UDC 621.396.946 (045)

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MODELING OF ADS-B MESSAGES TRANSMISSION VIA IRIDIUM SATELLITES COMMUNICATION CHANNEL

In this article the idea of ADS-B message transmission via communication channel by means of Iridium satellites was considered. The transmission model based on real parameters was created and investigated.

With the continuous aviation development amount of flights through the Poles and regions with reduced radar coverage grows annually due to its economic efficiency. So aviation met the challenge that consists mainly in conversion from ground-based CNS systems that are not available at any point of the globe and expensive at service to satellite-based systems that are cheap at service and cover 100% of the Earth. This conversion will be beneficial for either airspace users due to decreased air navigation service cost and air navigation service providers due to low cost of equipment maintenance and constant awareness of air traffic situation in any point over the globe.

1. General formulation of the problem

An ADS-B-equipped aircraft determines its own position and periodically broadcasts (about once a second) this position and other relevant information to ground stations and other aircraft equipped with ADS-B technology. Position and velocity vector are derived from the Global Positioning System (GPS) or a Flight Management System (FMS). The special interest consists in ADS-B messages transmission via the Iridium satellite constellation, because there are 66 satellites at an altitude of 780 km that cover 100 % of the Earth surface. These significantly result in elimination of message transmission delay and high satellites availability. Iridium satellites are able to perform intersatellite connection with 4 satellites simultaneously transmitting data at a rate of 10 Mbit/s.

2. Communication channel modeling

For modeling of ADS-B message transmission via communication channel by means of Iridium satellites the computer program NetCracker® Professional is used [1]. Communication channel model (fig.1) consists of the following components: airborne stations that are aircraft ADS-B systems, Iridium satellite and ground ATC center. The model parameters are set according to the real parameters of the Iridium satellites and ADS-B system [2].

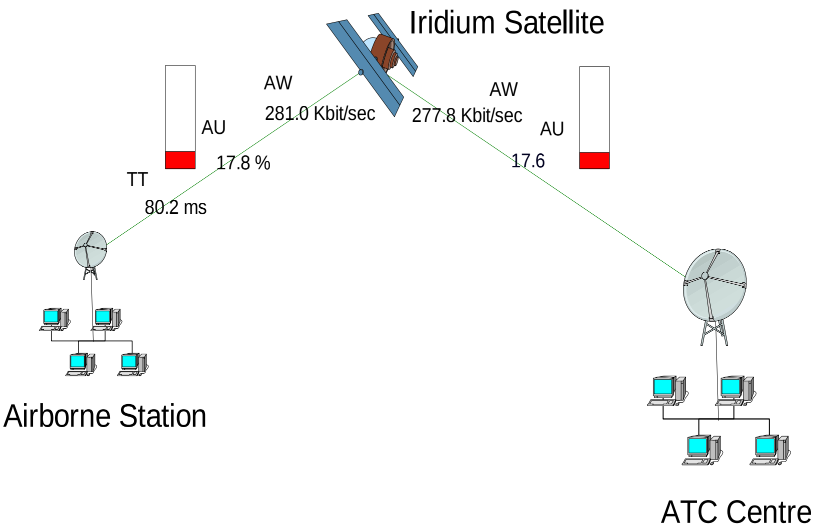
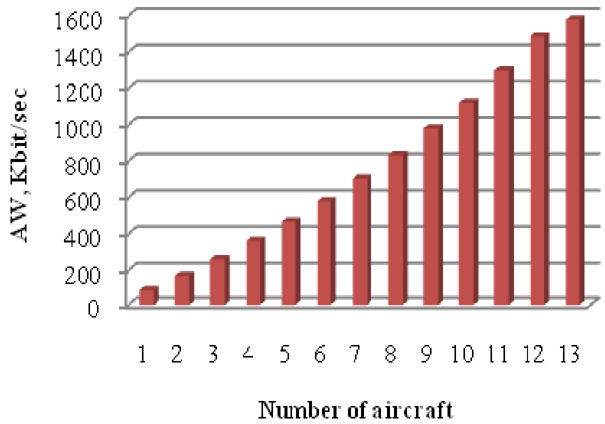


Fig. 1. ADS-B message transmission via communication channel by means of Iridium satellites modeling

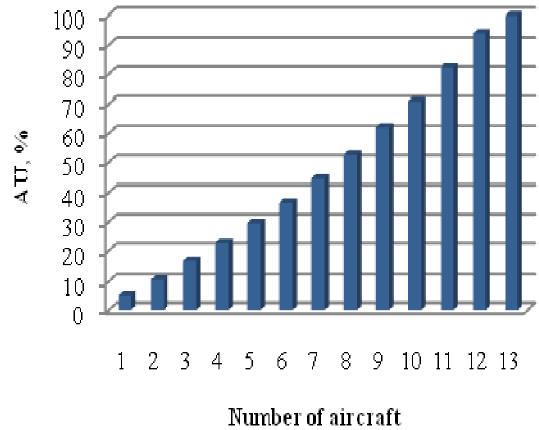
For model analysis the parameters of average workload (AW) of the link, its average utilization (AU) and travel time (TT) of traffic between airborne station and ground ATC station were chose. Analysis of this model reveals that connection of each additional ACFT involves increase of average workload (fig. 2, *a*) and average utilization (fig. 2, *b*) of the link.

The saturation point of the link is reached when 13 ACFT are connected. It means that communication channel constructed with a given parameters is able to serve 13 ACFT simultaneously. That is not enough for aviation purposes. So the problem is how link capacity can be increased.



a

Fig. 2, AW/Number of ACFT dependence (a)



b

AU/Number of ACFT dependence (b)

3. Investigation of modeling results

For solution of the problem it is important to highlight what average workload, average utilization and travel time influence and depend on. For this purpose the simplified model with one airborne ADS-B system is investigated. Analysis reveals that average workload, average utilization and travel time depend on: Transaction Size, Time Between Transactions, Link Latency and Link Bandwidth. In its turn, average workload, average utilization and travel time influence Bit Error Rate and Packet Fail Chance.

Such parameters as transaction size, link latency, bit error rate and packet fail chance are the subjects of profound analysis in this article.

Transaction Size (TS)

The transaction size of airborne ADS-B system – Iridium satellite – ATC center link influences the investigated parameters. Average workload and average utilization increase constantly with transaction size increasing (fig. 3, *a*, b). Their marginal values are achieved when transaction size equals to 90 Kbits. The Travel Time rapidly increases in the beginning. As from 1000 bytes moderate growth is observed with increasing of transaction size (fig. 3, *c*). Models of 1000 bytes transaction size and 3500 bytes transaction size are compared in fig. 3, *d*.

Link Latency (LL)

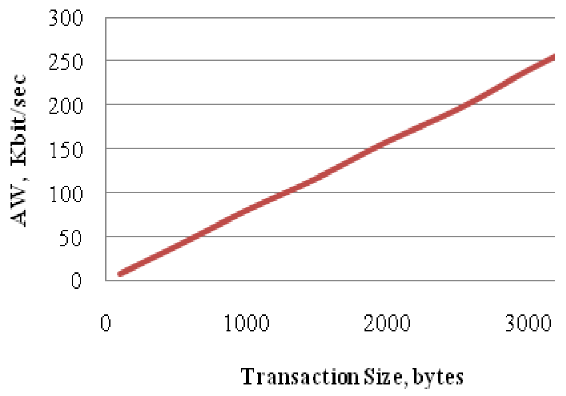
Latency of airborne ADS-B system – Iridium satellite link affects travel time in a way represented on fig. 4, *a*. Average workload and average utilization don't depend on link latency. One the engineer's purpose should be the reduction of latency as far as it is possible to decrease travel time as this parameter influences the message transmission effectiveness. Changes of models' indicators during the latency increase are shown in the fig. 4, *b*.

Bit Error Rate (BER)

Average workload influenced by transaction size, time between transactions, link latency and link bandwidth affects bit error rate (fig. 5, *a*). This impact causes the average utilization and travel time changing (fig. 5, *b*, *c*). The analysis reveals that pattern of change of investigated parameters doesn't depend on the type of protocol. The models' comparison (fig 5, *d*) shows the disability of the link – at BER equals 0,07 % average utilization is already 100% that means that link is not available for message transmission any more.

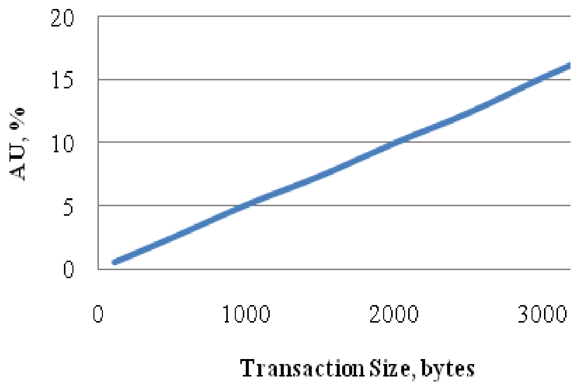
Packet Fail Chance (PFC)

The Packet Fail Chance of Iridium satellite is affected by average workload as well (fig. 6, *a*), that causes the changes in average workload of the link and travel time of transmission (fig. 6, *b*, *c*). Packet Fail Chance shows up the reliability of the satellites, that's why the AW should be held on a suitable level for refusal number decreasing.



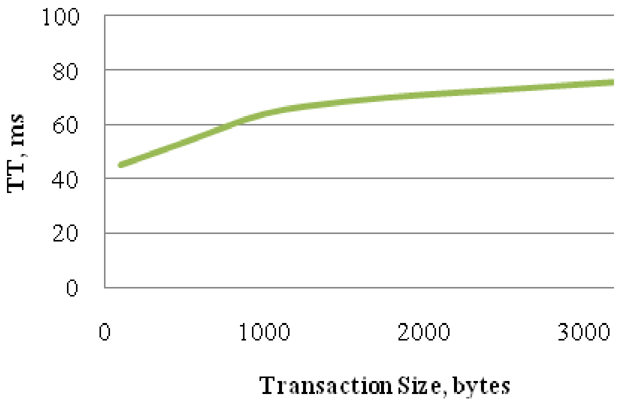
a

AW/TS dependence (a)



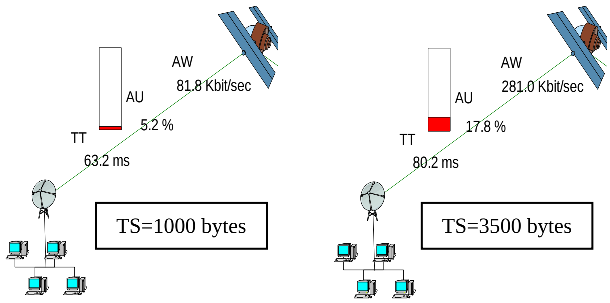
b

AU/TS dependence (b)



c

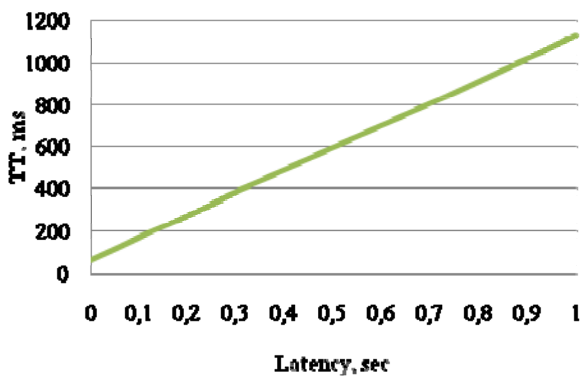
TT/TS dependence (c)



d

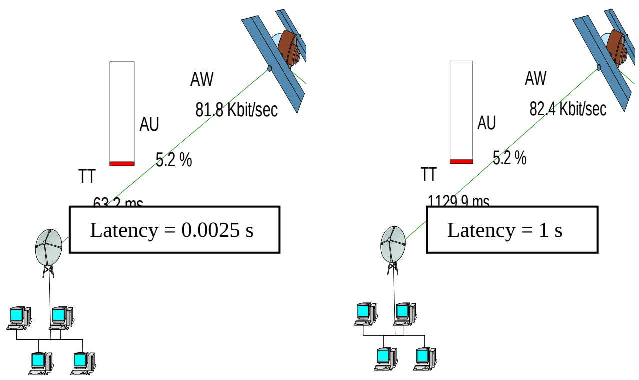
Models’ comparison (d)

Fig. 3



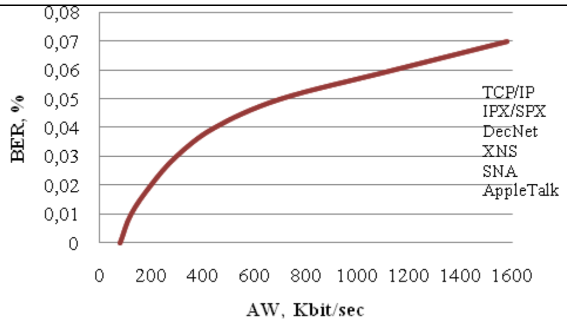
a

Fig. 4, TT/Latency dependence (a)



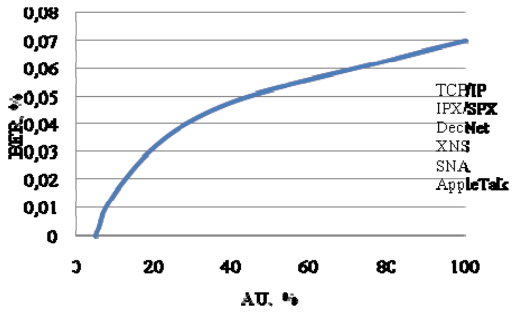
b

Models’ comparison (b)



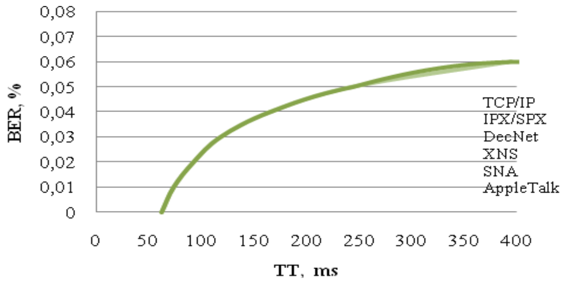
a

BER/AW dependence (a.)



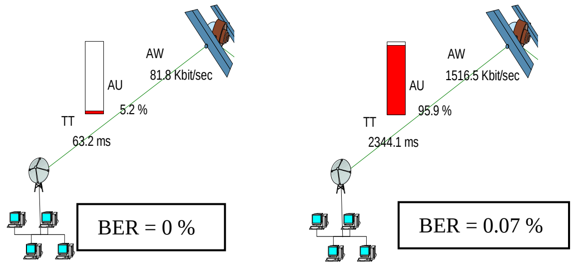
b

BER/AU dependence (b)



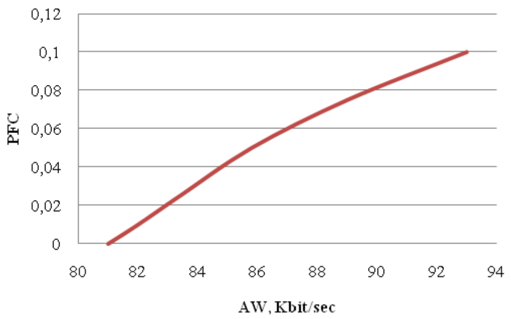
c

Fig. 5, BER/TT dependence (c)



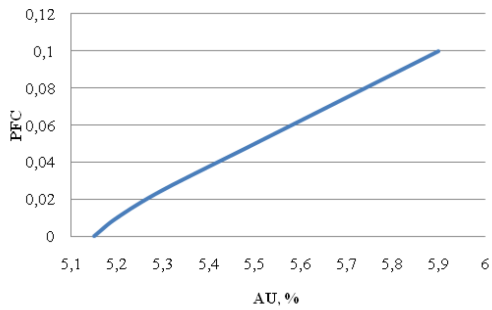
d

Models' comparison (d)



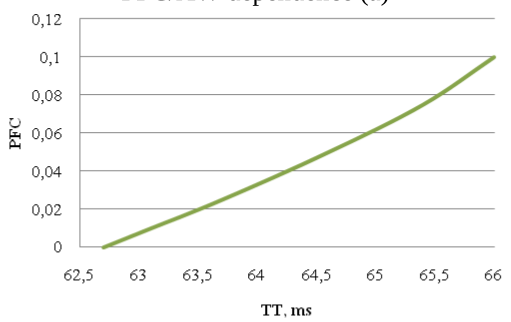
a

PFC/AW dependence (a)



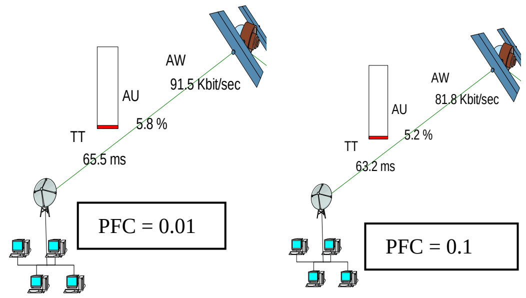
b

PFC /AU dependence (b)



c

Fig. 6, PFC/TT dependence (c)



d

Models' comparison (d)

Conclusion

In future usage of Iridium satellites will be beneficial due to great productivity and availability. And the preliminary research is very important for choosing the optimum parameters of the link to ensure the best capacity, efficiency and reliability of it.

References

1. *Netcracker Technology.* NetCracker User`s and Reference Manual. – 2006.
2. *Manual* for ICAO Aeronautical Mobile Satellite Service. Iridium. – 2007.

Scientific supervisors – Grekhov A. M., professor, Barabanov Y. M., assistant professor