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Concept for an M2M Communications Infrastructure via Airliners

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Abstract: A new concept of machine-tomachine (M2M) communication infrastructure over aircraft is presented. We will cover the most important principles and the challenges that come with them. Initial research into the possibility of covering scheduled aircraft within Europe and North America confirmed the feasibility of the concept. In addition, aspects of system dimensions are explored in a proof-of-principle method to understand their feasibility. All 24hour commercial flights were considered based on actual flight data. The purpose of this paper is to stimulate further research activities and ideas in this area.

Keywords: Airliner, M2M Communications, Coverage, System Dimensions.

1. INTRODUCTION

The demand for Machine-toMachine (M2M) communication is growing all over the world. M2M communication refers to the need to read/send data to/from remote sensors or devices. Its purpose is to track specific events or monitor automated systems. (a) Industrial SCADA (supervisory control and data acquisition) systems. (b) Public systems such as highway toll gates and traffic controllers. (c) Energy system. Current sensors in solar arrays, water level sensors in dams, oil pressure in pipelines, etc. (d) It can also be used for civilian services such as fleet management (i.e. monitoring truck pool positions).

These types of communication are primarily based on sending short messages containing data read by sensors or commands to be executed by remote devices. Most services require a low bit rate and low bandwidth connection. In fact, the messages are short, on the order of a few hundred bytes, and sent several times a day or once an hour. Additionally, services often have to tolerate very high packet error rates. If a message is lost, it is often not resent because updated information should be resent several minutes later. In recent years, M2M communications are increasingly built over wireless networks, allowing a large number of distributed small devices to communicate with a central entity that collects information. First, the proliferation of 2G/3G networks (and later GPRS and HSPDA) led to the use of simple SMS for these types of services. However, deploying M2M services over terrestrial networks proves to be a limited solution due to many uncovered areas such as oceans, mountains, and uninhabited areas. This restriction does not affect all his M2M services (such as public systems), but it obviously affects some others, such as: B. Pipeline monitoring (in remote areas) or ship tracking. If no wireless terrestrial network is available, M2M messages can only be sent via satellite. Despite their high cost, satellites are popular due to several competitive advantages. g. Given the inherent transboundary nature of satellites. Therefore, many satellite operators (Globalstar, Orbcomm, Inmarsat, Eutelsat, etc.) have started targeting the M2M market in recent years, and now there are new existing satellite systems providing messaging services. Despite the advantages of satellite-based M2M, the system also has to deal with drawbacks such as high clearance losses. This is because the clearance loss is proportional to the distance to the satellite. For LEO (Low Earth Orbit) satellites, hundreds of kilometers away can significantly reduce the link budget. This means that M2M satellite terminals must use powerful amplifiers or bulky satellite dish antennas to obtain enough transmission gain to close the link budget. This link budget is actually very unfavorable. B. Comparison with terrestrial cellular M2M systems (operating on 2G/3G networks). Additionally, when using a satellite dish, the alignment with the satellite (usually his GEO satellite for his M2M service) must be accurate. Again, a fixed station would be preferable. As a result, satellite M2M terminals are more expensive and bulky than terrestrial terminals and, as a result, are less popular. Due to the cost of airtime, operating costs are also high. Also, the integration of his M2M terminal on the satellite and on the ground in the same device is very difficult due to the large differences in hardware characteristics (especially antennas). Therefore, his M2M infrastructure, both terrestrial and satellite, has limitations. This paper proposes a new innovative and complementary concept for M2M infrastructure based on the use of scheduled services by aircraft. This concept will be introduced and evaluated in Section 2 as part of a proof-ofprinciple to understand its feasibility. Section 3 examines coverage and Section 4 discusses system sizing. Research questions are highlighted in Section 5. Finally, Section 6 draws conclusions.

2. AIRLINERS M2M INFRASTRUCTURE

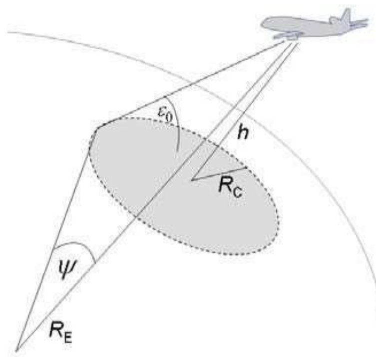

FIGURE 1. Coverage area of an airliner

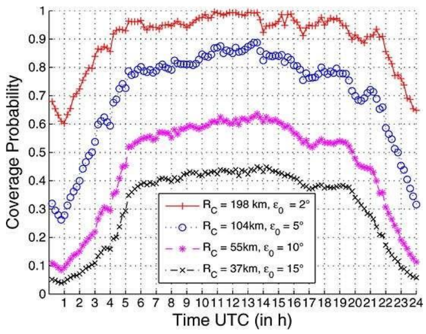

FIGURE 2. Coverage areas of 2092 airliners on the 21st of May, 2007 at 15:00 UTC over Europe

The main novelty of this white paper is to consider airplanes as relay stations for M2M services. From the regular flights of regular flights, we know that countries with large populations (Europe, North
America, Far East, etc.) have a very high density of regular flights. To examine the extent of aircraft lineof-sight through existing traffic, the area on the ground is represented as a circle h. Coverage area of the calculated result. A scheme representing the relevant parameters is shown in Figure 1. where □0is the elevation angle of the aircraft in degrees, RE is the radius of the earth, and h is the altitude of the aircraft. In our study the following values were considered:a
□ =□ 0/180.□, RE □6378000m, h=10000m
□ is the so-called earth central angle [5]:
(1) □= arccos(RE /(RE+h).cos(
□)) - □

The coverage radius RC of
each aircraft is [5]
(2) RC =□.RE□ .
Hence, with the setup parameters and by using □0 □ 5□ , we obtain:
RC =104km

If each aircraft were equipped with a simple transceiver (receiver and transmitter), all M2M terminals in the area would only need to broadcast their messages to any aircraft flying over that location at the time. increase. Figure 2 shows a snapshot of Europa on May 21, 2007 at 15:00 UTC. The resulting coverage is represented by the blue circle. A real traffic scenario was used for this simulation. It contains his world flights for one day (May 21, 2007) extracted from the world flight database [4], [6], [7]. This database includes scheduled passenger flights only (excluding military, helicopter, cargo and general aviation). A transceiver aboard the aircraft may operate according to the following alternative approach:

- May be transparent. In that case, it simply amplifies the message and relays it to the ground stations within its coverage area.

- Messages can be decrypted and forwarded (decoded and forwarded) to earth stations within the service area.
- Can decode messages, consolidate them into “summary” messages, and rebroadcast to ground stations or airports within its coverage area.

Considering commercial aircraft fly about 10 km apart, the link budget is much cheaper than for satellites. For GEO satellites he is 3,600

times better and for LEO satellites several orders of magnitude better.
After examining this new HIS M2M infrastructure, the focus of the next section is to evaluate coverage using examples from his two densely populated regions in Europe and North America.

3. COVERAGE EVALUATION

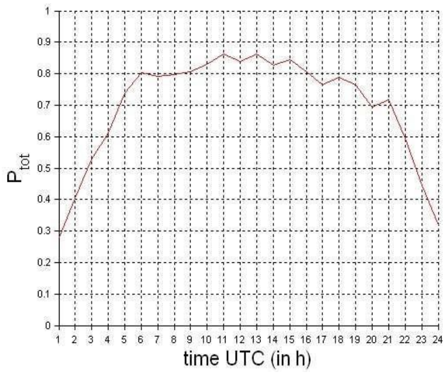

FIGURE 3. Europe-wide

coverage on May 21st, 2007 For evaluating the proposed communications coverage via airliners the worldwide flight database from [4], [6] and [7] is In a first step, coverage used although the focus is here on across Europe was the coverage over European and explored. Figure 3 shows North American landmasses. Two the percentage of European different grids have been defined, land area covered by his namely: M2M infrastructure of - In Europe, 0.5° granularity is commercial aircraft. It considered for latitude and should be noted that it is not longitude (55 km x 55 km possible to cover the whole square). Latitude is from of Europe completely. 35°N to 75°N and longitude Coverage is lacking in is from 10°W to 40°E. sparsely populated areas - In North America, on the such as northern other hand, 1° resolution Scandinavia and low traffic was chosen for latitude and density at night. longitude. Latitude is from Nevertheless, more than 25°N to 75°N and longitude 70% of Europe has his is from 165°W to 50°W. aircraft-based M2M communication Additionally, the simulation time infrastructure available step was set to 30 minutes. This anytime between 5am and means that at each time step a 9pm. sample was taken of whether the aircraft was visible in such Note that the database an area. starts with flights on May 21st and does not include 5.1 Overall Coverage flights arriving or already active on the previous day. On the other hand, the database considers all flights that started on the 21st and ended on the 22nd. Let P21st be the probability of being covered in the 24 hours on May 21 by one or more aircraft of matching neither the departing May 21, and let aircraft launched on P21st be the probability of May 20 nor the aircraft being covered in the 24 launched on May 21. hours by one or more aircraft departing May 21. (3) 1-Ptot = (1- Let's call it P22nd. On May P22nd)(1- P21st), 22nd. 24 h is not (4) Ptot = P21st + P22nd - representative as the P21stP22nd . coverage curve is not symmetrical when P21st is 5.2 Geographic Dependent applied alone. To calculate Coverage a realistic probability of coverage for a 24-hour Ptot, we need to consider all A better picture can be aircraft that took off the day obtained by looking at before and are still flying on geographically dependent May 21st. Let's assume: European and North • Since the flight plan American coverage, as for May 20th is the shown in Figures 4 and 5. same as May 21st, The percentage coverage we take P22nd as strength over 24 hours for the probability of each squared area being covered by at evaluated is shown. least one aircraft that took off on May 20th and is still flying on May 21st. can do. P21st and P22nd are uncorrelated, so at any point in time at any location, the probability of being covered by an aircraft departing on Figure 4: European supply the same day is density over a 24-hour period, independent of the □0 = 5o probability of being covered by an aircraft departing the previous day. Using these assumptions, we can derive an approximation for Ptot from the simulation results as follows: The probability of not matching any aircraft is the probability

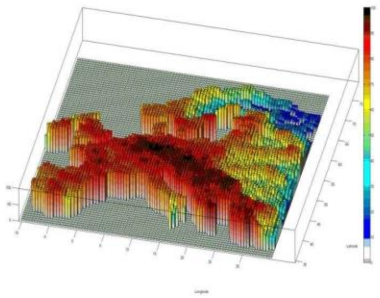

FIGURE 5. North American supply density over 24 hours,

0 = 5o These ratings look directly at lesser-covered regions of Europe. B. Kola Peninsula. Central Europe, Great Britain, the Pyrenees, the Alps and the Iberian Peninsula, on the other hand, are fully covered throughout his 24-hour period, which also correlates with the population density of these regions. The North American continent is also interesting for such a concept due to its high density of scheduled services. As shown in

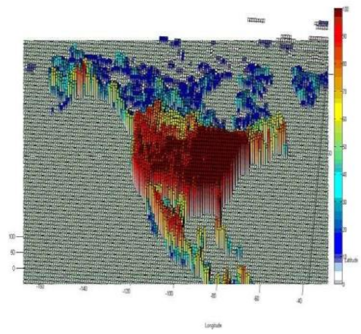

Figure 5, the 48-degree low (that is, the continental United States) and southern Canada have very good coverage. Even the most remote areas of Canada and Alaska have 10% or better coverage. Figure 6: Red borders indicate less European regions Figure 7: Coverage of regions with less coverage in North America to better identify areas that are not covered, Figures 6 and 7 show areas with less than 20% coverage in Europe and North America as solid red lines. However, in uncovered areas, there are 4 or more contacts in a day, with coverage values greater than 10%. Many types of M2M communication via commercial aircraft can therefore be considered fully covered across Europe. Within North America, uncovered regions have been identified, such as the northwestern part of Mexico. B. Chihuahua, and northern regions. Again, only a very small, very remote portion of the northern populated area has less than 10% coverage. Finally, higher coverage is expected today due to the increase in commercial air traffic since 2007. Thus, coverage of his M2M communications by commercial aircraft appears to be sufficient in Europe, the mainland United States, and southern Canada.

4. ASPECTS ON SYSTEM

Dimensions: All aircraft today are equipped with antennas and transceivers in the VHF band ([117.975; 137] MHz) used for Air Traffic Management (ATM). The concepts described in this white paper can be implemented at these frequencies, reusing hardware and devices already qualified for aircraft. This gives him two big advantages: reduced deployment costs and an attractive business model. VHF frequencies can be used in three ways:

1. Assign an ad-hoc channel to this service.
2. Use of dynamically unused channels (due to new cognitive radio technology);

By using Code Division Multiple: Access (CDMA) spread spectrum technology, it operates well below the noise floor of traditional ATM transceivers. The third option is probably the best to implement. (b) The required bit rate for M2M services is guaranteed even with low signal energy distributed across the bandwidth. Nonetheless, we recognize that there are severe limitations in restricting traditional ATM systems and overlay systems. Another interesting frequency band could be the future digital L-band (960-1164 MHz) data link LDACS. The first and second options can certainly provide higher bitrates, but require changing regulatory standards and more complex systems, making them more suitable in the long run. Therefore, the focus of current work is on Option 3. Below you can see the system sizes that are achievable with just a touch of the surface. The new CDMA is expected to operate over legacy ATM systems, resulting in little or negligible interference on all channels across the 19.025 MHz VHF band allocated for ATM. We want to keep these glitches below a certain level of noise □. therefore, (5) SNIRATM = E/N0 + EC* N and

(6) EC* N = □ N0 □ EC* = □ N0 / N

where ES is the energy per symbol for ATM legacy systems, E*c is the energy per chip for CDMA systems, and N is the number of CDMA users transmitting simultaneously. In a CDMA system, the SNIR occurs as follows [5], [9].

(7) SNIRCDMA = E*/ N0 +ES+(N1)EC* = PEC* / N0 + ES +(N-1) EC*'

where E*s is the energy per symbol of the CDMA system connected to E*c by the length P in chips of the CDMA sequence. Using these equations, it is possible to derive the length P* that a given target SNIR*CDMA will provide for a given SNR of ATM Legacy Systems (ES/N0) ATM, thereby satisfying the objective Allows correct decoding for CDMA users with a

BER of (bit error rate):

(8) P* = SNIR*CDMA [1+(ES / N0)ATM + (N-1/N) □]N/□

As a result, the bitrates experienced by CDMA users are: (9) RB* = RC*rlog2(M)1/P*,

where r is the code rate, M is the modulation order (r log2M is the spectral efficiency of the CDMA system), and R*c is the chip rate, ie the bandwidth used in the CDMA system. Finally, Figure 8 shows simulation results for this scenario using conservative values for the parameters mentioned above.

(ES/N0)ATM = 4dB, = 0.1, rlog2M = 1, R*C =15 MHz. Even with thousands of M2M devices transmitting simultaneously in the aircraft's coverage area, we find that the system can handle message lengths of hundreds of kilobytes, which is highly unlikely.

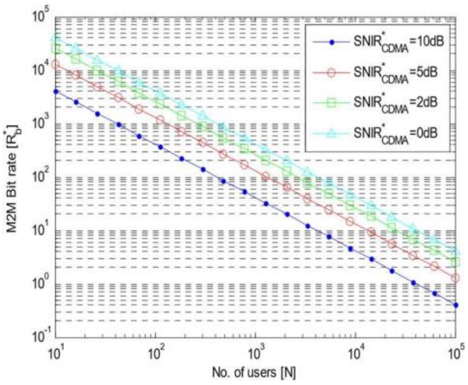

FIGURE 8: Achievable bit rates for M2M services and number of active M2M devices.

Another aspect of the system dimension has to do with media access control (MAC). The MAC layer implemented in his M2M terminal on the ground should be as simple as possible. For this reason, Random Access (RA) techniques have been identified for this purpose. In recent years, RA techniques have advanced and some new ideas have been introduced to improve the throughput of these uncoordinated channels. This keeps the idea of a simple transmitter with minimal complexity while shifting complexity to the gateway side. 10], [11]. With RA technology, you can keep the number of users accessing the channel simultaneously at the desired level. This affects the number of users N. The number of users is not fixed, but can change dynamically, adjusting each user's activity (or probability of accessing the RA channel) within the CDMA system to control N. CDMA despreading also handles decoding of simultaneously transmitted users. It is also possible to employ new techniques that combine RA and spread spectrum solutions (eg [11]).

5. CHALLENGES

With a better knowledge of the system and its requirements, new concepts with small omnidirectional antennas can be used to build inexpensive M2M terminals. If desired, these terminals can be easily integrated into conventional M2M terminals operating in mobile networks. Sizing and requirements are derived from research on the following slightly more difficult topics:

- Regulatory aspects related to air traffic management and civil aviation.
- Waveform study, synchronization and equalization.
- Short FEC Code. Based on

Galois field;

- Random access method.
- Header compression and efficient upper layers.

We believe that these challenges will motivate future research topics in this new field.

6. CONCLUSIONS

An idea of M2M communication infrastructure via airplane is presented. A first proof of principle is provided by occultation analyzes on European and North American land masses. We were able to show that comprehensive coverage of these areas by airliners is possible. In addition, CDMA systems assigned to the VHF band were tested for their ability to support the requirements of M2M communications. The areas, techniques and techniques already highlighted in this document are only the first glimpse of many potential research areas in his emerging field of M2M communications via aircraft.

REFERNCES

[1]. S. Hattangady, “Wireless M2M – The Opportunity Has Come! (Part 1)”, http://emblazeworld.co m

[2]. 3GPP TS 22.368 V10.1.0, "Service requirements for machine-like communications", July 2010. ESA SAMOS Project, www.eas.int Innovata. [Online]. Available: http://www.innovatallc.c om/

[3]. E. Lutz, M. Werner, A. Jahn, “Satellite Systems for Personal and Broadband communications”, Springer, Berlin, 2000.

[4]. Donner, A.; Kisling, C.; Ermenia, R.; "Satellite Constellation Networks for Aviation Communications: Traffic Modeling and Link Load Analysis", Communications, IET, Vol. 4, No. 13, pp. 1594-1606, 3 September 2010.

[5]. Ermenia, R.; Kisling, C.; Donner, A.; "Delay Models for Satellite Constellation Networks Using Intersatellite Links," Satellite and Space Communications, 2009.

