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Authorization of Commercial Communication Satellite Grounds for Promoting Turkish Data Relay System

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***Abstract*—**Uninterrupted and continuous satellite communication through the whole orbit time is becoming more indispensable every day. Data relay systems are developed and built for various high/low data rate information exchanges like TDRSS of USA and EDRSS of Europe. In these missions, a couple of task-dedicated communication satellites exist. In this regard, for Turkey a data relay system is attempted to be defined exchanging low data rate information (i.e. TTC) for Earth-observing LEO satellites appointing commercial GEO communication satellites all over the world. First, justification of this attempt is given, demonstrating duration enhancements in the link. Discussion of preference of RF communication is, also, given instead of laser communication. Then, preferred communication GEOs – including TURKSAT4A already belonging to Turkey- are given, together with the coverage enhancements through STK simulations and the corresponding link budget. Also, a block diagram of the communication system is given on the LEO satellite.

***Keywords*—**Communication, satellite, data relay system, coverage.

I. Introduction

SATELLITE communication, today, is indispensable for a variety of needs all over the world. When the communication speed and limitations in the frequency spectrum allocated for RF communication are taken into consideration, intersatellite communications concept is emerging as an important technology and the value that can be achieved through a single satellite is substantially increased thanks to this technology. For example, time visibility between a standard low altitude sun sychronious LEO and an earth observation satellite ground station is limited to about 10 minutes for each pass. In our country, during the 10-minute average each of total 4 passes in a day, this communication can be established [1].

When a communication link between a satellite in low altitude and a relay satellite at 42 degrees East in geostationary orbit (GEO), communication facility provided can go up to daily 12/year-mean and total communication time between the two satellites, up to 17 hours. The actual total communication time schedule proceeds as in Fig. 1.

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According to Fig. 2, just after 1 year, communication between the LEO and the dedicated GEO satellite is about 13 times more time than having to communicate with the ground station in Ankara. A look at the communication facility shows the ratio of approximately 9. The response times, which are the periods between two successive communication time established between two satellites are not seen from this graph. Although the response was comparable period can be offered within a chart as in Fig. 3. This chart shows, for a period of 4 days, communication response time change of a LEO satellite ground stations spread across different geographical regions all over the world and the same alteration with the addition of a GEO relay satellite. With a single ground station, communication response time can go up to 13 hours while, with the addition of relay satellite, that time is reduced dramatically. Accordingly, the maximum response time when the relay satellite is added, is seen to be about 40 minutes.

II. Communication Types

There are two main means of communication for the implementation of inter-satellite communication (ISL) in practice: Radio frequency connection (RF) and optical/laser communication. RF communications systems, providing easy large scale networkless communication with a point to point coverage. The optical system does not include regulatory restrictions in terms of bandwidth and is jamming resistant. 'Narrow beam' and 'high versatility' features of laser reduce the possibility of interference fairly. However, optical communication, can reach up to 'Gbps' data rate speeds but has a relatively low angle optical sensors (FOV support). Thus, for global coverage, many optical pieces should be used or by scanning, viewing areas should be expanded. Furthermore, the optical sensor systems, for a healthy communication link, must have the subsystems of extremely well monitoring, pointing and locking. These systems, during "Target Scan" and "Connection Establishment" processes, require direct line-of-sight, that high relative velocity makes this process extremely complex. Such a communication link is established with up to 50 Mbps, between SILEX (Semiconductor Laser Intersatellit Link Experiment) subsystem on ARTEMIS (GEO) and SPOT-4 (LEO) on a daily basis [2].

Compared to optical sensors, RF communication seems to be more convenient. Achievable speeds of the RF links are lower than the optical connections, but if the dedicated satellite mission requires only telemetry/telecommand messages, the navigation information from the health and status information, and a high volume of non-scientific knowledge, then the bit rates as low as 10 Mbps is more suitable for RF connection. The above-mentioned positive characteristics of the optical systems (e.g. Adjacent channel interference, multi-channel degradation, atmospheric and anthropogenic noise resistance), through a careful system (e.g. Use of spread spectrum techniques) and RF design can be made more reliable and easy-to-apply. At the same time, for very high-speed communications and optical sensors with a very precise directivity information, optical systems are the best solution but RF communication should be preferred for smaller satellite systems. [3]

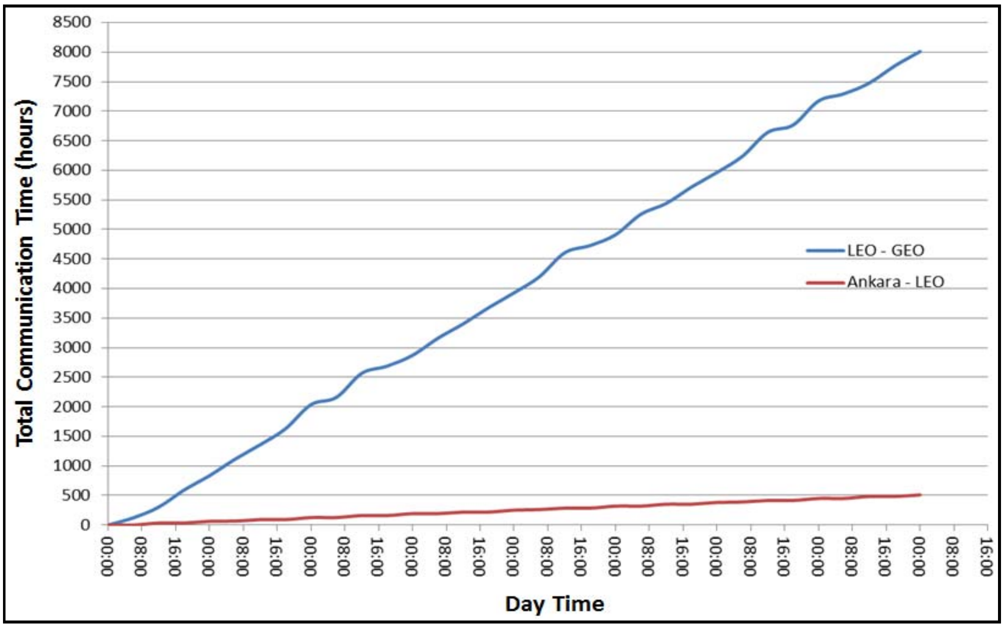

Fig. 1 LEO Satellite - Ankara (Red) and LEO Satellite - 42 Degrees East GEO Relay Satellite (blue) within 8 days, time-dependent total communication time

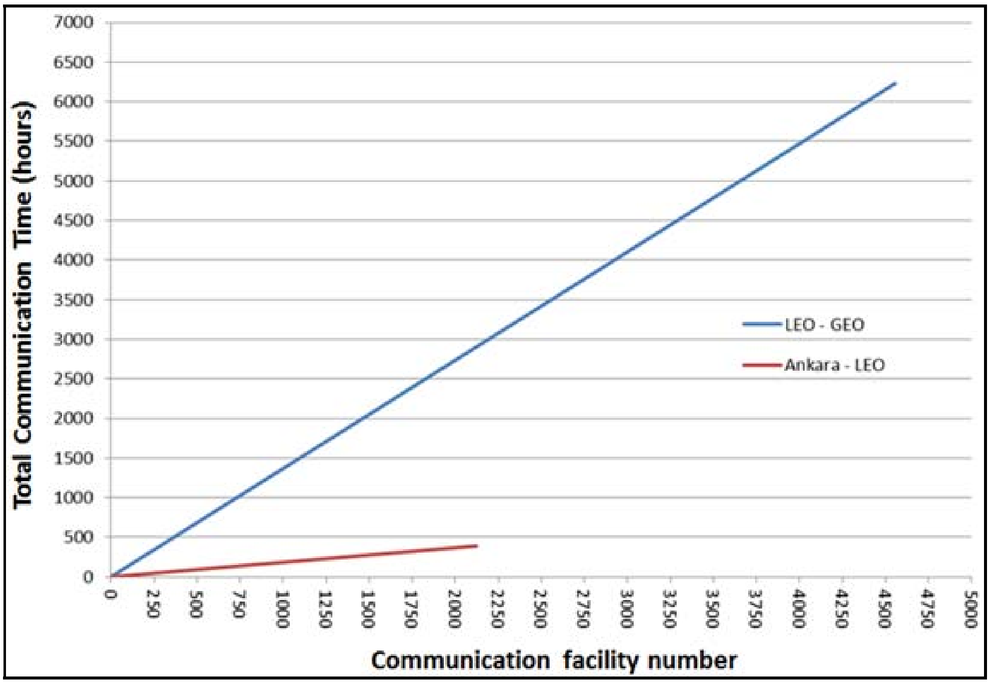

Fig. 2 LEO Satellite - Ankara (Red) and LEO Satellite - 42 Degrees East GEO Relay Satellite (blue) for a total time of 1-year communication facilities and a total communication time chart (cumulative)

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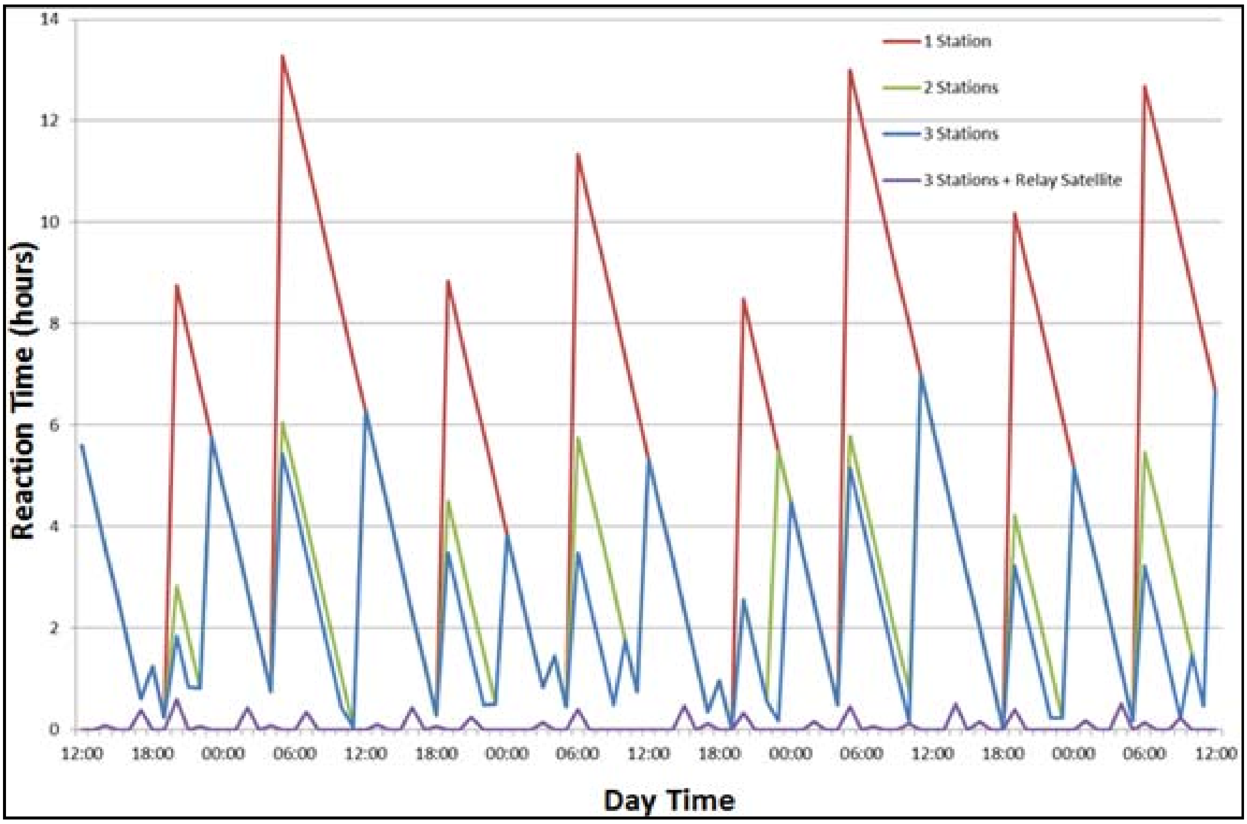

Fig. 3 Communications Response Time between Earth-station and Satellite

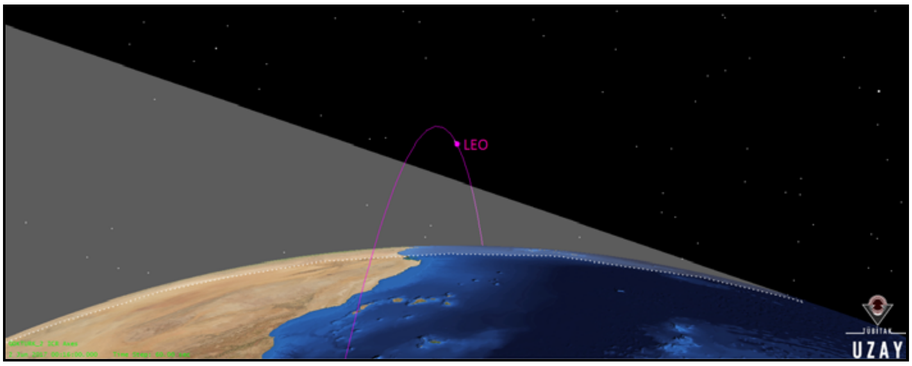

Fig. 4 LEO situation going out of the coverage area of GEO

III. Example Scenario

The example used in real case scenarios, three GEO satellites already in orbit are as follows [4]:

- T4A – 42° East
- NSS6 – 95° West
- TELSTAR11N - 37° West

One of the three satellites above (T4A) belongs to TURKSAT, but others (NSS6 and TELSTAR11N) are intended to provide global coverage in terms of satellite coverage areas. At the same time, when global coverage areas of TURKSAT with satellites to be launched until 2019 are taken into consideration – where the fact, at least three-sum produced in our country, with a total of seven satellites forming a fleet, consisting of South America, North America, Eastern Europe, Asia and adding to our coverage of western Austria with all of Africa, and thus 91% of the world's population accessibility through our satellites is clearly specified [5] – LEO/GEO data transfer for these two satellite locations can, also, generate suggestions.

In Fig. 4, an interesting example is shown during LEO and GEO satellites communication. The mentioned situation is the non-intersection between the GEO coverage area and LEO. Thus, in Fig. 5, dashed area shows the actual ground coverage areas of corresponding GEO satellites, whereas bold areas indicates affective communication areas.

Here, Fig. 5 effectively dealt with in each of the three satellite communication antenna (G/T ≥-6 dBm / Hz) and the earth coverage (dotted lines), respectively. Under these conditions, the average increase in LEO communication time is calculated as:

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- LEO regular communication = 64.6833 sec duration of the day, 3880,998 min = ~ **1h**
- **T4A** supported additional communication time =1375.124 sec = ~ **22 min**
- **Telstar11N** supported communication time =7471.245 sec = 124.52075 min= ~ **2 hours**
- **NSS6** supported communication time =5207.140 sec = 86.7856 min = ~ **1,446 hours**

Total additional support of NSS6+Telstar11n+T4A is approximately ~ **3 hours and 42 minutes**.

It should be noted that, these given values show the GEO transfer time from LEO. Ankara is covered by each three satellites with different EIRP values.

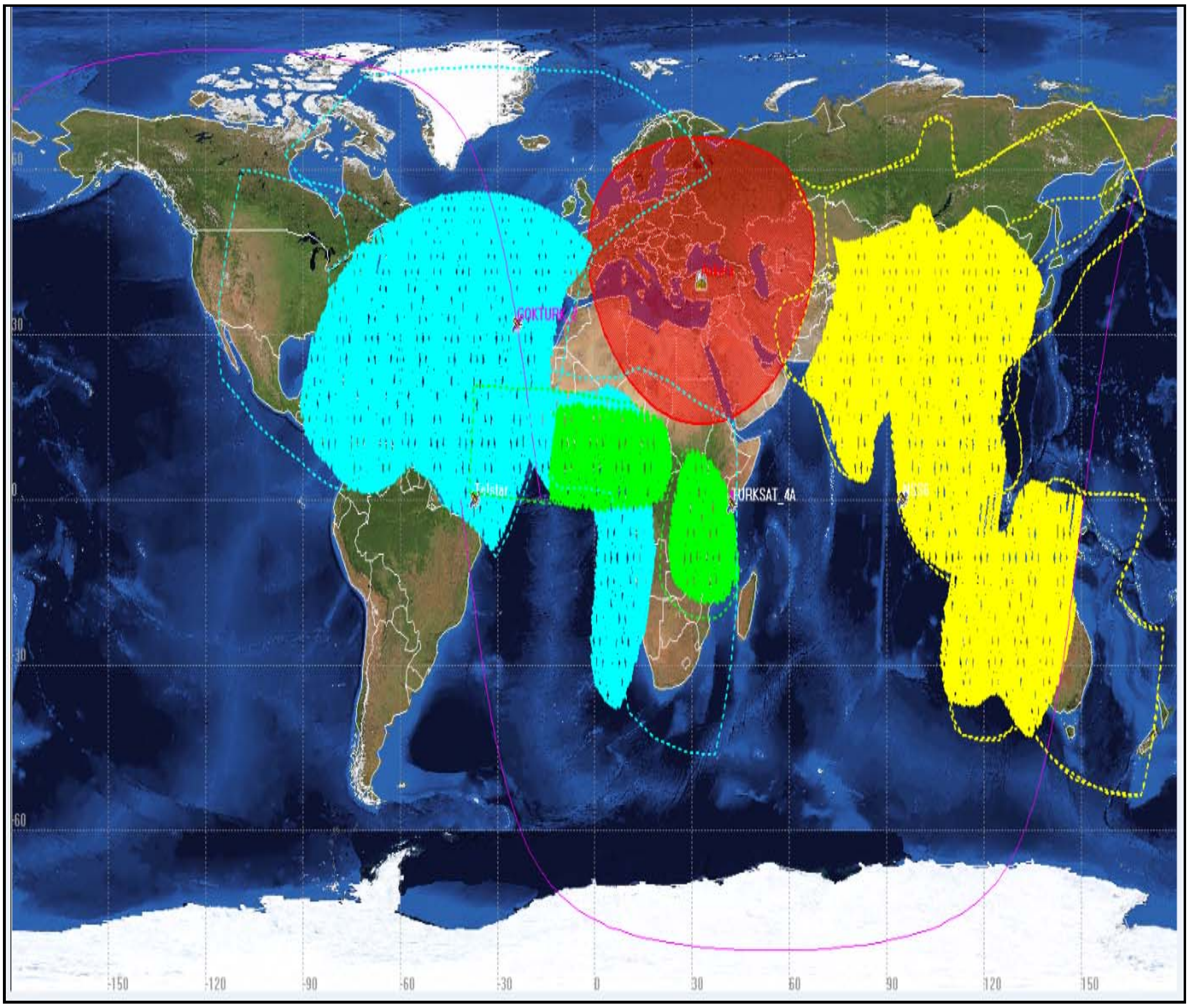

Fig. 5 The effective coverage of all three GEO satellites used (Telstar 11N: Blue - NSS6: Yellow -T4 to: Green (partial))

IV. Communication Link Budget Analysis

Fig 6, Example link budget calculation (from LEO to GEO) is issued as a worst-case link budget (Fig 7). This budget provides ~20W output power of the transmitter at the end, using possible values on LEO. (On transmitter during the transition, the assumption that the adaptive power adjustment is not carried out). Also, an exemplary RX/TX chain on LEO satellite on space facing facet is given in Fig. 8.

V. Data Relay System

TDRS (Tracking and Data Relay System) in the United States and the newly born EDRS (European Data Relay System) in Europe, a similar structure, passing from the use of communications satellites launched projects. Satellites of these systems are in orbit GEO and LEO-only earth station (TDRs / EDRS), manned flights-ground station (TDRs) and so on. They are used for data transmissions.

TDRS is the most advanced and oldest example of the above-described communication system. S in Ku and Ka band is capable of relaying tasks. But also of importance for our global coverage that task is performed in the S-band.

Like a relay GEO satellites, Turkey Data Relay System (TVRS) within can be constructed to operate in C-band.

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Link Budget Equations and Calculations	
PT (in dBm, output power of the transmitter)	**43**
Loss due to the imperfections of the transmitter(the transmitter deforms the modulated output and this deformation increases the theoratical required Eb/N0 value)	**0,5**
Cable loss (total loss between the antenna and the transmitter)	**0,7**
Tx antenna gain (in dBi)(minimum value of antenna gain at this elevation)	**33**
EIRP (in dBm)	74,8
Path (in m)(path for a satellite at 40000 km orbit from GEO)	**40000000**
Frequency (in MHz)	**17500**
Loss due to radom(if it is not planned to use a radom, then this value can be ignored)	**0,35**
Atmospheric Loss (in dB) (total atmospheric loss including, gasses,clouds and rain for Ankara for an valiability of 99.5%)	**0,1**
G/T degradation due to rain for the avaliability of 99.5%	**0**
Pointing Loss (in dB)	**2**
Polarization loss (in dB, includes both the polarization loss due to satellite antenna and the polarization loss due to receive antenna, 1,0dB is from the transmit antenna and 0,5 dB from receive	**1,5**
Rx Antenna Gain (in dBi)	**21**
Noise Temp of Antenna (K)	**235**
Noise Temp of LNA (K)	**255**
Total Noise Temp (K)	490
Total Noise Temp (dB/K)	450
G/T of receive antenna (calculated)	-5,9019608
Data Rate	**0,01**
roll off	**0,5**
Implementation Loss (loss due to the imperfections of the receiver,0.5 is taken as typical value)	0,5
Multipath Loss	0
Processing gain	0
Eb/No (G/T as input)	13,607476
Required Eb/No @ 10-6 BER	**10,6**
Margin	**3,007**

Fig 6 Link Budget Calculation

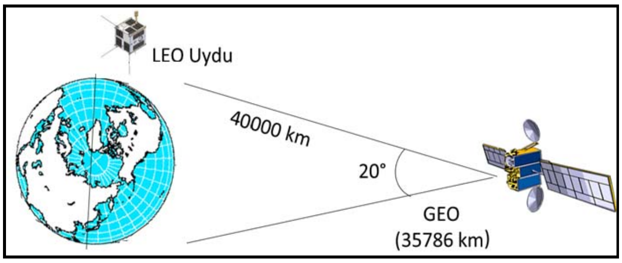

Fig 7 LEO satellite and GEO satellite – worst case scenario

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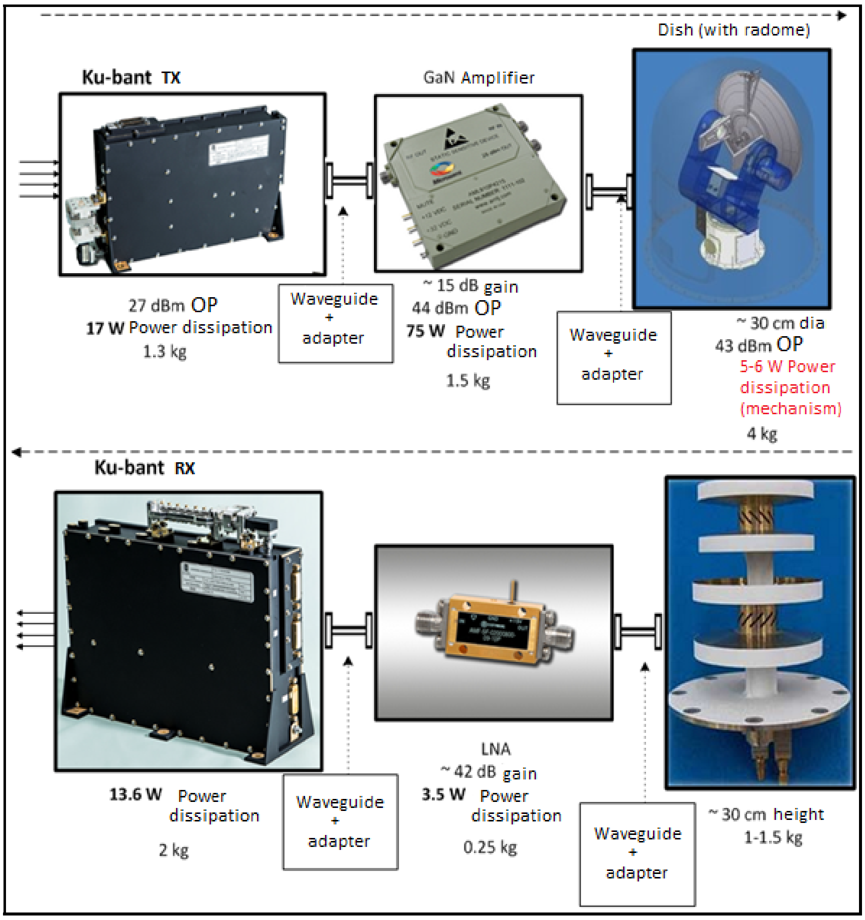

Fig. 8 Exemplary RX/TX on LEO

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