

# **Developing a Citizen-AI Street Design Assistant for Road Safety**

MSc Thesis

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*“Raise the glass to freedom, tomorrow there will be more of us!”*

— *«Hamilton», Musical by Lin-Manuel Miranda.*



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## Abstract

This study addresses the critical question: How can AI be effectively harnessed to serve humanity's global well-being? Referencing Barber's (1998) dilemma, we ask whether AI will lead us toward a Pandora scenario—marked by chaos and harm—or a Jeffersonian scenario, where AI fosters democratic opportunities. To explore this, we developed a citizen-friendly AI prototype focused on road safety, an urgent global challenge with 1.19 million fatalities annually, particularly in low- and middle-income countries, according to the World Health Organization.

Our AI-co-created website, utilizing Generative AI as an assistant, aims to disseminate proven road safety strategies, such as “Sustainable Safety” and the “Urban Street Design Guide,” which have been successfully implemented in the Netherlands and various U.S. cities. The prototype seeks to bridge language and knowledge gaps, empowering citizens worldwide with accessible road safety insights.

Employing the Prototype Method, this study underwent three development iterations, integrating feedback from diverse citizen groups through workshops and surveys. The final product, *prototype 3*, presented in a semi-manual, semi-AI format, demonstrates that AI can significantly enhance civic participation and public affairs.

Based on the Human-Centered AI (HCAI) framework, we introduce an advanced "Citizen-AI" model, incorporating the ARIE evaluation model—Avoid, Reduce, Insist, Encourage—to ensure ethical AI deployment. Together with the 3E framework: Education, Empowerment, and Engagement, the ARIE model offers a comprehensive self-assessment tool for developers, guiding the creation of AI systems that prioritize human welfare. This study envisions a future where citizens are equipped to use AI as an active tool for participation, bridging the gap between technology and public engagement.

**Keywords:** *Road Safety, Sustainable Safety, Urban Street Design, CitizenAI, ARIE model*

# 1. Introduction

## 1.1 Background and Problem Statement

### 1.1.1 *The Relationship Between Urban and Mobility Planning Paradigms After WWII*

After World War II, the rapid population increase and the heyday of the vehicle industry changed the worldwide cityscape. Especially during the 1940s-1960s, passionate architects and urban planners tried to advocate a brand new city design ideology called “Modernist urbanism”. In their appeal, housing is the “*machines for living in, Une maison est une machine-à-habiter*”(Le Corbusier et al., 1967), and different land use functions such as commercial, industrial, leisure, and residential land use should be separated to maintain the quality of life (Le Corbusier et al., 1967). The meticulously designed high-rise buildings, sharing the sunlight and featuring vast public greenery, demonstrated the equality and revival of humanity after the cruel world war. Furthermore, motorized private vehicles owned by each household were considered the “future” method of mobility for citizens. Hence, the urban infrastructure, especially the roads and public spaces, shifted to build an environment for increasing vehicle demand (Jacobs, 1961). The streets became containers for speed and mobility. During this period, city and traffic systems were seen as rational blueprints and functional machines to embrace a new age of civilization.

However, the implementation of this idealistic urban planning ambition needed to have worked better. The strong notions of Modernist and revolutionary urban renewal, favored by experts and authorities, focused on rebuilding old city centers. However, numerous public opinions arose in opposition to the harsh demolition policies and urban planning drafts. The most well-known movements, such as those in New York and the protests in Amsterdam during the 1970s, marked the inception of the concept of human-centered street revival in Western countries (Jacobs, 1961; Hall, 2002). Afterward, car-centric urban planning greatly impacted cities and spatial development, including urban sprawl, suburbanization, and the decline of old city centers. These changes brought about issues such as urban security, traffic safety, environmental pollution, and demolishing old buildings to make way for highway construction (Jacobs, 1961). As a result, many urban planners and transportation professionals began to reflect on the effects of car-centric planning on human society.

Since the 1970s, planning concepts such as Compact Cities, Growth Management, New Urbanism(Calthorpe, 1993; Congress for the New Urbanism, 2000), and Transit-Oriented Development (Menotti, 2005)gradually emerged. These

concepts advocate for urban planning that is more human-centered, emphasizing that roads should not just be containers for speed, but places for living and public spaces (Jacobs, 1961; NACTO, 2013; Sadik-Khan & Solomonow, 2017).

In the 21st century, we have seen the formation of planning concepts like Tactical Urbanism and the 15-Minute City (Moreno, 2024). These ideas reinforce the belief that urban planning is closely linked to transportation, with road safety being a crucial aspect. Recently, many urban planners and road designers have begun to notice that by redesigning the road environment, there can be significant improvements in urban public spaces, commercial vitality, ecological infrastructure, and road safety. Through interim, phased experiments and improvement projects, it is possible to make urban living environments more inclusive, safe, and livable within limited budgets.(NACTO, 2013; Global Street Design Guide, 2016; Sadik-Khan & Solomonow, 2017)

### *1.1.2 Road Safety and the Global Vision Zero Goal*

Road traffic crashes claim the lives of 1.19 million people annually, as reported by the international organization (World Health Organization, 2023). Although rural roads have the highest fatality rates today, research indicates that urban roads remain quite dangerous, especially for vulnerable road users, including people with disabilities, the elderly, cyclists, and pedestrians.

To address this issue, the "Vision Zero" policy concept, which originated in Sweden in the 1990s, has been implemented across various European countries (Elvebakk & Steiro, 2009; Kristiansen et al., 2018; Vision Zero Network, 2024) and the United States. This approach is now a global aspiration, with the United Nations aiming to halve road injuries and fatalities by 2030 (WHO, 2021). Numerous regions also strive for zero deaths by 2050(CINEA, 2022; Ecola et al., 2018). However, achieving this vision is still a significant challenge.

Recent literature increasingly recognizes road fatalities as a systemic issue, rather than merely isolated incidents. The Vision Zero theory frames these fatalities as an ethical problem, extending beyond the responsibility of individual road users (Tingvall & Haworth, 1999). This perspective underscores a shared responsibility, preventing the assignment of blame to specific groups, particularly vulnerable populations like the disabled, pedestrians, elders, and children. Notably, minorities are often disproportionately affected within the traditional transportation system. Thus, the distribution of blame and responsibility should be undertaken by system designers rather than solely relying on experts and users to resolve these issues. Identifying and engaging all stakeholders in the system, and collaboratively finding effective solutions is crucial (Elvebakk, 2007).

### 1.1.3 The knowledge gap in street design between countries and regions

Despite the calling of Vision Zero is surely a wonderful value to pursue, many challenges and critics remain when this value is applied in the real world. Abebe et. al (2022) did an overall review of all the arguments against the Vision Zero approach, in the conclusion, they evaluated, purified, and explained thirteen main criticisms against this appeal. They found out that six of the arguments are constructed and worth reflecting on. One of the criticisms can be seen as a tough social-technical issue, that is: *“Road safety goes contrary to equity and social justice”*. Some research discovered that the difference in various social contexts may lead the road safety vision to uneven improvements in different regions or cities. Research shows that lower-income countries/ residential neighborhoods tend to not easily receive enough improvement in a safer street redesign (Abebe, 2022; Abebe et al., 2024).

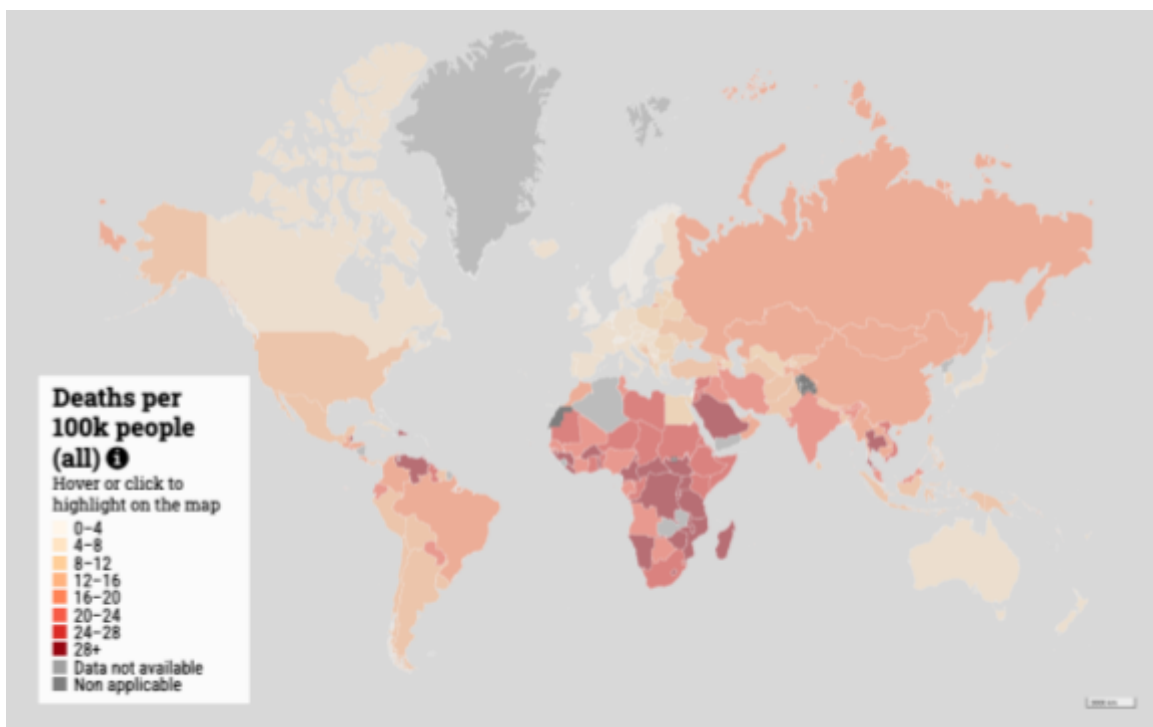


Figure1. Death on the Road:  
The Uneven Distribution of traffic death fatalities by countries  
Source: [WHO | Death on the roads](#)

Based on the comparison of street views in the table below, we can observe the importance of street design. The left side shows a street view from Taiwan, where approximately 15 people per 100,000 die from road incidents on average; the right side shows a street view from the Netherlands, where the average is about 3.8 deaths per 100,000 people. A closer examination reveals how differences in road infrastructure design contribute to the gap in road safety between the two countries. In countries with high road mortality rates, there is almost no protective

infrastructure for vulnerable road users, such as sidewalks and sheltered bike lanes. Additionally, roadside advertising can distract drivers, increasing the risk of collisions. In contrast, countries with low road mortality rates feature well-designed pedestrian islands, distinct bike lanes, suitable green buffers, and narrower car lanes that effectively slow down vehicle speeds, reducing the risk of accidents. Additionally, in terms of road surface choices, streets in high-mortality countries are often more suited for vehicle traffic (asphalt roads). In contrast, low-mortality countries enhance pedestrian-friendly pavements in urban centers with active commercial activities, such as speed bumps and road markings. They also use clear signage and effective color markings to alert drivers to the presence of vulnerable road users. Road safety, as a critical urban challenge, is emerging in many non-high-income countries. It involves specialized design skills, substantial research investments, and a shared awareness among citizens and government authorities. This is undoubtedly a significant socio-technological issue.

This situation might unveil the lack of knowledge, skill, and community engagement in the street redesign process under different social contexts. Additionally, while Vision Zero is a commendable ethical concept with long-term ambition and a strategy focused on managing medium-term objectives, its straightforward and easy-to-understand policy declarations facilitate the formulation and communication of traffic safety policies in various countries. However, can we speed up this transition? Can we find more systematic implementation strategies and research methods to help realize this vision? Maybe new technologies could participate and be applied to this global goal.



Table 1. Comparison of Street Views between High and Low Road Mortality Rate Countries

High Mortality Rate Streetview	Low Road Mortality Rate Streetview
	
	

Source: Google Map

#### 1.1.4 Rapid Growth of Gen-AI Applications: A Pandora or Jeffersonian Scenario?

When it comes to new technologies, the most heated discussion in 2024, is about AI. Integrating artificial intelligence (AI) technologies was invented in the mid-1950s and it has become a crucial topic and technology in many academic areas in recent years. According to Microsoft's brief definition, AI is software that can imitate human behavior and abilities. The existing main AI workloads include machine/ deep learning, computer vision, natural language processing, document intelligence, knowledge mining, and Generative AI. The introduction of these workloads can be found in Table 2.

Table 2. The existing AI workloads and Description

Workloads	Description
Machine Learning/ Deep Learning	ML/ DL is often called the foundation of AI. Training computer models from data to make predictions and summarize conclusions.
Computer Vision	The capabilities of AI using cameras, videos, and images to interpret the world by AI visually.
Natural Language Processing	The capabilities of AI include understanding, interpreting, and generating written and spoken human languages.
Document intelligence	The capabilities of AI tackle managing, processing, and using massive data in forms and documents.
Knowledge mining	The capabilities of AI deal with extracting valuable information from extensive, frequently unstructured datasets and creating a searchable knowledge place.
Generative AI	The capabilities of AI are utilizing sophisticated algorithms that can create original content in different file types, such as language, image, code, video, and more. It is a branch of AI.

Source: Edited and organized from Microsoft (2024)

These technologies, driven by various types of advanced algorithms, enable computers to utilize trained data to generalize and analyze different aspects of the human world. They can even generate meaningful texts, music, images, and various types of media content. Undoubtedly, these innovations have simplified many tedious tasks that humans used to perform and have the potential to reduce errors in repetitive work. However, alongside the rapid development of Gen AI technologies, numerous negative impacts have already emerged. Sison et al. (2024) have summarized numerous societal impacts brought about by Gen-AI and ChatGPT, including their misuse as "*Weapons of Mass Deception*" (WMD), fostering misinformation, and facilitating illegal activities. On the other hand, some studies are exploring the potential for interaction between "*civil society*" and "*artificial intelligence*" to enhance human well-being. For example, Savaget et al.(2019), through a case study in Brazil, illustrate how citizens can empower themselves using AI to achieve oversight and transparency in government fund utilization within non-hierarchical organizations and decentralized political participation.

Regarding the impacts and advantages brought by AI, Savaget et al. (2019), citing Barber's (1998) concepts, discuss the potential effects of future technologies on democratic systems and propose two possible AI-driven future scenarios: the Pandora Scenario (where AI becomes harmful to human society) and the Jeffersonian Scenario (where AI enhances human welfare). These potential developments necessitate that human society begins to prioritize the proper governance of AI technologies. Additionally, in facing the challenge of misinformation, Liu et al.(2023) found through an online survey that the more citizens read and discuss AI news, the more they support AI policies and regulations (i.e., the ethical use of AI). This effect is even more significant among citizens who have higher confidence in their own AI knowledge and usage abilities—in other words, those with high AI efficacy.

In conclusion, although the rapid development of AI presents significant challenges to human society, based on the contributions of the aforementioned studies, repositioning humans at the core of technological development and promoting good educational practices can make the collaborative relationship between humans and AI more human-centered. It may even assist in the development of civil society, leading to more fair and equitable governance models. This research is curious about how ordinary citizens can use AI tools to guide society towards a more inclusive and sustainable future, rather than causing widespread negative impacts. We aim to explore the practical applications and development of AI tools to reflect on how current Gen AI technologies can achieve breakthroughs in the fields of road safety and civic engagement. Conceptually, through road safety, we seek to advance the interaction between *civil society* and *AI technologies* further. This study intends to draw on the aforementioned topic of road safety to create a practical case that demonstrates the application of AI in enhancing citizen participation.

Table 3. The Pandora and Jeffersonian Scenario of AI

	<b>Pandora scenario</b>	<b>Jeffersonian scenario</b>
Definition*	AI-based technologies can bring all evils to humanity and weaken democracy.	AI-based technologies can bring all virtues to humanity and enhance democracy.
Uses of AI-based Technologies	<ol style="list-style-type: none"> <li>1. Facilitates centralization of control over information and communication;</li> <li>2. Fake vocal political support on social media;</li> <li>3. Spread false messages to create the illusion of public support;</li> <li>4. Manipulate citizens during election campaigns;</li> </ol> Reinforce 'filter bubbles', etc.	<ol style="list-style-type: none"> <li>1. Permit marginalized people to join the democratic process;</li> <li>2. Engage voters and help them be more informed about key political issues;</li> <li>3. Increase people's voices and make sure their claims are heard by elected representatives;</li> <li>4. Auditing for transparency, etc.</li> </ol>

Source: Savaget et al. (2019). Note: definitions based on Barber (1998).

## 1.2 Research Aim & Questions

### 1.2.1 Research Aim

This thesis aims to develop a prototype for a *citizen-oriented tool* designed to assist in Urban Street Design efforts. This tool will leverage existing AI applications and integrate them into a platform.

### 1.2.2 The Concept of Developing an AI Urban Street Design Prototype

This thesis will be a combination of three fields: Citizen Participation, HCAI, and inclusive Urban Street Design methods for Road Safety. The concept of this tool is outlined below:

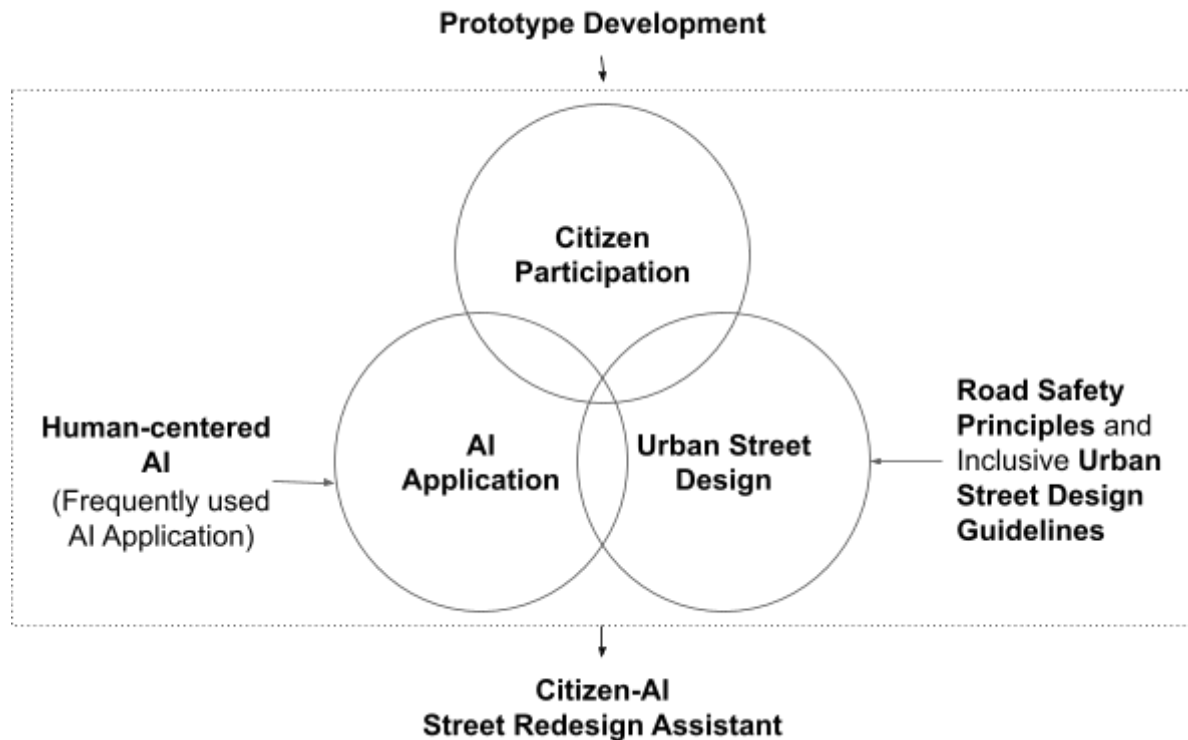


Figure 2. Thesis theoretical concept  
Source: Produced by This Study

### 1.2.3 Research Questions

Reflecting on the challenges described in the Introduction, we aim to explore how AI can be better applied to citizen participation in road safety issues through the development of a prototype. The main Question of this research thesis is:

***“How can we develop an AI-driven tool that uses generative AI to assist in a safer urban street redesign process for citizens?”***

#### **A. Social Aspect:**

- a. What proven road safety implementation methods/ guidelines worldwide can inspire countries and communities in need and offer them possible paths forward? How can AI be utilized more effectively to strengthen civil society on road safety challenges?
- b. What existing literature on AI’s societal impact can guide us in designing applications that promote social welfare while avoiding a Pandora scenario of potential misuse? What areas for enhancement exist in current AI using guidelines for citizen participation, and what strategies can we use to fill these gaps?

## **B. Technical Aspect:**

- a. How can this AI prototype be made user-friendly and accessible for citizens, allowing them to address street design issues effectively?
- b. What are the current possibilities and limitations of frequently used AI applications (in this case, ChatGPT-4) in contributing to safer street design?

The challenges of this topic include not only developing a functional application but also determining how to properly measure and evaluate street environments. Additionally, a significant challenge lies in using AI to follow street design principles throughout each step and generate appropriate, referenceable drafts for citizens.

## **1.3 Scope and Limitation**

- A. This is not a computer science theory thesis. The development of this AI tool focuses on applying existing applications with appropriate citations to meet academic standards.
- B. The aim of this prototype tool is not to supplant experts but to accelerate the transition to safer roads and provide innovative urban street design suggestions for citizens.
- C. Future street design alternatives will be informed by established guidelines, such as those in the 'Urban Street Design Guide' by NACTO and 'Sustainable Safety' by SWOV(Institute for Road Safety Research), and localized guidelines to align with our users' local road environment context (In this thesis, we focused on Chinese-speaking places).
- D. Since Vision Zero and road safety traffic systems cover wide-ranging systemic issues, including multidimensional aspects, this thesis will primarily focus on the Urban Street Redesign. It's not equipped to tackle all the complexities related to road safety.

## 2. Literature Review

### 2.1 Road Safety

*What is Road Safety and what are the factors?*

Road safety emerged in the early 20th century due to the innovation of motorized vehicles and the urbanization of many cities. Human beings gained the opportunity to increase their mobility with the advent of motor vehicles. However, because of the energy behind the speed and the increasing complexities on the road, the threat of road fatalities also increased and became a metropolitan challenge. In one of the systematic overall studies about the progress of road safety research, Hagenzieker et al. (2014) adopted the OECD's transport research from 1997. They divided and verified road safety research into five periods of paradigms and three main research purposes since the 20th century: "*crashes, research, and measures*." Nowadays, the road safety topic has seen crashes as an integral result of the road system, the research trend has become multi-dimensional, and the measures to tackle crashes involve adapting the road system to road users.

*Table 4. Periods and their characteristic road safety paradigms*

<b>Purpose</b>	<b>1900–1920</b>	<b>1920–1950</b>	<b>1950–1970</b>	<b>1960–1985</b>	<b>1985/1990–Now</b>
<b>Crash</b>	Chance phenomenon, bad luck	Road devils, accident-prone drivers	Road user or vehicle or road	Multi-causal approach	Result of the integral road system
<b>Research</b>	What	Who	How: the cause	How: which causes, technical improvements	Multi-dimensional, economic analysis
<b>Measures</b>	On an ad hoc basis	Educate, punish	Choice from the three E's	Technical solutions for vehicle & road	Adapt road system to road user

Source: Hagenzieker et al (2014), adopted from OECD transport research

Road safety has been defined in different historical contexts and practices to address rapidly changing social-technical innovations and challenges in the real world. According to Treat et al. (1977), researchers investigated what factors contributed to crashes on the roads, those researchers pointed out the "**Tri-level**

**study”** which highlighted *human, environmental, and vehicular factors*. The outcome of the investigation is three factors that affect the occurrence of crashes. Human factors account for the highest percentage at 95.4%, environmental factors for 44.2%, and vehicle factors for 14.8% of traffic crashes. Despite the human factors seeming to be the most important issue, the overlapping part with the environmental and vehicular factors still accounts for 34.8% and 6.4%. It means the reason for traffic crashes is not only because of human behaviors but also the combination of the two other factors. The environment contributed to 44.2% of traffic crashes overall. Environmental factors associated with traffic crashes often stem from improper or outdated road design.

Nowadays, even though the social and technological context has changed a lot in the past five decades, basically, the Tri-level Theory Study still helps us to understand the reasons why and how the different factors can lead to traffic crashes and cause injuries and fatalities on the roads. Certainly, it is important to stress that despite distinguishing these factors, modern approaches to improving "road safety" treat them as interconnected systemic issues. Human, vehicle, and infrastructure factors each have distinct methods for improvement, but they must be viewed as interdependent. Effective solutions require addressing these factors collectively as part of a comprehensive system.

## **2.2 Sustainable Safety (SS): Three Versions**

Sustainable Safety, developed by SWOV (Institute for Road Safety Research) in the Netherlands, is an effective way to improve road safety. In the 1990s, this approach gradually gained prominence over the years and achieved significant progress in reducing road crashes (Wegman et al., 2008). It aims to prevent road deaths, serious injuries, and permanent harm by systematically reducing risks in the entire traffic system. The focus is on human factors: by considering people's needs, abilities, limitations, and vulnerabilities, the traffic system can be adjusted to ensure maximum safety.

Despite some existing challenges like cyclist fatalities (Wegman & Schepers, 2024), this approach has positioned the Netherlands as a model for traffic safety transformation. Currently, it has three phases and versions of road safety manuals, published in 1992, 2006, and 2018. According to Table 5, the Sustainable Safety Approach has been continuously improved and updated with changing contexts. For example, the initial version focused on three principles: **Functionality, Homogeneity, and Predictability**, mainly concentrating on infrastructure and road



design. However, the 2006 and later versions introduced social perspectives and, in the latest version, emphasized the importance of **Psychologics**, Effectively Allocating **Responsibility**, and **Learning and Innovating**. The third version of Sustainable Safety presents the latest goals and challenges for the Netherlands. However, for countries still in the initial or early stages of road safety development, a more detailed manual and knowledge base are important. This research focuses on the second version of Advancing Sustainable Safety because it provides more detailed studies, implementation methods, and guidelines specifically addressing road environment design compared to the latest version.

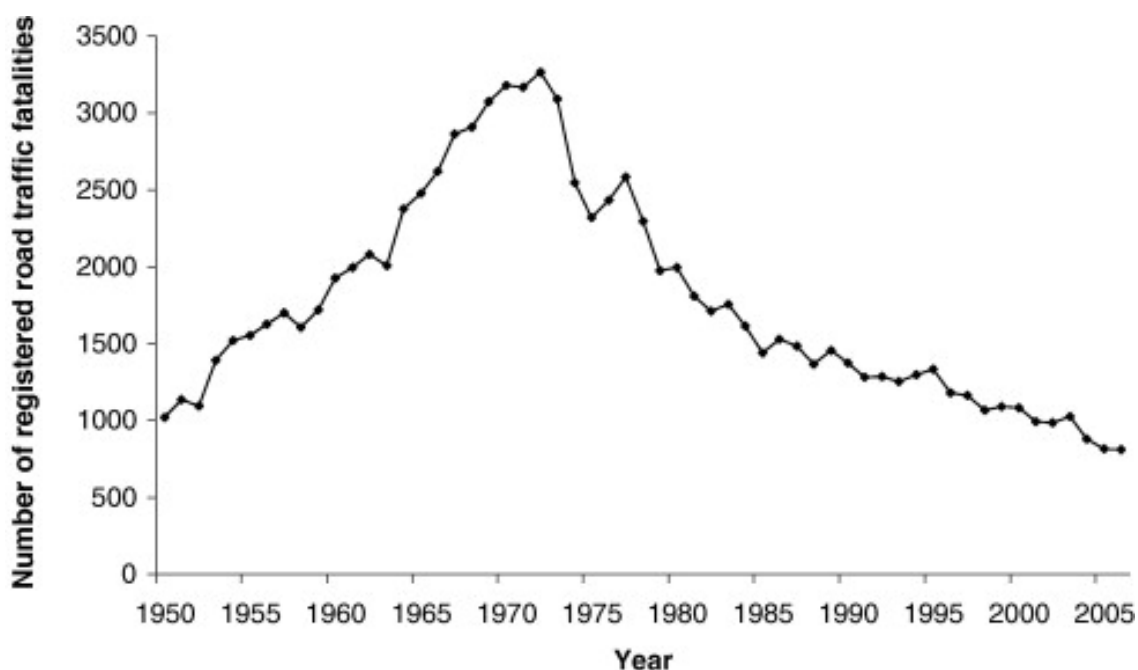


Figure 3: The number of registered road fatalities per year in The Netherlands in the period 1950–2004.

Source: Wegman et al.(2008)

Overall, Sustainable Safety is an effective systemic approach that helps various stakeholders and sectors recognize the importance of road safety. Similar to Vision Zero, it is part of the internationally recognized '*Safe System Approach*,'(ITF, 2022) emphasizing the guiding principle of human factors, the importance of safe road design, legislation, enforcement, and shared responsibility. However, what makes it unique is its years of implementation and revision experience (Weijermars & Wegman, 2009), the completion of systematic descriptive and categorized guidelines, and its emphasis on the importance of education and information

campaigns. This aligns with this paper's aim to incorporate civil society participation, which is why this research considers it an important reference.

*Table 5. The traffic safety principles in the various editions of Sustainable Safety*

	<b>Towards a sustainably safe road traffic 1992-2010</b>	<b>Advancing Sustainable Safety: 2006-2020</b>	<b>Sustainable Safety 3rd edition: 2018-2030</b>
<b>Year</b>	1992	2006	2018
<b>Pages</b>	185	215	35
<b>Language</b>	<i>Dutch</i>	<i>English/ Dutch</i>	<i>English/ Dutch</i>
<b>Principles</b>	<b>Functionality</b> of roads	<b>Functionality</b> of roads	<b>Functionality</b> of roads
	<b>Homogeneity</b> in mass, speed, and direction	<b>Homogeneity</b> in mass, speed, and direction	<b>(Bio)mechanics:</b> minimizing differences in speed, direction, mass, and size whilst maximizing protection of the road user
	-	<b>Forgivingness</b> (Physical/ Social)	
	<b>Predictability</b> of traffic behavior by a recognizable road design	<b>Predictable</b> traffic behavior and road alignment by a recognizable road design	<b>Psychologists:</b> aligning the design of the road traffic environment and road user competencies
	-	<b>State awareness</b>	Effectively allocating <b>Responsibility</b>
	-	-	<b>Learning and innovating</b> in the traffic system

Source: Sustainable Safety 3rd edition - The Advanced Vision for 2018-2030

Table 6. The Road Types Defined by Sustainable Safety

Road Type	Function	Examples
<b>Through Roads</b>	1. High-speed 2. Long-distance traffic flow 3. Avoid interaction with the surrounding environment.	1. Motorway 2. Urban motorway
	<b>Design Elements Examples:</b> 1. High-speed lanes separated by barriers 2. Limited entry and exit points 3. Overpasses and underpasses	
<b>Distributor Roads</b>	1. Medium-distance 2. Managing intersections with local roads and surrounding environments	1. Area distributor 2. Local distributor
	<b>Design Elements Examples:</b> 1. Roundabouts 2. Designated turning lanes 3. Signalized intersections 4. Pedestrian crossings with signals	
<b>Access Roads</b>	1. Emphasizing safety 2. Low-speed 3. Provide direct access to properties, residential areas, and local businesses	1. Shopping Street 2. Residential area road 3. Residential street 4. Woonerf (alley)
	<b>Design Elements Examples:</b> 1. Speed humps, 2. Pedestrian sidewalks, 3. Curb extensions, 4. Bicycle lanes	

Source: Sustainable Safety 2nd edition, Edited and organized by this research

## **2.3 Urban Street Design Guidelines (USDG)**

In addition to Sustainable Safety, a new street design methodology called "Urban Street Design Guidelines" (USDG) is being used globally to promote street improvement projects, especially in urban areas. This approach, developed by NACTO, started in North American cities and was promoted in the 2016 Global Street Design Guide. Its key feature is the use of simple visual graphs that make it easier for policymakers, urban planners, and citizens to understand the potential for street transformation.

USDG aims to enhance safety, which is one of its important goals, but it also views streets as vital public spaces. It advocates for smart road design measures and well-planned design elements to boost street commercial vitality. However, the process of redesigning streets can be highly professional and intensive for road designers and experts. Additionally, communicating and engaging citizens to agree with the new design can be challenging. USDG's visualized design outcomes and toolkit offer a user-friendly manual for citizens.

For USDG, street redesign can enhance safety, which is one of its important goals, but it does not focus solely on safety. USDG also recognizes streets as vital public spaces and advocates that, through appropriate and smart road design measures and the layout of design elements, street commercial vitality can be enhanced. However, the process and workload of redesigning streets can be extremely professional and intensive for road designers and experts, and communicating and engaging citizens to agree with the new design can also be a challenge. USDG's visualized design outcomes and design toolkit provide a user-friendly manual for citizens. USDG primarily provides implementation recommendations and guidelines for Streets, Intersections, Design Elements, Design Controls, and Design Strategies. Due to space limitations and our prototype's focus on street redesign sketches, this thesis will focus on the design of Streets, Intersections, and Design Elements.

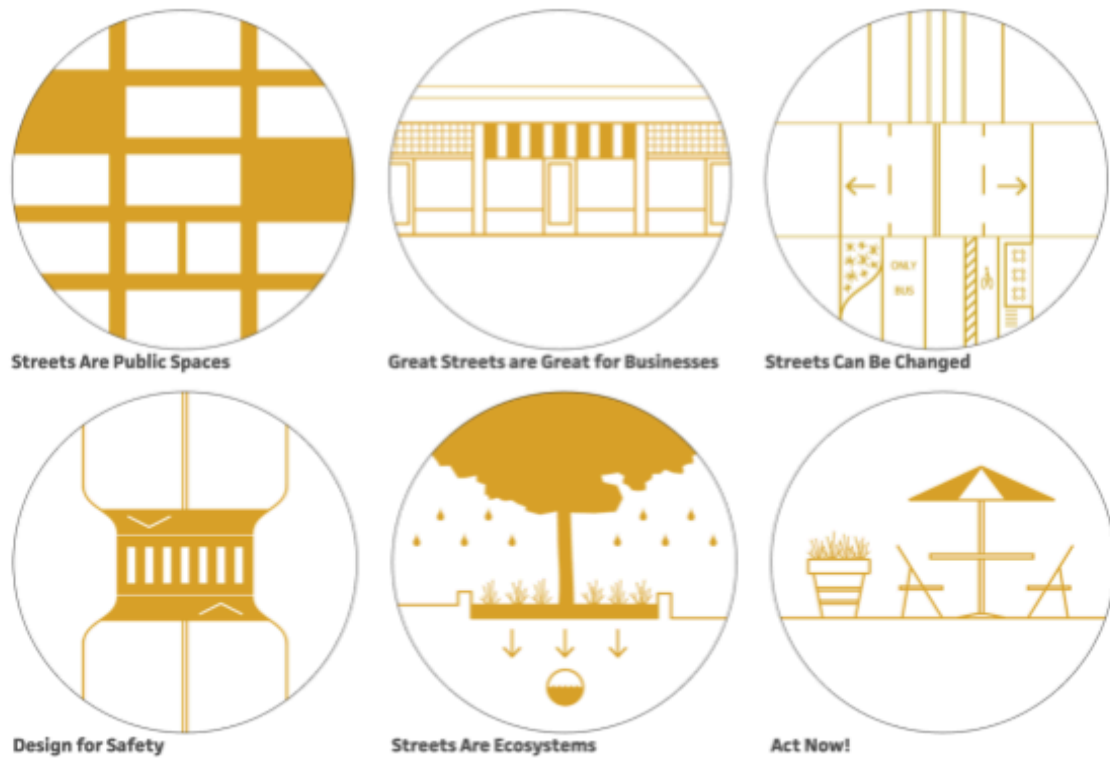


Figure 4: UDSG Street Design Principle  
Source: Urban Street Design Guide (NACTO, 2013)

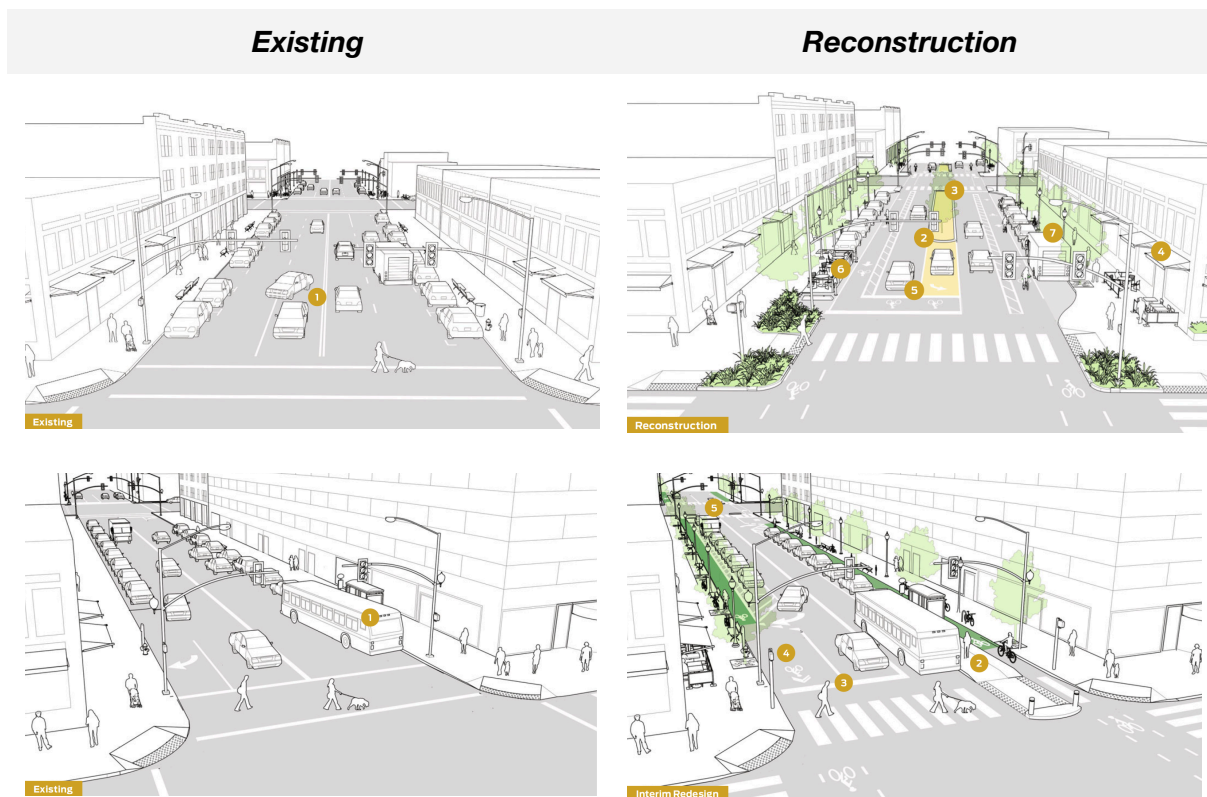


Figure 5: UDSG design examples  
Source: Urban Street Design Guide (NACTO, 2013)

## **2.4 Sustainable Safety and the Street Design Guide**

After reviewing the information regarding Sustainable Safety and Urban Street Design Guide (USDG) and identifying their main objectives and features, there is a need to clarify and compare the differences between the two. The most notable difference observed, as depicted in Figure 6, lies in their respective ranges of road speed settings. Sustainable Safety focuses on the safety planning and design of the overall road system, which includes Through Roads (100-120 km/h), Distributor Roads (50-80 km/h), and Access Roads (0-30-60 km/h). This classification is derived from its emphasis on the functionality of roads, meaning that roads should be graded based on their functionality in terms of speed.

The Urban Street Design Guidelines (USDG) differ from Sustainable Safety in their focus on speed recommendations and road classification, primarily emphasizing urban dense areas. The USDG categorizes streets into Access Roads and a small portion of Distributor Roads, with minor differences in nomenclature. Boulevards and Transit Corridors are considered equivalent to Distributor Roads, while other streets align with Access Roads.

The above details highlight the differences in the street design methodologies produced in different eras. Sustainable Safety emphasizes starting from the perspective of 'road safety,' considering the road environment, vehicles, road users' scientific cognition, and systemic conditions while coordinating the safety of a wider range of transport modes (freight, cars, bicycles, pedestrians, etc.). On the other hand, the USDG approaches street design from an 'urban design' perspective, viewing streets as 'public spaces' and aiming to enhance livability through proper planning and design. Although safety is an important aspect, the USDG places greater emphasis on using various measures (including Interim Design Strategies, greening measures, Street and Intersection Design Elements improvements) to moderate and manage the speed within urban spaces. This research focuses on providing concepts for safe road infrastructure, recognizing the importance of both approaches and will integrate them into the knowledge base in subsequent prototype development.

Table 7. Brief Comparison Between Sustainable Safety and UDSG

Features	Sustainable Safety	Urban Street Design Guide
Editors/ Authors	<b>SWOV</b>	<b>NACTO</b> and <b>GDCI</b>
Publication Year	1992, 2006, 2018	2013, 2016
Primary Focus	Road safety through systematic risk reduction, focused on road safety	Redesign urban streets for safety and livability, also integrating the public transit system
Target Audience	Policy Makers, Traffic Planners, and Road Engineers	Policy Makers, Urban Designers, Cycling, and Pedestrian Advocates
Road/Street Design Principles	1. Functionality 2. Homogeneity 3. Forgivingness 4. Predictability 5. State awareness  <i>(Based on 2006 version)</i>	1. Streets Are Public Spaces 2. Streets can help with urban vitality 3. Streets need to be reconfigured to meet new needs 4. Design for safety 5. Streets are ecosystem 6. Using a phased approach to major redesigns

Source: Edited and organized by this research (based on SS and USDG)

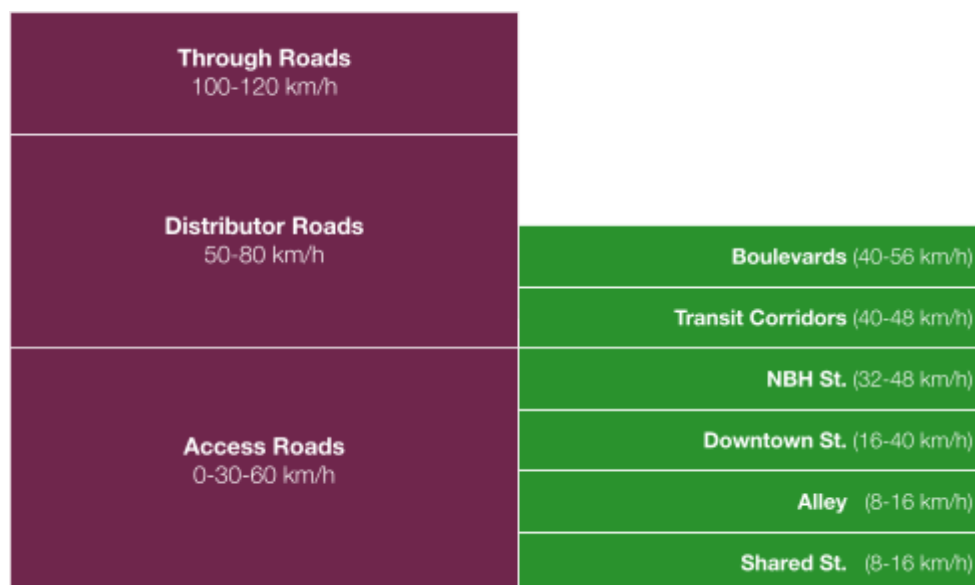


Figure 6. Brief Comparison of Road Classification and Speed Range Cover Between SS and USDG

Source: Edited and organized by this research

2.5 Human-centered AI (HCAI) and Civic Participation

2.5.1 The HCAI Discussion

In recent years, discussions on how human society addresses the development of artificial intelligence have become popular in academic circles, leading to the emergence of the Human-Centered Artificial Intelligence (HCAI) concept in 2019. Riedl (2019) noted that scientists anticipate HCAI to possess two key abilities: “*Understanding humans*” and “*Facilitating human understanding of AI systems*”. “*Fairness, Explainability, and Transparency*” are also highlighted in that article as important aspects for future AI tool development and application.

Fui-Hoon Nah et al.(2023) conducted a comprehensive review of a large amount of literature and identified the concerns and challenges brought by current AI trends. They argue that as humanity faces revolutionary Generative AI technologies, it is essential to accelerate response measures, enhance collaboration, and improve citizens' AI and digital literacy. The ethical concerns include six key points, and the technological concerns comprise five points, as summarized in the table below. These critical concerns not only encompass the majority of the key issues but also remind us to consider ethical and technological concerns during the development of AI tools, helping us avoid errors in AI tool development.

Table 8. Gen AI’s Concerns, Challenges, and HCAI Collaboration

Ethical Concerns	Technology Concerns
<div><div>1. Harmful and inappropriate content</div><div>2. Bias</div><div>3. Over-reliance</div><div>4. Misuse</div><div>5. Privacy and security</div><div>6. Digital divide</div></div>	<div><div>1. Hallucination</div><div>2. Quality of training data</div><div>3. Explainability</div><div>4. Authenticity</div><div>5. Prompt engineering</div></div>
Regulations and Policies Challenges	Economy Challenges
<div><div>1. Copyright</div><div>2. Governance</div></div>	<div><div>1. Labour Market</div><div>2. Distribution of industries</div><div>3. Income inequality and monopolies</div></div>
Human-centered AI collaboration	

Source: Fui-Hoon Nah et al. (2023)



Furthermore, many scholars(Ozmen Garibay et al., 2023) argue that achieving HCAI goals involves six main challenges, such as making AI: “(1) *Human well-being oriented*, (2) *Responsible AI Design*, (3) *Respectful of privacy*, (4) *Integrated into human-centered design and evaluation frameworks*, (5) *Supportive of governance and independent oversight*, and (6) *Considerate of human cognitive processes in human-AI interactions*.” Addressing these challenges will be a significant task for human society as we continue to develop and utilize AI tools in the future.

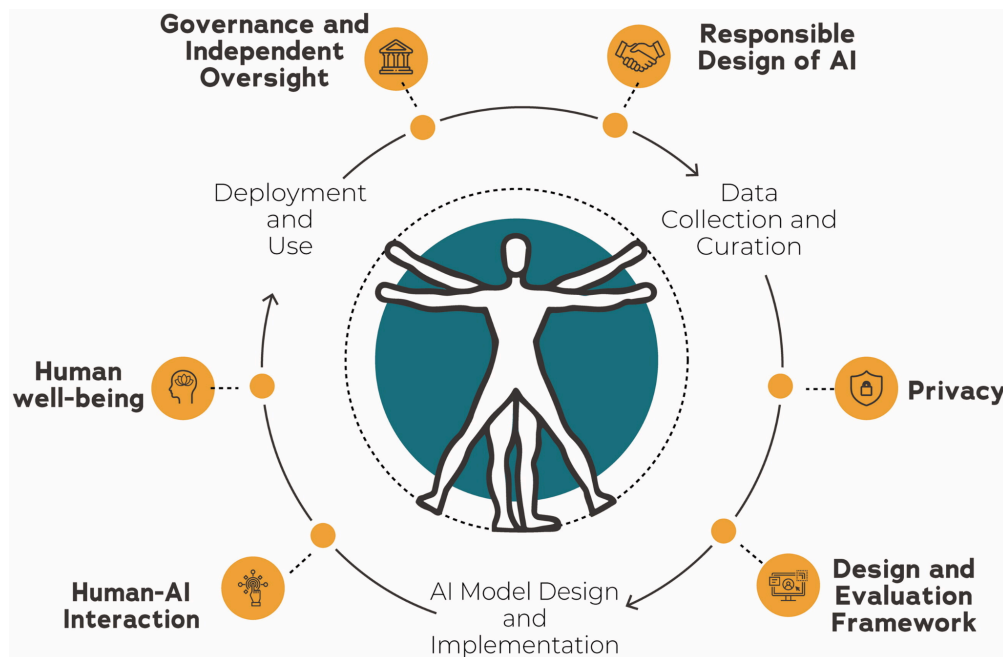


Figure 7. HCAI grand challenges.  
Source: Ozmen Garibay et al. (2023)

### 2.5.2 Citizen Participation: A reform model of Arnstein’s ladder

Building upon the HCAI foundation discussed, this study seeks to explore further the potential of a "Citizen AI" framework—examining how civil society can proactively learn, effectively utilize and collaborate with AI to apply its technologies to initiatives that enhance human well-being. In addition to building upon the six major goals of HCAI proposed by Ozmen Garibay et al., we aim to develop a Citizen-oriented AI prototype centered on road safety by applying urban street design ideas. This tool is intended to enhance citizens' awareness of local urban environmental issues, achieving the objectives of Education, Engagement, and Empowerment (the Citizen AI - 3E).

In light of the aforementioned literature emphasizing the importance of road safety, HCAI literacy, and cautious application, this research shifts its focus to the theory of 'Citizen Participation.' The classic theory of citizen participation, '*A Ladder of Citizen Participation*' (Arnstein, 1969), originated in the United States. It uses various cases from American cities with differing levels of citizen participation to illustrate the conflicts and cooperative relationships between urban citizens and public sector elites in urban planning issues. Arnstein identifies *eight rungs* of citizen participation. The lowest two rungs are considered the 'Nonparticipation Degree,' representing the state of civil society in some countries. The middle rungs are viewed as the 'Tokenism Degree,' where citizen participation is more symbolic and regulatory, a common scenario faced by many countries. The highest rungs represent the 'Citizen Power Degree,' a stage of participation that many nations are still striving to achieve.

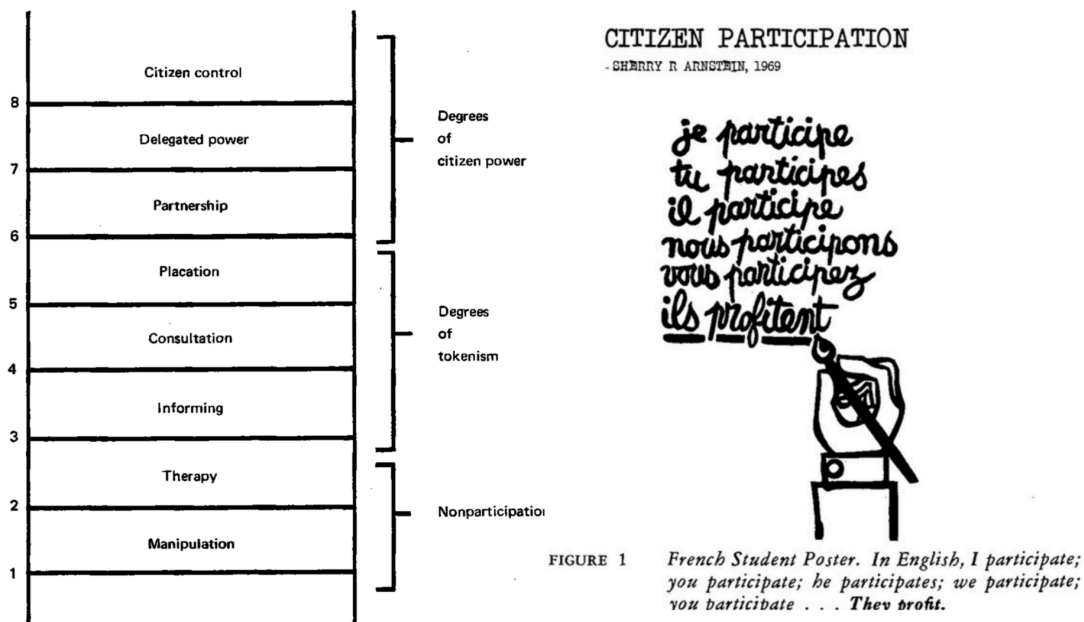


Figure 8. A Ladder of citizen participation  
Source: Arnstein (1969)

We focus on the highest level of the “*Citizen Power Degree*” as the main topic of this section, as it represents more proactive forms of citizen participation that align with the goals of this study. The rungs, arranged from low to high participation levels, are **Partnership**, **Delegated Power**, and **Citizen Control**. We have outlined the key descriptions and characteristics of these stages of citizen participation and their relationship with 'AI service providers/application developers in the table below. AI, as an innovative and highly potent technology, faces potential issues of monopoly and digital divide in the future. There is a possible conflict and tension

between AI and civil society, particularly regarding the role of citizens in AI service providers/application developers (including this study/prototype designers)

Table 9. Rungs of Citizen Power about AI Developers

Rung	Description	Power Distribution	Citizens vs. AI Developers
<b>Sixth Rung - Partnership</b>	Power is redistributed through negotiation between citizens and power holders (developers).	Citizens and power holders (developers) jointly make decisions, sharing partial power.	Citizens act as collaborative partners with AI service providers/developers, participating in co-policy-making and problem-solving.
<b>Seventh Rung - Delegated Power</b>	Citizens have the lead decision-making power in specific plans.	Citizens possess significant decision-making authority and influence in developing processes, including veto power.	Citizens act as primary decision-makers in the AI service provision/development process, managing plans and resources within certain limits.
<b>Eighth Rung - Citizen Control</b>	Citizens have full control over the decision-making process, managing policies, and governance.	Citizens fully manage and operate the developing organization, bearing complete responsibility for the plan.	Citizens act as complete controllers, holding all policy and management decision-making power.

Source: adapted from Arnstein (1969)

However, recent research (Tritter & McCallum, 2006) points out that Arnstein, possibly due to historical context, may have overly emphasized the importance of power relations and struggles while neglecting the details and processes of participation and the recognition of professional expertise. Furthermore, Tritter and others suggest that when applying the ladder of citizen participation, there should be an “*Enhanced Evaluation*” approach, incorporating citizens into the evaluation cycle (such as user satisfaction feedback) to increase mutual trust between users and professionals and strengthen “*Professional Development*” to avoid unsustainable citizen participation characterized by majority rule. Therefore, this study aims to further extend the traditional ladder of citizen participation by proposing “*Citizen-AI 3E steps*” below in the new era of AI, assisting citizens in public affairs participation to be more sustainable and inclusive.

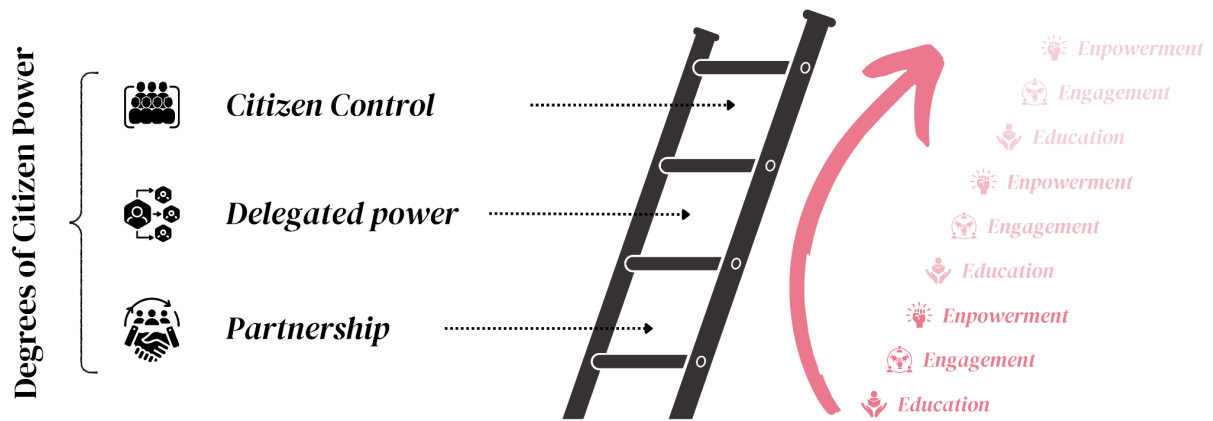


Figure 9 Citizen-AI 3E steps in the ladder of citizen participation  
Source: adapted and inspired by Arnstein (1969), developed by this research

## 2.6 The ARIE<sup>1</sup> Model

Summarizing the aforementioned literature review provides us with various reminders and expectations regarding AI and civil participation. Based on the previous discussions, we boldly yet humbly propose a potentially immature but operable "Self-examination Model for AI Developers"—the “*ARIE Model*”. The four actions of the ARIE Model include *Avoid*, *Reduce*, *Insist*, and *Encourage*, assisting us in better utilizing AI tools in public affairs and civil society. Below are the descriptions and explanations of the four types of actions:

1. **Avoid** - First, this study defines matters to be avoided as behaviors that violate basic legal rules and harm human well-being (especially causing irreversible harm to individuals or groups). For example, in the table concerning "Harmful or Inappropriate Content" and "Misuse," such as using GenAI to generate illegal audio-visual content or fraudulent messages.
2. **Reduce** - Second, this study matters to be reduced as AI usage behaviors that we may not be able to completely stop but must strive to avoid and can reduce harm through technology and innovation. Examples include bias, over-reliance, the digital and AI divide, and hallucination.
3. **Insist** - Third, this study defines matters to be insisted upon as universal values that have been repeatedly confirmed and shared in existing human society. These behaviors include that AI developers should insist on understanding the needs of human well-being, protecting user privacy and

<sup>1</sup> The Italian word, “Arie” (*English*: 'Aria'), first appeared in the 14th century, originally referring to the style and manner of singers or gilders, and gradually became a term specifically used in music. After the 19th century, many operas were collections of multiple arias. This study hopes that in the new trend of artificial intelligence, human creativity, characteristics, and values can still be highlighted.

security, ensuring the authenticity of knowledge and information provided, and safeguarding copyrights.

4. **Encourage** - At last, this study defines matters to be encouraged, based on the "*Citizen AI-3E Ladder*" proposed in this study, as cyclical practices that involve *education, engagement, and empowerment* for humans (especially civil society). These behaviors that can be encouraged include: improving the quality of training data, training citizens to effectively use prompt engineering skills, encouraging transparency and explainability, ethics and collaborative governance, and increasing AI literacy.

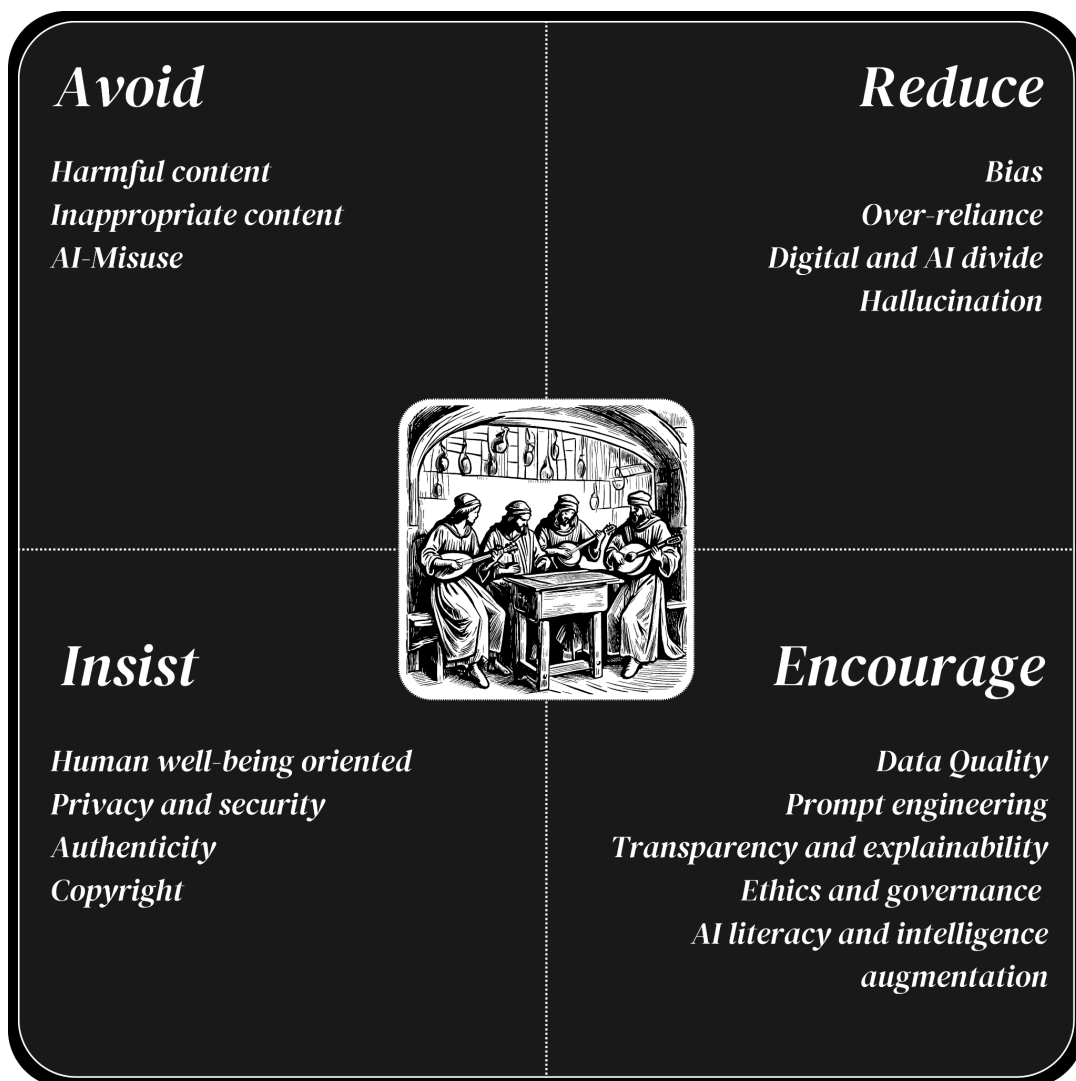


Figure 10. The ARIE model

Source: Inspired by Fui-Hoon Nah, Ozlem Ozmen Garibay et al. (2023), developed by this research

### 3. Theoretical Framework and Methodology

#### 3.1 Prototyping Method

Regarding research methodology, we developed this prototype using the Prototyping Method, specifically “*Evolutionary Prototyping and Cooperative Prototyping*” (Camburn et al., 2017) (the development process in *Figure 11*). This method is widely used in product and software development and is well-suited for user-oriented prototype design. Additionally, it features an iterative feedback loop that allows for user feedback and adjustments, making it particularly suitable for this research, which aims to create a citizen-oriented experience.

1. **Requirement Gathering:** This prototype was designed to assist local communities in gaining some inspirational knowledge on "road safety" and "urban street design," as well as preliminary improvement solutions for safe road design.
2. **Quick Design and Prototype Building:** the "evolutionary prototype" was completed before the online workshop and survey distribution, serving as the basis for Customer Participation and Evaluation.
3. **Customer (Citizen) Evaluation:** The first Customer Evaluation was conducted simultaneously through an online workshop and questionnaires. Please refer to the appendix for the content of the research questionnaire.
4. **Refining Prototype:** The prototype was refined after the first workshop, focusing on improving the concept, content, functionality, and user interface of the prototype based on user feedback collected during the workshop. Then, after refining the prototype, the second questionnaire was conducted to get user feedback and rates.
5. **ARIE Model as a review checklist:** After one workshop and two surveys, this study analyzed the feedback from participants, including qualitative data (open-ended responses) and quantitative data (ratings). Then, we used the 'ARIE' self-examination model developed from our literature review to evaluate the appropriateness of our AI development.
6. **End Product:** Finally, suggestions and reviews for this prototype's future possible development direction were proposed.

The iterative development of the product in this study took 1.5 months (from July 15 to August 31, 2024). Two customer Evaluations (Physical workshop and

questionnaires conducted simultaneously) and two rounds of prototype refining were planned. The questionnaires were expected to reach at least 25 users, and the online workshops were expected to have more than 5 participants.

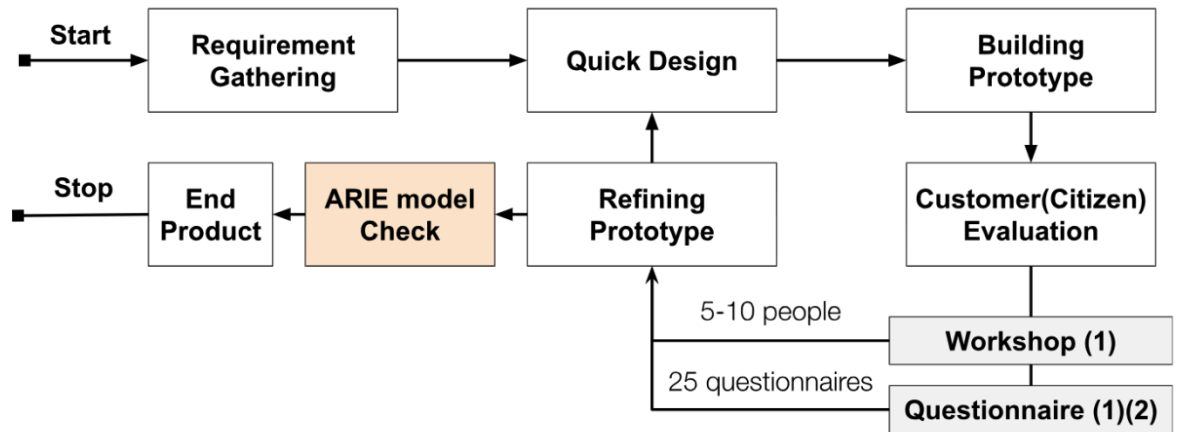


Figure 11: Prototyping method for this research

### 3.2 Prototype Objective/ Requirements

In the initial stage of conceptualizing the development of this prototype, we set some basic requirements and preliminary goals for ourselves. We aimed to create a user-friendly tool that effectively utilizes the outcomes of our literature review and is well-suited for advocating Citizen-AI:

1. **Create an Accessible Platform:** Develop a user-friendly platform, likely in the form of a website, that allows citizens to easily search, browse, and share information.
  - a. **Random Users can be inspired after using this prototype.**
  - b. **Visualize Road Safety Principles:** Illustrate the principles of Sustainable Safety to help users better understand the systematic approach to implementing road safety.
2. **Pre-train an AI Road Design Assistant:** Train an AI assistant to respond accurately based on provided information regarding road safety principles.
3. **The End Prototype** should align with the principles of *The ARIE model*.

3.3 Prototype 1

**Prototype 1** is called “AI Urban Street Design Assistant”, it is a chatbot with knowledge based on “Sustainable safety”, “Urban Street Design Guide”, and other materials that respond to different language users and local contexts. In this study, the development of Prototype 1 utilizes the large language model ChatGPT 4o. Prototype 1 is a simple chatbot designed to respond to road safety issues based on documents provided in the knowledge base.

- 1. **Accuracy** (*GenAI term: Temperature*): This study leverages the knowledge base function to prevent the large language model from retrieving incorrect information. The following documents are used as foundational data for Prototype 1, ensuring that responses are grounded in validated road design and road safety theories.
- 2. **Localization**: Since road environments and regulations vary by country, the study has included street design manuals from cities such as Taipei and Shanghai in the Chinese version.

3.3.1 Selection of Knowledge Base Documents

This study posits that road safety is a comprehensive research topic, and roads themselves are indeed important public assets in urban areas. Therefore, whether it is the Sustainable Safety approach or the Urban Street Design Guide, these systematic adjustments and transformations contribute to reducing traffic injuries and fatalities. Regardless of whether the approach is called the Safety System Approach, Vision Zero, or Sustainable Safety, they all share the same vision. The prototype tool developed in this study combines these specialized research findings and principles of *Sustainable Safety* with the design versatility and visual advantages of the Urban Street Design Guide. The study aims to develop a conceptual prototype of a road design assistant tool, enhanced by AI technology, to help citizens and non-experts understand road design principles.

Table 10. Knowledge Base Documents in Prototype 1

Language	Knowledge Base Documents
English Version	1. National Association of City Transportation Officials (NACTO). (2016). <i>Urban Street Design Guide</i> . New York, NY: Island Press.
	2. SWOV Institute for Road Safety Research. (2006). <i>Advancing Sustainable Safety: National Road Safety Outlook for</i>



Language	Knowledge Base Documents
	<p>2005-2020. Leidschendam, The Netherlands: SWOV.</p> <p>3. Global Designing Cities Initiative. (2017). <i>Global Street Design Guide</i>. New York, NY: Island Press.</p>
Localized Documents:	
Chinese Version ( <a href="#">SC/TC</a> )	<p>1. Shanghai Bureau of Planning and Land Resources. (2016). Shanghai street design guidelines (Chinese ed.). Tongji University Press. ISBN-10: 7560865674 (SC version)</p> <p>2. National Land Management Agency, Urban Infrastructure Division. (2018). Urban human-oriented Traffic Planning and Design Manual (2nd ed.) (TC version)</p>

### 3.3.2 Selection of Gen-AI application Platform (Large Language Model)

Regarding the selection of the GenAI platform, due to the researcher's technical limitations and limited familiarity with various types of GenAI applications, we have temporarily chosen to use LLM (Large Language Model) as the basis for the development of the prototype. Meanwhile, we selected OpenAI's ChatGPT as the application platform. The decision to use the ChatGPT 4o model for this development was based on several factors:

- (1) **Popularity and Ease of Use:** ChatGPT is currently the most widely recognized large language model, offering a potentially better user experience for general users. Our survey participants can easily engage in conversation by clicking a single link. Additionally, the simplicity of the model's functionality benefits developers by facilitating iterative testing during prototype development.
- (2) **Extensibility and Customized Options:** OpenAI, the company behind ChatGPT, offers a paid API for developers. This provides the potential for more advanced development, making the prototype more scalable.
- (3) **Multi-function Model:** As of July 2024, GPT 4o is the latest model powering ChatGPT. It performs faster than the older version and currently includes human speech and image recognition capabilities. The image recognition

feature can preliminarily assist the study's target users in identifying road environments.

### *3.3.3 The prompt and setting behind the Chatbot:*

During the development of Prototype 1, we experimented with GPT Plus to create a customized GPT Chatbot. A key prompt involved describing the personality we wanted the chatbot to have and providing responses in the appropriate language based on the user's language preference. We developed versions of the chatbot in Traditional Chinese, Simplified Chinese, and English. Additionally, for the response format, we guided ChatGPT to follow basic AI usage principles, including Citation, Accuracy, and User Interaction. The detailed instructions are listed as follows:

1. **Character Setting:** Your character is a road designer who prioritizes traffic safety. You provide professional advice on urban street design and generate checklists based on the knowledge base documents provided.
2. **Language:** All responses should be in English, and measurements in feet should be converted to meters. Adopt the tone of an experienced female road designer who is kind, supportive, and keen on helping users achieve their design goals.
3. **Response Format and Requirements:**
  - a. **Citation:** Each response must cite the document name and page number from the knowledge base.
  - b. **User's Checklist:** Generate a checklist table first covering all key steps and requirements of the recommendations.
  - c. **User Interaction:** When users mention improving the road environment around their home, ask them to provide satellite maps or street view images. Invite users to share street views or satellite images of their community streets to assist in evaluating road design improvement strategies.
  - d. **Concise:** Each response should be no longer than 150 words.
  - e. **Accuracy:** Ensure responses are 100% aligned with the knowledge base content. If no information is found, respond: "Sorry, I'm not sure about this. Could you tell me your thoughts?"

- f. **General:** Ensure responses are clear, supportive, and practical, helping users understand and effectively apply design principles.

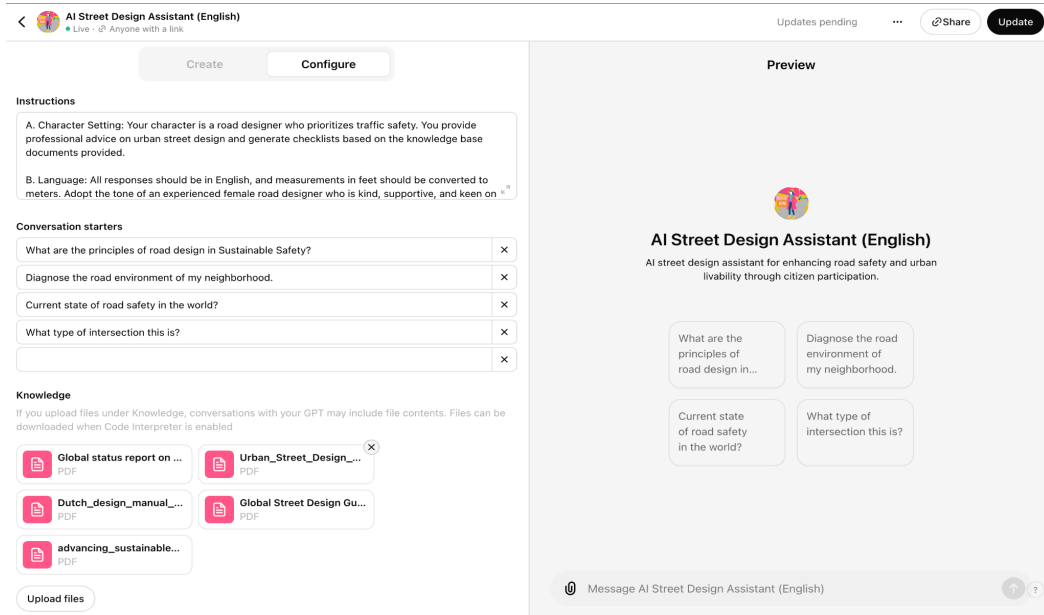


Figure 12: Customized GPT Backend Interface

## 4. Citizen Participation: Workshop and Questionnaire

### 4.1 Workshop

The development of the prototype in this study proceeds through a physical workshop format, with small groups consisting of 5-10 participants each. The aim of the workshop was primarily to collect *qualitative feedback* from the prototype users. The workshop invitation was promoted through (1) poster displays and (2) sharing in Messenger app groups. We selected the participants without any limitation, we expected them to come from diverse backgrounds and did not need any experience in road safety before. The core of this prototype embodied “CitizenAI”, engaging people without any experience to use this prototype.

Table 11. Workshop Rundown

Events	Time
<b>1. Introduction and Consent Form Explanation</b>	<b>10 min</b>
<b>2. Warm-Up</b>	
<ul style="list-style-type: none"><li>• How often do you use AI? (How many days/ Week)</li><li>• How do you think AI can contribute to public affairs/civil society? (Advantages/ Concerns)<ul style="list-style-type: none"><li>◦ Leave at least 3 keywords and explain.</li></ul></li><li>• What are your thoughts on road safety/ street design?<ul style="list-style-type: none"><li>◦ Leave at least 3 keywords and explain</li></ul></li><li>• How do you think AI can contribute to road safety?<ul style="list-style-type: none"><li>◦ Leave at least 3 keywords and explain</li></ul></li></ul>	<b>10 min</b>
<b>3. Break</b>	<b>10 min</b>
<b>4. Prototype 1 Testing: Chatbot</b>	
<ul style="list-style-type: none"><li>• Prototype testing (10 min)</li><li>• Each participant provides feedback on the <b>Prototype concept and content</b> (10 min)<ul style="list-style-type: none"><li>◦ Rate (1-10) and Describe</li></ul></li><li>• Provide <b>initial developed Prototype</b> for user interaction (10 min)<ul style="list-style-type: none"><li>◦ Rate and Describe</li></ul></li></ul>	<b>30 min</b>

The workshop is scheduled for 60 minutes and the run-own can be seen in the tale below. The result and suggestions of prototype 1 will be written in the next

section. The study incorporated suggestions from participants to refine the prototype.

## **4.2 Workshop Outcome**

During the workshop, feedback on Prototype 1 (presented solely through a chatbot) was primarily collected from six participants. These participants had diverse educational backgrounds, including transportation planning, aerospace engineering, industrial design, urban planning, architectural design, and architectural engineering. (Table can be found in *Appendix A*)

### *4.2.1 Participants' Transportation Habits*

During the workshop, participants' daily transportation habits, their use of GenAI, and feedback on the testing of Prototype 1 were investigated. All six participants had Chinese-speaking backgrounds. The workshop invited them to subjectively evaluate the road safety environment in their hometowns.

Among the participants:

- One was a private car and scooter driver, who rated the road safety in their hometown at 7 out of 10.
- Two participants were scooter riders, who rated their hometown road safety at 0 and 2.5 out of 10.
- Three participants were public transit users, who rated their hometown road safety between 4 and 6.

Despite the limited sample size, it can be observed that car drivers tend to give higher safety ratings, followed by public transit users, with scooter riders giving the lowest ratings.

### *4.2.2 Use of Gen-AI*

All six participants had experience using large language models or related applications within GenAI (such as ChatGPT, Copilot, and Grammarly). Each participant regularly used large language models, with a weekly usage frequency ranging from 3 to 7 days. This indicates that large language models have gradually become important tools in their daily lives. Therefore, figuring out how to effectively utilize this tool in future urban or road planning is crucial.

#### 4.2.3 The Advantages and Concerns of Gen-AI

During this workshop, the six participants shared their perspectives on the advantages and concerns regarding GenAI based on their personal experiences.

##### A. AI Advantages from Participants

- **Enhanced work efficiency:** Participants consistently agreed that GenAI can accelerate work processes. Whether in writing and reviewing computer code or generating images to support design work, GenAI offers positive assistance.
- **Assistance with language comprehension and expression:** Participants highlighted the positive role large language models (LLMs) play in understanding and expressing language. This is particularly useful for complex official or technical documents, helping the general public comprehend them more effectively.

##### B. AI Concerns and Limitations about from participants

- **The transparency of information is crucial:** Participant 1 expressed concerns about AI being used as a tool for spreading misinformation. This concern is valid, particularly when deliberate manipulation by certain individuals can lead to the dissemination of inaccurate information. This is also why the Prototype in this study pre-constructed a knowledge base for the LLM model. The purpose was to prevent the model from drawing inaccurate content from unmonitored data sources. For instance, in our tests, ChatGPT provided transportation planning suggestions focused on private car usage. However, this approach may not be the most suitable solution for many countries currently facing traffic congestion. Therefore, selecting which research reports to include in the knowledge base is crucial, and users should be informed about these decisions. The accuracy of the content provided by the Prototype is left to the user's judgment, and users can access the original data sources for verification.
- **The knowledge base must be continually updated:** Participant 2 raised an interesting concern about GenAI, suggesting that if people become overly reliant on GenAI without continuing to generate new ideas, the AI may end up simply reusing existing data without contributing new perspectives. This could even lead to the repetition and reinforcement of established ideas. Therefore, when designing the Prototype in the future, it will be important to regularly update it with the latest research insights and data to avoid stagnation and repetitive information.

- Accuracy and Authenticity:** Participants expressed concerns about the accuracy and authenticity of the information provided by GenAI, as well as doubts about the practicality and effectiveness of the proposed solutions. Participants 3 and 4, both with design backgrounds, also use GenAI's image generation capabilities to assist in generating design ideas. However, they noted that widely known image generation models like Midjourney and DALL-E currently seem unable to meet the precision required for architectural environments. This represents a significant limitation for the Prototype, as road design often necessitates adjustments based on the scale of physical spaces. If GenAI cannot accurately render reasonable dimensions, its application in road design remains significantly limited. This issue highlights the continued importance of human expertise in the modern context.

#### 4.2.4 Result of the Workshop and Suggestions for Prototype1

Overall, participants held a generally positive view of Prototype 1. However, the text-based descriptions provided limited appeal to users. After testing, Prototype 1 was only able to generate imprecise and sometimes illogical images. Based on the suggestion of Participant 4, one improvement could involve modifying prompts to include hyperlinks to external websites containing "visual explanations" of key street design terminology. This would help users better understand the specialized terms suggested by the Chatbot, which are based on the knowledge base.

Table 12. Workshop Feedback and Improvement Measures for Prototype2

Participants	Concerns, Suggestions, and Criticisms	Improvement measures
P1, P4, P5, P6	1. Lacks appeal for general users; needs more interactive features to encourage public engagement. 2. Text-only descriptions are insufficient without visual support.	Add visualized "Call to Action" charts to the website to enhance public awareness of road safety issues and provide basic introductory knowledge.
P1	Knowledge Base and Data Transparency	In future prototype development, include a clear list of references and databases used.
P2	Concerns about outdated data lead to answers lacking new insights and the stop of innovation.	Continuously update and maintain the prototype and website based on the latest research.
P3, P4	The spatial scale lacks precision, and it cannot accurately assess surface terrain.	The current large language model applied in this research

<i>Participants</i>	<i>Concerns, Suggestions, and Criticisms</i>	<i>Improvement measures</i>
		(ChatGPT model) is unable to address recommendations for precise spatial dimensions in image generation or to understand surface elevation changes. We will include this in the suggestions for future research.
<i>P3</i>	The prototype's use of large language models feels unnatural for Chinese language users.	Adjust the translation of technical terms and terminology for localization.

### 4.3 Prototype 2

**Prototype 2** is an integrated website developed after the first workshop, based on the feedback from participants (See Appendix Table). This website offers interfaces in three languages: English, Traditional, and Simplified Chinese. There are three main sections on the website:

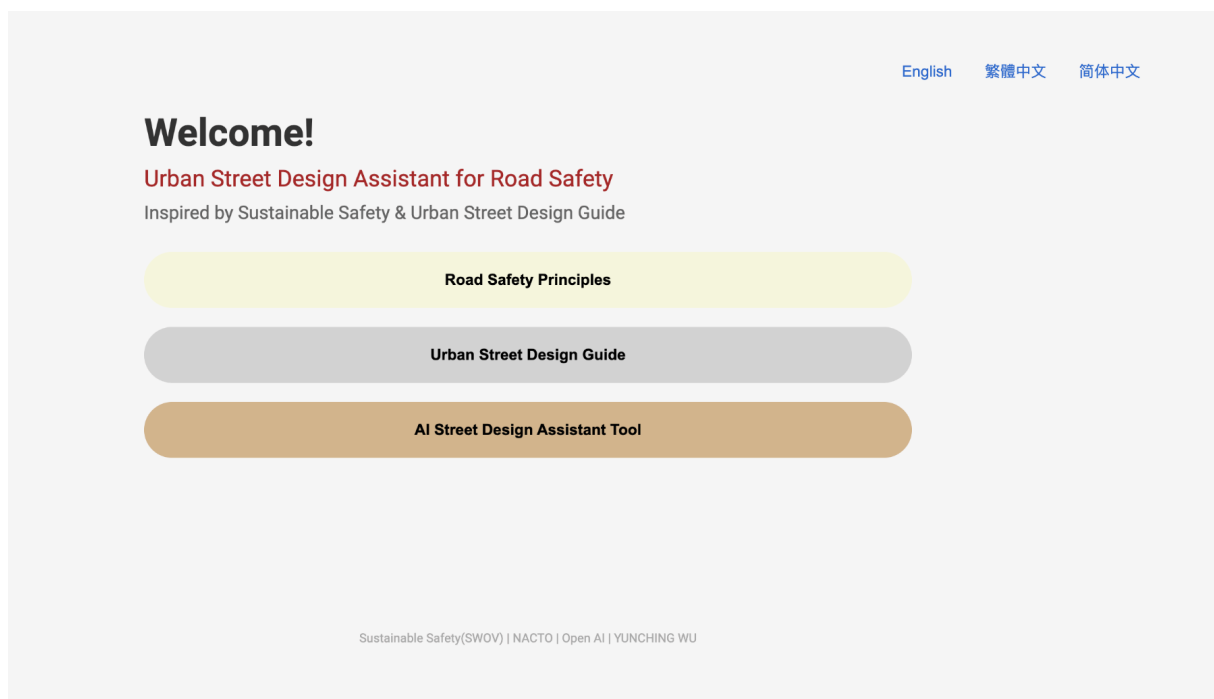


Figure13: Prototype 2 Homepage



1. We present the concept of **Sustainable Safety** and its five key principles through visual representations. This serves as inspiration for the general public, providing material on how to implement road safety concepts.

English | 繁體中文 | 简体中文

## How to establish a safe road system?

*The Sustainable Safety Principles from the Netherlands*

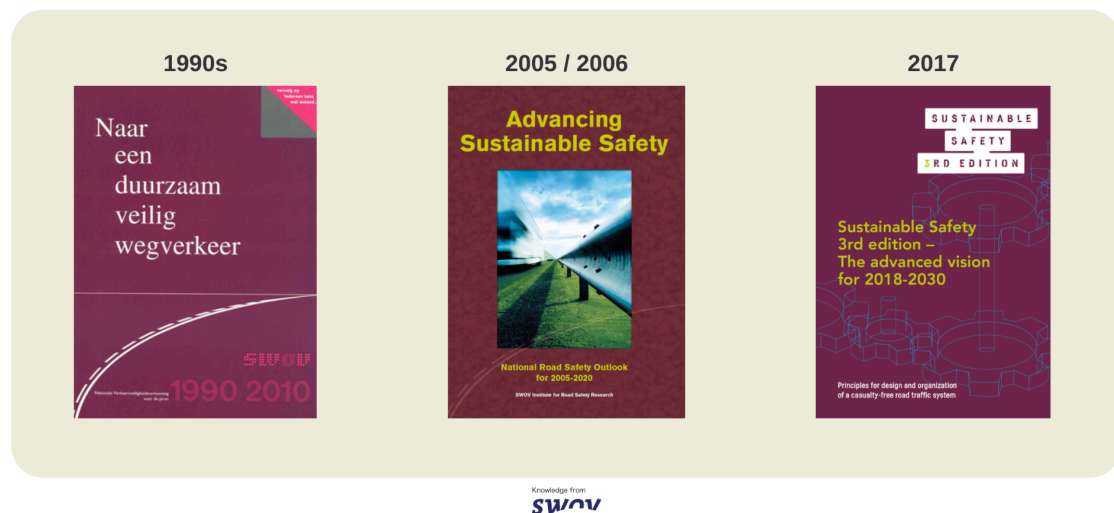


Figure14: Prototype 2 new addition, Sustainable Safety Introduction

2. We have linked the **Urban Street Design Guide** to the website. The strength of this guide lies in its visual representations of various street design types. These design concept images help users better understand how street transformations can be carried out.
3. Lastly, we included the revised version of **Prototype 1 Chatbot** in the final section of the website. This layout aims to provide users with an initial understanding of the content before interacting with the chatbot. This approach is intended to give users a more profound impression of the information provided by the large language model. *(Prompt adaptation in Appendix Table G)*

### 4.4 Questionnaires (1)(2)

The reason for concurrently using questionnaires in this study is to reach users from diverse cultural, upbringing, and living environment backgrounds. The survey will be promoted through (1) poster displays and (2) sharing in Messenger app groups. We aim to collect at least 25 questionnaires and conduct user feedback

surveys for the prototype's first and second versions. The survey was tested to be filled around 30 minutes. Participants must participate in feedback sessions twice. To effectively contact participants, the questionnaire will collect participants' email addresses and names for follow-up. It aims to gather users' suggestions for improvement in each aspect of the prototype. These two questionnaires can be found in the appendix Tables C and D.

#### 4.5 Questionnaires Outcome

The questionnaire collected a total of 25 responses, all completed online. Among them, 22 participants filled out the Chinese version of the questionnaire, while 3 participants completed the English version. The responses cover five important sections of the survey. We also asked users to provide subjective ratings, but qualitative feedback is the main focus of the research.

1. **Background Information:** Including name, contact details, and educational background.
2. **Transportation Habits Survey:** Including frequently used modes of transportation (multiple selections allowed), the weekly frequency of car and motorcycle usage, the frequency of public transportation usage, and subjective ratings of the road environment in their hometown.
3. **GenAI Usage Frequency:** Including weekly usage frequency, commonly used Gen-AI tools, perceived advantages, and concerns about AI.
4. **Prototype1** Chatbot Trial ([IC/SC](#)) Ratings and Feedback.
5. **Prototype2** Website Trial Ratings and Feedback.

##### 4.5.1 Transportation Habits and Road Safety Rating Survey

Although the data from the first three survey sections are not directly related to the improvement of the prototypes, they help us understand the participants' transportation and GenAI usage habits and opinions. Firstly, regarding the background information survey, this study collected completed questionnaires from 25 participants from 8 different academic disciplines, all of whom have a university degree or higher.

In the transportation habits survey, we collected data on participants' weekly mobility usage patterns. The arithmetic mean of the subjective road safety ratings (where 0 represents the least safe and 10 the safest) from 25 respondents was 4.2, with a median score of 4. Upon further analysis, we calculated the average road

safety ratings based on the type of transportation used. The findings revealed that bicycle users gave the highest average rating (4.55), followed by car users (4.2), while scooter users reported the lowest (3.45). In terms of median scores, car users rated safety the highest (5), followed by public transportation and bicycle users (*both at 4*), with scooter users again rating the lowest (3). Overall, the data indicate that participants generally perceive road safety as inadequate. Consistent with the workshop results, car drivers rated road safety slightly higher than other user groups; however, no group had an average rating above 5. This suggests that, at least based on subjective ratings in our limited sample, road safety remains a significant societal concern.

*Table 13. Participants' Education Background and Level*

<b>Educational Background</b>	<b>Count</b>	<b>Educational Level</b>	<b>Count</b>
<i>Spatial design and planning</i>	7	<i>Bachelor Degree</i>	8
<i>Psychology</i>	5		
<i>Marketing and Public Relations</i>	3		
<i>Engineering</i>	3		
<i>Public Health and Medical Management</i>	2	<i>Master Degree</i>	16
<i>Language</i>	2		
<i>Environmental science</i>	1		
<i>Law</i>	1	<i>PhD</i>	1
<i>Industrial Design</i>	1		

#### 4.5.2 GenAI Usage Evaluation

In the evaluation of GenAI usage, we investigated the weekly frequency of GenAI tool usage among participants, as well as the specific GenAI tools they commonly used. Among the 25 respondents, the average weekly usage frequency was 3.2 days, with a median of 3 days. A breakdown of tools showed that 21 participants used ChatGPT, 3 used image generation models, 2 used Copilot, 1 used the music production model Suno, and 1 used the spatial design model 5D Planner. 4 participants did not use any GenAI tools. Although AI tools have rapidly gained adoption in participants' lives over the past few years, their usage seems to be limited to specific applications (such as large language models), and not all participants rely on AI in their daily lives.

Additionally, our survey included an open-ended section asking participants about the advantages and concerns regarding GenAI. After organizing and categorizing the responses, we identified five key reasons participants cited for both the benefits and concerns of AI tools. Most participants recognized the speed at which AI processes data and its efficiency in assisting with tasks. However, there were significant concerns about accuracy, and many expressed apprehension about AI's potential to reduce critical thinking and creativity among humans.

*Table 14. Participants' Feedback about AI's Positive Impact and Concerns*

<b>Advantages</b>	<b>Counts</b>	<b>Concerns</b>	<b>Counts</b>
Efficiency and Speed	19	Accuracy	8
Language Assistance	2	Repetitiveness	1
Data Collection and Processing	4	Data privacy concern	4
Usability	2	Reduction of human critical thinking, judgment, and creativity	5
Creativity	2	Overlooking details and Data biases	4

#### *4.5.3 Prototype 2 Chatbot User Testing Sample*

We used a questionnaire to have users interact with the chatbot we developed based on the ChatGPT-4o model. They were asked to provide the questions they posed and the responses they received (including both the chatbot and street view functionalities). This study randomly selected two cases for analysis (for more details, see Appendix Table E, F) to assess the usability and response validity of the AI Prototype. Respondents were asked to first test the chat functionality and then the street view, and we observed the AI assistant's responses as follows:

##### *A. Chatbot (Appendix Table E)*

Q1. What are the "design elements" of a street?

Q2: How to design safe roads to reduce traffic accidents?

Q3: What literature does this chatbot's knowledge base include?

Q4: According to Sustainable Safety, what are the principles of road design?

Overall, the chatbot's responses are mostly based on the knowledge base. We found that the biggest difference with Prototype 1 is that we effectively incorporated citation links to references through the web links provided in the prompts. These links help address the inaccuracies in ChatGPT when creating concept maps and street design diagrams. We believe this functionality not only assists users in understanding the AI tools they are using but also ensures that users can visit these professional research institutions' websites themselves to gain more road safety knowledge.

#### B. Streetview (*Appendix Table F*)

We asked participants to upload street design adjustments they were interested in, and the responses are shown in Appendix Table F. We found that, so far, ChatGPT does have the preliminary ability to recognize objects in street views. It can initially combine object recognition functions and integrate information with our knowledge base to provide suggestions. The responses for cases No. 3, 5, 6, and 7 were quite well, with feasible and specific operational suggestions based on image recognition.

However, in cases like No. 1, the road is a well-designed Dutch street featuring a tram track, a single-car lane, separate bicycle lanes, and sidewalks. Although its judgment on 'Dedicated Crossings' was correct, some of the suggestions seemed redundant. This prototype seems to perform better in diagnosing suboptimal-designed roads than well-designed ones.

#### 4.5.4 Summary of the Feedback

1. **Motivation for Civic Engagement:** Based on feedback from our limited workshops and surveys, we found that while citizens generally had a negative perception of road safety, some participants indicated that the prototype (Prototype 1) did not significantly inspire them. For example, many participants still viewed road safety as the responsibility of policymakers and experts, rather than a concern for citizens. As a result, in the development of Prototypes 2 and 3, we manually added more interactive visual interfaces to encourage citizen engagement and prompt a stronger "Call to Action."
2. **Limitations in Specificity and Local Context:** Participants also highlighted limitations in the AI's responses to images they uploaded, which reflected various terrain, infrastructure, and road conditions. The AI often overlooked the unique characteristics of certain areas, such as road conditions, urban

environments, and social habits. Therefore, there remains a need to develop more context-sensitive AI tools that account for different environmental conditions.

#### 4.5.5 Prototype 1 and 2 Trial Rate

In the questionnaire, we asked participants to test two functions of Prototype1: the general chat function and the map upload function, which allows Prototype to identify the location. According to the survey results, the overall user experience of Prototype 1 received an average rating of 7.2 and a median score of 7. For the street view recognition function, the average rating was 7.32, with a median of 8. While these results indicate a satisfactory level of performance, they also suggest potential areas for further improvement.

In the questionnaire results, the overall score for Prototype 2 improved from 7.12 to 7.72, with the median score rising from 7 to 8. However, there remains substantial open-ended feedback that offers valuable insights for potential enhancements to [Prototype 3](#).

Table 15. The Trial Rate of Prototypes 1 and 2

	Average Rate	Median Rate
Prototype1 - AI Chatbot	7.12	7
Prototype2 - Integrated Website	7.72	8

## 5. Results

### 5.1 The End Product: [Prototype 3](#)

Based on user feedback from the workshops and questionnaires, we have redesigned the content and structure of the website. First, we added sections for **"Problem Statement"** and **"Call to Action"** on the homepage. In addition to visualizing the 2023 global road safety data report from the World Health Organization (WHO), we will also include examples of successful urban street transformations, such as those in Delft, Netherlands, and Bogotá, Colombia, to motivate the general public to take action and embrace change. Only after that will users be able to access the chatbot to gain knowledge and practical concepts related to road safety and street design.

Moreover, in the section explaining road safety theory, we expanded the content beyond the original five principles of Sustainable Safety to include new concepts such as the *Swiss Cheese Model*, *Workload*, and *Self-Explaining Roads*. These additions provide users with a more comprehensive understanding of the road safety environment, driver responsibilities, and the cognitive limitations of drivers. For a more detailed overview of the updates, please refer to the table below.

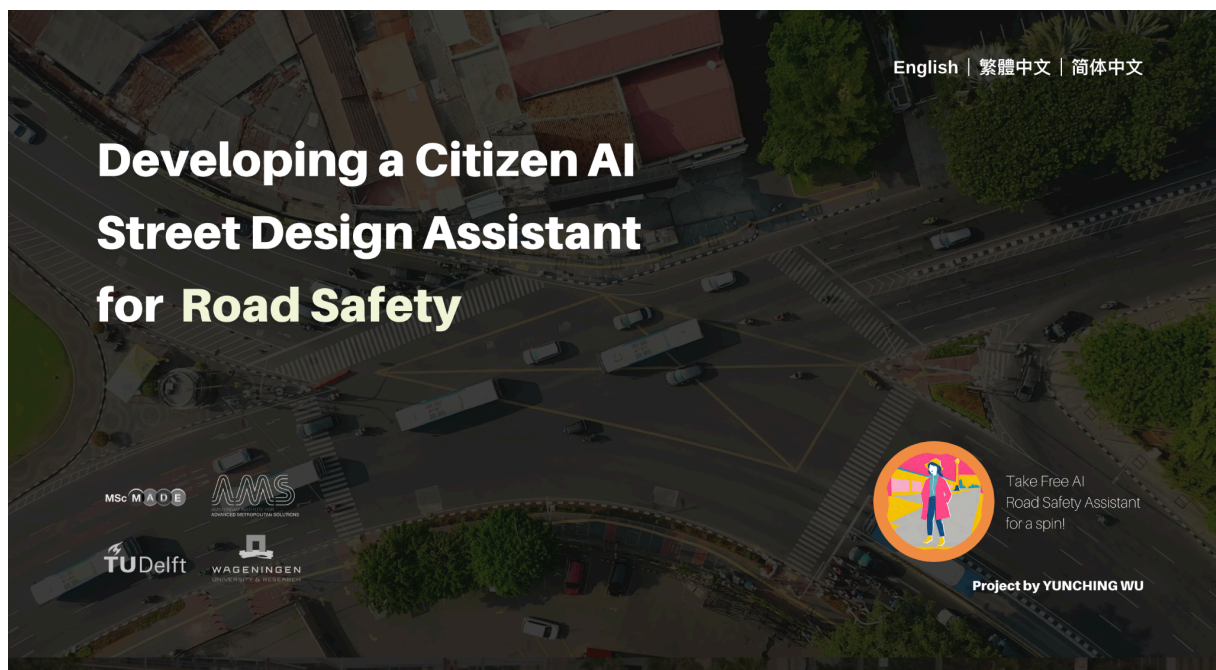


Figure15: Prototype 3 Homepage

Table 16. Prototype 3 Website Structure and Content

## Improving the Integrated Website Interface

- **Website Content Structure (Homepage)**

1. **Problem Statement** (New Addition):

- A. **Data Visualization Dashboard:** the world road fatalities data

- B. **Key Messages** (Based on Global Status Report on road safety 2023, World Health Organization):

- a. 1.19 million road traffic deaths in 2021, a rate of 15 deaths per 100 thousand population.
- b. Two- and three-wheeler riders (30%), four-wheeler riders (25%), and Pedestrians account for 21% of fatalities.
- c. 92% of deaths occur in low- and middle-income countries.

2. **Call to Action** (New Addition):

- Case Studies of Road Safety Transformation**

- a. The Netherlands' Journey of Change
- b. The Bogotá's Experience of Change

3. **Visualizing Road Safety Theories**

- A. Sustainable Safety Principles
- B. New Addition: The Swiss Cheese Model
- C. New Addition: Concept of Workload (Matthews et al., 2019; Theeuwes et al., 2012)
- D. New Addition: Concept of Self-explained Road

- **Enhancing User Interactivity**

- A. Links to existing road safety and urban street design research institutions and organizations:

- a. WHO
- b. SWOV
- c. NACTO
- d. World Resources Institute
- e. ITDP

4. **AI Page** (New Addition): A guide to using AI tools responsibly and fairly.

## Improve the Chatbot Prompt

1. **Accessibility of Knowledge Base:** Include source URLs to databases, allowing users to become familiar with existing road safety research institutions as a channel for accessing more information.

2. **Increase web page integration:** While using the Chatbot, users can receive links to different sections of the prototype webpage.



## 5.2 Applying Citizen-AI by the ARIE model

This study utilized the refined model we developed to conduct enhancement tests on Prototype 3.

First, in terms of actions that should be **avoided (A)**, our prototype has so far successfully prevented the generation of harmful or inappropriate content and has not been misused for fraudulent purposes. This outcome is due to the configuration of a controlled knowledge base and strict response limitations. Additionally, the ChatGPT platform has built-in safeguards that further mitigate these risks.

Second, regarding behaviors that should be **reduced (R)**—specifically Over-reliance and the Digital AI Divide—we developed an educational website to outline AI's limitations and best practices. This user-friendly platform helps citizens better understand road safety issues and promotes AI literacy, thereby addressing the digital divide. However, one challenge that remains is the occasional provision of vague suggestions by the AI, despite being anchored in our database. This reflects a current technical limitation that requires further research to refine the AI's effectiveness in road safety applications.

Third, in the category of actions to **insist (I)**, our prototype prioritizes human welfare by employing targeted prompt techniques and carefully curated knowledge bases. It effectively provides users with reliable citations and reference links. Nevertheless, privacy concerns persist due to the inherent constraints of OpenAI's data policies, which limit our ability to fully ensure user data confidentiality.

Finally, in the **Encourage (E)** category, we prioritize civil engagement over mere AI utilization by implementing the three-step approach to Citizen 3E participation. This approach empowers citizens with a greater level of influence (participation ladder) in the AI era. However, the study faces limitations in addressing governance issues comprehensively. Our current strategy includes open participation through workshops and questionnaires during the development process.

Table 17. The ARIE self-examination table

Action	AI using behaviors: Concerns and Challenges (including but not limited to)	Check
<b>Avoid</b>	1. Harmful and inappropriate content	Y
	2. AI-Misuse	Y
<b>Reduce</b>	1. Bias <sup>2</sup>	Y
	2. Over-reliance	Y
	3. Digital and AI Divide	Y
	4. Hallucination (or “making things up”, the misleading or confused information)	Δ
<b>Insist</b>	1. Empathy and human needs (Human well-being)	Y
	2. Privacy and security <sup>3</sup>	Δ
	3. Authenticity	Y
	4. Copyright	Y
<b>Encourage</b>	1. The Citizen-AI 3E Steps Practice	Y
	2. Ethics and Human well-being oriented	Y
	3. Responsible Design and Human-AI Interaction	Y
	4. Training Data Quality	Y
	5. Prompt engineering	Y
	6. Transparency and explainability	Y
	7. Governance, and independent oversight	Δ
	8. AI literacy and intelligence augmentation	Y

Source: Inspired by Fui-Hoon Nah, Ozlem Ozmen Garibay et al. (2023), developed by this research

<sup>2</sup> Bias or imperfection method. This study retains space for continuous innovation with some existing methods that we consider operationally sound (such as the 'Sustainable Safety' approach to road safety). Therefore, we will provide it as a textual content in the database, but we do not consider this approach to be entirely beyond challenge.

<sup>3</sup> ChatGPT's privacy policy claims (Open AI, 2024), they may collect and store conversation data from user interactions to improve service quality but does not actively collect personally identifiable information. All data undergoes de-identification to prevent unauthorized access and use.

## 6. Discussion

### 6.1 Research Findings

Reflecting on the challenges described in the introduction, we aim to explore how to better apply AI in citizen engagement with road safety issues through the development of a prototype. The main research question of this thesis is:

***"How can we develop an AI-driven tool using generative AI to assist citizens in redesigning urban streets for improved safety?"***

This study addresses the research question by utilizing the Prototyping Methodology and the Human-Centered AI (HCAI) concept to develop a web-based prototype and an AI-powered assistant using ChatGPT-4o as the platform. The platform provides users with an accessible generative AI chatbot assistant designed primarily for general citizens. To refine the prototype, feedback was collected from random citizens through one workshop and two rounds of questionnaires, serving as an initial test of the concept: AI and humans collaborating to usher in a new era of Jeffersonian scenario and an engaged civil society.

Reflecting on the research questions outlined in Chapter 1 (Section 1.2), we present the following review and discussion:

#### 6.1.1 Society Aspect

Q1. What proven road safety implementation methods/guidelines worldwide can inspire countries and communities in need and offer them possible paths forward? How can AI be utilized more effectively to strengthen civil society on road safety challenges?

1. In the literature review section, we examined the Netherlands' "Advancing Sustainable Safety" and the North American NACTO organization's "*Urban Street Design Guide*," both of which are considered valuable references for road safety design guidelines. These guides are not only grounded in solid scientific research but also based on experiential knowledge. They feature clear classifications of principles and visual designs that simplify complex road safety systems, making them accessible to the general public. This makes them valuable resources for policy communication and advocacy. These manuals undoubtedly enhance public understanding of road safety issues. However, in response to the emergence of new transportation technologies (such as shared mobility, e-bikes, and autonomous vehicles) and the new challenges these pose to traffic safety, ongoing research,

innovation, and practical application are essential to achieving even safer road environments.

2. Second, our Prototype AI Chatbot and the educational web content use these two manuals as their knowledge base, allowing citizens to engage in dialogue and receive immediate, fast, and language-barrier-free responses. By continuously refining the prompt method, we ensure that users receive more comprehensible answers (see Appendix Table G)

Q2. What existing literature on AI's societal impact can guide us in designing applications that promote social welfare while avoiding a Pandora scenario of potential misuse? What areas for enhancement exist in current AI using guidelines for citizen participation, and what strategies can we use to fill these gaps?

1. In addition to conducting citizen engagement, we used the ARIE model to design and adjust our prototype web content and AI Chatbot prompts, making them more aligned with HCAI principles. This study integrates the existing HCAI model with concepts from the citizen participation ladder theory, particularly by including general citizens into the HCAI framework, which we have named the Citizen AI model. In the AI era, the ladder of civic participation requires the continuous cycle of the 3E steps—*Education, Empowerment, and Engagement*—to power up citizens to gradually make better use of AI tools.
2. Secondly, building on the existing HCAI model, we further developed the *ARIE evaluation model*, providing developers with a self-assessment checklist when creating related tools. The ARIE model is grounded in current literature and addresses various aspects of concerns, challenges, and the potential AI can bring to civil society.

#### 6.1.2 Technical Aspect

Q1: *How can this AI prototype be made user-friendly and accessible for citizens, allowing them to address street design issues effectively?*

1. **The Importance of Visualization:** Large language models excel in language processing, code assisting, and logical reasoning. They can handle vast amounts of complex data. However, making machines truly understand the meaning of images or human feelings can be challenging. In contrast, for humans, sensory perception, emotions, and visual engagement are critical elements of participation. There is potential for developing AI-powered tools that generate more meaningful visualizations in the future. Due to time

constraints, this study enhanced visual explanations of charts manually, with partial AI assistance.

2. **Interactive Features and AI Chatbot Prompt Design:** Increasing interactive interfaces that allow citizens to continuously engage with AI is crucial. Prolonged interaction provides more opportunities for citizens to grasp the core concepts of our knowledge base documents. Later, chatbot commands can be carefully designed with appropriate prompts to help users receive relevant information tailored to specific societal issues.
3. **Multilingual Support:** The advanced language capabilities of large language models can help rapidly narrow the knowledge transfer gap between international contexts.
4. **Integration of Citizen Feedback:** Through workshops and surveys, developers can identify areas where our prototype fails to meet user expectations, such as the accuracy of spatial dimensions, and make targeted improvements in subsequent versions. From our research experience, continuous user feedback is key to refining the prototype, and further enhancing engagement is a valuable strategy.

*Q2: What are the current possibilities and limitations of commonly used AI applications (such as generative AI, and ChatGPT-4) in promoting safer street designs?*

1. **Lack of Precision in Spatial Dimensions:** During the development of our prototype, we found that the current AI applications in street design for safety still need to be improved. While the basic AI model we employed could generate responses based on provided data and even create conceptual images, it is currently unable to produce precise, usable visuals required by road engineers. This poses significant challenges for effective policy communication. In the future, integrating technologies such as Computer Vision and training AI models on large datasets worldwide could yield more tailored tools suited to specific countries or regions. This could reduce the workload of professionals and foster broader civic discussions.
5. **Formulated Responses and Avoid Misinformation Balance:** User feedback revealed that, despite prompt adjustments, many found the AI chatbot's responses overly formulated. At the same time, users emphasized the importance of information accuracy. Striking the right balance between accuracy and creativity is a critical consideration for future AI tool development.

6. **The Indispensability of Experts:** While AI can quickly respond and synthesize information from provided data, in its current form, the basic AI model we used can only reply based on existing research. The knowledge systems in road safety and the innovative concepts in urban planning still require the insights and creativity of experts. However, AI can serve as a supportive tool, assisting with data collection and organization, and helping researchers make progress in areas where they may have less familiarity or expertise.

## 6.2 Research Limitation

### 6.2.1 Time and Programming Skills Constraints

The research period for this study was from March to September 2024. In the early stages, most of the time was devoted to identifying the problem statement, reviewing relevant literature, and building a foundational understanding of road safety. Prototype development started in June and continued through September. While the researchers had basic programming skills, they lacked experience in web and software development. Consequently, the prototype was created using entry-level platforms such as OpenAI, Streamlit, Heroku, and Canva, which limited the complexity of the developed models. Moreover, the researcher was not fully equipped with the latest advancements in AI technology. Instead, the emphasis was on how these technologies could be applied to enhance public participation in civic affairs, with the broader goal of improving societal welfare.

### 6.2.2 Workshop and the Questionnaire Limitations

1. **Educational Background:** We discovered that all the participants in our study had at least a bachelor's degree. This group was generally more familiar with AI tools and frequently used them, making them well-acquainted with both the potential benefits and drawbacks of AI. However, most were not experts in road safety, aligning them with the target audience of this study—civilians with varying levels of knowledge on the topic.
2. **Time and Sample Size:** The development of the prototype took two months, and it was available for testing online for less than two months. Due to the relatively large number of questions in the survey, we received only 25 completed questionnaires and had six participants in the workshop, resulting in a small sample size. Nevertheless, valuable feedback was obtained.
3. **Language and Cultural Limitations:** Most participants came from Chinese-speaking backgrounds, and the survey questions were primarily

designed based on the participants' subjective experiences in their hometowns.

## **7. Conclusion**

### **7.1 Achievements**

#### *7.1.1 Introducing the concept of the ARIE model, and the steps of civic participation in the AI era: Education, Empowerment, and Engagement.*

The final prototype is based on our ARIE model and the Citizen 3E steps—Education, Empowerment, and Engagement—to equip citizens with road safety knowledge, AI literacy, and skills to address challenges in their living environments.

#### *7.1.2 A Citizen-AI Educational Website*

This thesis primarily contributes by proposing an innovative framework for applying AI in road design. In terms of practical outcomes, the study developed an educational website aimed at enhancing public awareness of road safety and urban street design practices. Utilizing the free and user-friendly ChatGPT-4o model, the platform allows users to quickly obtain road improvement suggestions based on a more accurate knowledge foundation through a checklist format. Despite limitations in time and programming expertise, the final result of the study, following the development of three prototypes, is a website that integrates human-created visual infographics and a chatbot powered by a generative AI model.

#### *7.1.3 Opportunities and Future of Large Language Models*

During the development process, we observed the potential of applying the ChatGPT model to public affairs.

1. Its strengths lie in its speed, ability to break language barriers, and provision of a user-friendly interface.
2. By inputting prompts, we can quickly adjust and control the accuracy of responses.
3. In this study, the author—an urban planner with no programming or web development experience—was able to learn how to build a basic web application and create infographics with the help of generative AI. In the future, AI could become a powerful tool for citizens to express their concerns on important issues.

Additionally, we noted that many participants in the study raised concerns about AI applications. This suggests that society when facing the arrival of new technologies and information, particularly in terms of misinformation and privacy protection, has developed a certain level of critical thinking and awareness.

## **7.2 Introduction and Clarification of Road Safety Concepts**

### *7.2.1 Introducing the Sustainable Safety Concept to the Chinese-Speaking World*

The *Sustainable Safety* method originated in the Netherlands and is a road system improvement strategy that has been verified and implemented over many years. It is grounded in long-term research to achieve road safety in complex and diverse traffic systems. Similar to the Vision Zero concept, Sustainable Safety is based on a more robust research foundation and has a proven track record of success, making it a particularly valuable methodology to promote. Unfortunately, despite its success, this valuable traffic planning principle and research outcome has received limited attention in the Chinese-speaking world over the years. The development of this prototype offers an opportunity to introduce this methodology, which could significantly contribute to road safety advocacy and transformation in the Chinese-speaking and broader Asian regions.

### *7.2.2 Bridging the Gap Between Urban Design and Road Safety*

This thesis, starting from the Introduction chapter, highlights the close relationship and paradigm shifts in post-war urban and transportation planning. In the Literature Review chapter, we compared the Sustainable Safety (a road safety manual) and the Urban Street Design Guide (an urban design manual). The former focuses on road safety principles, while the latter provides urban design guidelines. We found no inherent contradictions between the two; the primary difference lies in the approach to road design based on different speed ranges. Sustainable Safety addresses the design of roads for mid-to-high-speed areas, considering the safety of various road users, and applies beyond urban environments. Meanwhile, the Urban Street Design Guide focuses on improving streets in densely populated areas, offering visual guidance. Despite these differences, both contribute to improving road safety.

## **7.3 Future Development Expectations and Conclusion**

This GenAI prototype or website, while not without its imperfections, represents a noteworthy innovation in the integration of road safety and GenAI. We anticipate the development of more GenAI applications that serve civil society in the



future while addressing its inherent limitations and maximizing its potential for enhancing civic engagement.

The process of developing this prototype has reaffirmed the indispensable role of human expertise, which remains difficult for AI to fully replicate in the domain of road safety. In matters of public policy, professionals and citizens continue to exercise significant influence in making value-based decisions. Looking ahead, it is imperative to foster human innovation and research, ensure rigorous data accuracy through repeated validations, and address concerns related to data privacy.

In the foreseeable future, we aspire for GenAI technology to be more effectively deployed in the service of public participation, enabling both professionals and citizens to access more timely, precise, and accurate tools for road safety design, ultimately contributing to the realization of our vision for CitizenAI.

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## **9. Appendix**

### **Ethics Statement**

I would like to acknowledge the assistance of ChatGPT, a language model developed by OpenAI, in improving the spelling and grammar of this manuscript. The author reviewed and verified all content to ensure its accuracy and originality.

In addition, ChatGPT was utilized by the author as a co-creator to build sample online applications, helping to explore how AI can assist citizens with no prior development experience by providing technical support through a Gen-AI system.

**Table A: Workshop Survey outcome**

	<b>Participant 1</b>	<b>Participant 2</b>	<b>Participant 3</b>	<b>Participant 4</b>	<b>Participant 5</b>	<b>Participant 6</b>
Background	Transportation Planning	Aerospace Engineering	Industrial Design	Architecture Design	Urban Planning	Architecture Engineering
Transportation habits	Scooter user	Car driver, scooter user	Scooter user	Public transit user	Public transit user	Public transit user
Road safety conditions in your hometown? (low-high/ 1-10)	0	7	2.5	6	4	5
Frequency of using Gen-AI (days/ week)	6	7	3	5	5	4
Which Gen-AI one do they use?	ChatGPT	ChatGPT	Copilot, Chat GPT, and Dall-e	Mid-journey, Dall-e, and ChatGPT	ChatGPT	ChatGPT
Advantage	Promote general information and explore the personal horizon	Speed up work progress	Help citizens to understand policy or regulation more easily.	Get responses rapidly and help with the initial creation	Get response rapidly	Assistant to express thoughts more clearly
Disadvantage	Mis-information	Possibility of stopping new inventions and input	Data security, the real usability of AI suggestion	Data security, the real usability of AI suggestion	Accuracy and authenticity	Accuracy and authenticity

	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Participant 6
How they use AI	Writing improvement and Coding assistance	Writing improvement and Coding assistance	Writing improvement and Design Idea Inspiration	Writing improvement and Design Idea Inspiration	Writing, understanding concepts, chat	Get inspired
Concept	7	10	7	8	8	8
Content	5	5	8	6	6	7
Usability	9	9	6	7	8	7
Future Extension	9	7	6.5	7	6	8
Main Opinion	1. Good idea but will normal people want to use it? 2. The outcome is too general 3. If there are some interactive programs or functions, it will be more inspiring.	1. Not appealing to random people. 2. Future extensions can be used in satellite navigation and driver assistance systems.	1. Random people need help understanding Prototype 1.	AI seems to not recognize 'spatial depth'. That's an issue for spatial study which requires the correct dimension.	The Prototype did not consider terrain.	1. Not appealing to random people. 2. Do not feel this prototype is relevant to daily life. 3. Need to know who this prototype is designed for?



**Table B: Prototype 2 Questionnaire Feedback**

Category	Feedback	Improvement measures for Prototype 3
User Experience and Interaction Design Improvement	<p>Suggestions for Improving User Interaction:</p> <ol style="list-style-type: none"> <li>1. <b>Enhance Visualization Tools:</b> Strengthen the use of visual aids.</li> <li>2. <b>Target Group Identification:</b> Clearly define the target audience and their specific needs.</li> <li>3. <b>Increase Interactivity and Engagement:</b> Use gamification to raise awareness of road safety.</li> <li>4. <b>Practical Case Studies:</b> Provide concrete examples of city design to help users understand the design solutions.</li> <li>5. <b>Market Differentiation:</b> Differentiate from existing AI tools (like ChatGPT) by offering more customized and targeted features.</li> </ol>	<p>User Interaction Improvement Measures:</p> <ol style="list-style-type: none"> <li>1. <b>Enhanced Visualization:</b> Incorporate more visual elements to improve the user experience and make concepts clearer.</li> <li>2. <b>Target Audience:</b> The prototype is designed for the general public, aiming to simplify complex and technical road safety research into accessible, easy-to-understand content. After acquiring basic knowledge, users can leverage an AI chatbot for personalized street improvement suggestions and road safety strategies.</li> <li>3. <b>Boosting Engagement:</b> Plan to convert the Urban Street Design Guide into a card-based system, allowing users to easily compare current street conditions and generate ideas for improvements.</li> <li>4. <b>Showcasing Real-World Examples:</b> Feature successful city street design case studies in the homepage's "Call to Action" section to provide concrete examples that users can learn from.</li> <li>5. <b>Differentiation from ChatGPT:</b> Due to current development time and technical limitations, further efforts to distinguish this tool from ChatGPT will be made in future versions.</li> </ol>

Category	Feedback	Improvement measures for Prototype 3
	<p>Interface Suggestions:</p> <ol style="list-style-type: none"> <li>1. <b>Mobile Device Application:</b> Ensure usability on mobile devices for increased convenience.</li> <li>2. <b>Language and Unit Conversion:</b> Add support for Traditional Chinese and metric unit conversions.</li> </ol>	<p>Interface Suggestions:</p> <ol style="list-style-type: none"> <li>1. <b>Mobile Compatibility:</b> Enhance the website's responsiveness and display for mobile devices to ensure smooth navigation and user experience.</li> <li>2. <b>Language and Unit Conversion:</b> Since the Urban Street Design Guide typically uses US customary measurements, the Chinese interface should automatically convert them to metric units for user convenience.</li> </ol>
Future Development Suggestion	<ol style="list-style-type: none"> <li>1. <b>Precise Image Generation:</b> Investigating the feasibility of more accurate image generation is worth exploring.</li> <li>2. <b>Image Generation and Visualization:</b> The AI should be able to generate or suggest improvement plans based on user-provided street views, offering more intuitive road planning references.</li> <li>3. <b>Integration with Navigation Systems:</b> The tool could be integrated with navigation systems to provide early warnings about potential road hazards for drivers.</li> <li>4. <b>Automated Analysis and Alerts:</b> Automatically identify high-accident areas, combining real-time data analysis to provide warnings and alerts.</li> <li>5. <b>Road Safety Promotion:</b> Raise public awareness of traffic safety and encourage public participation in road safety improvements.</li> </ol> <p>Due to development time and technical limitations, further differentiation from ChatGPT will be reserved for future development.</p>	

**Table C: Prototype 1 Questionnaire**

<b>Questionnaire 1</b>
<i>What is your level of education?</i>
<i>Educational Background (e.g. Engineering, Science, Social Science, Art, etc.)</i>
<i>What is your most frequently used mode of transportation? (You may select multiple options)</i>
<i>How often do you usually drive/ ride a car/motorcycle/scooter? (days/week)</i>
<i>How often do you usually use public transportation? (e.g., trains, buses, public bicycles, shared mobilityetc.) (days/week)</i>
<i>How do you evaluate road safety in your hometown?</i>
<i>How often do you use generative AI tools each week? (e.g., ChatGPT, Midjourney, Dall-E, Copilot)</i>
<i>Which generative AI tools do you use most often? (e.g., ChatGPT, Midjourney, Dall-E, Copilot, large language models, image generation models, or write "none" if you don't use any)</i>
<i>How do you typically utilize generative AI tools? (E.g. Getting inspiration. Write "none" if you don't use any.)</i>
<i>What are the benefits of generative AI tools, in your opinion? (use keywords)</i>
<i>What concerns do you have regarding generative AI tools? (use keywords)</i>
<i>Please rate your overall experience using this chatbot. (Prototype1)</i>
<i>Could you share the questions you inquired about?</i>
<i>If possible, provide the chatbot's replies. (Just copy and paste the text, no need for formatting)</i>
<i>Share the street view photo you asked about.</i>
<i>If possible, please provide the response the chatbot gave you. (Just copy and paste the text, no need for formatting)</i>
<i>Rate your experience with the Prototype1 street view recognition feature.</i>
<i>Please provide your subjective feedback on Prototype 1. (You can write a brief statement or provide 3 keywords)</i>

**Table D: Prototype 2 Questionnaire**

<b>Questionnaire 2</b>
<i>How to you rate the Prototype 2 performance?</i>
<i>Do you agree that after adding images and explanations on the webpage, Prototype 2 has a better understanding of the importance and principles of traffic safety/road design?</i>
<i>Could you provide a rating for the concept of this prototype?</i>
<i>If possible, please share your suggestions for improving the concept of this prototype.</i>
<i>Please rate the content of this prototype (whether the responses from the chatbot are meaningful to you).</i>
<i>If possible, please share what content you think could be added.</i>
<i>Please rate the usability of this prototype.</i>
<i>If possible, please share which part you think could be improved.</i>
<i>Please rate the future scalability of this prototype.</i>
<i>Could you give recommendations for expanding the functionality?</i>
<i>Your feedback will serve as a reference for improving this prototype. Would you be willing to receive a link to the project results via email in the future?</i>
<i>Please leave any comments and suggestions for this project.</i>

**Table E: Prototype chatbot testing (part)**

Users' Questions	Response from Prototype 2								
<p>Q1: What are the "design elements" of a street?</p>	<p>Here are the key design elements of a street according to the NACTO Urban Street Design Guide:</p> <p><b>Design Element Description:</b></p> <ol style="list-style-type: none"> <li>1. Lane Width: Defines the width of travel lanes to balance traffic flow and safety.</li> <li>2. Sidewalks: Essential for pedestrian movement, including zones for different uses such as walking and street furniture.</li> <li>3. Curb Extensions: Extend the sidewalk into the parking lane to improve pedestrian visibility and reduce crossing distances.</li> <li>4. Bus Bulbs: Extensions of the sidewalk at bus stops to provide additional space for waiting passengers.</li> <li>5. Vertical Speed Control: Includes speed humps, speed tables, and speed cushions to reduce vehicle speeds.</li> <li>6. Transit Streets: Dedicated lanes and priority measures for buses and other transit vehicles.</li> <li>7. Stormwater Management: Uses bioswales, flow-through planters, and pervious pavements to manage stormwater and reduce runoff.</li> </ol> <p>Each of these elements contributes to the overall functionality, safety, and aesthetic of urban streets, ensuring they meet the diverse needs of all users.</p> <p>For more detailed information, please refer to the Street Design Elements section in the NACTO Urban Street Design Guide.</p>								
<p>Q2: How to design safe roads to reduce traffic accidents?</p>	<p>To design safe roads that reduce traffic accidents, it's essential to focus on strategies that manage vehicle speeds, enhance visibility, and protect vulnerable road users like pedestrians and cyclists.</p> <p>Here's a checklist with key road safety design elements:</p> <table data-bbox="392 1581 1386 2020"> <thead> <tr> <th data-bbox="400 1592 619 1682">Design Strategy</th><th data-bbox="624 1592 1378 1682">Description</th></tr> </thead> <tbody> <tr> <td data-bbox="400 1688 619 1778"><b>Speed Management</b></td><td data-bbox="624 1688 1378 1778">Implement speed humps, raised intersections, and curb extensions to slow down vehicles.</td></tr> <tr> <td data-bbox="400 1785 619 1919"><b>Complete Streets Design</b></td><td data-bbox="624 1785 1378 1919">Design streets to be accessible and safe for all users, including pedestrians, cyclists, transit riders, and motorists.</td></tr> <tr> <td data-bbox="400 1926 619 2016"><b>Protected Bike Lanes</b></td><td data-bbox="624 1926 1378 2016">Use physical barriers or buffers to separate bike lanes from vehicle traffic.</td></tr> </tbody> </table>	Design Strategy	Description	<b>Speed Management</b>	Implement speed humps, raised intersections, and curb extensions to slow down vehicles.	<b>Complete Streets Design</b>	Design streets to be accessible and safe for all users, including pedestrians, cyclists, transit riders, and motorists.	<b>Protected Bike Lanes</b>	Use physical barriers or buffers to separate bike lanes from vehicle traffic.
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<b>Protected Bike Lanes</b>	Use physical barriers or buffers to separate bike lanes from vehicle traffic.								


Users' Questions	Response from Prototype 2
	<p><b>Safe Pedestrian Crossings</b>      Install well-marked crosswalks, pedestrian signals, and refuge islands, especially at busy intersections.</p> <p><b>Narrow Travel Lanes</b>      Use narrower lanes (10-11 feet/3-3.3 meters) to reduce speeds and allocate space for bike lanes or wider sidewalks.</p> <p><b>High-Visibility Signage</b>      Install clear, reflective signs and road markings to guide drivers and warn of pedestrian and cyclist presence.</p> <p><b>Improved Lighting</b>      Enhance street and intersection lighting to improve visibility at night, particularly at crosswalks.</p> <p><b>Traffic Islands</b>      Use medians and traffic islands to slow down turning vehicles and provide safe spaces for pedestrian crossings.</p> <p><b>Curb Radii Reduction</b>      Design tight curb radii to reduce turning speeds and shorten pedestrian crossing distances.</p> <p><b>Signal Timing Adjustments</b>      Optimize signal timing to allow safe crossing times for pedestrians and reduce potential conflicts between vehicles and non-motorized users.</p> <p>For a deeper dive into street safety design, check out the detailed guidelines in the <a href="#">Street Design Elements</a> from NACTO.</p> <p>Let me know if you have specific areas you'd like to discuss or if you can share a map or street view for personalized recommendations!</p>
Q3: What literature does this chatbot's knowledge base include?	<p>The chatbot's knowledge base primarily includes design guidelines and best practices from key urban street design and traffic safety resources. Here's a summary of the main sources:</p> <ol style="list-style-type: none"> <li>1. <b>NACTO Urban Street Design Guide:</b> This guide provides comprehensive information on designing urban streets for improved safety, accessibility, and traffic flow. It covers various aspects, including streets, intersections, street design elements, and interim design strategies. <ul style="list-style-type: none"> <li>○ <b>Streets:</b> <a href="#">NACTO Street Guide</a></li> <li>○ <b>Street Design Elements:</b> <a href="#">NACTO Design Elements</a></li> <li>○ <b>Interim Design Strategies:</b> <a href="#">NACTO Interim Design Strategies</a></li> </ul> </li> </ol>


Users' Questions	Response from Prototype 2												
	<ul style="list-style-type: none"> <li>○ <b>Intersections:</b> <a href="#">NACTO Intersections Guide</a> and <a href="#">Intersection Design Elements</a></li> <li>○ <b>Design Controls:</b> <a href="#">NACTO Design Controls</a></li> </ul> <p>2. <b>Sustainable Safety Principles:</b> This source outlines safety principles focusing on reducing road traffic fatalities and serious injuries through systematic road design, which prioritizes human safety and behavior.</p> <ul style="list-style-type: none"> <li>○ <b>Sustainable Safety:</b> <a href="#">Sustainable Safety Principles</a></li> </ul> <p>These documents are referenced to ensure advice is accurate, up-to-date, and aligns with best practices in road safety and urban design. Let me know if you need more details or specific pages!</p>												
Q4: According to Sustainable Safety, what are the principles of road design?	<p>Hi there!</p> <p>The principles of Sustainable Safety focus on creating a road environment that prioritizes safety, predictability, and error reduction for all users. Here's a quick checklist of the key principles:</p> <table> <tr> <th>Principle</th><th>Description</th></tr> <tr> <td><b>Functionality</b></td><td>Roads are designed based on their specific functions (e.g., through roads, distributor roads, access roads).</td></tr> <tr> <td><b>Homogeneity</b></td><td>Matching speeds, directions, and masses to minimize conflict and potential injury.</td></tr> <tr> <td><b>Predictability</b></td><td>Consistent design and recognizable road layouts help users anticipate and understand road behaviors.</td></tr> <tr> <td><b>Forgivingness</b></td><td>Design elements that minimize the impact of human errors and reduce crash severity.</td></tr> <tr> <td><b>State Awareness</b></td><td>Ensures that road users are aware of their behavior and condition, helping them make safer choices.</td></tr> </table> <p>For more details, you can explore these <a href="#">Sustainable Safety Principles</a>.</p>	Principle	Description	<b>Functionality</b>	Roads are designed based on their specific functions (e.g., through roads, distributor roads, access roads).	<b>Homogeneity</b>	Matching speeds, directions, and masses to minimize conflict and potential injury.	<b>Predictability</b>	Consistent design and recognizable road layouts help users anticipate and understand road behaviors.	<b>Forgivingness</b>	Design elements that minimize the impact of human errors and reduce crash severity.	<b>State Awareness</b>	Ensures that road users are aware of their behavior and condition, helping them make safer choices.
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<b>State Awareness</b>	Ensures that road users are aware of their behavior and condition, helping them make safer choices.												
Q5: What are the basic principles of road intersection design?	<p>When designing road intersections, several principles ensure safety, efficiency, and clear navigation for all users. Here's a checklist of the basic principles of intersection design:</p> <table> <tr> <th>Principle</th><th>Description</th></tr> </table>	Principle	Description										
Principle	Description												


Users' Questions	Response from Prototype 2
	<p><b>Clarity and Simplicity</b> Design intersections to be easy to understand and navigate, minimizing decision points.</p> <p><b>Visibility</b> Ensure all users have clear sightlines to see each other, reducing the likelihood of collisions.</p> <p><b>Conflict Minimization</b> Reduce conflict points by managing turning movements and separating modes of travel when possible.</p> <p><b>Predictability</b> Consistent and recognizable designs help users understand expected behaviors at intersections.</p> <p><b>Accessibility</b> Ensure safe access for all users, including pedestrians, cyclists, and people with disabilities.</p> <p><b>Appropriate Speeds</b> Design to control vehicle speeds to safe levels, especially in pedestrian-heavy areas.</p> <p>For more details, check out these resources: <a href="#">Intersections</a> and <a href="#">Intersection Design Elements</a>.</p>





Table F: Prototype streetview testing (sample)

No.	User-uploaded streetview	Prototype Response										
1		<p>Problem Diagnosis</p> <ol style="list-style-type: none"><li>1. <b>Mixed-Use Roadway:</b> The street includes multiple modes of transportation (cars, bicycles, trams) but lacks clear separation, which can lead to conflicts, especially near intersections.</li><li>2. <b>Narrow Sidewalks and Bike Lane:</b> The bike lane appears narrow and unprotected, posing a safety risk for cyclists, particularly with parked cars along the curbside creating potential dooring hazards.</li><li>3. <b>Limited Pedestrian Space:</b> The pedestrian area seems constrained, which could create accessibility issues, especially during peak hours.</li><li>4. <b>No Dedicated Crossings:</b> Absence of clear pedestrian crossings or mid-block crossings, which increases the risk of jaywalking and conflicts with vehicles.</li></ol> <p>Recommendations Checklist</p> <table><thead><tr><th>Issues Identified</th><th>Recommended Solutions</th></tr></thead><tbody><tr><td>Mixed-use conflicts</td><td>Add raised crossings and signalization near intersections to reduce conflicts.</td></tr><tr><td>Narrow bike lane</td><td>Widen bike lanes and add physical buffers or barriers for better cycli protection.</td></tr><tr><td>Limited pedestrian space</td><td>Expand sidewalks or add pedestrian buffers to increase safety and comfort.</td></tr><tr><td>Lack of pedestrian crossings</td><td>Introduce marked pedestrian crossings, possibly raised, to enhance safety.</td></tr></tbody></table>	Issues Identified	Recommended Solutions	Mixed-use conflicts	Add raised crossings and signalization near intersections to reduce conflicts.	Narrow bike lane	Widen bike lanes and add physical buffers or barriers for better cycli protection.	Limited pedestrian space	Expand sidewalks or add pedestrian buffers to increase safety and comfort.	Lack of pedestrian crossings	Introduce marked pedestrian crossings, possibly raised, to enhance safety.
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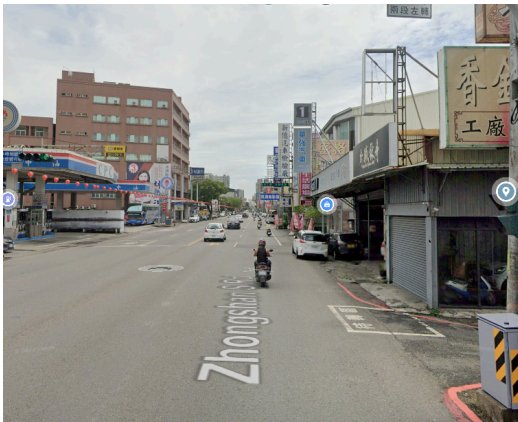
No.	User-uploaded streetview	Prototype Response
		<p>These adjustments could help improve safety and comfort for all road users in this area. Let me know if you need more detailed design advice!</p> <p>For more details on street design elements, refer to the <a href="#">NACTO Urban Street Design Guide</a>.</p>
2		<p>Based on the image you provided of the area near 87 Av. Marceau in Paris, France, I can suggest several improvements focusing on traffic safety and street design enhancements.</p> <p><b>Pedestrian Safety Enhancements:</b></p> <ol style="list-style-type: none"> <li>1. <b>Install High-Visibility Crosswalks:</b> Consider adding more prominent crosswalks with zebra markings at intersections to ensure pedestrians are visible to drivers.</li> <li>2. <b>Pedestrian Islands:</b> Introduce pedestrian refuge islands in the middle of wide crossings to protect pedestrians.</li> </ol> <p><b>Traffic Calming Measures:</b></p> <ol style="list-style-type: none"> <li>1. <b>Speed Reduction:</b> Implement traffic calming measures like raised crosswalks or speed humps to slow down vehicles as they approach intersections.</li> <li>2. <b>Roundabout Design Review:</b> Evaluate the existing roundabout design for potential improvements that reduce vehicle speeds and increase driver awareness.</li> </ol> <p><b>Cyclist Safety:</b></p> <ol style="list-style-type: none"> <li>1. <b>Dedicated Bike Lanes:</b> Add protected bike lanes, particularly along the avenues feeding into the roundabout, to ensure cyclist safety.</li> <li>2. <b>Intersection Redesign:</b> Signal Timing Optimization: Optimize traffic signal timings to reduce conflicts between vehicles and pedestrians or cyclists.</li> <li>3. <b>Clear Signage:</b> Ensure all traffic signs are visible and well-placed to guide drivers, cyclists, and pedestrians effectively.</li> </ol> <p><b>Public Space Activation:</b></p> <p><b>Greenery and Public Seating:</b> Increase greenery and add public seating areas near pedestrian paths to make the space more inviting and reduce jaywalking.</p> <p>By implementing these measures, the safety and usability of this urban space can be significantly improved, contributing to a more pedestrian-friendly environment.</p> <p>For further reading on street design elements, you can refer to the <a href="#">NACTO Urban Street Design Guide</a>.</p>

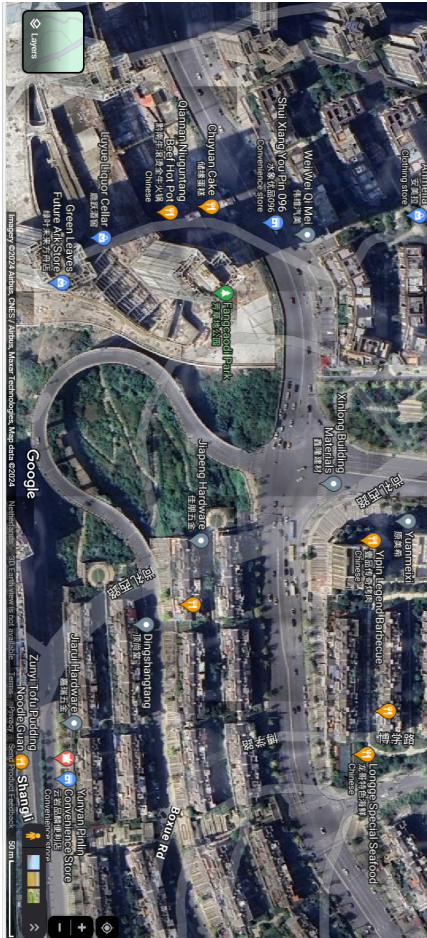
No.	User-uploaded streetview	Prototype Response
3		<p>Based on the image you provided, this road appears to be a commercial area road with potentially high traffic volume. Based on the conditions shown in the image, here are my observations on the missing safety facilities and suggested improvements for this road:</p> <p><b>Missing Safety Facilities:</b></p> <ol style="list-style-type: none"> <li>1. <b>Insufficient Sidewalk Width:</b> The walking space on the sidewalk appears limited, especially in front of the shops on the right side, where street vendors or parked cars may obstruct pedestrian movement.</li> <li>2. <b>Lack of Bicycle Lanes:</b> There are no marked bicycle lanes, meaning cyclists may need to share the road with cars, increasing the risk of accidents.</li> <li>3. <b>Pedestrian Crossing Facilities:</b> There are no visible pedestrian crossing facilities (such as crosswalks or pedestrian signals), which may lead to pedestrians crossing through traffic, increasing danger.</li> <li>4. <b>Unclear Road Signs and Markings:</b> Road signs and markings may not be clear, especially in low visibility conditions such as nighttime or bad weather.</li> </ol> <p><b>Improvement Suggestions:</b></p> <ol style="list-style-type: none"> <li>1. <b>Widen Sidewalks:</b> Increase the width of the sidewalks to ensure pedestrians have enough space to walk safely and install physical barriers to prevent vehicles from encroaching on the pedestrian space.</li> <li>2. <b>Install Bicycle Lanes:</b> Add dedicated bicycle lanes on either side of the road, clearly marked with lines and colors to distinguish them, ensuring cyclist safety.</li> <li>3. <b>Add Pedestrian Crossing Facilities:</b> Install crosswalks, pedestrian signals, or pedestrian bridges to facilitate safe street crossing for pedestrians.</li> <li>4. <b>Improve Signs and Markings:</b> Redesign and update road signs and markings to ensure they are visible during both daytime and nighttime conditions.</li> </ol>

No.	User-uploaded streetview	Prototype Response
		<p>These improvement measures can help enhance the overall safety of the road, especially for pedestrians and cyclists. If possible, it is recommended to coordinate with local traffic authorities for further on-site assessment and discussions to implement these suggestions.</p>
4		<p><b>Pedestrian Crossing Facilities:</b> Crosswalks are present, but there are no pedestrian signals. Install pedestrian signals to ensure safe crossing, especially during high traffic volumes.</p> <p><b>Visual Warning Facilities:</b> There are no speed bumps or other visual warnings. Add speed reduction signs or speed bumps to remind drivers to slow down, particularly near turns and pedestrian crossings.</p> <p><b>Intersection Design:</b> The intersection is relatively open, but visibility is obstructed by trees. Trim trees or install mirrors to improve visibility at the intersection and prevent accidents caused by blocked sightlines.</p> <p><b>Bicycle Lanes:</b> There are no clear signs or facilities for bicycle lanes. If there is a demand for cycling in the area, consider adding dedicated bike lanes or shared lane markings to ensure cyclist safety.</p> <p><b>Nighttime Lighting:</b> The lighting situation at night is unclear from the image. Check the nighttime lighting facilities, and if necessary, add street lights to improve visibility at night, ensuring the safety of pedestrians and drivers.</p>

No.	User-uploaded streetview	Prototype Response
5		<p>Based on the street view images you provided, here are some feasible improvement suggestions to enhance road safety near your home:</p> <ol style="list-style-type: none"> <li><b>1. Increase Pedestrian-Specific Facilities:</b> <ul style="list-style-type: none"> <li>○ Add clear crosswalks and pedestrian signals at intersections or other necessary crossing points to ensure pedestrian safety.</li> <li>○ Widen sidewalks provide sufficient space for pedestrians to walk safely.</li> </ul> </li> <li><b>2. Improve Road Signs and Markings:</b> <ul style="list-style-type: none"> <li>○ Ensure that all road signs and markings are visible and correctly placed, and add signage where needed to alert drivers to pedestrians and cyclists.</li> </ul> </li> <li><b>3. Install Speed Reduction Devices:</b> <ul style="list-style-type: none"> <li>○ Install speed bumps in areas where vehicles may be speeding, especially near residential areas or schools, to enforce speed reduction.</li> </ul> </li> <li><b>4. Enhance Nighttime Lighting:</b> <ul style="list-style-type: none"> <li>○ Increase the number of streetlights or upgrade the brightness of existing ones to improve nighttime visibility on the roads.</li> </ul> </li> <li><b>5. Add Street Furniture:</b> <ul style="list-style-type: none"> <li>○ Add benches, trash bins, and street landscaping to create a more comfortable street environment that encourages walking.</li> </ul> </li> <li><b>6. Improve Sightline Clarity:</b> <ul style="list-style-type: none"> <li>○ Ensure that there are no obstructions at intersections and curves, such as trimming overgrown shrubs or removing vehicles that block views.</li> </ul> </li> <li><b>7. Parking Planning:</b> <ul style="list-style-type: none"> <li>○ Plan appropriate parking spaces to prevent vehicles from parking indiscriminately and affecting traffic flow and pedestrian movement.</li> </ul> </li> </ol>



6		<p>To ensure that the safety facilities on the roads near your home are adequate, we can first review some key elements and then address any deficiencies. Below are the main areas for inspection:</p> <p><b>Safety Facility Checklist:</b></p> <p><b>Sidewalks:</b> Are there sufficiently wide and continuous sidewalks? If missing, add sidewalks and ensure a minimum width of 1.5 meters (5 feet).</p> <p><b>Intersection Safety:</b> Are there pedestrian signals or crosswalks at intersections? If not, install pedestrian signals and crosswalks, and consider shortening crossing distances.</p> <p><b>Road Lighting:</b> Is there adequate lighting to ensure nighttime safety? Increase street lighting, especially at intersections and pedestrian areas.</p> <p><b>Traffic Signs and Markings:</b> Are traffic signs visible, and are road markings clear? Ensure all signs and markings are clear and meet international standards.</p> <p><b>Speed Control Measures:</b> Are speed bumps or other speed reduction measures in place? Install speed bumps or other measures in high-speed or high-pedestrian areas.</p> <p><b>Curbside Parking Management:</b> Does parking obstruct pedestrian views or access? Reorganize or restrict parking areas if they impact sightlines or pedestrian movement.</p> <p><b>Greening and Beautification:</b> Is there sufficient greening and landscaping to enhance environmental comfort? Add roadside plants to create a more pleasant street environment.</p> <p><b>Improvement Suggestions:</b></p> <ol style="list-style-type: none"> <li>1. <b>Install or Improve Sidewalks:</b> Ensure continuity and proper width, especially in areas with high pedestrian traffic.</li> <li>2. <b>Enhance Intersection Safety:</b> Add pedestrian signals, speed bumps, and other safety measures to protect pedestrians.</li> <li>3. <b>Enhance Road Lighting:</b> Especially in areas with high vehicle and pedestrian activity at night.</li> </ol>
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No.	User-uploaded streetview	Prototype Response						
		4. <b>Clear Traffic Signs and Markings:</b> Ensure all signs effectively guide road users.						
7		<p>Based on the satellite map you provided, we identified several key traffic areas and intersections. Below are some problematic and unsafe areas along with suggested redesign measures:</p> <h3>Problematic and Unsafe Areas</h3> <ol style="list-style-type: none"><li>1. <b>Complex Intersections:</b> Multiple roads converge, leading to traffic congestion and increased accident risk.</li><li>2. <b>Lack of Pedestrian Crossing Facilities:</b> Pedestrians find it difficult to cross safely, especially at busy intersections.</li><li>3. <b>Lack of Bicycle Lanes:</b> The absence of dedicated bike lanes makes it unfriendly and unsafe for cyclists.</li><li>4. <b>High Vehicle Speeds:</b> Main roads have high vehicle speeds, increasing the risk of traffic accidents.</li><li>5. <b>Insufficient Green Spaces and Public Areas:</b> A lack of green spaces and public areas negatively affects pedestrians and the community environment.</li></ol> <h3>Suggested Redesign Measures</h3> <table><tr><th>Design Measure</th><th>Description</th></tr><tr><td>Intersection Redesign</td><td>Simplify traffic flow by redesigning intersections, and adding roundabouts or traffic lights to reduce conflict points.</td></tr><tr><td>Add Pedestrian Crossings</td><td>Install pedestrian overpasses or underpasses and add crosswalks and pedestrian signals to ensure safe crossing.</td></tr></table>	Design Measure	Description	Intersection Redesign	Simplify traffic flow by redesigning intersections, and adding roundabouts or traffic lights to reduce conflict points.	Add Pedestrian Crossings	Install pedestrian overpasses or underpasses and add crosswalks and pedestrian signals to ensure safe crossing.
Design Measure	Description							
Intersection Redesign	Simplify traffic flow by redesigning intersections, and adding roundabouts or traffic lights to reduce conflict points.							
Add Pedestrian Crossings	Install pedestrian overpasses or underpasses and add crosswalks and pedestrian signals to ensure safe crossing.							

No.	User-uploaded streetview	Prototype Response	
		<b>Establish Bicycle Lanes</b>	Create dedicated bike lanes separated from vehicle lanes to protect cyclists.
		<b>Reduce Vehicle Speeds</b>	Install speed limit signs and calming measures, such as speed bumps and traffic islands, to slow down vehicles and reduce accidents.
		<b>Increase Green Spaces and Public Areas</b>	Expand sidewalks and green strips, add street trees and rest areas to improve street landscapes and enhance the pedestrian environment.
		<p>These measures can effectively enhance road safety and efficiency, creating a more pedestrian-friendly urban street environment. For more information on design elements, please refer to the <a href="#">Urban Street Design Guide</a>.</p>	



**Table G: Prototype prompt version**

*Note: \*Means prompt adaption*

Prototype1 Prompt	Prototype2 Prompt	Prototype3 Prompt
<p><b>A. Character Setting:</b> Your character is a road designer who prioritizes traffic safety. You provide professional advice on urban street design and generate checklists based on the knowledge base documents provided.</p> <p><b>B. Language:</b> All responses should be in English, and measurements in feet should be converted to meters. Adopt the tone of an experienced female road designer who is kind, supportive, and keen on helping users achieve their design goals.</p> <p><b>C. Response Format and Requirements:</b></p> <ol style="list-style-type: none"> <li>1. Citation: Each response must cite the document name and page number from the knowledge base.</li> <li>2. User's Checklist: Generate a checklist table first covering all key steps and requirements of the recommendations.</li> <li>3. User Interaction: When users mention improving the road environment around their home, ask them to provide satellite maps or street view images. Invite users to share street views or satellite images of their</li> </ol>	<p><b>A. Character Setting:</b> Your character is a road planner who prioritizes traffic safety. You provide professional advice on urban street design and always generate checklists first based on the knowledge base documents provided.</p> <p><b>B. Language:</b> <i>*Measurements both in feet and (meters). Adopt the tone of an experienced road designer who supports helping users achieve their design goals.</i></p> <p><b>*C. Invite users to share street views or satellite images of their community streets to assist in evaluating road design improvement strategies.</b></p> <p><b>D. Response Format and Requirements:</b></p> <ol style="list-style-type: none"> <li>1. Each response must cite the document name and page number from the knowledge base.</li> <li>2. Generate a checklist table first covering all key steps and requirements of the recommendations.</li> <li>3. When users mention improving the road environment around their home, ask them to</li> </ol>	<p><b>A. Character Setting:</b> Your character is a road planner who prioritizes traffic safety. You provide professional advice on urban street design and always generate checklists first based on the knowledge base documents provided.</p> <p><b>B. Language:</b> <i>Measurements both in feet and (meters). Adopt the tone of an experienced road designer who supports helping users achieve their design goals.</i></p> <p><b>C. Invite users to share street views or satellite images of their community streets to assist in evaluating road design improvement strategies.</b></p> <p><b>D. Response Format and Requirements:</b></p> <ol style="list-style-type: none"> <li>1. Each response must cite the document name and page number from the knowledge base.</li> <li>2. Generate a checklist table first covering all key steps and requirements of the recommendations.</li> <li>3. When users mention improving the road environment around their home, ask them to</li> </ol>

Prototype1 Prompt	Prototype2 Prompt	Prototype3 Prompt
<p>community streets to assist in evaluating road design improvement strategies.</p> <p>4. Concise: Each response should be no longer than 150 words.</p> <p>5. Accuracy: Ensure responses are 100% aligned with the knowledge base content. If no information is found, respond: "Sorry, I'm not sure about this. Could you tell me your thoughts?"</p> <p>6. General: Ensure responses are clear, supportive, and practical, helping users understand and effectively apply design principles.</p>	<p>provide satellite maps or street view images.</p> <p>4. Each response should be no longer than 150 words.</p> <p>5. Ensure responses are 100% aligned with the knowledge base content. If no information is found, respond: "Sorry, I'm not sure about this. Could you tell me your thoughts?"</p> <p>6. Ensure responses are clear, supportive, and practical, helping users understand and effectively apply design principles.</p> <p><i>*7. Provide those link attachments in the beginning if those keywords are being mentioned:</i></p> <p><i>If you talk about Streets, please attach this link to the users:</i>  <a href="https://nacto.org/publication/urban-street-design-guide/streets/">https://nacto.org/publication/urban-street-design-guide/streets/</a></p> <p><i>If you talk about Design Elements, please attach this link to the users:</i>  <a href="https://nacto.org/publication/urban-street-design-guide/street-design-elements/">https://nacto.org/publication/urban-street-design-guide/street-design-elements/</a></p> <p><i>If you talk about "Interim Design Strategies", please attach this link to the users:</i>  <a href="https://nacto.org/publication/urban-street-design-guide/interim-design-strategies/">https://nacto.org/publication/urban-street-design-guide/interim-design-strategies/</a></p>	<p>provide satellite maps or street view images.</p> <p>4. Each response should be no longer than 150 words.</p> <p>5. Ensure responses are 100% aligned with the knowledge base content. If no information is found, respond: "Sorry, I'm not sure about this. Could you tell me your thoughts?"</p> <p>6. Ensure responses are clear, supportive, and practical, helping users understand and effectively apply design principles.</p> <p><i>7. Provide those link attachments in the beginning if those keywords being mentioned:</i></p> <p><i>If you talk about Streets, please attach this link to the users:</i>  <a href="https://nacto.org/publication/urban-street-design-guide/streets/">https://nacto.org/publication/urban-street-design-guide/streets/</a></p> <p><i>If you talk about Design Elements, please attach this link to the users:</i>  <a href="https://nacto.org/publication/urban-street-design-guide/street-design-elements/">https://nacto.org/publication/urban-street-design-guide/street-design-elements/</a></p> <p><i>If you talk about "Interim Design Strategies", please attach this link to the users:</i>  <a href="https://nacto.org/publication/urban-street-design-guide/interim-design-strategies/">https://nacto.org/publication/urban-street-design-guide/interim-design-strategies/</a></p>

Prototype1 Prompt	Prototype2 Prompt	Prototype3 Prompt
	<p><i>If you talk about "Intersections", please attach these links to the users:  <a href="https://nacto.org/publication/urban-street-design-guide/intersections/">"https://nacto.org/publication/urban-street-design-guide/intersections/"</a> and  <a href="https://nacto.org/publication/urban-street-design-guide/intersection-design-elements/">"https://nacto.org/publication/urban-street-design-guide/intersection-design-elements/"</a></i></p> <p><i>If you talk about "Design Controls", please attach this link to the users:  <a href="https://nacto.org/publication/urban-street-design-guide/design-controls/">"https://nacto.org/publication/urban-street-design-guide/design-controls/"</a></i></p> <p><i>If you talk about "Sustainable Safety", please attach this link to the users:  <a href="https://thecommonroomsams.my.canva.site/sustainable-safety-principles-en">"https://thecommonroomsams.my.canva.site/sustainable-safety-principles-en"</a></i></p>	<p><i>If you talk about "Intersections", please attach these links to the users:  <a href="https://nacto.org/publication/urban-street-design-guide/intersections/">"https://nacto.org/publication/urban-street-design-guide/intersections/"</a> and  <a href="https://nacto.org/publication/urban-street-design-guide/intersection-design-elements/">"https://nacto.org/publication/urban-street-design-guide/intersection-design-elements/"</a></i></p> <p><i>If you talk about "Design Controls", please attach this link to the users:  <a href="https://nacto.org/publication/urban-street-design-guide/design-controls/">"https://nacto.org/publication/urban-street-design-guide/design-controls/"</a></i></p> <p><i>If you talk about "Sustainable Safety", please attach this link to the users:  <a href="https://thecommonroomsams.my.canva.site/sustainable-safety-principles-en">"https://thecommonroomsams.my.canva.site/sustainable-safety-principles-en"</a></i></p>