Temperature Monitoring IOT system design report

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Summary

The aim of this report is to design and implement an IoT prototype product for a regional firm to execute employees' temperatures for monitoring COVID-19 purposes to track the record of users' body temperatures and identity to access in random premises. Employee's temperature can be designed as a prototype of temperature by using few components like microcontroller, Arduino.

The designed prototype of this report applies the Internet of Things connectivity so that temperature information can be quickly sent to the Aston IoT trainer board through same WIFI network to record users body temperature & ID and permit access if their bodily temperature ratio is within an allowable range.

The evidence on IoT adoption and economic effects during its early years is reviewed in this paper. This paper also evaluates the possible effect of the IoT on productivity using a growth account system.

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1.0 Introduction

The internet of things (IoT) is playing an increasingly important part in people's lives by allowing the integration of many physical devices via the internet, where the devices are intelligently coupled together, enabled new types of communication between things and people, as well as between things themselves, to share information for monitoring and controlling devices from anywhere on the planet using internet connection. Furthermore, IoT applications allow communication between machines or devices without the need for human intervention.

The major task for this report is to design an IoT prototype for a company where temperatures for employees going to record for observing the Covid-19 purposes. This assessment is going to use microcontroller tool to execute the whole process. To enter the company premises, an employee must scan their unique RFID card to the device. After a successful scan of RFID card, the gadget will then track a record of this entrance access endeavour and at the same time will permit access if users physical temperature measurement is within acceptable range.

This report is also going to illustrates about design and implementation of the device, the impact analysis of societal, privacy security and commercialisation of the device as well as the deployment consideration of the device.

2.0 Design and implementation

The purpose of COVID-19 monitoring systems is to offer continuously a clear information about employer's body temperature and ID. With this proposed design, the monitored data can be used for preventive maintenance, early detection of warning and evaluation of probable COVID virus infected people. This device composed with various components such as trainer board, which is consist of ESP8266 microcontroller, RFID (MFRC522), Grove – LCD RGB backlight, potentiometer as temperature controller and so on. Firstly, the device will be connected through the main power so that the current should need to be change from alternating current to direct current. Though, there will be some battery for this device as a backup in case of emergency. This device basically tries to connect with local area WIFI network. Device itself will try various attempt whilst it got connected successfully with WIFI. Then device will be connected consecutively through dashboard to MQTT and webpage though HTTP. Accepted range of human body temperature to enter any premises will be selected precisely through HTTP. Now, the device will ask the person to scan the RFID card. In real life situation, there will be a particular temperature sensor to detect the temperature to enter the premises. If the temperature is not in acceptable range, then the device will display the person to go back to home. However, in this device the value of the temperature is changeable through potentiometer. After that, device will receive the value and will open the door if the temperature is in acceptable range otherwise device will signal the person to back to his residence. Then, the RFID number, temperature and device location will upload both on MQTT and HTTP and webpage HTTP will show last ten attempts.

- **Flow Chart**

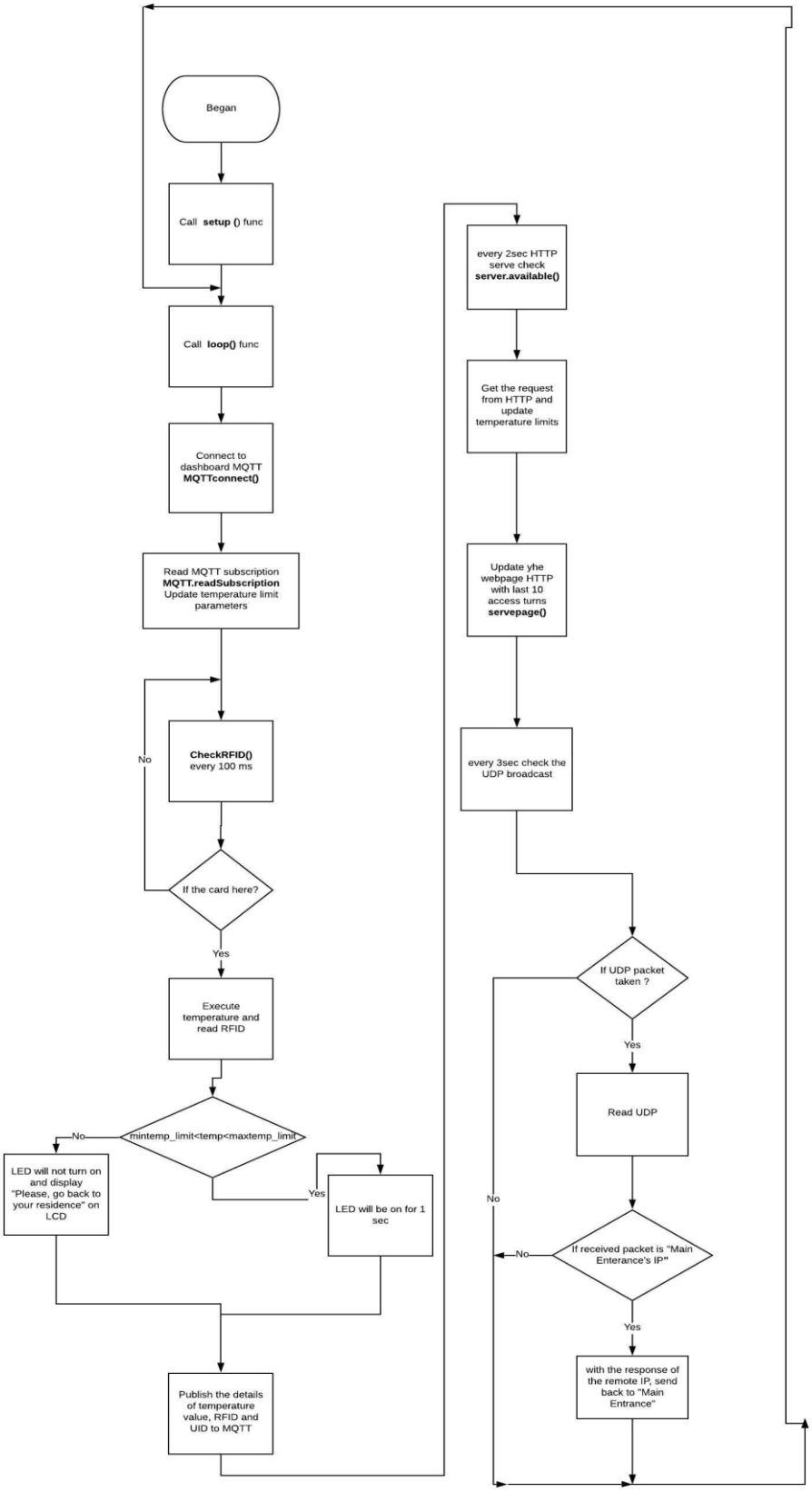

Figure 1. Device Flow Chart

- **Block Diagram**

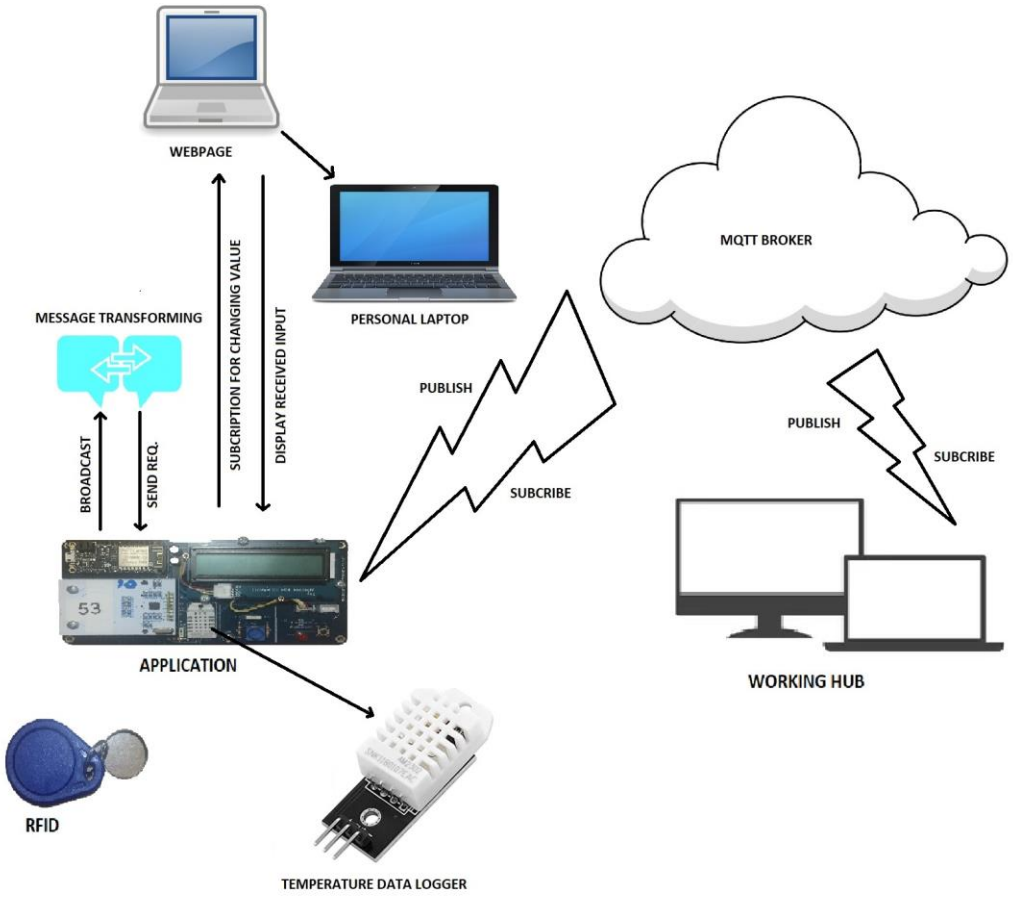

Figure 2. Block Diagram

3.0 Societal, privacy and commercial impact analysis

The future projection of the result of the IoT on society most often overweight the role of present technology and presume a motive which is not certainly exist. in the view of social science approach, it can perform an important role in executing and competing presumptions related to the design, implementation, and impact of the IoT in different societal, pivotal, and commercial circumstances. The social science research has given the variation of IoT in business platform practices, innovation, security maintenance, regulations and on our daily commodities. In the view of COVID-19, devices are utilized to prevent the spread of virus to others by performing early diagnosis, observing the patients, and enabling different protocols after successfully recovery of the patient. This section will provide the information and possible analysis using IoT prototype for tackling COVID-19 in three main aspects, consisting societal, privacy, and commercial.

- **Societal impact analysis**

Since early 2020, the global world has been suffering with the pandemic caused by the novel respiratory syndrome coronavirus by striving to monitor the growth of virus. The temperature measuring IoT device is a smart device which can gather data for remote reporting. This device is useful in decreasing the level of corona by measuring the temperature and collecting the personal data varying from age-to-age manner. If a person found with high temperature, then that person can be taken as probable corona infected list so that safeguard issue can be enabled for that person to prevent the spread of the pandemic virus. Considering the situation in any city, which is densely populated, this IoT device can be very useful in terms of the regulations of installing such kind of product because of monitoring the massive population. Government and health institution need human error platform and fast collecting data method to deploy a strong statistical forum where government is eager to provide subsidies as well for this type of construction. Though the product is very potential in the view of its working function however if the product costs significant amount of money, then civilians will receive this as an unwise product to finance. So, to understand the impact of IoT device on economy and on the huge society, it is quite important to think twice about the manufacturing cost and the quantity of the product. Collecting data and gathering information through a sensor is using increasingly and transforming hand to hand towards convenient control and audit. These collecting data can be transparent for the customers because companies are most often in under pressure on providing data to clients as well as health insurance companies. Some societal community or media will be opposed on giving personal data through sensors because there is some older person who are not even been familiar with recent technology so that the transparent view of collecting data can be also effective on societal point of view. Additionally, the rapid use of IoT devices will lead consumers to depend on analytics to make high standard choices as the sensors, data storage, and internet facilities become faster, cheaper, and more integrated together [1]. Most of the companies provides massive range of internet facilities to their employees to use such kind of IoT devices in bearable way. As IoT technology communicate over internet connection so the legislation issue of this temperature device needs to consider these following practices such as the technology behind the IoT system, telecommunication equipment, electrical tools, intellectual property overview, licensing issue, consumer protection, compliance requirements, legal aspects of the future and so on [2]. Inferred heating panels generate small carbon footprint which means environment damage is less and this product is made from 100% recyclable materials [3]. In addition, the heat inferred products creates that helps to the hall to dry which prevent damp and mould so that the entire atmosphere inside of the house maintain healthy environment. According to the research, the light emits from the temperature measuring device would not be able to penetrate through the barrier of the human body skull therefore this device is also fit for human body [4].

- **Privacy Impact Analysis**

Consumers are getting huge benefits from IoT device but there is also a great matter of concern is that the risk where one such type of risk is a change on how we observe privacy. The temperature measurement and ID collecting IoT device usually send data over the local network using a webpage and over the internet using Message Queuing Telemetry Transport (MQTT). Therefore, some criteria must need to be overlook for such as the ability of consumer to determine how information about them is collected and used. Consequently, the ability to retreat from the gaze of and interactions with other as well as the ability to control the data impression of which one gives off. Basically, HTTP is a communication protocol which is Internet Protocol (IP) based and deliver data through the webpage. HTTP works on IP/TCP

protocols which provide a reliable communication. MQTT is usually designed for sending a message to one or more devices with less delay and the message can be between the size of 0-256 Mb where this is not seized as to send a huge amount of data [5]. In IoT applications, the data needed is very low so that for this temperature and ID collecting device, as well as other IoT devices MQTT protocol is very useful for messaging over fragile network. MQTT generally consists of two message patterns on a connection named as “Publish” and “Subscribe” [5]. Message send utilizing publish and the message received by subscribing it. According to the MQTT implementation for this sensor based IoT device, the user utilizing MQTT client RFID to subscribe the temperature and ID topic and ESP8266 (Node) publish the current temperature by collecting the data form the sensor and the devices while all are subscribed the same topic will gather the current temperature and ID information using MQTT Broker [5]. However, HTTP protocol is worthy but MQTT is preferable in terms of the development IoT for example MQTT is data centric whereas HTTP is document-centric, throughput of MQTT is 93 times faster than HTTP’s, complexity, and message size. In addition, MQTT also use encryption protocol such as Transport Layer Security (TLS) or Payload encryption which means data is encrypted end to end. On the other hand, because of not having strong encryption protocol the information in this HTTP protocol can be misguided. For ensuring the privacy protection and having internal control over anyone details the IoT device must need to be accomplished the Privacy by Design approach before releasing the product in the market. Objectives of Privacy by Design illustrates these following missions such as the proactive not reactive measurement, privacy as the default setting, privacy embedded into design, positive sum not zero sum, end to end security, visibility, and keep it as user centric.

- # Commercial impact analysis

The widely use of IoT applications lead everyone to understand how these devices interact with organizations and people, and the commercialisation workability of any IoT device. Before commercialisation, this temperature measuring IoT device, there are several aspects need to be overlooked where strength, weakness, opportunities, and threat (SWOT) analysis create a proper impact on the market. By giving a proper a view on the main factors affecting on and on the upcoming future, a SWOT analysis helps to understand where a business has a competitive advantage and what type of area should be outlining. The temperature measuring IoT device has a lot of strength such as this device is one of the models of cost reduction because to use this product working function does not require human interference so that it can save monthly salary of human being, as prescribed before that this device is environment friendly, ease of use where massive range of data can be collected faster. However, in the view of weakness it can determine that massive level of data going to be stored from employees so better infrastructure is highly mandatory. In addition, recent activities from hackers trying to gain control over smart devices is also not doing a positive sight to the reputation of IoT. In terms of opportunities, this temperature measuring sensor IoT device perform as healthcare application with a big range of information which can easily be provided to any hospitals or health insurance companies. In the matter of threats, this application will perform as a waste of investment if the cost of product is too high. So, in the market there will be a lack of demand due to the high cost of the product. There are also three major parts which is quite important for market analysis such as Total Addressable Market (TAM); this market is the total market demand for a product or service, Serviceable Attainable Market (SAM); is the market is the segment of the TAM targeted by products and services which is within the geographical reach and Serviceable Obtainable Market (SOM) is a percentage of the SAM which expected to easily capture. Some researchers found that the global

temperature sensor market size is 6.3 billion USD in 2020 and expected to grow 8.8 billion USD by 2027, recording a Compound Annual Growth Rate (CAGR) is 4.8% [6]. This global market is represented as TAM. In terms of Europe, The European market size is 1.5 billion USD and if it is considered in percentage then it is around 24% and projected to expand at 5% CAGR by 2026 [7]. UK sensor market size expected to reach 1028.66 million USD by the end of the 2020 [6]. This represented as SAM. Assume Birmingham market size is 21-22% of the UK which worth around 216 million USD representing SOM. In 2018, there were almost 7 billion IoT applications deployed on the market and in 2019 already 26.66 billion IoT devices already on the market where every second 127 new IoT applications are connected to webpage [9]. In addition, 31 billion IoT devices already captured in 2020 market. During the COVID-19 pandemic time, government and health insurance companies are suffering for providing legitimate information on the governmental data base. There are several companies who are providing temperature measuring sensor IoT device but not in every sector of any local area. So, in this hazardous situation to deploy this IoT device is in its optimal time. However before deploying and selling the product on the market the price of the device itself create great impact on the market. According to the research the price of this device is given below:

Equipment	Rate (£)
Micro-controller (ESP8266)	9
RFID reader	7
Liquid Crystal Display (LCD)	4
Temperature measuring sensor (Inferred)	6.5
Manufacturing and service cost	10.5
Battery	3
Net wroth	40

Table 1. Estimated Value of the Device

The estimated cost for this device is 40GBP. According to research and compute, in the competitive market, this device can be sold by 110GBP. So, the number of sales can be estimated by the following measurement:

Quantity of sales = SOM / device price
Quantity of sales = 155415240£ (216000000USD) / 110£
= 1.4 Million sales can be attained

Cashflow

Month	1	2	3	4	5	6	7
Revenue							
Device Selling Quantity target (Pieces)	-	100	100	100	100	100	100

Device Sales Target (Pieces x Device price)	-	11000	11000	11000	11000	11000	11000
Total Revenue	-	11000	11000	11000	11000	11000	11000
Total Funding							
Seed Investment	11000	-	-	-	-	-	-
Total Funding	11000	-	-	-	-	-	-
Total Cost							
Employees							
Chief Technology Officer (CTO)	2200	2200	2200	2200	2200	2200	2200
Software Engineer (part time)	1000	1000	1000	1000	1000	1000	1000
Mechanic (part time)	-	800	800	800	800	800	800
Direct Cost							
Components & Assembling	-	3700	3700	3700	3700	3700	3700
Updating Cost							
Software Updates	-	-	-	150	150	-	-
Fixed Costs							
Office Rent	300	300	300	300	300	300	300
Land Phone	20	20	20	20	20	20	20
Desktop & Office Equipment	1000	-	-	-	-	-	-
Marketing							
Traditional Marketing (leaflet, booklet)	100	100					
Website	1000	-	-	-	-	-	-
Digital Marketing	500	500	500	500	500	500	500
Total cost	6120	8620	8520	8670	8670	8520	8520
Profit of the Month	6120	2380	2480	2330	2330	2480	2480
Date to Date Profit	-6120	-3740	-1260	1070	3400	5880	8360
Cash Flow	4880	2380	2480	2330	2330	2480	2480
Remaining Bank Balance	4880	7260	9740	12070	14400	16880	19360

Table 2. Cashflow of the Product

This device can provide a business company to the ability to collect data from the network and use advance analytic technology compared to collecting data from human based device to uncover business insights, opportunities and reduce the operational cost. After providing successful service to sectors like companies or offices, business can be spread to variant platform like schools, industries and so on. This can conclude on the feasibility of bringing such a device to market.

4.0 EE4IOT ONLY – Deployment considerations

This section will derive the consideration of connectivity and deployment of the device from the gateway which means the proper communication between the IoT device and the router.

For collecting temperature and employees ID, the temperature measuring IoT device need to be deploy in front of the company's premises for maintaining the communication with router. So, the device distance should be in possible range. If the company house size is up to 3200 square feet and using D-Link WIFI router (AC2600) [9] which internal distance is 50m then two routers are enough to cover the distance from any point of WIFI router to the COVID-19 monitoring IoT device. Link budget calculation is considerable for executing the distance between the IoT application (using ESP8266 specifications) [10] and the router (using D-Link WIFI specification) [9]. Calculations are given below.

$P_{sen\,(ESP)} = -65\ dBm$,

$P_{sen\,(D-Link,AC2600)} = -67\ dBm$,

$P_{T\,(D-Link,AC2600)} = 15.5\ dBm$,

$P_{T\,(ESP)} = 14\ dBm$,

$G_T = 2\ dBi$,

$G_R = 2\ dBi$,

$\lambda = 0.125\ \text{m}$,

$d = 50m$

- **<u>The received power at the temperature measuring IoT device</u>:**

$P_{sen\,(ESP)} = -65\ dBm$

$= \frac{10^{\left(\frac{-65}{10}\right)}}{1000}$

$= 3.16 \times 10^{-10}\ W$

$P_{R(ESP)} = P_{T(\ D-Link,AC2600\ )} \cdot G_T \cdot G_R \cdot \left(\frac{\lambda}{4\pi d}\right)^2$

$P_{R(ESP)} = 3.53 \times 10^{-9}\ W$, the received power to the IoT device.

- **<u>The received Power at the gateway (router):</u>**

$P_{sen\,(D-LinkAC2600)} = -67\ dBm$

$= \frac{10^{\left(\frac{-67}{10}\right)}}{1000} = 2 \times 10^{-10}\ W$

$P_{R(D-Link,AC2600)} = P_{T(ESP)} \cdot G_T \cdot G_R \cdot \left(\frac{\lambda}{4\pi d}\right)^2$

$P_{R(D-Link,AC2600)} = 2.5 \times 10^{-9}\ W$

Comparing both cases, the power sensitivity is less than received power. So, device will get enough communication connection if the device is placed within 50m of range.

The total deployment cost for this device depending on some major parts like equipment cost, production cost and installation cost. According to the table 1, equipment cost is 37GBP and approximate production and installation cost is consecutively 10GBP and 10GBP. On the other hand, the power consumption from each component of this device needs to be undertaken. According to the datasheet,

- **Power consumption of IoT device**

The current load of the Micro controller = 70mA [11]
The current load of the temperature sensor (MLX90614) = 1.5Ma [12]
The current load of the RFID = 18 mA [13]
LCD current drawn = 50mA [14]
All total = 139.5mA
According to the theorem total power consumption, P = V * I
P = 3.3V * 0.1395A, = 0.46W

- **Running cost per year of IoT device**

Assuming, working day per year = 260 days, and Working hours per day = 8 hours
So, Power consumption per day = 0.46 * 8, =3.68 W, = 0.0036 kW
Running cost per day = 0.0041 * 14.4, = 0.05 pence (UK electricity cost 14.4 pence per kWh) [15].
So, the running cost per year = 0.05 * 260 = 13 pence.

This IoT device can be better device for people in terms of its design and implications. The strong cryptography used in this device like HTTP and MQTT is safe a platform for encrypting the information of the employees. However, more software updates over the air programming such as radio signal strength, battery strength, free storage memory to store the update, enough memory to run the device, sanity/signature checks etc., and hardware install could be placed for this device for future prospective in security manner.

5.0 Conclusion

IoT devices collect and transmit data to track critical processes, provide new insights, increase productivity, and enable business to make better decision. The impact of this device in terms of technology and business is profitable because the device itself is bearing a reliable system to gather information and price of the product is cheap. In addition, this provides some more merits such as easy to set up, remote data access with wireless connectivity, excellent data integrity and so on. There are some demerits like delay response time, self-heating, sometimes device provide wrong information because of technical error compared human operating device. However, IoT based devices help to control power, traffic flow, population activity, grow the local economy, and enhance citizens' quality of life by creating a more reliable and sustainable infrastructure.

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