# CubeSat: LEO Mission Control Unit Potential Communication Concept for AMR System

**A.S. Yahya, W. Hashim, A.F. Ismail, S.H. Sulaiman, M.F. Sulaiman**

***Abstract:** The dramatic drop in equipment pricing, better services and efficiency of small satellite candidate is an interesting communication technology alternative for the deployment of Smart Grid (SG). The use of commercial-off-the-shelf (COTS) components and the ongoing miniaturiza-tion of several technologies have already led to scattered instance of mission with promising scientific value. In this paper, the potential of Low Earth Orbit (LEO) Mission Control Unit (MCU) for small class satellite payloads is presented with the goal of providing utilities in-dustry to low cost and efficiency system towards enhancement of the services provided. Many commercial companies have emerged to cater this objective, however most of them provide an expensive LEO satellites solution. Therefore, this paper proposes a low cost and compact platform to substitute the conventional one. The proposed solution in this paper is targeting Automatic Meter Reading (AMR) system spe-cifically at rural area meter. In particular, this research is intended mainly for the researchers to start an exploration of new technology to be implemented in near future. Advanced development and assessment of CubeSats for SG will make it possible to be used as an alternative communication link.*

***IndexTerms:** CubeSat; AMR System, Satellite Communication, Smart Grid; LEO Satellite.*

## I. INTRODUCTION

Today, satellite becomes an important role in daily life. The evolution of small satellite has occurred rapidly where the significances of low-cost small satellites used for scientific research and application continuously grows in the fields of earth observation, precise climate monitoring, geoinformatics, mobile and personal communications, urban sprawl prediction, etc [1]. With the development of nanotechnology, cube satellites (CubeSats) have achieved a great success proven by increasing number of successful CubeSat launched in space.

According to 2017 World's Largest Database of Nanosatellites, till 14th March 2017, it was recorded that in total, 685 nanosatellites and 613 CubeSats were launched, 405 nanosatellites in orbit, 321 operational nanosatellites and over 71 NanoSats destroyed on launch [2]. Based on these data, it shows that the technology has matured enough where the CubeSat be a part of the trend towards an increasingly diverse set of platforms for pursuing space and earth sciences. Figure 1 shows that CubeSats are likely to be used for educational and technology demonstration purposes, and only 24% of CubeSats were used for science and communications missions [3].

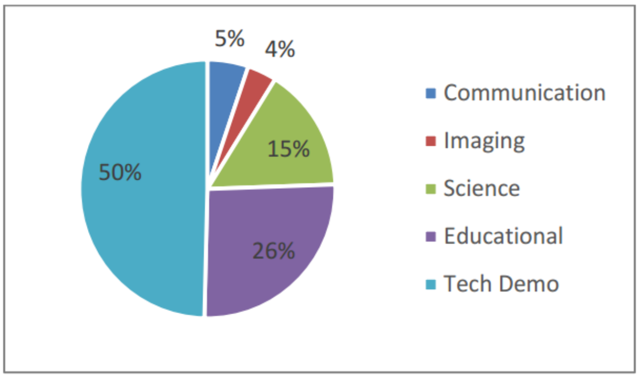


**Figure 1. Cubesat distribution**

CubeSat provides an opportunity to prove new technological innovations at a fraction of the cost of traditional large satellites. These small satellites reduce the launch cost, development cost and time for development because mostly it relies on the COTS components [4]. With high data rate and reliable communication connectivity, CubeSat potentially expected to substitute the growing trends of traditional LEO satellites application in utility industry specifically for rural remote areas.

The advancement of wireless communication technologies has attracted many companies to provide the solution for utilities specifically in Advanced Metering Infrastructure (AMI). There are several options for utilities in deploying wireless communication technologies such as cellular communication specifically at the rural areas. The implementation of cellular technology in AMR raised an issue where the coverage of communication connectivity is not fully covered at the rural and new development areas. It is due to some interference caused by large natural or man-made obstructions. As the result, utility companies suffered a loss of huge amount of money [5]. Therefore, many commercial companies have emerged with a satellite-based solution. However, the solutions provided are expensive due to development and launch cost of satellites. This paper proposed a solution to the predicaments especially in rural remote areas where the capabilities of CubeSats in AMR is presented and discussed. Figure 2 shows the graphical representation of the solution.

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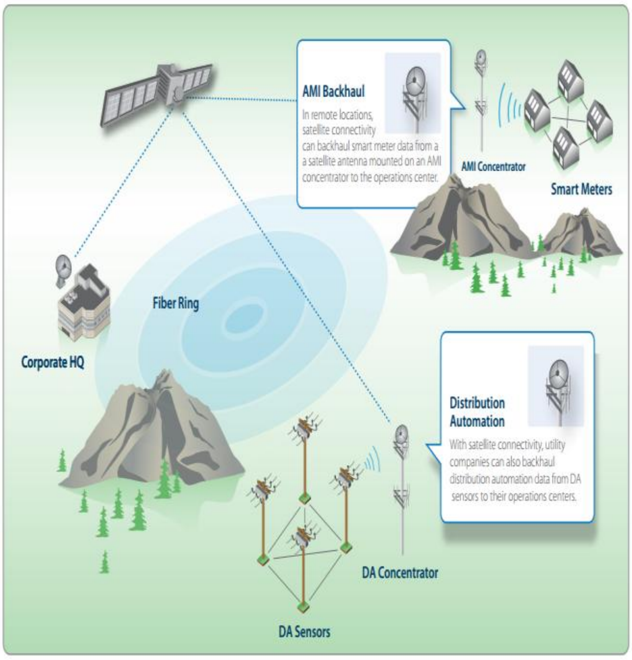


**Figure 2. Satellite implementation in smart grid by C.Bergan, iDireect**

## 1. AMR System

Over the years, the communication technologies to be deployed in AMR system had been greatly discussed by utility companies (electricity, gas, and water supplier), researchers and governments towards enhancing the quality of provided services [6]. The AMR application continuously grows in the fields of utility industry where the significance of automation technology used for collecting the measurement (consumption, diagnostic and status data) from metering devices automatically to the central database and possibly send commands to the meters. Figure 3 shows the AMR system architecture by Tenaga Nasional Berhad, Malaysia [7].

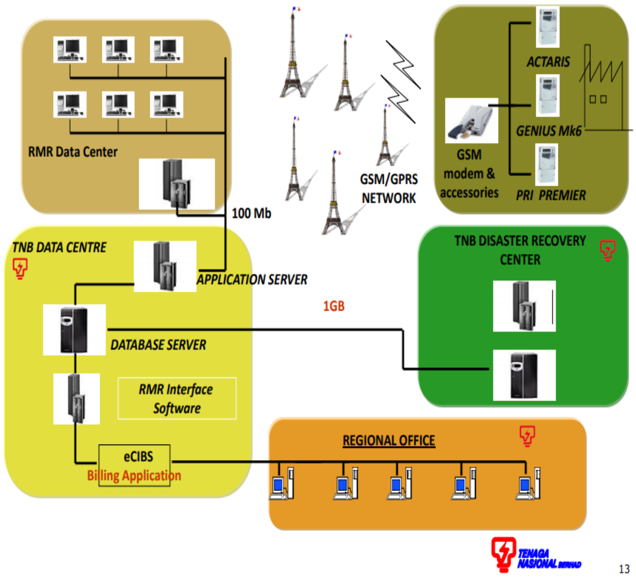


**Figure 3. Tenaga Nasional Berhad (TNB) AMR system architecture**

In AMR system, the communication network plays a vital role as the backbone for a successful system. There are two major types of communication networks categorized into wired and wireless. Various of technologies have been implemented by utility companies in defining optimal communication link such as power line carrier (PLC), cellular network, telephone/Internet, short range radio frequency and satellite communication [8]. It is becoming the most significant challenges faced to define the optimal communication technologies to be used in order to match with the utility's ultimate business needs.

The need for robust and reliable communications connectivity between remote devices and the control center is critical because the power distribution network extends beyond urban areas where cellular connectivity can sometimes be spotty or not available specifically in less population and new development areas. The utilities company mostly relied on cellular network connectivity for that specific areas to monitor and control remote devices such as Supervisory Control and Data Acquisition (SCADA) system and AMR system in near real time in order to increase operational efficiency.

Due to all those facts, it is crucial for utilities to look into other alternatives where cellular wireless communication is not yet an ideal solution to implement at rural areas for AMR system. The increasing trends of satellite-based solution for rural areas where there is low meter density and the meters are far apart but may also be very practical in big cities that would necessitate a large amount of endpoint and other infrastructures [9]. As a solution, satellite-based communication is expected as a good alternative for utilities to overcome that problem. Table 1 shows the comparison of communication technologies for cellular and satellite-based at rural remote areas.

**Table 1. Comparison of cellular and satellite communications**

| Cellular | Satellite |
|---|---|
| Limited coverage at specific areas | Reliable connectivity & broad geographic coverage |
| Tendency to experience congestion | Low latency |
| Restricted bandwidth | Flexible bandwidth |
| Vulnerability to natural and other disaster | Resistance from disaster |

## 2. Potential of Cubesat in AMR System

Satellite communication technology creating an innovative solution for the utilities industry. The high costs and signal delay that limit the use of satellites in the past are giving way to expand the capabilities of small, LEO satellites. With the advancement of nanotechnology, CubeSat potentially provides innovative opportunities for efficient utility business. In this section, the potential of CubeSat is presented and discussed in details.


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### 3.1 Low Cost of Implementation

Today, satellite technologies offer flexible options for utilities to own, manage and deploy a network with low upfront capital investment and minimal operational expenses [10]. Table 2 shows the commercial space launch pricing by Spaceflight.com.

**Table 2. Commercial space launch pricing in USD**

| | Containerized | | | Satellite Class | |
|---|---|---|---|---|---|
| Payload Type | 3U | 6U | 12U | 50 kg | 100kg |
| Length (cm) | 34.05 | 34.05 | 34.05 | 80 | 100 |
| Height/Dia (cm) | 10.00 | 10.00 | 22.63 | 40 | 50 |
| Width (cm) | 10.00 | 22.63 | 22.63 | 40 | 50 |
| Mass (kg) | 5 | 10 | 20 | 50 | 100 |
| Price - LEO | $295 | $545 | $995 | $1750 | $3950 |
| Price - GEO | $915 | $1400 | $2750 | $4600 | $8400 |

The comparison between current and LEO cost proves that LEO satellite is more cost effective compared to traditional cellular AMR system [11] The emergence of satellite-based solution provider's concomitant with the rapid advancement of technology allows the smart system to be implemented at a lower cost compared to the past. Meanwhile, the total cost (development and launch) of placing an educational CubeSat in orbit estimated to be USD52,000 [12].

### 3.2 High Data Rate

Due to size and power constraints of the CubeSat, the selection of transmitter for radio communication links become most challenging part of the development process. The communication requirements for SG in terms of bandwidth is categorized as tabulated in Table 3 [13]. With the capabilities of high data rate up to 100MHz, the CubeSats demonstrated the potential for SG utilization particularly at AMR due to low data rate usage.

**Table 3. Bandwidth characterization requirement for SG**

| | Descriptions |
|---|---|
| Low | Less than 250kbp and often as under 20kbps |
| Medium | 250kbps up to ~1Mbps |
| High | Above 1Mbps |

### 3.3 Reliable Coverage Connectivity

Satellite communication technology introduces less man-made or geographical terrain interferences that led to reliable communication between remote devices and control center compared to cellular communication. In addition, it is more accessible where rugged terrain prevents installing phone line at a reasonable cost. Table 4 depicts the three types of satellites characteristic and the number of required satellites for global coverage. For LEO application more satellites required compare to others.

**Table 4. Features of LEO, MEO and GEO satellite by Phala, 1999**

| Features | LEO | MEO | GEO |
|---|---|---|---|
| Altitude (km) | 750-1500 | 750-11000 | 36000 |
| Operating RF | Below 500MHz) | 1.6 & 2.5GHz | 19 & 29GHz |
| No of satellite coverage | 48-70 | 10-12 | 3 |
| Delay (ms) | 10 | 80 | 250 |
| Hours to orbit | 1.5 | 5-12 | 24 |
| Services offered | Data | Voice & data | Video, Voice & data |

## II. CONCLUSION

LEO application has the potential to improve operational efficiencies of the power utility as well as offering new revenue opportunities to embark utilities industry. Satellite technology, specifically the technology for small LEO satellite (CubeSat) will make it possible to remotely monitor and control dispersed equipment and system by using relatively inexpensive, rapidly deployable infrastructure on the ground.


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