INSA INSTITUT NATIONAL DES SCIENCES APPLIQUÉES TOULOUSE

# REPORT ENERGY INNOVATIVE PROJECT

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# Introduction

Innovation is an important part of our curriculum as future engineers specialized in the world of Internet of Things. In our present and future, we are and will be led to conceive systems. Those might be of any size, of any purpose. But a constant constraint that will be met in any IoT system is the energetic one. Connected objects often are modest in energy source, and it is important to ask ourselves how we want to power and save energy to make it as efficient as possible. In this report, you will find our reflection regarding the energy side of our last year Innovative Project.

# Presentation of our System

Our Innovative project concerns an electric tricycle created for suburban transportation. Our goal is to implement a device that would communicate the cardiac rhythm and adapt the effort the driver needs to put to have a comfortable and safe ride. Our system is composed by three main components:

- A smart watch that will measure the vital constants of the driver
- The phone that will display and manage the communication
- An ESP32 that will transmit the change of cadence to the motor

# Powering the System

The ESP32 that we are using for the command law, is directly connected to the flisky controller of the tricycle and the battery, and so does not need external power input. In that way, there is no specific optimization to do on this part. The second part of the system is the watch and the smartphone in which it is linked to. On this side, small batteries are already designed and embedded within the watch and smartphone devices. Hence, we are more thinking in terms of consuming the minimum power needed, which is the element we are focusing on in the next parts of this report.

## Ambient energy recovery from the tricycle

One of the huge challenges on this is ensuring that the energy spent to catch this wasted energy is negligible compared to the energy obtained. This is not necessarily the case, especially because there is only a small amount of energy that we would be able to catch. The other question is how to use it in our system. In fact, we can be sure that the place available on the tricycle and the battery on it allows us to not have power issues. In fact, there are not so many possibilities in our project. The only one we can see is a mechanical energy restore. Maybe an optimization is done on the GenePi Generator, but we do not really have this information within the documentation.

# Saving Energy

## Communication between devices

A first point of the consumption that might be energy intensive is the wireless communication between the components of our system. As we need real time response from the watch to the motor to ensure the proper use of the effort adjustment, we need to send data regularly at a rapid pace.
To keep the efficiency while reducing the energy used for the communication, multiple solutions can be deployed.

### Reduction of the size of the exchanged data

A first step can be the reduction of the payload, to make sure that only the necessary information is transferred. As we are using floats or integers for most of our values, the size of the payload remains light. This applies if the payload is treated as such and not as string, in which case it would be quite heavy.
As we are currently using the Bluetooth Low Energy Protocol, we are limited when it comes to the size of the header. We are currently using the Generic Attribute Profile, or GATT, that is working using Services and Attributes to communicate the data (after connection)

### Reduction of the number of exchange

Another way of reducing the energy put into the exchange is to reduce the frequency of the exchange itself.

A first way to reduce the energy could be to ensure that we only send data that will be used. Some of the information that we want to exchange will be used to calculate. A problem that we had was to choose where some of the math would be done. For instance, do we want to calculate the new cadence on the phone by getting the cadence and power from the esp32 or do we want to calculate on the esp32 by getting the cardiac rhythm and the chosen level of effort from the phone. This choice might change the energy for the communication, but it is hard to estimate without proper testing.

A second way to approach this solution is to send the data only when a big enough difference is calculated between the previous communicated measure and the new one. However, the lack of messages from a device could be from an unchanged value or a problem in the communication: this last one could not be known with the previous method. A way to address this issue could be to send periodic messages to let the other device know that the communication is still on. However, this might require clock synchronisation, and it is out of the subject of this report about energy.

### Reduction of the number of exchange

Besides the elements cited before, related to the format of their data exchanged, we can also consider code optimizations, with for example, the use of interruption in the code, rather than delays that may cause periodic energy losses, and the possibility of failures. Using interruptions allows better management of the system, even if the implementation is likely more complex and time consuming when developing the code.

# Conclusion

Our project is highly dependent on existing systems: the tricycle, the watch and the phone. For that reason, the input power of our system is not a limitation. However, It remains interesting to ask ourselves how we could reduce the consumption of the energy, as we have seen, in the communication and redaction of the code.