Embedded System Engineering - Project 01

Team 3

No.	Name/Example
1	**Phuc** Satellite IoT Networks - Satellite Networks The satellite IoT networks can apply in various types of embedded systems such as Forest Fire Detection, Precision Farming, Mining, Smart Cities,... - ***Reactive Systems:*** Satellite IoT systems are equipped with various real-world sensors that collect data on different parameters like weather parameters (temperature, wind, humanity,...), location (GPS), natural disasters, outer space statistics. This data is transmitted to ground stations and processed to provide valuable insights for environmental monitoring and device management. - ***Real-time Operation*** Real-time response for sending and receiving data through the global coverage system. Satellites provide data of tracking location and movement of objects like shipping containers, vehicles and cargo. This real-time response helps optimize operations, improve supply chain efficiency and enhance security. Flexible channel allocation enables a system with seamless connectivity. Dedicated channels for real-time connectivity, especially in emergency cases or direct command. - **Continuous/Discrete/Hybrid Behavior** The satellite IoT network systems can be considered as hybrid systems as these are a combination of continuous and discrete behaviors where they can interact and influence each other. For instance, consider a satellite-based forest fire detection, the satellite might continuously collect imaging of forest area and environment parameters. Based on this data and predefined thresholds, the system

could trigger some actions like dispatch direction signals for fire fight systems, provide route optimization and send urgent messages to the forest service office or department of agriculture.
This model uses state machines to transit between continuous monitoring to dispatch state in discrete steps.

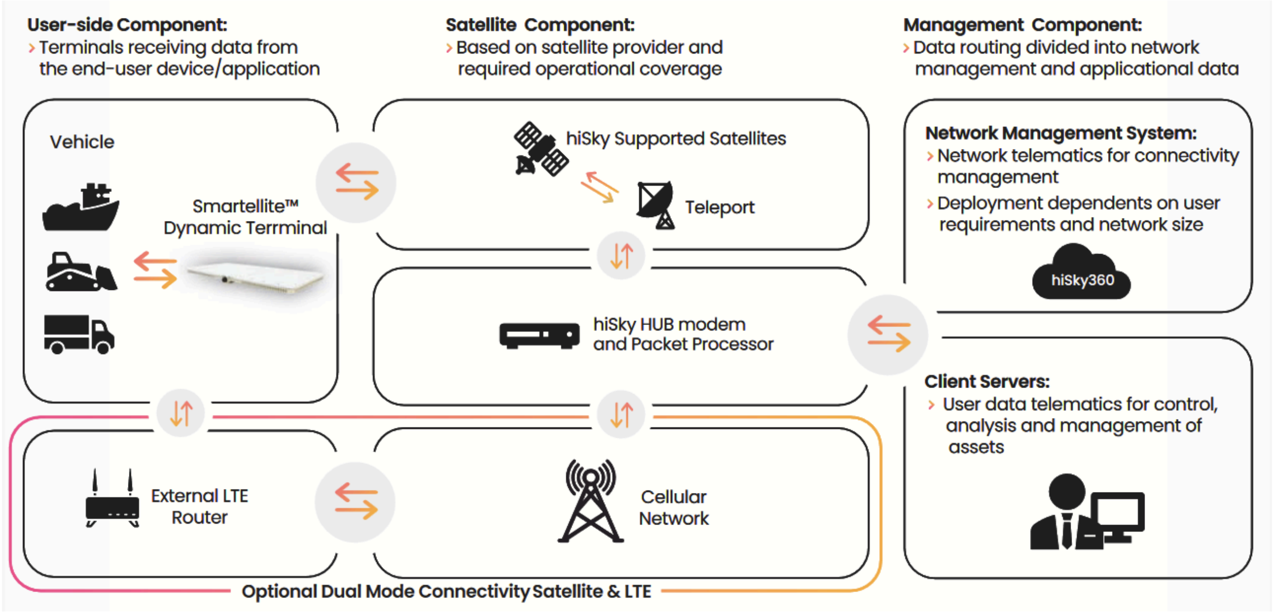
- ***Dependability***

According to the private satellite network, it ensures data security and network privacy.
Satellite communication systems enable reliable communication between devices from space to ground, providing essential services for navigation, safety. These characteristics emphasize the importance of dependability in embedded systems, partially in applications where safety is important.

- ***Distributed Elements:***

Satellite IoT systems use multiple interconnected components, including satellites, ground-based IoT sensors and gateways for wide-area connectivity with satellites acting as central hubs
For example, the agriculture monitoring system integrates data from thousands of IoT devices spread across fields. Thousands of IoT sensors are distributed across forest regions, each collecting localized data such as temperature, humidity, and smoke levels.

Satellite IoT System Architecture Sample:*

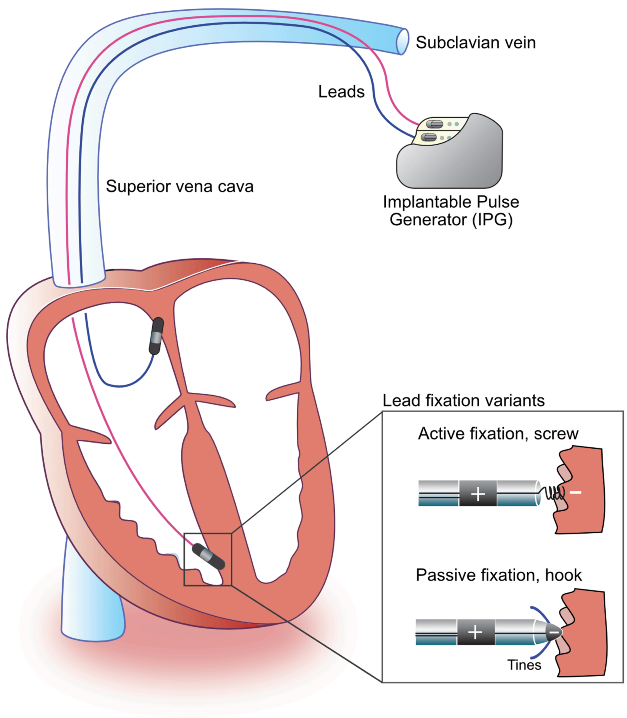


**from hiskysat document*

2	**Dao** Electric power steering system (EPS) - Automotive domain **1. Reactive system** - Active return function in the steering system updates input continuously such as angle of steering wheel and gear position to calculate the angle for correcting the steering wheel as well as gear position. - This system has to calculate the steering angle from the user continuously to provide an appropriate assistance force. **2. Real-Time system** - The electric power steering system is a hard real-time system because an accident may occur if the output (assistance force) provided by this system does not meet the deadline. This situation leads to catastrophic consequences. **3. Continuous/discrete/hybrid systems** - Continuous system: o This system may use differential equations to calculate the relationship between steering wheel angle and the corresponding turning of the wheels continuously. o Relationship between physical force applied by driver to steering wheel and the response of the ECU - Discrete system: o Sensors for measuring torque, steering angle, ... collect data at discrete time interval. o State machines are applied to this system for some purposes, such as handling errors or resetting variables. **4. Dependable systems** - Reliability:

	○ The EPS system must provide correct torque assistance in the given period of time to guarantee the safety of drivers. ○ If some functions do not run correctly while driving, there may be some backup solutions to generate correct torque assistance. - Availability: ○ Because the EPS system must continuously generate the correct torque based on the speed, steering wheel angle, ..., this system must have a high probability that the system will function correctly at any given time. - Safety: EPS systems are developed under ISO 26262, which outlines Automotive Safety Integrity Levels (ASIL A-D) to manage risk. - Security: ○ The system can generate identification keys to encrypt the message when communicating with other systems in a car by CAN or FlexRay, such as engine systems, and brake systems. In this way, the EPS system can protect the whole system in a car from hackers. **5. Distributed Systems** - Sensors, the ECU, and the electric motor work concurrently to deliver real-time steering assistance. - Sensors, ECU, and motor controllers use their local clocks for operations and data sampling. - Continuous diagnostics identify and isolate faulty components to prevent cascading failures.
3	**Quyen** *<u>Medical device - **Pacemaker**</u>* Medical devices are one of the most important fields of embedded systems in the medical field. Pacemaker is the most classic example of embedded systems in medical devices.

	1. **Reactive System**: continuously interacting with the heartbeat - Detects changes in the heart's electrical activity. - Senses trouble with the heartbeat. - Adjust pacing to stabilize heartbeat. 2. **Real-time System:** timely response to heart's stimulus - Periodically read the heartbeat pace. - Quickly and accurately diagnose whether the patient has an abnormal heart. - Deliver a synchronized rhythmic electrical stimulus to the heart muscle in order to maintain an effective rhythm for a long period of time. 3. **Continuous System:** - Heartbeat is calculated as beat per minute and it is a continuous variable. - Heart wave/graph (ECG) is also considered as continuous with time. 4. **Dependence System:** - Reliability: It can adjust the pace of the heart and correct any kinds of malfunctions (heart squeeze too strong/weak or squeeze in wrong order). - Availability: The pacemaker senses and paces the heartbeat when requested. - Safety: It will not endanger patient life during operation and ensure not to deliver therapy when it is needed, or receiving extra therapy when it is not needed. - Security: This device stores data in its own memory. 5. **Distributed System:** - Pacemaker consists of an Implantable pulse generator (IPG) which contains electronics, a battery and two leads. - IPG generated electric current which is delivered via the leads. - The lead tip is equipped with two electrodes. These electrodes are the contact points between the pacemaker and the heart. They are used for both pacing and sensing the heartbeat.

	
4	**Stevenson** **Characteristics of Embedded Systems in Automotive Applications** **1. Reactive Systems:** Reactive systems continuously interact with their environment and must respond to external stimuli in real-time or near real-time. Example: Adaptive Cruise Control (ACC). **2. Real-Time Systems:** Real-time systems require timely responses to external stimuli to function correctly. Example: Airbag Deployment System **3. Continuous/Discrete/Hybrid Systems:** These systems may use continuous or discrete data, or a combination of both (hybrid), for operation. Example: Engine Control Unit (ECU) **4. Dependable Systems:** Dependability encompasses reliability, availability, safety, and security. In automotive systems, dependability ensures consistent operation under all conditions. Example: Electronic Stability Control (ESC) **. Distributed Systems:** Distributed systems consist of multiple computing nodes working together, often connected through communication networks like CAN (Controller Area Network). Example: Autonomous Driving Systems

Addressing Dependability Attributes in Automotive Systems

1. Reliability
 - Example: Powertrain Control Modules
 - How: Extensive testing under various environmental conditions (temperature, vibration, humidity).

2. Availability
 - Example: Infotainment Systems
 - How: Redundancy in communication buses and power supplies ensures continuous operation.

3. Safety
 - Example: Lane Keeping Assist System
 - How: Complies with ISO 26262 and undergoes Hazard Analysis and Risk Assessment (HARA) to ensure safe operation under failure conditions.

4. Security
 - Example: Vehicle-to-Vehicle (V2V) Communication
 - How: Encryption and secure communication protocols prevent unauthorised data interception or manipulation.

Summary of Safety Standards

- ISO 26262: Functional safety standard for automotive applications.
- IEC 61508: General safety standard that ISO 26262 is derived from.
- AUTOSAR (Automotive Open System Architecture): Ensures standardization and dependability across distributed automotive systems.