycled polyester (rPET), commonly employed in the construction of smart travel bags, is subjected to a series of standardized performance evaluations to ensure its suitability for such demanding applications. These

assessments are designed to simulate real-world conditions and are often conducted in accordance with internationally recognized protocols, such as those established by the International Organization for Standardization (ISO) and the American Society for Testing and Materials (ASTM). Among the critical parameters tested are water resistance, which ensures the material's ability to repel moisture and protect internal contents; stress and strain durability, which evaluates the fabric's capacity to withstand tensile forces and deformation; abrasion resistance, which determines the material's ability to resist wear from repeated contact or friction; and thermal stability, which assesses the fabric's performance under variable temperature conditions. The results of these rigorous evaluations confirm that recycled polyester not only meets but frequently exceeds the performance benchmarks required for modern smart luggage. The following sections provide a detailed examination of each testing methodology and demonstrate how rPET effectively addresses the functional challenges of contemporary travel.



Figure 17 Three major U.S. airlines have announced new restrictions on "smart luggage" because of the fire hazard posed by lithium-ion batteries in cargo holds. The airlines say any such batteries need to be removable. (Laurel Wamsley, 2017)

Water Resistance Testing

Recycled polyester fabric is certainly hydrophobic, which means it repels water rather than soaking up it. To quantify water resistance, manufacturers carry out exams inclusive of spray checks and hydrostatic stress checks. In a sprig take a look at (e.g. AATCC 22 or ISO 4920) (Hill et al., 2020), water is sprayed onto the fabric to evaluate surface wettability – a durable water repellent (DWR) end will cause water to bead up and roll off, indicating good resistance. Hydrostatic head checking out (ISO 811) measures the pressure at which water penetrates the material. For example, a material might be rated to 1500 mm or extra of water

column, meaning it may face up to heavy rain earlier than leaking (Fred Perrotta, 2023). Recycled polyester clever bag materials are regularly lined or tightly woven to acquire high water resistance, protective the digital components inner from rain or spills. Because polyester doesn't absorb moisture, a moist bag may also dry fast, warding off introduced weight or sagging whilst exposed to rain (Sfameni et al., 2023). This inherent water-repellence, blended with coatings and sealed seams, is established thru lab checks in order that the TARS Smart Bag stays functional even in damp situations.

Water beading discovered on polyester fabric is indicative of the cloth's hydrophobic floor homes, an essential feature evaluated at some point of water resistance testing. For clever luggage intended for ordinary exposure to environmental moisture along with light rain or incidental splashes popular trying out protocols determine the extent to which water penetrates the cloth or vital ingress points (Kowalski et al., 2022), inclusive of zippers and seams, under controlled conditions. In evaluation, bags explicitly designed to be water-resistant, specifically those supposed to guard touchy electronic devices at some stage in greater excessive environmental conditions consisting of heavy rainfall or brief submersion, are subjected to greater rigorous evaluation techniques. These tests may additionally consist of full submersion assessments and standardized Ingress Protection (IP) score techniques. Such protocols commonly involve the controlled software of water via immersion or excessive-strain jets to decide the product's ability to hold internal dryness beneath pressure conditions. Recycled polyester, owing to its densely woven construction and the common incorporation of water resistant laminates or coatings, is nicely-ideal for reaching various stages of water resistance or waterproofing required for journey-oriented programs (Kumar & Joshiba, 2020). Manufacturers regularly cite these practical attributes in product descriptions the use of phrases which includes "water resistant" or through the specification of an IPX rating. These claims are generally substantiated by using laboratory-primarily based trying out, aligning with diagnosed enterprise requirements.



Figure 18 Polyester Royalty Free Getty Image

Stress and Load Testing

Smart baggage are challenge to large mechanical pressure during routine use, including compression in overhead compartments and the sustained guide of heavy contents through shoulder straps and handles. Consequently, the substances used in their production ought to show high tensile strength and load-bearing ability (Chauhan, Vinay et al., 2020). Recycled polyester, employed in each the outer shell and straps of such bags, is carefully evaluated thru standardized mechanical testing to make certain its suitability beneath these situations. Tensile electricity exams typically involve subjecting cloth samples to a tensile testing equipment that elongates the fabric until rupture, quantifying the force important for breakage (McCullough & Sun, 2019a). Polyester yarn, including its recycled variants, well-known shows inherently excessive tensile strength and exceptional resistance to deformation and fracture (Khe-Yo, 2024a). These traits allow recycled polyester fabric to reliably preserve sizable weight without failure. Additional mechanical opinions, consisting of static load checks, are conducted to simulate actual-world stresses. In these checks, a hard and fast weight normally between 20 to 30 kilograms—is suspended from the handles or shoulder straps of the bag for extended durations (CIRS). The objective is to validate the structural resilience of each the seams and the cloth beneath non-stop stress. Complementary drop tests in addition

investigate effect resistance: the bag, loaded to its operational ability, is dropped from a height of approximately one meter a couple of times. These repeated influences test for ability disasters in fabric integrity or sewing.

Another critical component in evaluating fabric overall performance for smart luggage is seam and attachment power. Standardized exams, which includes ISO 13935, are employed to assess the tensile pressure required to rupture stitched seams, thereby presenting a quantitative measure of structural integrity. Recycled polyester demonstrates commendable performance in this regard due to its inherent longevity, which contributes to long lasting and resilient seam production. Additionally, additives which includes zipper enclosures and incorporated electronics housings which include battery wallet are subjected to rigorous pull trying out to ensure they could resist mechanical strain without failure. While recycled polyester well-known shows barely lower power-to-weight ratios as compared to nylon, its performance is augmented by using the capability for tighter fabric weaves and its resistance to deformation under load. Consequently, these residences permit the fabrication of lightweight smart baggage capable of securely helping heavy contents, a declare substantiated through systematic stress checking out (CIRS; Fred Perrotta, 2023)

Abrasion Resistance Testing

Travel bags are automatically subjected to mechanical pressure, such as dragging, rubbing, and frictional touch with various surfaces which includes all through insertion and removal from overhead booths or whilst brushing towards hard textures. To assess the durability of the recycled polyester fabric generally used in such luggage, abrasion resistance trying out is employed. A widely diagnosed approach is the Martindale abrasion check, standardized under EN ISO 12947. In this procedure, a round specimen of fabric is subjected to repeated rubbing against an abrasive surface under managed stress situations. The take a look at measures the range of rub cycles the fabric

can bear earlier than visible signs and symptoms of wear and tear, along with thinning, fuzzing, or pilling, emerge as obvious. Empirical evidence helps the high abrasion resistance of polyester substances. In a consultant examine, polyester fabric together with those synthetic with recycled Fibers demonstrated the potential to face up to up to 15000 rub cycles without any observable damage (Melisa Suha Aksaman, et al., 2024). This performance indicates a high degree of erosion durability. Notably, polyester reveals advanced resistance to abrasion as compared to many other commonplace bag materials (Arora), including nylon. It is less vulnerable to pilling and fraying, which contributes to maintaining a more recent look through the years and preserving the structural integrity of essential regions like seams.(Kaynak & Topalbekiroğlu, 2008)

Manufacturers frequently utilize standardized durability exams including the Taber abrasion test, which employs a rotating disk abrader, or situation fabrics to repeated touch with coarse surfaces to simulate extended utilization. In such evaluations, recycled polyester demonstrates similar overall performance to its virgin counterpart. Although sure research imply that recycled polyester may additionally showcase marginally greater floor fiber loss below precise situations (Mccullough & Sun, 2019b) , it even though keeps an excessive diploma of durability, rendering it well-applicable for prolonged use (Katić Križmančić et al., 2023). This durability implies that the exterior of the TARS Smart Bag is proof against scuffing and put on, even after repeated tour. The effects of these abrasion checks confirm the cloth's potential to resist commonplace stressors consisting of sliding across airport flooring or friction against different luggage without big deterioration, thereby putting forward its lengthy-time period resilience.

Thermal Durability Testing

From the study of (Katić Križmančić et al., 2023) Smart accessories are often subject to a wide range of environmental temperatures, from high heat of car tights during summer months to high altitude of high altitude without any aircraft cargo coaches. To

ensure material reliability under such situations, thermal durability test is employed to evaluate the performance of recycled polyester clothing. As a thermoplastic polymer with a relatively high melting point of approximately 250 ° C, the polyester opposes melting or deformation under typical environmental heat. Nevertheless, high temperatures may still have shrinkage such as soft or slight dimensional changes. To assess these effects, fabric samples are often subjected to heat - aging protocols, which may be involved in contact with continuous high temperatures for several days such as 70 ° C. Post-exposure analysis usually involves evaluating materials for changes in tensile power, visible fall, or other signals of thermal effects. Additionally, to assess the performance in the cold environment, the fabric is done by highlighting the fabric for sub-zero temperature (e.g., 20 ° C or less), which confirms its resistance to emission or fracturing under low temperatures.

5.2.3. Airline Compliance Standards for Smart Luggage

Smart luggage with electronic additives (like the TARS Smart Bag) ought to adhere to professional airline regulations to be allowed on board. Key regulatory our bodies and recommendations consist of the International Air Transport Association (IATA), the U.S. Transportation Security Administration (TSA, which enforces FAA policies), and the International Civil Aviation Organization (ICAO). These guidelines focus on battery safety but also encompass material and layout considerations to make certain the bag is safe and meets bring-on necessities.

Lithium Battery Safety Regulations

Lithium-ion batteries in smart goods are classified as dangerous goods if not properly handled due to the risk of fire. IATA guidelines (resonant by ICAO and FAA) said that any lithium battery in the bag should be removed and taken to the cabin if the bag is checked (IATA, 2025). In practice, this means that smart bags with built-in power banks or chargers require a user-purely battery. For example, the dangerous goods guidance of IATA states: "Equal items installed with non-purposeful

batteries are prohibited for a train more than 0.3 grams of lithium metal or 2.7 WH" (IATA, 2025). This threshold (0.3 g/2.7 WH) is very low-effectively all rechargeable lithium battery is more than 2.7 WH- if you need to check the smart bag, you must remove the battery and move it to the cabin (IATA, 2025). After Major Airlines, IATA and FAA direction, this rule was implemented around 2018: any smart suitcase with lithium battery should be removed before check-in, until the battery is too small (IATA, 2025; Laurel Wamsley, 2017)

For carry-on use, the battery may remain installed during flight, but it still must complete size limits. The general limit for unrestricted carry-on is 100 WH battery (Federal Aviation Administration, 2025) ; It covers almost all laptops or phone power bank batteries (IATA, 2025; Laurel Wamsley, 2017). Battery allows between biata and TSA 100 WH and 160 only with airline approval (usually up to two parts in this range)(IATA, 2025; Laurel Wamsley, 2017). TARS smart bag batteries will probably be well under it (such as many smart bags ~ 20 with batteries). Compliance here means using a certified lithium-ion battery pack that has been labeled UN38.3 security tests (intertek) (required for air transport) and clearly labeled its WH rating. Additionally, spare batteries or power banks (not installed in equipment) are never allowed in the goods checked-they should go to the carry-on according to the TSA/FAA rules. In summary, the design of the smart bag, to follow the airline safety standards, includes a user-poverty lithium battery pack under 100 WH, which the user can easily separate and take it to the cabin whenever necessary (tsa.gov).

Material and Design Compliance for Carry-On Bags:

In addition to ideas related to integrated battery, smart goods should follow the general carry-on baggage rules installed by Airlines and Aviation Officers. There are no specific prohibition against the use of materials such as recycled polyester in goods manufacture. In contrast, polyester-especially recycled polyethylene terephthalate

(rPET) are used in the manufacture of carry-on suitcase due to clothing, safety, and non-durable nature. Unlike some industrial materials, polyester clothing does not contain regulated toxins, sharp components or electrolysis that may cause safety risks or violate airline restrictions. In addition, the non-functional properties of the material ensure that it does not interfere with the aircraft instrumentation or communication systems.

A major design idea in the development of smart goods is compliance with aviation rules related to wireless communication equipment. Many smart bags include features such as GPS tracking or Bluetooth connectivity, which are subject to regulatory inspection. As per the guidance issued by the Federal Aviation Administration (FAA) and the European Union Aviation Safety Agency (EASA), and as referred to by the International Air Transport Association (IATA, 2025), such devices should include functionality that disables wireless transmission during flight. FAA advisory circular AC 91-21.1D (Federal Aviation Administration) gives the mandate that equipment capable of emitting cellular or Wi-Fi signals should have at least two independent methods to neutralize, such as manual switch or automatic "airplane mode" settings. Consequently, smart goods systems - such as Tars include smart bags - design features that allow transmission capabilities to be disabled during air travel to ensure complete regulatory compliance.

Size and design compliance is another factor. IATA recommends a standard cabin bag size (about 55 × 35 × 20 cm, or 22 × 14 × 9 inch) for Carry-on; While each airline determines its limits, the Tars bags should be within these dimensions that should be universally accepted as carry-on. The weight range (often 7–10 kg) for carry-on means the bag should be lighter - an area where polyester shines, as it is lighter than a metal or hard plastic luggage. Features such as e-tag or digital lock should also follow safety rules: For example, TSA requires any closed bag accessible (TSA-innovated locks). IATA has also defined recommended practices for electronic bag tag and how they should act, so it is important to follow those

standards. In summary, the design of Tars Smart Bag is directed by compliance:

- Battery rule (removable, size limit, proper labelling)
- Wireless device rule (ability to close transmitter)
- Carry-on size/weight restriction, and

Ensuring any prohibited material recycled polyester content perfectly correspond to airline policies as it is no threat. (IATA, 2025)

5.2.4. Suitability of Recycled Polyester for the TARS Smart Bag

Recycled Polyester (RPET) is an excellent material choice for Tars smart bag for several reasons: it provides high strength and durability on low weight, it carries significant environmental advantage, and it meets all compliance and safety requirements for the goods.

Strength and Durability

Recycled polyester is simply as strong and durable as virgin polyester, because it has the identical polymer make-up. It can deal with daily wear and tear "without falling aside," making it "difficult enough to resist numerous put on and tear" in use (paramatex.com, 2024). For a smart bag, this durability is critical to protect the electronics internal. The high tensile strength of polyester means the bag's material can endure heavy loads and resist tearing (Khe-Yo, 2024b), even as the extraordinary abrasion resistance ensures the bag maintains its integrity and look over the years. Polyester fibers also have low stretch, so the bag received sag or lose shape even if absolutely packed. All the standard luggage durability tests mentioned (water, pressure, abrasion, thermal) show that recycled polyester performs on par with traditional substances. In some instances, recycled PET cloth even showed higher retention of strength after aging than trendy fabric (dropping simplest ~15% electricity versus 26% for virgin in a single look at) (Chauhan, Vinay Kumar et al., 2020), indicating it can handle lengthy-term use. This energy and resilience justify that rPET will hold the TARS bag practical through many journeys.

Additionally, polyester is obviously mildew and mildew resistant (it doesn't keep moisture), and it has accurate UV resistance (coloration won't fade quickly), including to the bag's sturdiness.

Lightweight and Practical

Using recycled polyester facilitates keep the bag lightweight without sacrificing sturdiness. Soft-sided baggage fabricated from poly material is commonly lighter than hard-shell instances fabricated from polycarbonate or aluminum (Plastics-themag, 2024). His approach vacationers can Pack. Greater gadgets or non-public objects earlier than hitting airline weight limits. The strength-to-weight ratio of polyester is very favorable whilst nylon is barely more potent by means of weight, contemporary weaving techniques (like excessive-denier weaves or ripstop styles) allow polyester to gain the necessary power with minimal cloth(Fred Perrotta, 2023).The result is a bag that's easy to carry or wheel around. Recycled polyester cloth is likewise flexible, making it best for a smart bag layout that might include expandable cubicles or embedded sensors. The material's versatility (*Acetal Polyoxymethylene Homopolymer -POM*) let in the TARS Smart Bag to have padded sections (for a pc or battery), stitched channels for wires, or incorporated solar panels, all without cracking (something a rigid plastic might do). All these functions may be integrated even as keeping the bag's weight low and its form ergonomic. In quick, rPET lets in the TARS bag to satisfy the bring-on size and weight compliance without difficulty, while remaining person-pleasant.

Environmental Impact

Choosing recycled polyester closely helps the environmental and sustainability goals of the TARS Smart Bag. rPET is made from post-purchaser plastic waste (often from bottles), diverting that waste from landfills and oceans. Every meter of recycled polyester fabric essentially offers a 2nd existence to plastic that could in any other case pollute the environment. By using rPET, the manufacturing of the bag "cuts down on plastic waste" and reduces the need for brand new

petroleum assets. Manufacturing rPET consumes much less strength and water than producing virgin polyester (CFDA). it's said to apply a whole lot less power and yield lower greenhouse gasoline emissions (*Acetal Polyoxymethylene Homopolymer -POM*; paramatex.com, 2024). This approach the carbon footprint of the TARS bag is smaller, aligning with eco-friendly values. Many bags' brands are embracing recycled substances "without compromising on sturdiness, aesthetics or design", proving that sustainability can cross together with excessive performance (Claussen et al., 2023). The TARS Smart Bag can for that reason be marketed as a green product, attractive to environmentally aware vacationers. Moreover, using recycled polyester does no longer introduce any hazardous substances, it's nonetheless the identical PET polymer, just reclaimed. It also can be recycled again at the give up of the bag's life, contributing to a circular economic system approach. The environmental compliance is easy: rPET fabric can meet standards like OEKO-Tex or Bluesign (which make sure no dangerous chemical substances), helping the product meet any regulatory or purchaser protection standards for materials. In precis, the usage of recycled polyester in TARS Smart Bag appreciably lowers environmental effect even as keeping the nice and protection of the bag, making it an accountable preference.

Compliance and Safety

From a compliance standpoint, recycled polyester is a commonplace cloth in all airways and nations, because it's basically like standard polyester utilized in infinite bags. There are no cloth restrictions on polyester cloth in aviation – it's non-flammable below everyday situations (will melt in preference to ignite without difficulty) and isn't considered a risky appropriate. Thus, the rPET shell of the TARS bag increases no pink flags at airport safety or airline exams. In truth, many gentle-sided deliver-on luggage today are made of polyester or nylon; the Plastics Europe exchange company notes that "many gentle baggage collections. now are made from recycled PET" because the industry moves toward eco-friendly

options (*Acetal Polyoxymethylene Homopolymer - POM*). This suggests that recycled polyester has been confirmed in real products to fulfill airlines' sturdiness and protection expectations. Since the cloth is material, it additionally doesn't intervene with X-ray screening (the safety marketers can effortlessly scan the bag and any electronic gadgets inside) (EFSA Panel on Food Contact Materials, Enzymes and Processing Aids (CEP) et al., 2023). Furthermore, the usage of polyester allows in integrating the smart components correctly. For instance, the battery percent may be housed in a padded polyester pocket – polyester's excellent thermal stability manner it received trap fireplace or emit toxic fumes if a battery overheats (it might require extremely high temperatures to combust). And within the not likely occasion of a battery hearth, polyester will melt away from the flame, potentially now not fueling it (while a more flammable fabric might worsen a fire). That said, the primary protection compliance (detachable battery, and so on.) is unaffected by means of the selection of rPET – the bag can fully follow IATA/TSA (IATA, 2025) guidelines as discussed, with the battery effortlessly removable and the electronics meeting regulations.

5.2.5. TARS Smart Bag: Key Smart Features

Modern clever bags integrate advanced technology to improve protection, convenience, and connectivity for tourists, college students, and specialists. The proposed TARS Smart Bag combines more than a few capabilities spanning biometrics, IoT connectivity, and energy solutions to create an excessive-tech bags solution. Below, we element each key function, explaining how the generation works, its cost to customers, and real-global implementations or standards that inform its feasibility.

a) Biometric Fingerprint Lock

A biometric fingerprint lock uses your fingerprint to unencumber the bag, replacing conventional keys or aggregate dials. How it works: Most fingerprint locks rent a capacitive sensor that maps the ridges and valleys of a finger by way of

Finally, it's worth noting that notwithstanding being recycled, rPET fabric meets all the identical best requirements as virgin cloth. It may be tested and certified for power, colorfastness, and absence of dangerous materials. The truth that leading luggage agencies are presenting warranty-backed suitcases made from recycled poly is a strong vote of self-assurance. As one instance, a youngster's backpack line made from recycled PET is described as "water resistant... long lasting portions of baggage that can easily be reused... over the years", highlighting reliability. This real-world use case underlines that compliance and longevity aren't sacrificed. In end, recycled polyester is an appropriate and smart material preference for the TARS Smart Bag as it affords the specified energy and durability in a lightweight, green package, all even as completely complying with airline safety requirements (from fabric protection to battery rules). The cloth choice thereby complements the product's overall performance, person appeal, and regulatory acceptance concurrently.

measuring mild differences in electric rate (IDEX; Tang et al., 2018). When your area your finger at the sensor, an embedded microcontroller compares the scanned pattern to stored legal fingerprints and releases the lock if it fits. This generation has been miniaturized for use in padlocks and baggage locks; for instance, the Samsonite EVOA Tech suitcase (Samsonite, 2021) includes a built-in fingerprint reader for TSA-authorized locking. Capacitive fingerprint readers are fast and correct, commonly spotting a print in below a 2d and storing up to 10 fingerprints for multi-user get right of entry to (Song et al., 2017).



Figure 19 Hand Fingerprint Image

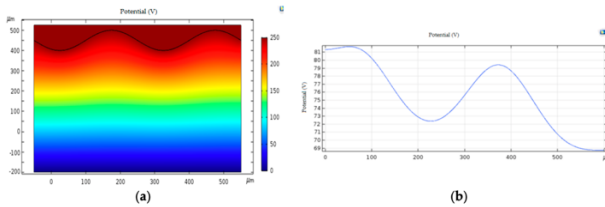


Figure 20 Fingerprint surface electrostatic field distribution. (a) the electric field distribution; (b) the electric field strength (Tang et al., 2018)

Value to customers: For travelers and commuters, a fingerprint lock offers brief, keyless access and improved safety (Busch, 2006). You now not want to hold keys or do not forget combinations your finger turns into the “key.” This reduces the danger of lost keys or forgotten codes, a prime convenience at some stage in journeys. Security is likewise advanced: fingerprints are difficult to spoof, and most effective legal customers (e.g. Own family individuals whose prints are enrolled) can open the bag. Professionals carrying touchy files or luxurious electronics advantage peace of mind that most effective they (or colleagues they enroll) can liberate the bag. In the event of a tried robbery, the lock cannot be picked like a conventional zipper lock. Notably, some smart padlocks even keep an audit trail of unencumber attempts through the associate app, so users can monitor any unauthorized access (Morosan, 2012)

Real-global use: Biometric locks are already utilized in safes and door locks and are emerging in tour equipment. Delsey’s prototype clever suitcase “Pluggage” (DELSEY redefines smart luggage.2017) featured fingerprint unlocking as a pinnacle user-voted characteristic (Rahul Kalvapalle, 2015). In that design, the bag will be locked/unlocked thru a fingerprint ID, integrated with a cellphone app for control. Several purchaser products nowadays put into effect this concept: the BenjiLock padlock and eGeeTouch locks are TSA-

authorized fingerprint locks for baggage, storing more than one fingerprints and permitting dozens of uses in line with rate. These show that fingerprint locks may be made climate-resistant and travel-friendly (some are water resistant and recharge via USB). Industry standards like the Travel Sentry TSA locks may be mixed with biometrics e.g. A fingerprint-activated lock that also has a TSA grasp keyway for airport safety get right of entry to. Overall, fingerprint lock technology is mature and feasible for clever baggage, giving customers a mix of excessive security and comfort.

b) Smart App Integration (Face ID, Bluetooth, Mobile App)

The TARS bag might characteristic a smart cellular app that connects to the bag through wi-fi technology (Bluetooth, and doubtlessly Wi-Fi or cellular) (Khadija Abdullah Salim Al Jabri et al., 2023b). This integration lets in the user’s telephone to behave as a remote manage and dashboard for the bag’s capabilities. How it works: The bag would incorporate a Bluetooth Low Energy (BLE) module that pairs with an app to your phone. Through this connection, the app can lock/unencumber the bag, reveal sensors, and configure settings. The app ought to use the smartphone’s built-in biometrics (e.g. Face ID or fingerprint authentication) to affirm the person’s identification before granting manage including a layer of security (Nagaveni et al., 2023). For instance, you could open the app and use Face ID to right away liberate the bag’s biometric lock thru Bluetooth sign. The app also can relay notifications from the bag (e.g. Open indicators, missing item reminders) to the user. This type of telephone integration is commonplace in IoT gadgets and smart luggage: Delsey Pluggage’s partner app allowed travelers to check if their bag turned into loaded on an aircraft or opened in transit, nd to control its electronic lock. Similarly, many clever locks (for houses and lockers) use Bluetooth apps, often leveraging smartphone biometrics for “keyless” but authenticated get admission to. Beyond Bluetooth, app integration may increase to internet connectivity. If the bag has Wi-Fi hotspot or cellular module (as later described later), the app

can communicate with the bag from anywhere (not only within the Bluetooth range). For example, if the GPS tracker of the bag reports its location for the cloud service, the mobile app can display a real-time location on a map even when away from the bag. If the bag contains a camera (although the possibility of face ID in our case refers to the face ID of the phone). In practice, this means that the user can simply look at their phone (trigger face ID) and immediately get access to bag controls - seamless and safe.

Value to customers: A committed cell app centralizes all the clever capabilities for clean manipulate. Travelers benefit by receiving immediate alerts on their smartphone if something is inaccurate (e.g. A person opening the bag or the bag transferring away) and with the aid of being capable of lock or discover their bag with a faucet. Students and experts can use the app to arrange contents (e.g. Test a packing checklist linked to the missing item characteristic) and interface with the bag's tech (switch on the indoors mild, check battery degrees, and so forth.). The use of smartphone biometrics like Face ID provides convenience (Khadija Abdullah Salim Al Jabri et al., 2023c). it guarantees that even though the smartphone is stolen, the thief can't manage the bag without the owner's face or fingerprint (Sk, 2024). It essentially ties the bag's security to the strong authentication techniques in contemporary smartphones. Moreover, app integration enables firmware updates and new features through the years, improving the bag's capability without needing new hardware.

Real-world examples: Most clever baggage comes with a mobile app, underscoring the importance of app integration. For example, the ForwardX Ovis suitcase (a car-follow clever suitcase) is paired with an app for monitoring and settings, and Samsonite's Track&Go makes use of Bluetooth and an app to locate luggage. The integration of cellphone-based totally biometrics is visible in smart home structures and will without difficulty practice to baggage: locking/unlocking the bag thru an app that requires Face ID has similarities to using Face ID to open a clever door

lock remotely. Standards like Bluetooth 5 permit greater variety and faster records transfer (Mouser Electronics), meaning a smartphone ought to live linked to a bag from dozens of meters away (AMIT MALEWAR, 2018). Additionally, IoT structures (like Tuya or TTLock for clever locks) already offer SDKs for mobile apps that take care of BLE conversation and consumer authentication. By constructing on these (Collotta et al., 2018), the TARS bag app can reliably control functions consisting of proximity signals, faraway locking, and consumer control. In summary, smart app integration leverages the ubiquity and safety of smartphones to make interacting with the bag intuitive and secure.

c) Waterproof Design

Travel luggage are uncovered to the elements, so the TARS bag is designed to be waterproof, defensive its electronics and contents from rain or spills. How it really works: The bag's substances and construction might adhere to ingress safety requirements. Typically, a combination of water-resistant coatings, sealed zippers, and impermeable substances (like TPU-lined nylon or polycarbonate shells) is used (ASHOK HAKOO, 2022) . For example, a hard-shell clever suitcase might use ABS or polycarbonate panels which can be inherently water-proof, with rubber gaskets around zipper seams. A cloth clever backpack may use a durable water repellent (DWR) coating at the material and water-resistant zipper enclosures. Manufacturers regularly look at baggage to an IPX score – a degree of water ingress safety. An IPX5 rating means the bag can withstand water jets from any direction (heavy rain), even as IPX6 can take care of stronger jets and storms. Some high-end dry luggage even reap IPX7 (Peter Susic, 2023), surviving submersion in up to one meter of water, Hough normal smart luggage cognizance on rain-proof rather than submersible. Achieving waterproofing also involves protective electronic components: circuit boards may be covered, and any external ports (like USB) have shielding covers. In the TARS bag, even the fingerprint sensor and charging ports could want sealing to prevent moisture ingress.

Value to customers: A water-proof design is essential for tourists and commuters who might also come upon terrible weather. For a commercial

enterprise professional, the bag might be carrying a computer, important papers, or electronics – the water-resistant function guarantees a surprising downpour Won't these items. Students on foot throughout campus in rain or cyclists commuting with the bag gain from understanding their textbooks and devices continue to be dry. Travelers regularly region bags on wet surfaces (airport tarmac, boat decks, and so on.); with waterproofing, the bag's electronics (GPS module, battery, and so forth.) are much less likely to brief out or fail due to moisture. This reliability is especially critical due to the fact the clever capabilities depend on the one's electronics – waterproofing protects the investment and functionality of the bag (Akkan et al., 2022). It also adds to durability: a nicely sealed bag also maintains out dust and dust (many water-resistant baggage are correctly dustproof too, as indicated through IP ratings that update the dirt digit with "X" when Understanding) (Craft Cadence Waterproof). In practical phrases, customers can travel to tropical climates or through heavy rain with peace of thoughts. The characteristic additionally manner simpler upkeep – the bag may be wiped down or even gently rinsed without harm (Chang & Liu, 2023)

Real-world standards and examples: Real-global requirements and examples: Many journey backpacks promote it water-resistance, however authentic waterproof overall performance comes with meeting IPX requirements. Cycling commuter baggage frequently purpose for IPX5–IPX6, in view that they face severe rain; one guide notes IPX5 is the minimum to label as "water-proof" and IPX6 because the gold preferred for heavy downpours. The TARS bag could similarly target round IPX5/6, (Craft Cadence Waterproof) meaning it might withstand any rain a tourist may come across. Some clever bags use materials like PVC tarpaulin or covered canvas to achieve this. For instance, the Airwheel SE3S smart scooter-suitcase makes use of an ABS shell defined as "tremendous resilient and water-proof" (Theresa Holland, 2025). Another instance is the Forward Ovis which has a Makrolon polycarbonate shell with a smooth water-resistant end. These show that incorporating waterproof substances is feasible even for tech-weighted down bags. Industry checking out protocols (along with ASTM or ISO

standards for luggage materials) frequently include water resistance checks. By following such requirements and possibly certifying an IP score, the TARS bag can guarantee customers of its all-climate performance. In summary, the water-resistant design isn't simply advertising – it's built on tested practices in technical bag production and is vital for a travel-prepared clever bag.

d) USB Port & Detachable Solar Pad

The TARS smart bag affords on-the-pass charging through an integrated USB port powered by means of an inner battery (Taverne et al., 2018), which can itself be recharged through a detachable solar panel pad. This twin machine ensures customers can charge devices anytime and even harvest sun power while outside. How it really works: The bag's internal battery (mentioned separately in the subsequent phase) is attached to a USB Type-A or Type-C port handy on the bag's outside. Users can plug in their telephone, pill, or other devices just as they might right into an energy financial institution. The detachable solar pad is a flat solar panel that can clip onto the bag (for example, on the front pocket or pinnacle flap) and hook up with the battery thru a cable. The panel is made of photovoltaic cells (frequently monocrystalline silicon for high performance in a small length) laminated in a flexible or rigid sheet. In sunlight, the solar cells generate electricity which a built-in charge controller feeds into the battery to recharge it appropriately. Essentially, the sun pad turns the bag into a mini solar charger. When not needed, it is able to be removed to lighten the bag or to higher position it closer to the solar. Many sun backpack designs use ~5W to 10W panels. For instance, a 7W sun panel on a backpack can output about 5V/1A through USB in direct sun, sufficient to trickle-charge a telephone. Higher-quit removable panels would possibly provide even extra (a few trekking packs have 10–20W foldable panels). The bag's gadget would include over-rate safety in order that devices aren't overpowered and the battery isn't overcharged. The sun pad possibly attaches with clips or magnets, and uses long lasting cabling to the internal electronics (Akin-Ponnle & Ponnle).

Value to users: This characteristic is especially useful for travellers, students, or specialists who spend long hours away from electricity stores. Travelers in faraway areas (trekking, camping, or simply travelling a city all day) can recharge their cell phone or camera directly from sunlight,

making sure they continue to be linked and their gadgets purposeful for navigation, photography, etc (Diwakar & Student). Even in airports or teach stations, wherein wall sockets are scarce, one could depend on the bag's battery (topped up by sun) to stay charged. Students on campus might sit down outside reading; the solar pad can quietly recharge their battery percent so that they have more juice for night training. It's an green way to stay charged, lowering dependency on electric stores and leveraging renewable electricity. For specialists, the sun panel offers an emergency backup – in case you're at a protracted outside occasion or commuting and your cell phone dies, you can get a rate without stopping at an outlet. The removable nature method if sun charging isn't wanted (e.g. On a business ride from taxi to office), one could leave it off, retaining the bag's look glossy. Conversely, on a sunny day, attaching it can continuously top up the electricity financial institution, extending the capability indefinitely with correct daylight. This adds a layer of self-sufficiency to the bag; it's now not simply sporting power, it's generating power. Over the span of a multi-day journey, solar charging can considerably supplement the battery, that's a big plus for sustainability and comfort.

Real-world examples: Solar-enabled backpacks are already available on the market and have tested the idea. The Solgaard Life pack is a backpack with a sun panel that charges an included energy financial institution (solgaard, 2019), providing a USB port inside the facet pocket for tool charging. Users of Life pack stated that its sun panel should maintain a cell phone charged with mild sun publicity. Another example, Voltaic Systems, produces backpacks with removable excessive-wattage solar panels that may even charge laptops. The fact that Travel + Leisure selected the Solgaard Life pack as “Best Solar-charging” backpack highlights the attraction of this feature for vacationers. In phrases of feasibility, small sun panels (~A4 paper size) can realistically produce a few watts; one product list indicates a 7W panel with USB 5V output, confirming that such panels can without delay price phones. There are also industry standards for sun chargers (USB output is usually regulated to 5V). The bag's USB port itself might observe the USB charging standards (in all likelihood helping USB-C Power Delivery for faster charging if a larger battery permits). Many clever suitcases incorporate USB ports powered via an inner battery; as an example, the Airwheel and ForwardX smart suitcases have dual USB ports for

charging devices. Combining that with sun recharging extends the usefulness in off-grid scenarios. With enhancements in bendy solar tech (some panels are actually thin and flex with the bag's form), integrating a detachable sun pad is quite practical for a smart bag. It aligns with the growing trend of sustainable tour gadgets, giving TARS bag customers both comfort and a bit of green power on the move.

e) Detachable Battery (Airline Approved)

Central to the TARS smart bag is a removable lithium-ion battery p.C. That powers its capabilities and costs gadgets. Crucially, this battery is designed to be easily removable to comply with airline guidelines (KRISTINA PORTILLO, 2018). How it works: The bag carries a battery percent (as an instance, a ten,000 mAh energy financial institution module) in a devoted compartment. This battery connects to the bag's electronics (USB ports, wireless charger, etc.) through a plug or docking connector. When needed, the person can eject or eliminate the battery usually by way of urgent a release mechanism with none gear (IATA, 2025; Jerri Ledford, 2023). The electrical connection is designed to disconnect thoroughly. This is crucial due to the fact as of 2018, primary airlines and the International Air Transport Association (IATA) (IATA, 2025) mandated that smart baggage batteries have to be removable for protection. Lithium-ion batteries can be a hearth threat if broken or overheated in flight, so being capable of do away with the battery approach it can be taken into the airplane cabin (where group can display it) rather than in an unreachable cargo maintain. The TARS bag's battery likely adheres to potential limits as nicely – maximum airways allow batteries up to a hundred Wh (~27000 mAh at 3.7V) in carry-on without special permission (Cabin Zero, 2023). A standard clever bag battery is round 37 Wh (like Away's 10,000 mAh) to without problems meet this (*All about the battery*). The battery module should have its very own USB-C port for charging it out of doors the bag and maybe an LED fame indicator. “Airline accredited” basically means it's underneath the energy restrict and quick detachable.

Value to users: For passengers, this feature is important. Many airlines will not accept a smart bag in check-in until the battery is removed (CHANEL VARGAS). With a violable battery, the user can simply pop out and move it, to avoid any

travel disruption. This ensures that the bag suits TSA and airline policies, so the user is not forced to leave the bag or battery at the airport (Maxine Builder, 2018). Beyond compliance, it is convenient to charge a removable battery: you can take the battery module to the wall outlet (or bedside in a hotel) to charge, without bringing the entire bag (KRISTINA PORTILLO, 2018). It also allows the battery to swap-a technique-loving professional can take an additional battery module for additional capacity (similar to the camera battery) (Cabin Zero, 2023). From the security point of view, if a battery problem arises (swelling, etc.) , it can be easily replaced. For students and everyday users, it means that the power source of the bag is not permanently fixed; If the battery technology improves, an advanced pack can be slot. In addition, when the bag is not required (says that you just go into the classroom with a laptop and leave the bag behind), you can remove the battery and use it separately. This flexibility is a value-add. Knowing the battery is "airline-analogue", it gives peace to the mind that anyone can take a bag on international flights without running the rules-some will appreciate the previous events of the smart bags that fly repeatedly, when the rules suddenly changed in 2018 (Maxine Builder, 2018).

Real-world examples: Real-international standards and examples: This feature is directly informed by means of enterprise policies. In January 2018, airways like American, Delta, and others up to date regulations requiring that “customers who tour with a clever bag have to be capable of remove the battery ... If the battery cannot be removed, the bag will now not be allowed.”IATA additionally advocated banning non-removable batteries.As an end result, main smart luggage makers adjusted designs. Away, a famous smart bags brand, designed its convey-Ons from the begin with a 37 Wh eject able battery; they later even provided kits to retrofit older models with short-eject batteries.Away’s battery can be popped out in seconds (Emily Price, 2018), illustrating precisely the kind of user-pleasant removal TARS bag might emulate. Another logo, Raden, blanketed a detachable charger in its cases (imparting as much as 4 full cell phone fees).The Blue smart bags logo failed in component because its batteries were non-detachable, reinforcing why TARS need to have this feature.From a technical widespread attitude, UN/DOT 38.3(UN 38.3) certification is needed for lithium batteries in

transportation – using a regarded battery module that meets those protection checks is prime. By making the battery removable, the TARS bag aligns with each regulatory compliance and user comfort. As one industry executive stated, designing with an without problems on hand battery pocket yields a better, safer product.In summary, the removable, airline-compliant battery ensures the smart bag’s tech benefits can be enjoyed without sacrificing journey flexibility or safety.

f) Missing Item Reminder

One of the progressive functions of Tars Bag is a lacking object reminder - a gadget that indicators you when you have left a distinctive crucial item before intending. How it really works: The bag uses sensors or tags to maintain music of unique items which you frequently take (as an example, your wallet, keys, laptops, or passports). During the setup, the person will "tag" it’s essential items both with almost or bodily tag. A viable implementation is through small RFID or Bluetooth low strength tags associated with the object. For instance, lumzag's bag supplied unique identity stickers (RFID tags) that connect with consumer accessories; The sensor machine of the bag then detects those items. If you start taking walks away and one of the gadgets tagged within the bag isn't always detected, the device sends an alert to your cell phone (and/or a beep from the bag), which informs you that you have forgotten something. Alternatively, Bluetooth tags (e.g. tiles) may be used: the interior hub of the bag can check if all registered objects are inside the tag range. If a tag (on your wallet) disappears while you close the bag or flow a sure distance, it triggers the reminder. More advanced techniques may additionally include weight sensors in particular pockets or compartments (for instance a strain sensor within the computer sleeve that knows whether or not the laptop is present).(Yanko Design, 2018)

But tag-based solutions are extra bendy and have been utilized in previous clever bag designs. NASA even developed a prototype for smart packing containers the use of RFID to tune contents with excessive accuracy (NASA TECHNOLOGY TRANSFER PROGRAM), showing that even

more than one small object may be tracked in an enclosure like a bag. In the TARS bag, the electronics would test for the presence of the paired tags whenever the bag is set to leave (perhaps caused through the bag's movement sensor or the user sending a "check" command through the app). If any tagged item isn't determined, a direct notification like "Your passport isn't always inside the bag" could pop up. This requires a database of which tags correspond to which item (setup within the app). The communicate between tag and bag will be through short-variety RF (RFID) – wherein case the bag would possibly have an RFID reader antenna internal – or via BLE, with tags broadcasting and the bag's hub listening.

Value to users: This function is a virtual failsafe against forgetfulness. Travelers advantage immensely: imagine packing up from a lodge and the bag reminds you that your passport or pill is not inside – doubtlessly saving you from a catastrophe of leaving it behind. For college students, the bag ought to alert if you're heading out without your computer or a particular textbook you normally convey. Professionals can make certain they haven't left vital documents, safety badges, or gadgets at home or within the office. It basically gives an automatic tick list. In hectic situations (checking out of a lodge, leaving a conference), humans can forget about gadgets; the smart bag has your returned by using maintaining an inventory. This reduces anxiety, in particular for vital files or electronics (M et al., 2016). It additionally deters theft or loss of man or woman objects – if someone picks your pockets out of your bag while you're no longer looking, the bag might word it's long past and warn you, potentially in real time. The convenience is which you don't must manually check each pocket; the bag "knows" and will let you know if something's lacking. This is a standout feature that goes beyond what standard baggage offers, effectively making the bag a guardian of your essentials. For every day existence, it is able to improve excellent behaviour (always percent sure gadgets) and prevent the disappointment of arriving somewhere simplest to recognise you left something vital at the back of. Ultimately, it gives peace of mind: one less issue to fear about while speeding thru your day.(Yvonne Ng, 2019)

Real-world examples: The missing item reminder changed into one of Lumzag smart bag's most touted features. They implemented it the use of tags and the accomplice app, in order that "if you appear to depart something at the back of Lumzag will notify you (Yanko Design, 2018)." This shows sensible viability – in the course of their Indiegogo, they validated how tagged gadgets cause an alert whilst not detected. Another instance is inside the IoT space: a few clever bag prototypes in academia have proposed RFID-primarily based inventory assessments. NASA's smart enclosure patent proves that with a proper association, even a duffle bag can sign up more than one RFID tags reliably, which can be leveraged for a customer product. Outside of bags, clever domestic structures (like a smart drawer) have used weight sensors or RFID to come across item presence, so the idea is adaptable. On an easier degree, many people use Bluetooth trackers (Tile, AirTag) to keep away from dropping gadgets; the bag's system basically internalizes that characteristic so it's computerized. Apple's AirTag will notify you if you depart a tagged item in the back of (the use of your cell phone's region), which is similar in spirit – though TARS's approach is extra localized (the bag itself assessments). The technology required (RFID reader or BLE scanner) is easily available and may be made small and low-strength. Standards like ISO 18000-6C (UHF RFID) (Yvonne Ng, 2019) can be used for passive tags that require no batteries, making it hassle-free for users to tag things. In end, the missing object reminder function is nearly implementable and addresses a common ache point. It leverages concepts demonstrated via existing monitoring tags and smart inventory research, giving TARS bag customers an extra layer of security for his or her property that only a few products currently offer.

g) Open Alert & Remote Anti-Theft Alarm

Security is a first-rate concern with baggage, so the TARS clever bag includes an open alert and a far flung anti-theft alarm device. How it really works: The bag is equipped with sensors that stumble on unauthorized beginning and motion. An open alert means if someone unzips or opens the bag without the owner (as an example, at the same time as you're now not paying interest), the bag will without delay ship a notification to your cell phone and/or sound an audible alarm. This may be carried out with an easy transfer sensor on the zipper or latch mechanism – whilst the bag is closed, the

circuit is unbroken; if it's opened (and the bag is in armed mode), the circuit breaks and triggers the alert. The faraway anti-robbery alarm refers to a characteristic where if the bag is separated from the proprietor by way of extra than a sure distance, each the bag and contact will alarm. Typically, this makes use of the Bluetooth tether: if the phone's connection to the bag drops or exceeds, say, 10 meters (indicative of the bag being taken away), it can reason the bag to emit an excessive-pitched alarm and the cell phone to alert the person. Lumzag's (Yvonne Ng, 2019) anti-robbery laboured exactly like this: whilst safety mode is on, "each time someone attempts to open your bag or thief it," you get notified, and if the bag is going beyond your set distance, a loud alarm on the bag turns on (Valluripally et al., 2020). The user can set this distance threshold inside the app (e.g. Five meters in a café state of affairs). The bag probably has a small siren or buzzer constructed in for the audible alarm. Additionally, the person can likely manually cause the alarm from the app (e.g. In case you recognize your bag is stolen, you could purpose it to alarm remotely to startle the thief). The gadget can also contain a movement sensor: if armed, any movement of the bag (a person grabbing it) should cause the alarm even earlier than distance is breached. The faraway thing implies you may get alerts even if you're not proper next to the bag, through a cloud connection if the bag has mobile/Wi-Fi, or as a minimum via the Bluetooth whilst in variety.

Value to Users: This feature greatly complements bag safety, especially in public spaces like airports, cafes, and stations. The anti-theft alarm notifies you if someone tries to transport or open your bag (Divya Kaushik, 2024), acting as a sturdy deterrent. A loud sound attracts attention, while a diffused chirp warns each you and any meddler. For students in libraries or specialists in meetings, it ensures your belongings live safe even when in short unattended. The far-off alarm also prevents unintended loss your smartphone signals you in case you walk out of range, growing a geo-fence around your bag. Like a vehicle alarm on your backpack, it gives peace of mind in crowded or

unfamiliar places, specially while sporting valuables or sensitive data.

Real-world examples: Anti-robbery alarms are already used in smart bags like Lumzag, which alerts customers through cell app and sounds an alarm if the bag is moved out of variety. Devices like Tile trackers provide comparable separation signals and audible earrings. The TARS bag integrates those features at once for a seamless, all-in-one revel in. Hardware-sensible, the usage of a buzzer and Bluetooth-primarily based proximity indicators is easy and tested like how laptops vehicle-lock when disconnected from a paired cellphone. Backpacks by way of PacSafe use mechanical anti-theft functions, while Delsey's Pluggage explored signals for unauthorized openings during transit. These examples show each feasibility and person demand. With no strict industry requirements, it's critical the alarm is loud sufficient for public spaces like compact bike alarms. TARS enhances this concept with smarter connectivity and energetic monitoring.

h) Real-Time GPS Tracking

The TARS clever bag gives worldwide actual-time GPS monitoring, letting users find their bag each time, anywhere. It makes use of a GPS receiver to determine vicinity and transmits records via a built-in SIM (3G/4G) or piggybacks on nearby smartphone/Wi-Fi. Users can track the bag live thru a cellular app, particularly helpful if it's lost or stolen. The device may also set off on call for or in periods to shop electricity.

User Value: This function is right for tourists if baggage is going missing at the airport or for the duration of layovers, customers can right away check its region. In theft cases, live updates help get better the bag speedy. It's additionally useful in daily existence college students or specialists can discover misplaced baggage immediately. The ability to monitor a bag's adventure brings peace of mind, just like parcel monitoring.(the gadget flow, 2017)

Real-World Examples: Devices like AirTag, Samsung SmartTag, and older trackers like Trakdot

display sturdy demand. Lumzag and Bluesmart blanketed 3G-based GPS tracking, and airlines now take delivery of such trackers. The TARS bag can construct on demonstrated tech (e.g., Qualcomm or

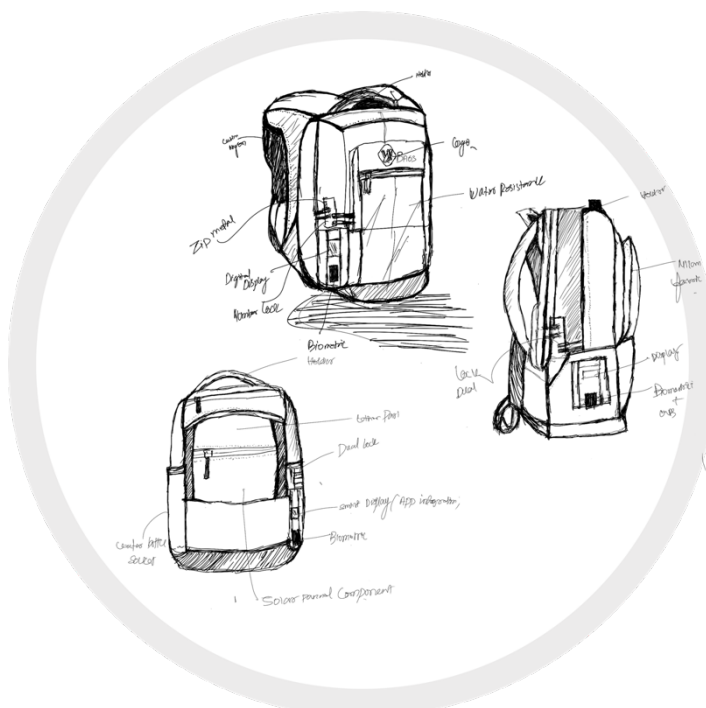
UBlox GPS-GSM modules), the usage of smart energy management and international SIMs for green, criminal global use.

5.3. Prototype Development 3D Model

5.3.1. Frame Sketch:



Figure 21 Concept Sketches carried out from Sketch in iPad



5.3.2. 3D Model

In developing the TARS Smart Bag prototype, I utilized Blender, a loose and open-source 3-D introduction suite famed for its comprehensive toolset in modelling, rendering, and animation. Blender Overview:

Comprehensive 3D Pipeline: Blender supports the entire 3D pipeline, encompassing modelling, rigging, animation, simulation, rendering, compositing, and motion monitoring. Utilizing Blender's strong modelling equipment, I crafted a detailed 3-D representation of the TARS Smart Bag, focusing on each external aesthetics and internal compartmentalization. The procedure worried:



Modelling: I started with the aid of creating the bag's simple form the usage of mesh modelling strategies, ensuring correct dimensions and proportions.

Detailing: Subsequently, I included tricky capabilities including zippers, pockets, and ergonomic straps, improving the version's realism.

Texturing and Materials: Applying appropriate substances and textures simulated the bag's supposed cloth and colour scheme, offering a practical visible illustration.

Rendering: Finally, I utilized Blender's rendering engine to produce amazing pics from numerous angles, showcasing the layout's nuances and functionality.

This method allowed for a complete visualization of the TARS Smart Bag, facilitating design evaluations and iterative refinements previous to physical prototyping.

Figure 22 3D Model of TARS Bag by Blender



Figure 23 TARS Bag with its Features

Chapter 6

6.1. The Hardware component breakdown

All functionalities are managed by an onboard microcontroller, such as the ESP32, which features a 240 MHz dual-core processor with integrated Wi-Fi and Bluetooth Low Energy (BLE) capabilities. This microcontroller is responsible for the seamless integration of various sensors, peripheral modules, and Bluetooth communication protocols. The device includes only a minimal local user interface, limited to LED indicators for power and battery status, while the majority of user interactions are facilitated through a dedicated mobile application.

Table 1 Hardware Case Plan List

Smart Feature	Hardware Components & Specifications
Fingerprint Lock	Fingerprint sensor module (optical, ~500 DPI, 3.3–5 V UART interface) makersportal.com ; electronic lock actuator (solenoid/servo, 5 V) for zipper latch; microcontroller GPIO for control.
Solar Charging Module	Solar photovoltaic panel (e.g. ~5 W, 12 V) mounted on bag file-8vbg8zkwvsz3qldjn1cn7k ; charge controller (Li-ion MPPT/linear charger, 5 V 1 A output); Battery – rechargeable pack (e.g. 10,000 mAh Li-ion) to store solar energy and power USB ports; 5 V regulator for device charging.
GPS Tracker	GPS receiver module (e.g. u-blox, 56-channel, ~2.5 m CEP accuracy); antenna integrated in bag; optional GSM/GPRS module (e.g. SIM808, 850/900/1800/1900 MHz) for sending location remotely; microcontroller UART interface to parse coordinates.
Anti-Theft Alarm System	Bag-open sensor (magnetic reed switch or Hall sensor at zipper) to detect unauthorized opening file-8vbg8zkwvsz3qldjn1cn7k ; motion/shock sensor (3-axis accelerometer) to detect movement; alarm buzzer (Piezo, ~85 dB, 5 V) for audible alert; Bluetooth module (in microcontroller) to notify user's phone.
Missing Item Reminder	Item identification tags for belongings (e.g. BLE beacons or RFID stickers yankodesign.com); wireless reader – BLE scanner (built into microcontroller) continuously checks for tag presence; if any tagged item not detected, triggers alert on smartphone.

6.2. Flow Chart and Algorithm

6.2.1. Solar Charging Module

Solar Charging Module Logic The Solar Charging Module within the clever bag is designed to optimize strength management by prioritizing renewable energy assets. The system by and large is predicated on sun electricity to fee the internal battery, thereby selling environmental

sustainability and enhancing energy efficiency. When sun irradiance is sufficient, the photovoltaic (PV) panel actively elements power to price the battery. However, in scenarios wherein solar input is inadequate due to factors which includes bad climate conditions or restricted publicity to daylight the system robotically transitions to a secondary charging mode making use of mains power through an adapter. This twin-supply

charging mechanism ensures uninterrupted strength availability. To preserve premier battery health and person cognizance, the system continuously monitors the battery's state of rate (SoC) (Brown et al., 2022). It is programmed to notify the consumer while the battery reaches complete ability or while the price drops under a crucial threshold throughout use. Such indicators are instrumental in allowing proactive power management and keeping off surprising power depletion. By integrating sun-first logic with a dependable fallback and user notification functions, the Solar Charging Module efficaciously ensures a steady and sustainable strength supply, leveraging solar electricity whenever conditions permit.(ur Rehman et al., 2025)

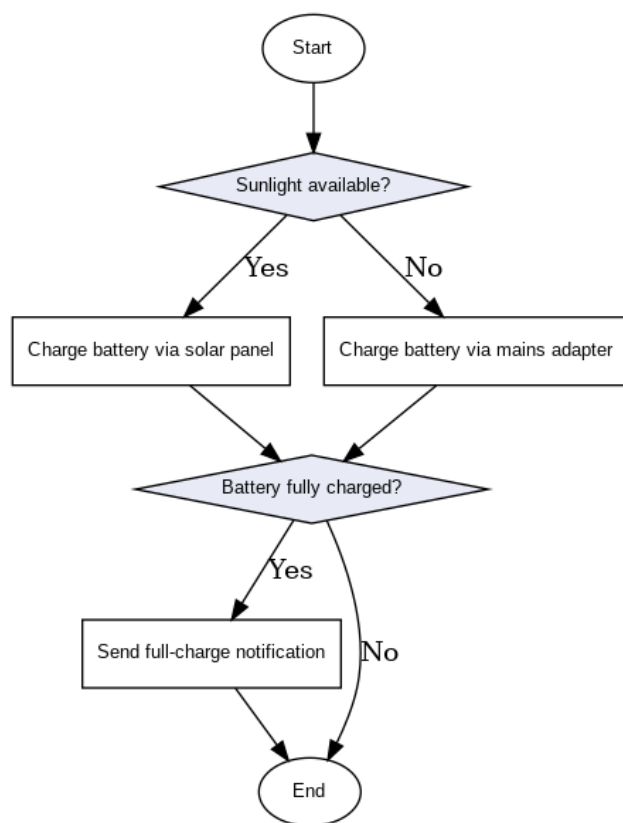


Figure 24 Flow Chart for Solar Charging Module

Algorithm (Solar Charging):

1. **Start** – Begin power management cycle.
2. **Check sunlight** availability using solar sensor/input.
3. **If** sunlight is available **then** charge the battery via the solar panel.
4. **Else** (no sunlight) **then** charge the battery via mains adapter (if plugged in).

5. **If** battery reaches full charge **then** send a “battery full” notification to user.
6. **If** battery level drops below threshold during discharge **then** send a low-battery alert to user (indicating recharge needed).
7. **End/Repeat** – Continually monitor conditions in a loop.

6.2.2. Anti-Theft Alarm System

Anti-Theft Alarm System good judgment. The anti-theft machine secures the bag whilst armed via the person (via app or switch). In armed mode, a microcontroller constantly monitors the bag’s reput (e.g. Zipper sensor). If an unauthorized commencing is detected, the machine straight away triggers an alarm buzzer and sends an alert to the user’s smartphone. This actual-time reaction allows deter thieves and inform the proprietor. (The bag can also combine a proximity alarm if the bag is separated from the proprietor’s telephone past a set variety – much like Lumzag’s protection mode).

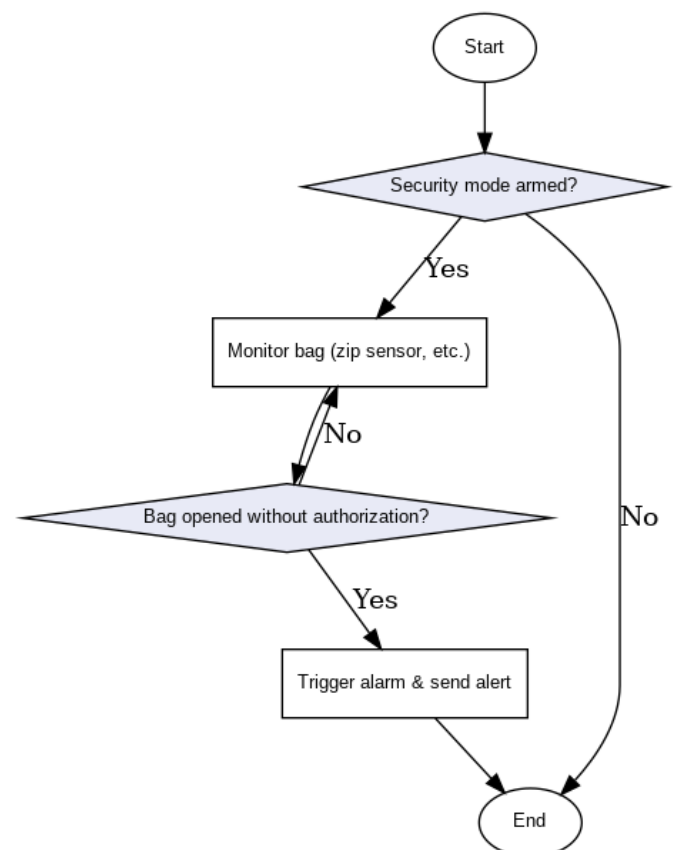


Figure 25 Flow Chart of Anti-Theft Alarm

Algorithm (Anti-Theft Alarm):

1. **Start** – Security monitoring begins (when user activates *security mode*).

2. **If** security mode is **ON** **then** continuously check bag status (zip closure sensor, motion sensor, etc.).
3. **If** the zipper is opened (or unauthorized access detected) **then** trigger the alarm buzzer and send a theft-alert notification to the user's phone.
4. **Else** (no intrusion) **then** keep monitoring (loop back to check continuously).
5. **End** – (Alarm continues until user resets, or system stays in monitoring loop until deactivated).

6.2.3. Missing Item Reminder

Missing Item Reminder Logic. This feature helps the user to remember all the essential commodities. The bag is equipped to scan for all registered items tag inside it. Before leaving the user or at set intervals, the system examines the presence of each tagged individual items. If an essential item is missing, it immediately informs the user so that they can retrieve it before leaving the item behind. If all items are present, no alert is required (the system can quietly confirm perfection).

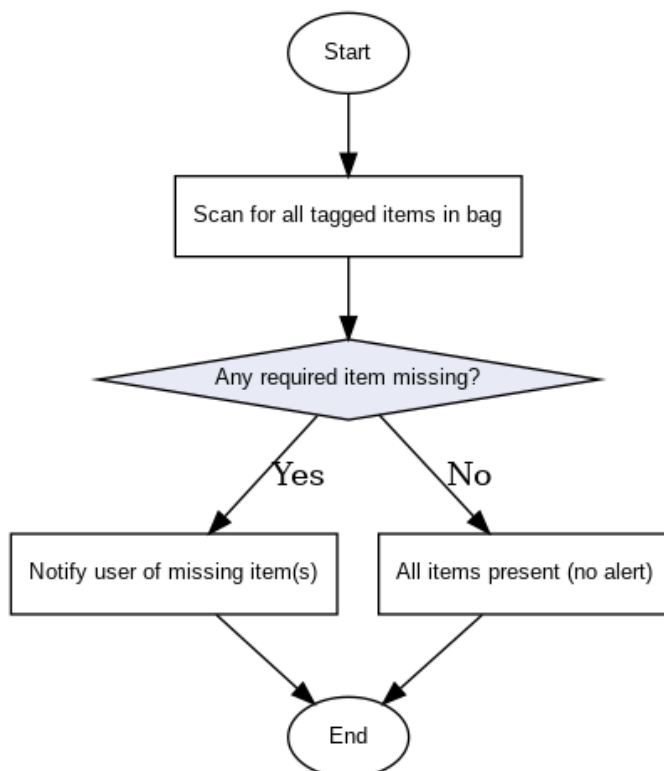


Figure 26 Missing Item Reminder Flow Chart

Algorithm (Missing Item Reminder):

1. **Start** – Inventory check is initiated (automatically when departing or on-demand via app).
2. **Scan** all paired item tags within the bag (via BLE or RFID reader).
3. **Compare** scan results to the stored list of required items.
4. **If** any item from the list is **not detected** in the bag **then** flag it as missing.
5. **If** one or more items are missing **then** send a notification to the user listing the missing item(s).
6. **Else** (no items missing) **then** indicate all items are accounted for (no action or an “all items OK” message).
7. **End** – (Repeat the check as needed, e.g. next trip or when items are added/removed.)

6.3. Feature–User Experience Mind Map

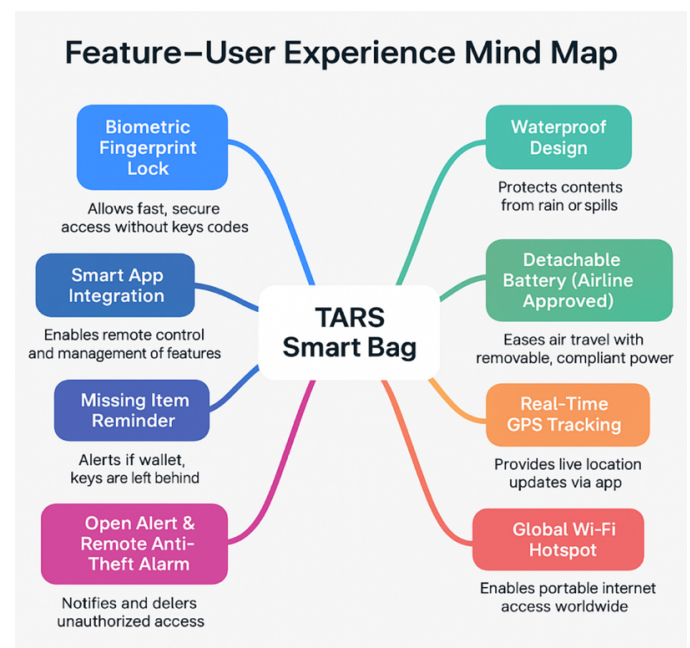


Figure 27 Feature Mind Map

6.3.1. Highlights of TARS Bag

Solar charging module → *off-grid power source and device charging*: provides renewable energy to charge moving devices, which provides freedom from wall outlets to the user and ensuring bags (and user gadgets).

Anti-Chori Alarm System → *Stolen Prevention and Alert*: Detect unauthorized access and protects

the goods. If someone tries to stole or tamper with a bag, a loud alarm is triggered and the user receives immediate warning, which provides peace of mind.

Missing item reminder → *inventory checks and no-item-left-behinds*: it connects the feature by tracking individual items. If they forget to keep a tagged item in the bag, they prevent losses and save time.

Integration of all three characteristics-solar energy utilization, anti-theft mechanisms, and object reminders, functionality-exclusively enhances the safety, convenience and reliability of the user. The inclusion of solar charging technology ensures continuous power supply to onboard electronics, which supports the continuous operation of smart features of the backpack. In addition, the anti-theft system provides a safe environment for valuable objects, which reduces the risk of unauthorized access or loss. Additionally, the object reminder functionality helps users to maintain preparations by warning essential commodities to forget. Together, these synergistic components redefine traditional backpacks, converting it into an interactive and user-centric smart accessory.

6.3.2. Conceptual Framework for Ergonomic Design

The ergonomic design of the Tars smart bags is directed by the industrial design principles established with the primary objective of maximizing the user's comfort and safety. This structure is informed by human-focused design method and biomechanical ideas, focusing on user postures, weight distribution, shoulder lease configurations, ventilation and long-term prohibitions (Mansoorian et al., 2019).

User posture and load position

Tars smart bags are engineered to promote the correct postural alignment by encouraging the use of double shoulder straps. This configuration also ensures weight distribution in both shoulders, reducing asymmetrical loading, which can lead to spinal misalignment or muscle tension. The form of the bag is adapted to keep the factor load high and

closer to the user's back (Genitrini et al., 2022). This design reduces the displacement behind the center of the mass, reduces torque on the spine and reduces the risk of postural deviation or fatigue.(Bouve & DiAngelo)

Load distribution and load transfer

A major ergonomic idea is the distribution of the weight of the bag in the user's torso. The tars bag covers a waist or hip belt that facilitates partial load transfer from the shoulders to the pelvic region (Lee et al., 2021), making the burden on the upper body effectively. The design adheres to the ergonomic guidelines that recommend the total backpack weight, which does not exceed 10% of the user's body weight (Ramadan & Al-Tayyar, 2020), ensuring safe and durable uses in the extended period.

Shoulder Strap Ergonomics

The shoulder straps are meticulously designed to beautify both comfort and biomechanical compatibility. With a width of about two inches and incorporated padding, the straps growth the touch place and reduce localized stress on the trapezius muscle mass (Matur et al., 2025). Their S-fashioned, anatomically contoured form aligns with the herbal curvature of the shoulders, at the same time as adjustability guarantees a secure and personalised match. Furthermore, the inclusion of a sternum strap enhances load balance by preventing strap slippage and decreasing lateral sway, for this reason maintaining even weight distribution in the course of dynamic movement.(Liew et al., 2016)

Ventilation and Back Support

To address problems of thermal pain usually associated with prolonged backpack use, the TARS clever bag functions a breathable mesh lower back panel and an imperative airflow channel. This layout promotes powerful air flow, decreasing sweat accumulation and improving normal thermal consolation. Strategically placed padding avoids strain points alongside the spine and scapular regions even as presenting cantered lumbar guide,

which is critical for maintaining spinal integrity in the course of prolonged put on.

Long-Term Comfort and Material Considerations

The integration of ergonomic components which include padded shoulder and returned panels, load-lifter straps, and a useful hip belt guarantees sustained comfort and decreases the threat of musculoskeletal stress. The materials used are each lightweight and durable, aligning with industrial standards for wearable load-bearing system. Edges and speak to surfaces are designed to take away sharp contours, further improving consolation and usefulness. This holistic and proof-based totally ergonomic layout supports secure, lengthy-time period day by day use of the TARS clever bag.¹

6.4. App Development – TRACK TARS Mobile Application

6.4.1. Overview

The “Track TARS” Mobile application features as an essential companion interface for the TARS clever luggage system, facilitating seamless interplay between the person and the bag’s embedded technologies via a Bluetooth connection. Designed to enhance consumer comfort and security, the app allows comprehensive manipulate and tracking of the clever bag’s capabilities in actual time. Key functionalities on hand via the utility encompass the potential to remotely lock or free up the bag’s fingerprint-secured mechanism, display the battery reputе, and track the bag’s geolocation. Additionally, the app serves as a protection and notification hub. It right away indicators the person thru visible and auditory notifications in the occasion of unauthorized access—such as the outlet of the bag’s zipper or if an object is inadvertently left behind. These notifications are customizable, making sure that users can tailor the

alert machine to their preferences and situational desires. The application’s intuitive user interface consolidates all smart functionalities into a single, available platform, thereby streamlining the management of the bag’s advanced functions. Through this integration, the “Track TARS” app exemplifies the convergence of mobile technology with smart journey add-ons, improving each the utility and safety of modern-day bags structures.

6.4.2. Information Architecture of the Track TARS Mobile Application

The Track TARS application employs a streamlined and user-centric records architecture, dependent into 5 primary interface screens. This modular corporation complements usability, providing efficient get right of entry to the middle functionalities of the TARS clever bags device. Each display serves a distinct operational purpose and collectively guarantees cohesive interplay with the tool.

1. Home Screen: System Dashboard

The Home screen functions as the central dashboard, offering a high-level overview of the bag's status. Key elements displayed include:

Battery Charge Level – Visual representation of remaining power.

Connection Status – Real-time indication of the Bluetooth link between the app and the bag.

Location Summary – A concise overview of the bag's current GPS-derived location.

Quick-Access Controls – Buttons for frequent actions such as locking/unlocking and activating alerts.

This screen acts as the user’s primary entry point for monitoring and engaging with the TARS system.

2. Bag Control Screen: Smart Feature Management

This interface allows for direct manipulation of the bag’s smart components. Users can:

Lock/Unlock the Fingerprint Lock – Remotely secure or access the bag.

¹ (References: ergonomic recommendations from health professionals and standards were incorporated to guide the

above design, e.g., two-strap use, weight limits, strap sizing, and inclusion of load-bearing belts.)

Arm/Disarm Anti-Theft Alarm – Activate or disable security alerts.

Ping the Bag – Trigger an audible alert to help locate the bag when nearby.

Monitor Solar Charging Status – View charging activity from the integrated solar panel.

These controls offer enhanced user autonomy over security and operational settings.

3. GPS Tracker Screen: Real-Time Location Monitoring

Dedicated to location-based functionalities, the GPS Tracker screen presents:

Interactive Map Interface – Real-time tracking of the bag’s geographic position.

“Locate Bag” Function – Manual refresh of the GPS signal to update location.

Navigation Directions – Route guidance from the user’s location to the bag’s position.

This screen is critical for mobility assurance and theft recovery.

4. Alerts Screen: Notification Center

The Alerts interface serves as a centralized log of security and activity events. It includes:

Time-Stamped Notifications – Events such as "Bag zipper opened" or "Item X missing" with precise timestamps.

Expandable Alerts – Tap-to-view functionality for additional contextual details.

This feature supports situational awareness and retrospective monitoring.

5. Settings Screen: Configuration and Customization

The Settings screen houses tools for personalization and system management, including:

Fingerprint Management – Enroll, edit, or delete registered fingerprints.

Missing-Item Reminder Setup – Add or remove tagged items from the inventory list.

Notification Preferences – Customize alert tones, alarm volume, and delivery method.

Device Pairing – Connect to new or additional TARS bags.

This section empowers the user to tailor the application to their preferences and operational needs.

6.4.3. Flowchart

Track TARS App consumer float. The diagram above illustrates key user interactions and navigation float in the app. Upon launching the app, the Home Screen provides an outline and standing of the clever bag. From the home interface, the consumer can choose distinctive capabilities via the menu. For example, selecting “Bag Control” opens the manipulate panel to operate locks or alarms, whilst tapping “GPS Tracker” brings up the map to find the bag. The Alerts segment is available to study any notifications, and Settings permits the user to customize the device. After finishing an action or viewing facts, the app returns to the home/menu (enabling the user to carry out another mission). This intuitive menu-driven waft guarantees that the person can quickly navigate among tracking the bag’s popularity, securing it, locating it, and dealing with preferences. The Exit alternative (or really ultimate the app) terminates the consultation. Overall, the Track TARS app’s architecture and float are designed for readability and responsiveness, immediately reflecting the smart bag’s features and offering a seamless user enjoy.

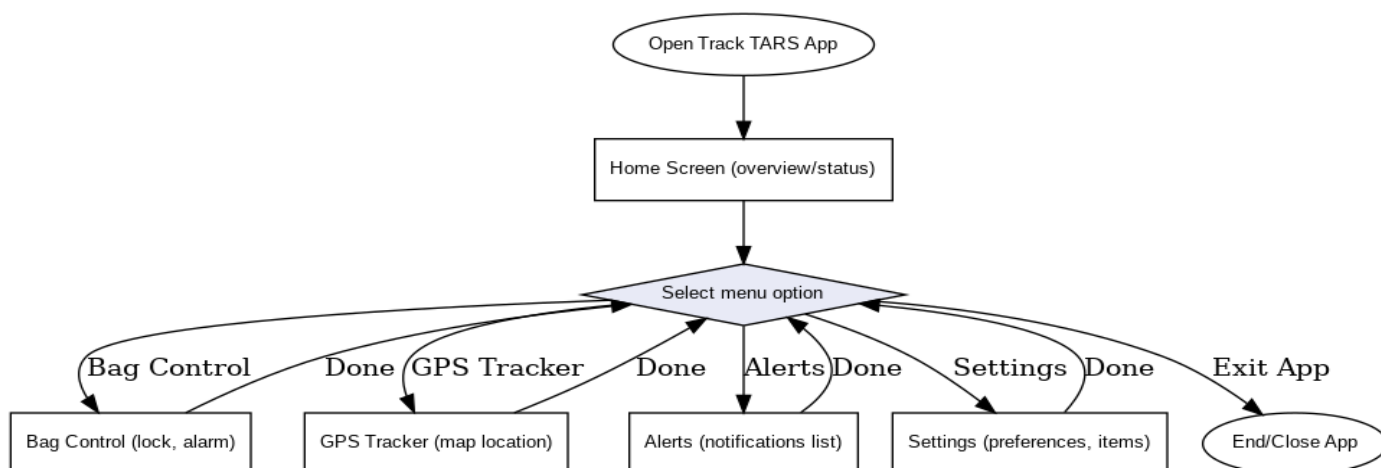


Figure 28 Flow Chart of Track TARS App

6.4.4. Track TARS App UI UX Design

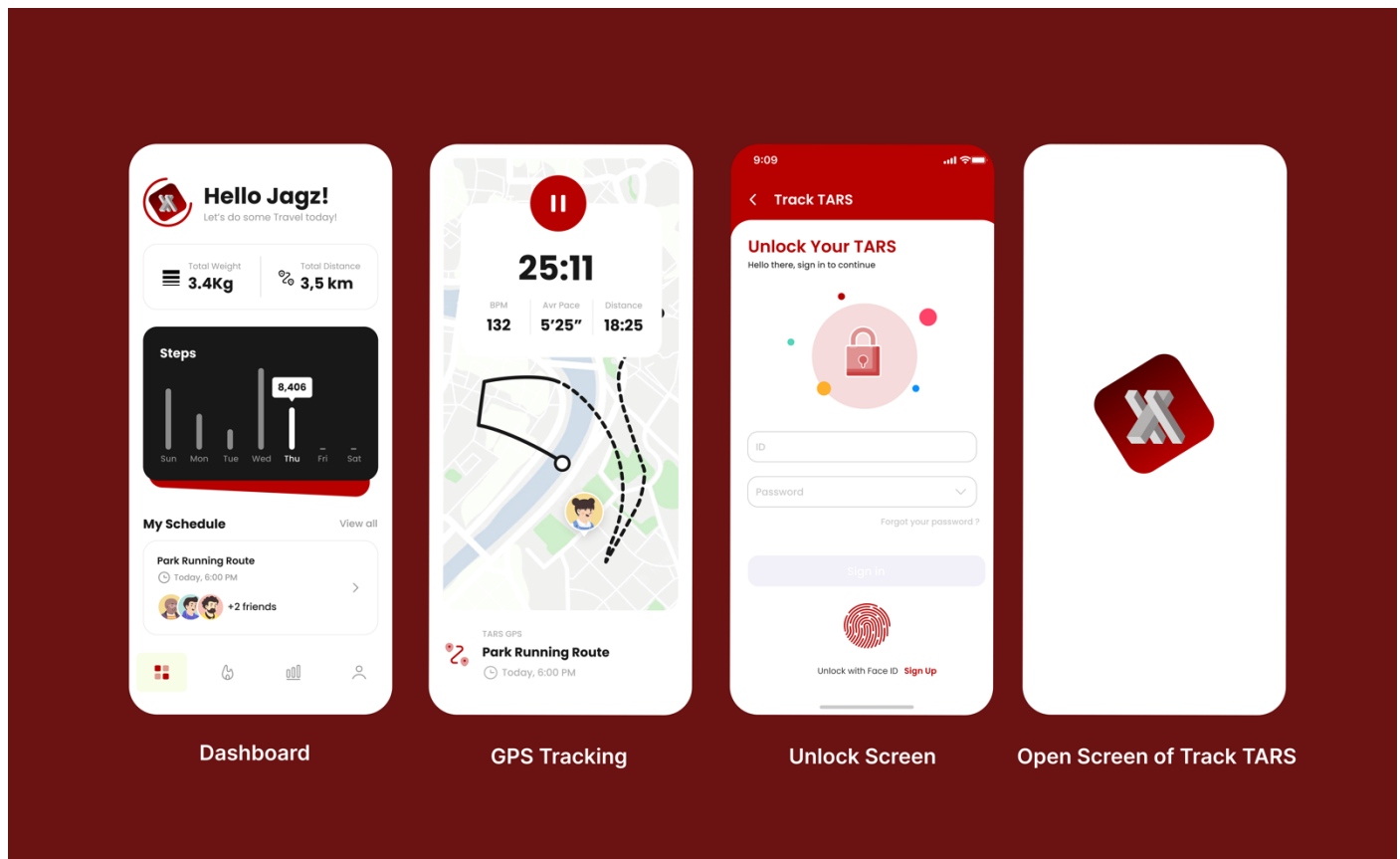


Figure 29 UI and UX developed Screens for Track TARS App

Chapter 7

7.1. Manufacturing & Production Process

For the production and manufacturing of a certain product the Supply Chain (SC) plays a major role in that. Here for the manufacturing of the smart bags the SC ensures the work process appropriately. The supply of the goods and the services without any interruption builds up the potential stability of a company. In the process of manufacturing possibilities is the disruption may be occurred in any of the step of the production like the occurrence of the raw material to the supply of the final organised product. In the phase of manufacturing the interruption in the SC affects in wider areas like cost increasing, sales declination, deadline missing, and a faithlessness among the customer relationships. This interruption might affect the reputation of the company and also it affects the confidence level of the investors. This leads the company to be turn up with a major loss.

In the phase of manufacturing the interruption in the SC are caused by various cases, consisting of security issues, natural disasters and also the pandemics (Kumar Kanike, 2023).

7.1.1. Supply Chain And Sourcing

The traditional SC function has been modernized based on the development of the advanced technologies (Tan, 2001). A new phase of digitalization has been developed in the manifestation of industrial revolution. It has been made with the smart manufacturing of the products. Resulting that the evolutions obtained by the digital technologies for operating the SC model includes smart factory, smart contract, smart logistics, smart product and so on (Hahn, 2020). These advancements are identified as the Fourth Industrial Revolution in short Industry 4.0 (I4.0). In the SC (SC) the I4.0 has advanced technologies that operate in autonomously and generates self-coordinating system (Hahn, 2020). The I4.0 was first represented in the year of 2011 in Germany, dealing with the assembly of parts in the manufacturing field. There is competition that lies among the manufacturer, supplier, and the retailer

and this is dealer with a significant effect of internet (Agarwal et al., 2019; Glas & Kleemann; Tupa et al., 2017). The strategic management of procurement operation performance is affected directly via SC process (Huber et al., 2004). The process of buying is procurement in which the phases like purchasing, renting, acquisition of supplies, services and also construction for external users also included (Glas & Kleemann; Gottge et al., 2020; Temofe Isaac Akaba, 2020). The management responsibilities followed by procurement managers are identifying, sourcing, accessing, and managing resources outside the company are followed here. Also, for fulfilling the strategic objectives of organisations are holding significant business value and creating an impact in profit making (Glas & Kleemann; Gottge et al., 2020; Temofe Isaac Akaba, 2020).

7.1.2. Manufacturing Process

One of the major parts in the production process is the process of manufacturing which is directly proportional to the change of form or dimension of the produced product. It excludes certain activities like transportation, handling or storage of parts, as these do not directly influence the transformation of the product's shape or size. The manufacturing selection process in the process planning part directly affects both quality and cost of the product. The selection of manufacturing has a higher demand on proper understanding about the capacity of the product including capacity to alter the shape, properties and quality of the parts of the product. In addition, it is necessary to adapt continuously and to get knowledge regarding enhancements or changes in the capacity of manufacturing process and these are executed by the machines. Moreover, in industries the process of choosing manufacturing models highly depends on the expert knowledge requires manual operation which is highly time consuming and cause error (Hussong et al., 2025).

Assembly stages

In the field of the manufacturing industry a continuous rise of automation levels has been found in recent years (Zhao & Melkote, 2024). Even though, in this transition, the cost-effective way of manufacturing is manual assembly in various fields including automotive, electronics, and aerospace manufacturing. Based on the flexible characteristics the manual assembly rectifies the requirement of the growth of product complexity and variety needed by the adaptive manufacturing systems. Rather than the increase of digitalisation

and automation based on Industry 4.0 paradigm, the manual assembly plays a major role in manufacturing. The disregarding principles of the Human Factors and Ergonomic (HF/E) and inappropriate designing of manual assembly systems affects the manufacturing process through increase of production cost and reduction in effectiveness. One of the main ways for error occurrence is manual operative mistakes, the imperfections in humans creates a major impact in the effectiveness of human assembly. These errors create loss of production, makes loss in the economy level and also reduces the quality of the product.

Hardware assembly and components attaching involves inbuilding of each part together, in which it consists of attachments like straps, handles, zippers, linings, IoT devices, battery, sensors etc. The hardware components like buckles, rivets, and clasps are added during this stage.to assure the secure and safe attachments the employees use specific tools and machineries. To check the functionality and appearance of the bag precision and attention towards detailing has a significant role (The Complete Guide to Bags manufacturing.) The final step before the bag reaches to the market finishing, in which the quality control checks for final product efficiency. The quality control ensures that the product is out of defect, having perfect seams, zippers smoothness, working conditions of IoT devices and check for flaws. The inspectors verify the consistency of design and the craftsmanship. The final step after the quality check is the packaging, where the perfect packaging helps to protect the bag and its Smart applications during shipping and delivery. Finally, the completion of the package is done with care instructions of the bag and tags regarding the brand logo (The Complete Guide to Bags manufacturing.)

Standards and Certifications

To ensure and guarantee the quality and efficiency of the product manufacturers should have to follow the industry standards and certifications. The standards for the quality management and the environmental management are ISO 9001 and ISO 14001 respectively. These standards are verified and the certifications are provided by the organizations like SGS or Intertek. These certifications create trust among consumer and ensure reliability.

Common Quality Issues and Solutions

The general quality issues arise during the quality check are weak seams, faulty zippers, and material defect (*The Complete Guide to Bags manufacturing*). The solutions that are identified to overcome these issues are

- Continuous inspection of the raw materials and the components before assembling.
- Test the seams and other attachments under stress.
- Check for the operation of the IoT devices like scanners, sensors, batteries etc. Also check the functioning of the zippers, buckles, and straps for proper working
- Identification of the issues earlier and avoids them helps to maintain the efficiency of the final product.

Safety testing

Product safety testing is an essential procedure that guarantees consumer goods are devoid of potential risks and adhere to established safety regulations. It consists of different types of evaluations like to analyse the durability and resistance to impact the

mechanical and the physical evaluations are included. Also, the chemical analyses are done to identify the toxic and harmful substances including heavy metals electric safety evaluations to prevent from malfunctions and fire risk (Barthe et al., 2021). In addition, the test regarding the environmental and biological conditions includes test for temperature resilience and skin irritation, which are conducted to ensure the compliance with health, safety, and environmental regulations. Regulatory agencies, such as the Consumer Product Safety Commission (CPSC), the Food and Drug Administration (FDA), and ISO international organizations, establish the benchmark standards for safety testing, ensuring adherence to health, safety, and environmental standards. Safety testing is vital not only for safeguarding consumers from potential harm but also for confirming that products function as promoted, mitigating legal penalties, and enhancing the reputation the brand. Eventually, it enhances the level consumer confidence, aids in regulatory compliance, and encourages ongoing product enhancement.

7.1.3. Smart Backpack Component Bill of Material (BOM)

Table 2 Bill of Material

Components	Vendors	Country	Estimated price	Actual price	Part Number	Material
Outer Shell	Repreve	USA	3	9	RP-600D-BK	rPET
Interior Fabric	Rockywoods	USA	2	5	RW#PC-WP-BLACK	Polycotton-Black
Battery	Tenergy	California	15	20	Tenergy USB C	Lithium-ion
Charging Ports	Alibaba	uk	5	10	IP67 USB-C(OEM)	Type-c
Circuit Boards	Adafruit	UK	15	25	ESP32-S2+MTK3339	Wifi+Gps
Zippers	YKK	UK	3	8	CN-10	Classic nickel
Fasteners	YKK	UK	2	6	SR-50	Slide-release buckle
Straps	YKK	UK	4	7	PW-30	Polyester webbing
Handles	YKK	UK	6	10	HG-150	Padded Nylon Handle
Sensors	Adafruit	UK	10	20	FPC1020A(#4651)	Finger Print & Motion sensors
Solar Panel	EESBAO Store	UK	2.3	3.9	BLK	Portable Solar Panel

This spreadsheet provides a detailed breakdown of the key components, providers, international locations of beginning, pricing estimates versus real expenses, and technical specifications (such as component numbers and substances) for the improvement of a smart backpack. The information supports value analysis and procurement decisions for integrating essential and progressive hardware (e.g., lithium-ion batteries, sun panels, sensors) along outstanding substances (e.g., rPET, Polycotton) sourced broadly speaking from the USA and UK.

Chapter 8

8.1. Costing & Lifecycle Costing

Costing and lifecycle costing of a TARS smart bag is calculation of the overall cost of manufacture, operation, and disposal thereof over its entire life. Costing is method of determining the direct and indirect costs like material, labour, production, and promotion. Lifecycle costing (LCC) also includes beyond startup expenses with repair, battery replacements, software patches, maintenance, and end-of-life recycling or disposal. This approach helps firms realize true cost of ownership, simplify pricing strategies, and drive sustainability by considering long-term cost determinants.

8.1.1. Costing for TARS Smart Bag

Outer Shell Material:

Sterling FR Faux Leather Fabric Smart Bag
These materials are commonly used for durable, weather-resistant outer shells. The price depends on the quality and supplier, typically ranging from £2 per yard. For a bag, it might require around 1 to 1.5 yards of material.

Estimated Cost per Unit: £3 for outer shell material.

Interior Fabric:

Plain Polycotton-Black: For the lining, typically light and soft. This material will cost around £2 to £3 per yard. A bag would typically need 0.5 to 1 yard of this material.

Estimated Cost per Unit: £ 2 for interior lining.

Smart Components:

Battery (Lithium-ion): Lithium-ion rechargeable batteries are the power source of cellular phones and several other portable electric devices today, and demand appears to dramatical increase(Wakihara, 2001). Lithium-ion batteries range in cost from: £ 5 to: £ 18 per unit, based on design and capacity.

Estimated Cost per Unit: £ 15 for the battery.

Sensors: These can be motion, location and fingerprint sensors integrated into the bag. Prices vary £1 to £10 each.

Estimated Cost per Unit: £3 - £10 for sensors.

Charging Ports & Circuit Boards:
Integrated features like charging ports (USB-C) and the necessary circuit boards for wireless charging or data transmission can range from: £ 5 to £ 20 depending on the technology used.

Estimated Cost per Unit: £ 5 - £ 20 for charging ports and circuit boards.

Zippers, Buttons and Fasteners:

Superior Zippers: Superior quality zippers used for function and longevity will cost between £ 1 and £ 3 per zipper depending on material and design.

Estimated Unit Price: £ 2 - £ 5 for fasteners and zippers (1-2 assumed buttons/fasteners).

Other Accessories:

Handles and Straps: These can be made of durable leather, nylon, or material blend. Material costs in this instance can range from £3 to £10 depending on design and quality.

Estimated Cost per Unit: £3 - £10 for straps and handles.

Solar panel: Folding Bag 120W Solar Panel Portable USB+DC Output Solar Charger Outdoor Power Supply Mobile Phone Generator(M. Maindola et al., 2024).

Estimated Cost per Unit: £2.30

Total Estimated Material Cost per Unit

Table 3 Material Cost Per Unit

Material	Estimated Cost
Outer Shell	£ 3
Interior Fabric	£ 2
Battery	£ 15
Charging Ports & Circuit Boards	£ 5 - £ 20
Zippers & Fasteners	£ 2- £ 5
Straps & Handles	£ 3 - £ 10
Sensors	£ 10
Solar panel	£ 2.30

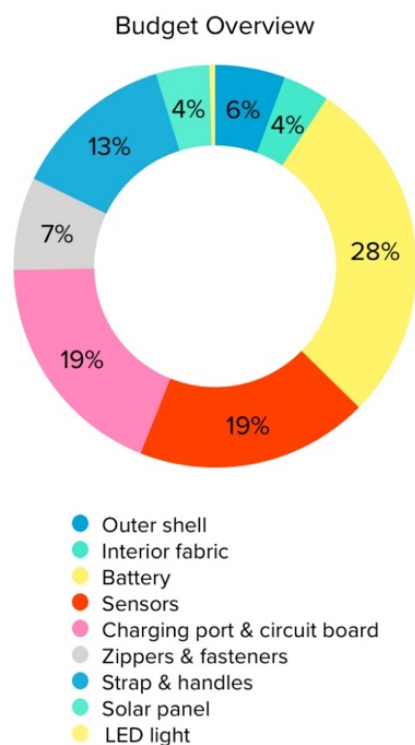


Figure 30 Budget Overview (Cost Model)

8.1.2. Lifecycle Costing of TARS Smart Bag

Lifecycle costing (LCC) is the process of reviewing the total cost of a product from production to disposal. It is applied by businesses and consumers to achieve the complete costs of the product throughout its life. In the case of the TARS Smart Bag, a next-generation bag product with advanced technology (including GPS, USB charging capability, and in-built power banks), the lifecycle costing would span various principal phases like

production, operation, and disposal (Iribarren et al., 2010).

Breakdown of Cost along the Life Cycle of the Product (from Production through to Disposal)

At end of life, the TARS Smart Bag is likely to be made up of a combination of materials—textile, metal, plastic, and electronic elements (e.g., the power bank, GPS, and other smart electronics). Recycling or disposing of the material properly can be a significant cost factor.

Smart Electronics and Circuitry Disposal:

E-Waste: The embedded electronics of the TARS Smart Bag, i.e., GPS module, sensors, microchips, and USB charging subcomponents, are e-waste. The components contain valuable metals but also need to be disposed of carefully so that toxic elements such as lead and mercury do not pollute the environment. The e-waste industry is a significant sector that is expanding at an annual rate of approximately 2 million tonnes (Mt), with the potential to reach 74.7 Mt by the year 2030 (Emmanuel et al., 2024) .

Non-Electronic Components Disposal

Textiles and Plastics: The fabric, wheels, zippers, and other components of the bag, though less hazardous than electronics, also must be properly disposed of. These materials may have to be recycled by textile recycling services or disposed of in an eco-friendly manner (Vishakha Kaushik, Jaehong Lee, Juree Hong, Seulah Lee, Sanggeun Lee, Jungmok Seo, & Chandreswar Mahata and Taeyoon Lee , 2015).

Potential for Refurbishment or Reuse:

Refurbishment: If the smart bag is in good condition and the internal structure (fabric, frame) is still intact, then there may be a chance to refurbish the bag. Refurbishment means cleaning, fixing broken parts (e.g., wheels, straps, or zippers), and recharging or replacing the battery if feasible, to provide it with additional years of life (Gharfalkar et al., 2016).

Power Supply and Battery Life

Built-in Power Bank and Charging Capacity:

The TARS Smart Bag's internal power bank is possibly one of its most useful features, providing on-the-go charging for devices like smartphones, tablets, or other electronic gadgets. The power bank itself, however, is a consumable function that will gradually wear out (C. Y. B. Suen et al., 2017).

Battery Degradation: Lithium-ion batteries like those commonly contained in a piece of equipment such as the TARS Smart Bag degrade over time. After having been charged-discharged a specified number of times, the power bank will subsequently no longer retain a charge quite as well and the user might see reduced functionality in charging levels or shorter life overall for GPS operations (Neubauer et al., 2015).

8.1.3. Cost of Replacement:

Battery replacement charges can vary depending on the battery is user-replaceable or requires professional servicing. If the battery is user-replaceable, the charge could be in the range of £ 15 to £ 20, depending on the capacity and type of battery. If the battery is embedded and must be repaired by a professional to replace, replacement would be more expensive, at a cost of estimated £30 to £ 50, including service labour fees (Naumann et al., 2015).

APP Development

Mobile applications have become increasingly central to our daily lives, providing us with a variety of services and utilities (often at no cost). Third-party services form an integral part of the mobile ecosystem: they ease application development and enable features such as analytics, social network integration, and app monetization through ads (Abbas Razaghpanah, Rishab Nithyanand, Narseo Vallina-Rodriguez & Srikanth Sundaresan, Mark Allman, Christian Kreibich & Phillipa Gill). We entrust apps with a wealth of information that enables them to carry out these functions, yet despite our reliance on these apps and our countless daily interactions with them. *Estimated Cost development - £ 45,000.*

Mobile App Updates and Support:

App Maintenance: The TARS Smart Bag most likely has a mobile app that utilizes the GPS, tracks location, or provides additional features. Every so often, the app will need to be upgraded to remain compatible with new operating systems (iOS or Android). The upgrades may be free but may be paid for if premium features are enabled or the app has subscription-based content.

Subscription Services: If the TRACK TARS app provides enhanced functionality (such as extended GPS tracking or cloud services to hold data), might be charged an annual subscription fee. It can range between £ 10 to £ 50 yearly depending on what services are being provided. With the similar service case study.

Customer Support Services:

Technical Support: smart products consumers may need customer support to troubleshoot technical issues with the app, firmware, or the smart features (e.g., GPS tracking failing to function correctly). Although run-of-the-mill customer support is generally free, more specialized support (such as replacing faulty electronics or troubleshooting complex issues) can cost money after the warranty has ended.

Support Fees: After the warranty period, support may be provided on a call-fee or internet-consult basis with charges between £ 10 to £ 20 per issue, depending upon the nature of support.

Extended Warranty: There are certain consumers who may purchase an extended warranty or support program, which would cover repairs, software issues, and replacements as needed. Extended warranties can cost between £ 30 and £ 50 per year.

8.2. Factory Setup Requirements for Production

To produce a smart bag that is both affordable to consumers and profitable for the manufacturing company, it is necessary to identify the end-end cost from R&D to sales. It is also necessary to estimate the near accurate expenses involved in each stage of the Product Development Lifecycle which includes R&D, raw materials procurement, Manufacturing, Packaging and Logistics,

Marketing, Human resources and Sales. Once we have established our product and brand among customers, next point of action would be to setup a factory to manufacture in bulk which would require a significant investment from the company.

Factory Setup requirements for production of TARS Smart bags Setting up a manufacturing facility requires careful consideration of availability raw material, Human resources, Infrastructure such as water, electricity, and roads for logistics etc., and adhering to local law and regulatory compliances etc. Below is a detailed overview of the key elements required, and the cost estimated for it.



Figure 31: Employee Facilities & Safety Measures(JENNIFER NEWTON)

Cost Projections for Factory Setup:

Breakdown of the expenses required to setup the factory and make it fully functional would require the following.

Facility location:

renting an office space of 20000 square feet in those areas would be around 7500.00 pounds/month. On the other side, (acquiring the land of same size and in the same region would be around 75000.00 £) + (Registration cost + Taxes + Other paperwork's would be approximately 6,000,000 British pounds). As for the construction, Contractor's quotation is around 50 British pounds per square feet and 20K * 100 is 1 million British pounds.

Minimum estimated cost for first year: £17,65,000.00

Machineries and other Equipment:

Specialized Equipment and machineries for manufacturing, assembling, stitching, Testing, and Packaging would require 250,000.00 British pounds. Maintenance of those equipment and Renewal of Licenses for Software. Require 20,000.00 British pounds.

Minimum estimated cost for first year: 270,00.00 British pounds

Human resources:

Manufacturing 200 Smart bags per day would need approximately 100 people for manual work including manufacturing and assembling. As per the UK regulation, 11.25 British pounds per hour per person (8 hrs per day* 5 days per week) would come around 180,000.00 British pounds per month.

Minimum estimated cost for first year:2,160,000 British pounds

Logistics:

Establishing supply chain management from raw materials procurement to product shipping for sales would require either establish a division as part of company or deal a contract with third-party logistics firm. Buying heavy vehicles would incur 10,000.00 British pounds per vehicle and distribution of product across the country would require at least 6 vehicles. So, totally 60,000.00 British pounds for purchasing. Whereas minimum of 60,000.00 British pounds per year would be needed to hire a logistics firm.

Minimum estimated cost for first year:60,000.00 British pounds

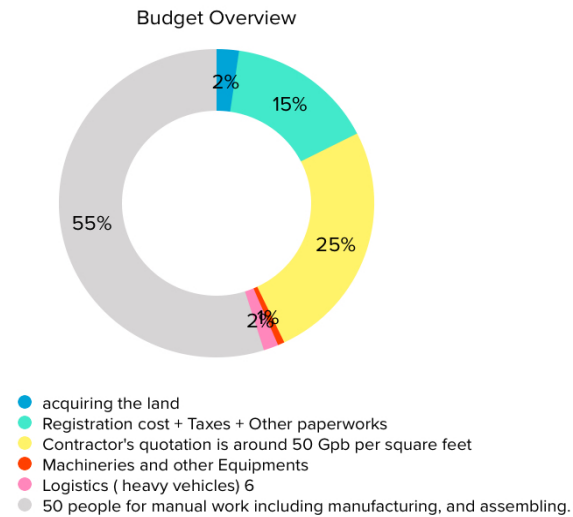


Figure 32 Over All MFG Overview

8.3. Production Model & Cost Structure

Our projected manufacturing output is 50,000 units per year. To understand our financial model. let's break down the cost structure:

Table 4 MFG Component Cost

Component	Value
Raw Material Costs	£ 2,078,970
Unexpected variable cost + app development cost	£ 250,000
3D printing cost	£ 10,000
Payment to convection	£ 4,523,970
Advertising cost	£ 200,000
Packaging cost	£ 75,000
Total	£ 4,773,970
QTY (pcs)	50,000 units
Cost of Goods per unit	£ 95

The cost structure is obtained from making a smart backpack; this cost consists of purchasing raw materials, purchasing components, making 3D printing, advertising costs and packaging costs. Detailed breakdown of the cost structure is provided in Table 4 MFG Component Cost

Fixed costs are placed at £20 per unit. They are costs that are incurred regardless of production volume, such as rent, machinery, and overheads. Variable costs are at £75 per unit, such as materials, labour, and other production-related costs. Combining the fixed and variable costs, our cost of production per unit amounts to £95.

Pricing & Profitability

We've determined a final price of £150 per unit, meaning we make a profit margin of £55(36.66%) per unit. But before that, we need to break even—that is, we need to recover all our costs.

Break-Even Analysis

Our break-even is 19,000 units, and that means we must sell at least 19,000 units to gain all our production expenses. Any sales beyond this will be towards making us profitable. With our own production of 50,000 units per year, we are well placed to generate significant revenue. And we used siemens software to demonstrate the actual value management of this report.

Revenue Streams

Table 5 Revenue Stream in Investment

Total Costs	£ 4,773,970
QTY (pcs)	50,000 units
Cost of Goods	£ 95
Selling price/pcs	£ 150
Profit/pcs	£ 55
Profit margin (%)	0.3666

Revenue streams represent the cash generated by each Customer Segment (costs must be subtracted from revenue to generate revenue). The revenue stream generated by the product in development is transaction revenue from one-time customer payments.

Based on the discussion of the model design above, we obtain the elaboration of nine elements of business model canvas smart backpack.

8.4. Business Model Canvas

Table 6 Business Model Canvas of TARS and its Key Partners

Key Partners	Key Activities	Value Proposition	Customer	Customer Segments
Supplier	Research and surveys related to customer desires and trend developments.	The product is made from waterproof Cordura which is water-resistant.	Relationships	Frequent travellers
DOM			Customer	
Convection			Retention	
Convection	Making bag design innovations based on popular trends.	The sold product is guaranteed if the product is defective or the order is not as specified, it can be returned and replaced	Customer	Working professional.
Sabata's	Product delivery to customers		Acquisition	
Tokopedia			Boosting Sales	
		Social Media		
			Engagement	
Distribution	Key Resources			
JNT Express	Gadgets,	Direct shipping (today's orders ship today)		Students
Sic pat Express				
Social Media				
Instagram	Warehouse.		Channels Online	
ZAKWOOW	Human resources:	Special offer for special customers every month	Marketplace and Social Media.	Tech Enthusiasts.
Convection			Using the services of a third person in its distribution (JNT &	
Marketplace			Sic pat)	
Shopee	packing staff, admin, shop assistant, data analyst.		Offline	
			SME Official Store	
Cost Structure		Revenue Streams		
Raw Material cost		The revenue model is obtained from the sale of bag products. The profit margin taken is 36.66%.		
Payment of production costs to convection				
3D Printing Cost				
Advertising on social media and marketplaces				
Packaging Cost				

Chapter 9

9.1. Marketing & Post-Production Strategy

The Smart Bag Marketing & Post-Production Strategy will involve creating hype before launch through social media teaser campaigns and influencer collaborations. Online marketing efforts will include SEO-driven content, paid social and Google advertising, and influencer collaborations to promote Smart Bag's unique features like GPS tracking, solar power charging, and anti-theft features. Post-launch, activity will be invited from customers using onboarding guides, rewards programs, and user campaigns to build a solid base of users.

Following activities post-launch will include seamless customer care, post-production tweaking with comments, and building in retail and e-commerce for long-term growth.

9.1.1. Brand Identity & Logo Development

TARS is more than a company. it's a movement dedicated to building a futuristic, networked world. Inspired by the determination and resourcefulness of the TARS robot in Interstellar, our technology is designed to learn and merge between industries. Just as TARS in the film learned to work in various settings and challenges, our technologies are designed to be versatile, intelligent, and game-changing. The term "TARS" itself is an acronym by name only; it is a variant of "STAR" which symbolizes its central role in the galaxy of technology innovation. As stars illuminate the universe, TARS endeavours to be an illuminating beacon of innovation that leads industries toward an integrated, smart future. Our mission is to provide innovative solutions that not just enhance technology but redefine the way technology is integrated into everyday life.



Figure 33 TARS Brand Logo

9.1.2. Logo Development

The TARS logo reflects the essence of flexibility, intelligence, and innovation just the same values evoked by the visionary AI in Interstellar. In an indication of transformation and easy fusion across industries, the logo signifies the firm's vision to stretch technology boundaries. The complex, advanced-looking design is a depiction of integration of cutting-edge technology with simplicity, just the same as the ability of the TARS robot to adjust to varying functions with ease.

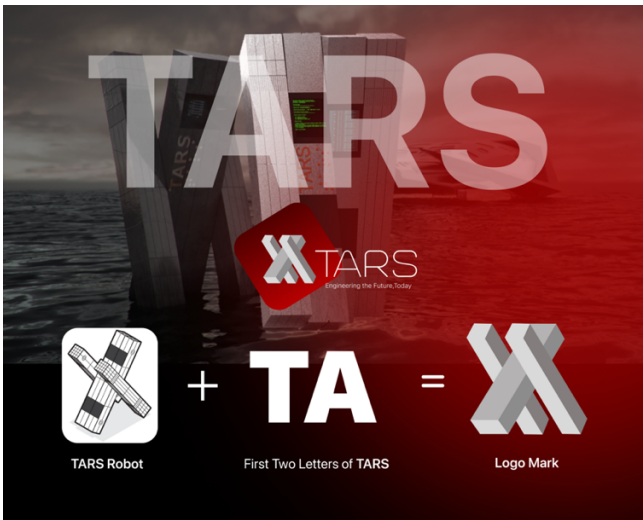


Figure 34 Evolution of TARS Logo

The typography is solid but space age, reflecting solidity, reliability, and forward movement. Where geometric or modular elements exist within the logo, these reinforce the flexibility and ability of the company to dynamically move between industries. The colour scheme, perhaps featuring dark blues, blacks, or metallic hues, represents sophistication, vastness, and infinite possibilities in innovation. In the end, the TARS logo is not simply a visual representation it is an expression of the company's vision to change industries, lead the way in progress, and spearhead a more connected, smarter world.

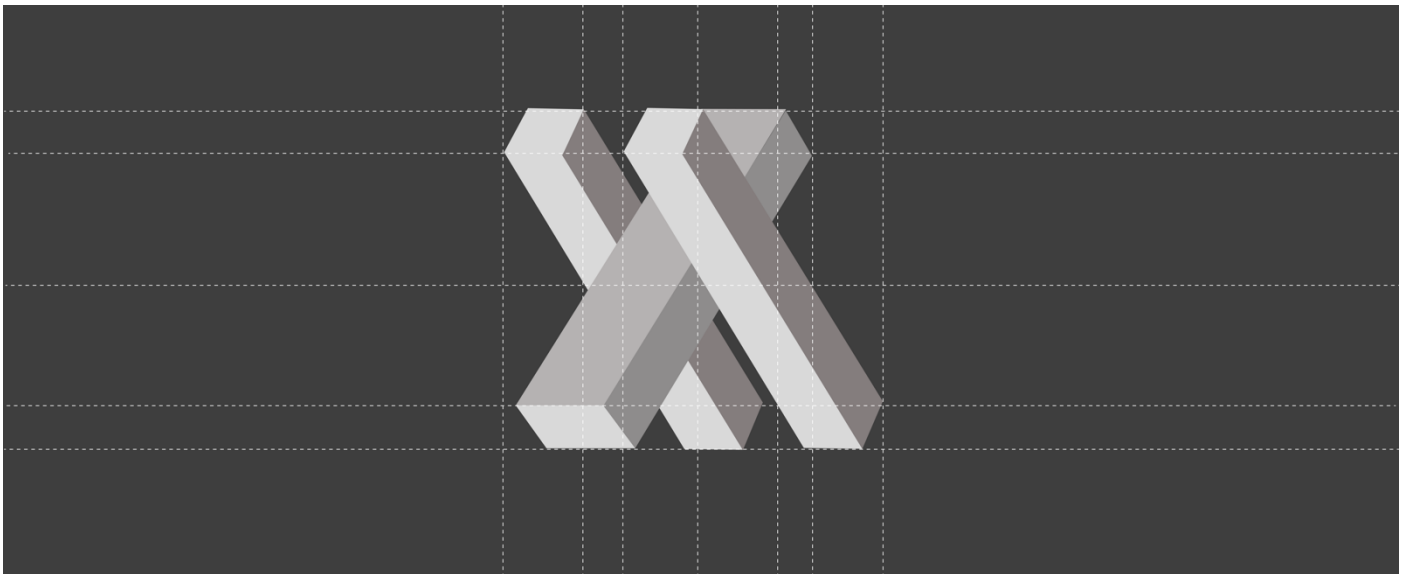


Figure 35 Main Component of Logo (TARS Overlay) Developed in Figma

Color psychology: According to the colour psychology the red and white combination in your logo gives rise to a strong and harmonious brand identity. Red is a highly emotive colour that speaks of passion, energy and confidence. Red captures attention and represents urgency, thus being suitable for brands that aim to make an impact. Red also elicits strong feelings, hence a suitable option for businesses that live off interaction and passion. White, on the other hand, represents simplicity, purity, and professional. It balances red's drama to create a fresh and contemporary look with better readability. White also signifies trust and openness, making your business appear more trustworthy and approachable. Red and white together create a dramatic contrast that is bold but refined, making the logo visually appealing and memorable. This colour combination is commonly used by

businesses that want to express both strength and reliability without compromising a professional look. Either in digital or print media, the red and white combination ensures a universal and bold design that will attract your target market.

9.2. Sales & Distribution Strategies:

Retail Partnerships: TARS will partner with technology stores and environment-friendly stores (online and offline), where the target market is likely to purchase tech-savvy and eco-friendly products. developed markets are also characterised by organised retail and wholesale chains, considerable use of technology and data by channel members, informed customers, high Internet penetration, sophisticated logistics, and strong

implementation of laws and regulations. Distribution channels in emerging markets are characterised by unorganised retailing and wholesaling; smaller, independent retailers and wholesalers; more levels in the distribution chain; less use of technology and data by channel members; scantier penetration of Internet; evolving logistics infrastructure; and poor implementation of laws and regulations. TARS will be partnered with reputable technology retailers who appeal to the tech-savvy customer who is an early adopter of the latest technologies and gadgets. The partnerships will ensure the brand is exposed to a market that values performance, reliability, and technology (Mulky, 2013).

Online Shopping Platforms: In addition to the physical retail partnerships, TARS will also focus on collaborating with the top online retailers so that it is made available to the masses across the world. The internet is where the majority of consumers are increasingly doing research and buying technology products (Rundel et al., 2024).

Pop-Up Partnerships: Temporary retail partnerships or pop-up shops with powerful green or tech-driven stores will also be on TARS's watch list. These can create hysteria and buzz around the brand and give direct customer contact and feedback (Gide & Riad Shams, 2011).

9.3. Advertising & Promotion:

To effectively bring the brand to market and establish a strong customer foundation, TARS will have a multi-pronged advertising and promotion strategy.

Through digital campaigns and influencer partnerships, TARS aims to enhance brand awareness and foster engagement with its target audience in a manner that is both approachable and

authentic. The primary emphasis of these efforts will be on highlighting the brand's technological innovations and sustainability initiatives, particularly in alignment with the values of eco-conscious consumers. (Kumar et al., 2025).

Digital Campaigns:

"TARS' digital campaigns will focus on authentic storytelling, educational content, and active engagement across major social media platforms. As highlighted by Arshanapally" (Arshanapally et al., 2022).), the integration of advanced technology with eco-friendly principles is essential in addressing everyday challenges, a concept that TARS aims to communicate through its campaigns.

Key Platforms

Instagram & Facebook: These will be the hub for content with visual appeal. TARS will post captivating images and videos showcasing its products with their innovative character and eco-friendliness credentials.

Social Media Marketing

TikTok: Taking advantage of the platform's younger, fashion-forward user base, TARS will create short, lively videos showcasing the products in action in daily life, peppered with eco-tips and challenges to encourage users to integrate sustainability into their lifestyle (Dupuis et al., 2025).

LinkedIn: This website will be used to communicate TARS' commitment to corporate social responsibility and sustainability in the technology arena. Thought leadership articles, case studies, and company news will address a professional audience interested in the intersection of tech and the world (Marin & Nilă, 2021).



Figure 36 Advertisement Case Plan

9.4. Video Content

Product Demonstrations:

Showing how TARS products are solutions and sustainable at the same time. For example, showing how TARS is compatible with an eco-friendly life or helps one reduce carbon footprints.

Hashtag Campaigns: Encourage users to post their own sustainable living practices with a branded hashtag like #TarsSustainable. Such hashtag campaigns may have challenges, such as reducing the use of plastics or recycling tech products, to generate engagement and create a community for the brand (Demirel, 2020).

University Activations: University students are trendsetters and early adopters of new technology, and they are increasingly environmentally aware. Activating on campus allows TARS to access this younger demographic while establishing the brand as a leader in sustainable innovation. On-campus activation points include pop-ups, campus representatives and partnering with like-minded sustainability groups(Mei-Ling Wei et al., 2008).

Sustainability Partnerships:

TARS will sponsor a student sustainability club or environmental-interest club to assist with event. An expression of the need for sorting out and this concept is the growing amount of partnership typologies that scholars have introduced. These collaborations will establish TARS as a brand committed to integrating sustainability into its culture. TARS can sponsor campus sustainability week activities, offering free trials(Van Huijstee et al., 2007).



Figure 37 Brand Merchandising Case Plan

Chapter 10

10.1. Discussion & Evaluation

10.1.1. Project Findings & Insights

User-Centered Design Insights and Strategic Feature Integration within the TARS Smart Bag

Comprehensive person studies, consisting of surveys and in-intensity interviews, coupled with an in depth competitor evaluation, yielded vital insights that immediately informed the layout and development of the TARS Smart Bag. The research recognized key user priorities protection, monitoring, consolation, and sustainability which eventually guided feature prioritization and layout strategies.

User Needs and Pain Points: The qualitative and quantitative records underscored that security and loss prevention are primary issues for tourists. Survey consequences indicated that over 70% of respondents expressed a sturdy interest in GPS-enabled luggage as a method of stopping loss (Aytın, 2014). This locating become corroborated by means of interview records, in which contributors emphasized the importance of real-time vicinity monitoring and stable locking mechanisms. In reaction, the TARS Smart Bag contains superior security features inclusive of a biometric fingerprint-lock system, a tethered anti-theft alarm, and incorporated GPS tracking. These factors were designed to mitigate unauthorized get right of entry to and facilitate the recuperation of out of place bags, as a result without delay addressing consumer-identified vulnerabilities (Times of India, 2024).

Ergonomic Design Considerations: Comfort emerged as a critical issue influencing consumer satisfaction, particularly among individuals the usage of backpacks in the course of extended tour or each day commuting. Common court cases focused around lower back and shoulder stress associated with conventional backpack designs

(Targus, 2019). Accordingly, TARS followed an ergonomically optimized form aspect presenting contoured lower back help, wide padded straps, and strategically balanced weight distribution. These design alternatives are supported by means of ergonomic standards indicating that right load distribution can significantly reduce bodily fatigue. Subsequent consumer checking out tested those upgrades; adjustable strap lengths and breathable padding have been mainly stated for his or her position in assuaging pain and promoting extended wearability.

Material Selection and Environmental Responsibility: Material preference turned into informed with the aid of both practical requirements and moral issues, reflecting a consumer preference for products that are concurrently durable and sustainable. The TARS Smart Bag employs recycled polyester cloth, decided on for its high tensile power, tear resistance, and weather-resistant houses. Importantly, this fabric additionally aligns with growing consumer demand for environmentally aware merchandise. By utilising recycled plastics, the product now not simplest reduces environmental effect but additionally reinforces the logo's dedication to sustainability. This twin emphasis on overall performance and ecological obligation guarantees the product meets both sensible and ideological person expectancies (Paramatex, 2024).

Competitor Benchmarking and Feature Prioritization: A thorough competitor analysis highlighted customary market gaps and knowledgeable the strategic inclusion of functions. While present smart baggage frequently includes USB charging ports and Bluetooth monitoring, few comprise superior security mechanisms which includes biometric locks. Additionally, early iterations of smart luggage confronted regulatory challenges because of non-detachable battery designs, resulting in bans via predominant airways. TARS pre-emptively addressed this trouble by way

of integrating a fully removable battery percent, ensuring compliance with FAA and TSA pointers (Christina Darby, 2022). Feature prioritization changed into in addition delicate using the Kano version, which categorizes product attributes based totally on their effect on consumer satisfaction. Core functionalities along with GPS tracking and anti-robbery alarms were identified as primary or overall performance functions important to person expectancies while optionally available additions like wi-fi charging were labelled as delighters and earmarked for future iterations.

Conclusion: The TARS Smart Bag exemplifies a person-targeted design method, wherein empirical consumer information and aggressive marketplace intelligence coalesce to tell the mixing of capabilities that directly cope with primary user needs. The methodological software of ergonomic principles, sustainable substances, and prioritization frameworks along with the Kano version guarantees that the product no longer only resolves key ache factors but additionally strategically differentiates itself in a competitive marketplace panorama.

10.1.2. Challenges and Limitations

Challenges and Limitations: Despite the successful integration of a couple of superior functions into the TARS Smart Bag, numerous demanding situations and boundaries emerged for the duration of the improvement and trying out stages. These spanned across hardware integration, regulatory compliance, software development, ergonomic trying out, and scope management.

Hardware Integration Constraints: The incorporation of digital additives along with the GPS module, biometric fingerprint sensor, Bluetooth module, and lithium-ion battery within a compact backpack form thing posed giant engineering demanding situations. Achieving a stability between capability, compactness, and sturdiness necessitated a couple of iterative prototypes. A crucial difficulty become ensuring the clever components remained blanketed in opposition to mechanical pressure, including impact and vibration, whilst additionally

preserving weight distribution and garage usability. This requirement imposed design constraints at the internal format, mainly with reference to the routing of wiring and the position of published circuit boards (PCBs). Extensive time was allotted to refining PCB layouts, insulating additives, and ensuring overall resilience of the electronics below ordinary utilization situations.

Battery Regulation Compliance: Smart luggage is issue to strict aviation safety guidelines, specifically concerning the integration of lithium-ion batteries. Most important airlines restrict non-removable lithium batteries in checked bags. To comply with these mandates, TARS carried out a detachable battery percent. While essential, this selection added extra engineering complexities. The layout needed to ensure both steady mounting throughout use and ease of elimination all through airport protection exams. Engineering a reliable release mechanism that would balance user convenience with flight safety delivered extra design overhead (Christina Darby, 2022). Furthermore, the battery's capability had to be slightly decreased from preliminary specifications to mitigate heat control problems and meet safety standards, thus demonstrating the need of prioritizing regulatory compliance over preliminary overall performance targets.

Application Security and Connectivity: The improvement of the partner cell software, Track TARS, brought challenges associated with both functionality and cybersecurity. Given the potential vulnerabilities associated with smart baggage, mainly concerning unauthorized get entry to GPS information or far flung manipulate of locking mechanisms, robust security protocols had been imperative. The application incorporated encrypted Bluetooth Low Energy (BLE) communication and multi-element authentication for vital commands (Rene Millman, 2021). These measures had been knowledgeable through protection studies figuring out common exploits in earlier generations of smart bags. Nonetheless, making sure a seamless but stable person revel in proved stressful; early versions of the application experienced intermittent

connectivity troubles, which required successive updates and rigorous trying out to solve.

Limited Testing and Ergonomic Optimization:

Due to the restrictions imposed by the venture timeline, subject testing of the pre-manufacturing prototypes was restrained. While laboratory tests effectively validated digital capability and sturdiness underneath simulated conditions, large real-global trying out across various user demographics and environments was not viable. Consequently, sure ergonomic optimizations along with modifications for varying body sorts, extended utilization comfort, and environmental resilience remain in part unvalidated. While the initial ergonomic capabilities were grounded in mounted layout standards and corroborated via preliminary consumer remarks, the absence of long-time period and massive-scale field trials introduces capability risks of unforeseen pain or overall performance degradation through the years.

Design Trade-offs and Feature Limitations: As with many innovation-pushed tasks, positive functions in the beginning envisioned have been excluded from the very last product because of technical, safety, and aid constraints. Notably, the inclusion of a wireless charging pad was deferred

10.2. Summary of Findings

Finalized Prototype Evaluation of the TARS Smart Bag: Integration of Ergonomics, Sustainability, and Smart Technology The finalized prototype of the TARS Smart Bag exemplifies a well-balanced integration of ergonomic layout, clever capability, and sustainability. From the initial degrees of improvement, the design manner changed into knowledgeable by way of complete person studies—an essential component in the advent of successful, person-centric merchandise. The findings from this studies directly inspired essential factors of the bag's layout, along with its shape aspect, weight distribution, cloth choice, and embedded technologies. Consequently, the final prototype provides a product this is snug, environmentally responsible, and technologically sophisticated. The TARS Smart Bag achieves high user satisfaction by aligning product functions with

due to challenges in accomplishing Qi certification and handling heat dissipation inside the layout envelope. Similarly, a proposed solar charging function changed into deserted because of its terrible impact on bag weight and waterproofing integrity. These exclusions underscore the pragmatic exchange-offs essential all through improvement, in which non-important or excessive-hazard capabilities had been deprioritized in prefer of ensuring the reliability and safety of middle functionalities. Future iterations of the TARS Smart Bag may revisit those improvements with additional research and development assets.

Conclusion: The development of the TARS Smart Bag illuminated various sensible constraints inherent inside the integration of smart technology into patron merchandise. While the crew efficiently addressed essential demanding situation particular within the domain names of safety, regulatory compliance, and consumer-focused layout some boundaries, in particular in prolonged usability testing and feature scope, continue to be regions for destiny enhancement. These insights offer a basis for ongoing new release and improvement in next product cycles.

sensible and emotional person desires. The ergonomic layout guarantees comfort all through prolonged use, while using sustainable substances particularly, recycled polyester fabric derived from repurposed plastic waste demonstrates a dedication to environmental responsibility. Moreover, the combination of clever functions enhances the bag's software and enchantment in a digitally linked world.

Key innovations featured in the prototype consist of:

A biometric fingerprint lock that enables secure, keyless entry through a TSA-compliant mechanism; A detachable lithium-ion battery percent for tool charging, designed to conform with airline protection regulations; GPS tracking capabilities, incorporated with a cell utility to allow real-time place tracking and far flung manipulate; A sustainable outside made from recycled

materials, helping eco-conscious product development. These features collectively mirror the successful convergence of person-driven necessities with technological advancement. The prototype not handiest fulfils its preliminary layout goals but additionally lays a sturdy foundation for

the future evolution of the TARS product line. As a primary-era offering, the TARS Smart Bag offers a scalable platform that may support destiny improvements and foster an expanding atmosphere of clever journey add-ons underneath the TARS logo.

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- Product Desing,3D Modelling, Poster and Advertisement Design, Documentation & Track TARS App Front End Design Credits: <https://www.behance.net/jagathguru> Jagathguru CEO of TARS.
- Cost Model & BMC of TARS: Anbucheliyan, Sadha Aravindh Production Manager of TARS
- Bill of Material Design: Francis, Fregin Supply Chain Manager of TARS



Understanding the user problem

Our research identified key challenges in current smart bags, including issues with non-removable batteries, inadequate security, heavy weight, limited storage, and short battery life. Addressing these problems is essential to enhance convenience, security, and overall user satisfaction.

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Student Self-reflection on performance

All students must complete the following sections for every piece of work they submit using this template. The aim of this is to help you use feedback more effectively to improve your marks and your skills as a professional engineer. This section is not formally marked, but your tutor may use it when discussing your work with you.

Describe how you have used AT LEAST ONE of the following sources of information to improve this piece of work:

- 1.) (PREFERRED) Feedback from previous assignment(s). This can be from the same module or from a previous module or previous year of study (e.g. comments from 1st year lab formal reports should be used to help improve your 2nd year lab formal reports).**
- 2.) The marking criteria or rubric provided for this assignment.**
- 3.) The Department Technical Writing Handbook for Students.**

The Department Technical Writing Handbook for Students.

Are there any aspects of this work that you would specifically like the marker to comment/or advise on? For example: “I wasn’t sure if my figure formatting looked professional and would appreciate feedback on this aspect”

I attempted to condense the report; however, I found that a detailed explanation was essential for a comprehensive understanding of the product. As a result, the report has extended to more pages than initially planned. I kindly request your feedback on any portions that may seem unnecessary or can be removed without affecting the clarity or depth of the report. All references have been cited using the University of Leicester's Harvard format, and I have also provided access to my RefWorks account for verification. I hope this report meets your minimum expectations and look forward to your valuable feedback.