Summary Sheet for Technical Report of

Project AECDIMEEIA

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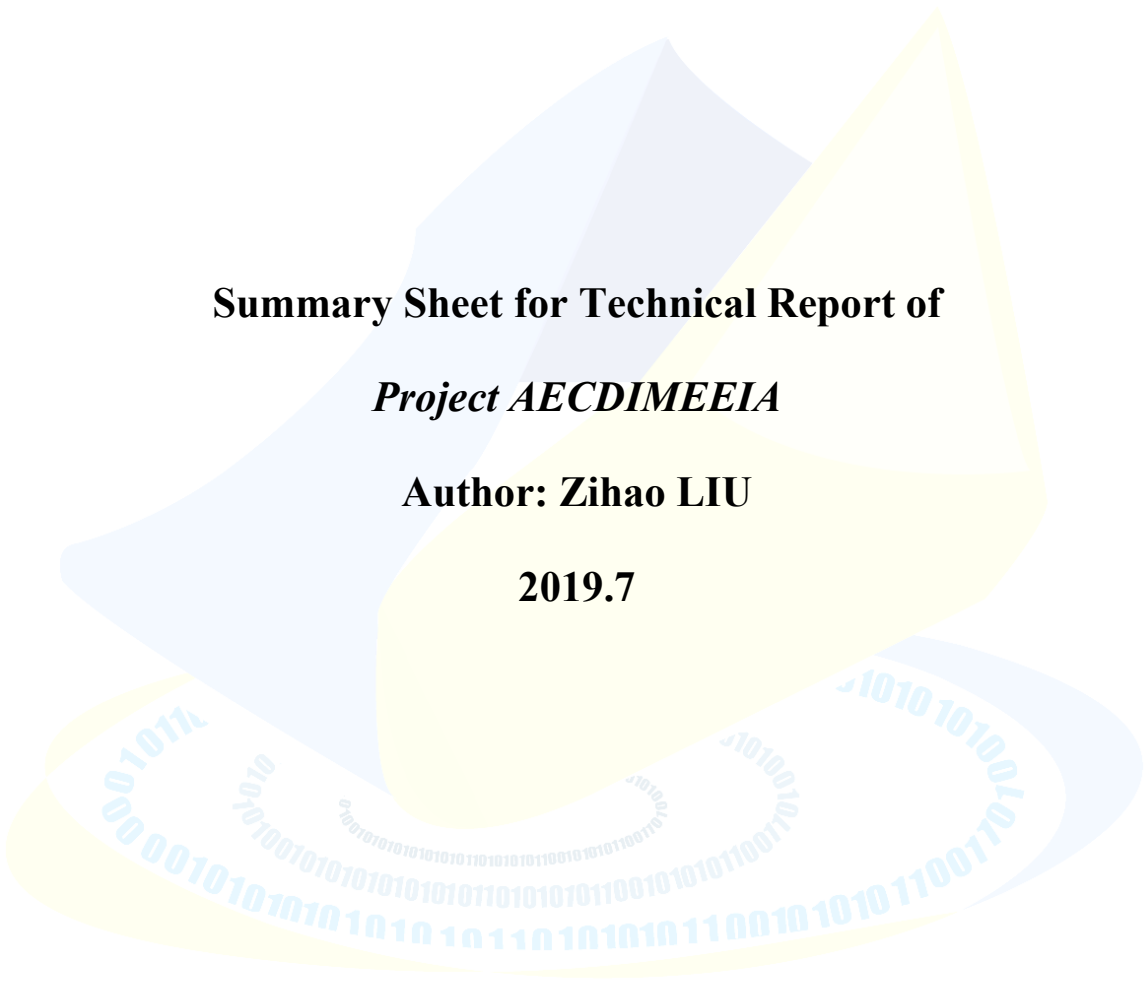

*Please don't fully rely on the summary sheet. Reading the technical report is still necessary

1. The project reads "academia".
2. By January 2020, FAA will mandate all aircrafts entering most of the airspace of US, one of the most important potential market, to be equipped with ADS-B system, removing the largest barrier for the mass application of this solution.
3. Bluetooth also supports long distance transmission as far as 1.6km on cheap commercial products. There are also cheap commercially available products with effective range of 1.5km, and some very special products with range 20km. With that being said, the line of sight should be guaranteed. Another particularly promising system is LoRaWAN, whose patent holder claimed that a maximum operation range of 10km can be achieved in rural areas, with a trade-off of data rate.
4. On the air side, the aircraft receives the weather forecast and market information received from the datalink, RF communications, or satellite mission load, which was uplinked by participating organizations. Using existing ADS-B equipment, the aircraft broadcasts the information to the ground receivers at the farmer's phone or home. On the ground side, the local weather stations collect the data of localized sensor and monitoring equipment and transmit it in the same ADS-B standard. Then data is interpreted to let the farmers aware of the weather information or market prices. The receiver can then display the information and make some decisions based on that. Most areas will be serviced, if the document 8168 requirements were properly observed. Africa is not an exception either.
5. For standard ADS-B message via mode-S transponder, the DF value is typically BIN 10001 (DEC 17), and such system is typically denoted as DF-17 system. By making use of aircraft identification bits, regulatory authorities can force the device to accept only the data provided by certain aircrafts, ensuring the network safety. "Type code" identifies what is actually transmitted.
6. Conceptually, compact position reporting divides the earth into different zones, and within a zone it only reports the movement inside, therefore dramatically reducing the

message size. 35 bits are sufficient to report positions in the worst case, even if we don't use CPR.

7. In the first 21-bit sub-scheme, WS denotes the windspeed in kilometer/h (up to 64km/h). WD denotes the wind direction (NNW, NNE, NWW, NEE, SSW, SSE, SWW, SEE). T denotes the temperature (up to 64 degrees centigrade). CW denotes the condition weather (32 cases should be more than sufficient for regular regions). Finally, EM/CPR bit is used as a flag. When we decide to use CPR to report the position, this bit is used to indicate whether it is an even or odd frame. It not, this is used to flag whether an emergency situation will be approaching. In the second sub-scheme, CT denotes the type of crop, CP is the price.
8. In the first 45-bit sub-scheme, all other denotations are the same. WS and CW were expanded for more accurate localized data processing. Now the wind direction is transmitted in either magnetic or true heading. ID here provides a way to assign ID numbers to the sensors deployed for data tracking and maintenance needs. NT is a special note that the platform which the sensors should send to the receivers. 00000 will be assigned as 'everything ok', while 11111 as 'Sensor not working. Please send engineers '. All other numbers will be assigned to denote different meanings to like accuracy and credibility of data etc. In the second sub-scheme, the CT and CP were expanded, and a 14-bit message can be sent as side note.
9. It is expected to transmit the information in an uncoded fashion. If really necessary, Reed-Solomon code is especially recommended, as it is proven very successful on satellite-based ATG communications. Compression algorithms are not recommended.
10. System security are ensured primarily via unilateral transmission. To identify fake messages, one particularly promising solution is to use the Direction of Arrival (DoA) to generate a key or detect the source of the signal. But encryption is strongly discouraged, as such a short message might cause security compromises by its nature, not to mention some features of the message is already known, making it even simpler to decipher.
11. In the aircraft, the only necessary step is to do a software update. On the ground, the transmission scheme can be based on any of the following solutions: pure regular Bluetooth, pure WIFI, LoRa+ BLE, BLE+WIFI, pure BLE, pure LoRa. The last two

three solutions are recommended, with the pure BLE and pure LoRa being the most recommended options.

12. By specification the two batteries can last at least 40 hours before replacement, assuming the device is drawing maximum power. Some devices with LoRa and especially designed low energy microcontrollers even claimed a battery life of 5 years to 10 years with AA batteries. Most of the extra sensors on the sensor platform will be built as separate components so that they can be easily swapped.
13. Comparing to other solutions envisioned, the most significant advantage is that this solution is really practical, cheap and easy to realize, meanwhile fulfilling almost all requirements that "Solutions could take the form of" have suggested. Even in countries as developed as Germany, there are cases where no network is available at all, not to mention mobile data. To use mobile-network-based services, somebody must bear the cost of electricity and transmission band. If the message failed to deliver to a certain region, it will cause fairness issues and possibly cause social unrest.
14. But for project AECDIMEEIA to work, the only requirement is that either in the 270km around you a friendly aircraft passes by, or your local weather station works and there is someone around you in 1km (for BLE) or 10km (for LoRa). Mobile network coverage, communication band license, or additional infrastructure is not required at all. For ADS-B based information transmission, the protocol is not yet fixed. There is still some room for discussion and revision. Besides, phones are still much more expensive than an embedded system. The detailed bill of materials and price estimation will be provided in the business report, but from calculation 4.91USD are more than sufficient for mass production .
15. A side benefit is to promote the development of aviation. It will lead to easier and more efficient planning, and build a healthy and positive cycle for civil aviation thereafter. Project AECDIMEEIA is in its core an IoT, Internet of Things, system. It is by nature "future-proof" comparing to regular SMS. All current progress and technologies in this field can be applied to the design directly.
16. The sensor station collects the data from the sensors via direct reading. The device initializes LoRa function, which works in the same way as regular WIFI, and now it

is able to communicate with other devices. After the data was obtained, it was printed on the screen. The device concatenates necessary data into a string and apply the aforementioned ADS-B format to it. The device transmits the data in packets, while on the receiver side, the receiver tries to receive the packet and parse it to retrieve the data. If the data can be correctly interpreted, then it is displayed. Either of the two devices can work as transmitter or receiver, and with some efforts it can even work in receiver and transmitter duplex mode.

17. When interpreting the data, the device first examines whether the data copes with the legitimate DF codes. If so and DF is not 24, the device later examines the ICAO address contained in the data. For DF-24 system, the device examines if the ID number is legitimate. If legitimacy is secured, the data is printed on the screen. Illegitimate data is discarded.
18. As information is transmitted, an emergency notice is also transmitted, with the location where the message intends to service also indicated. If we add a speaker, an aural warning can also be issued. These features are very important for intended use cases.
19. For DF-24 system, beside the emergency message, a side note is sent as intended. The farmers who received the message can inform the technician in time for maintenance work when necessary and reduce human labor cost.
20. The author proved a working range of 865 meters, from (36°06’55’’N, 120°32’21’’E) to (36°06’32’’N, 120°32’07’’E) as indicated by external GPS. It might be able to work over even longer distance, but due to terrain, a LOF larger than that cannot be achieved in the region around.
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22. The functionality of the device is not limited to what’s demonstrated in this report. It can be customized and data can be presented on the smartphone via USB or WIFI/BLE if required. Though the demonstrated functionalities fall primarily into “crowdsourced nowcast”, “climate information pipeline” and “packaging

information”, it is also doable to integrate sensors for crowdsource weather monitoring, with the data transmitted in the aforementioned scheme, with the luminosity information transmitted in the DF-24 scheme being an example. No modification is necessary. The exact content of the messages can also be customized.

23. Finally and most importantly, have a nice day.