National Aeronautics and
Space Administration
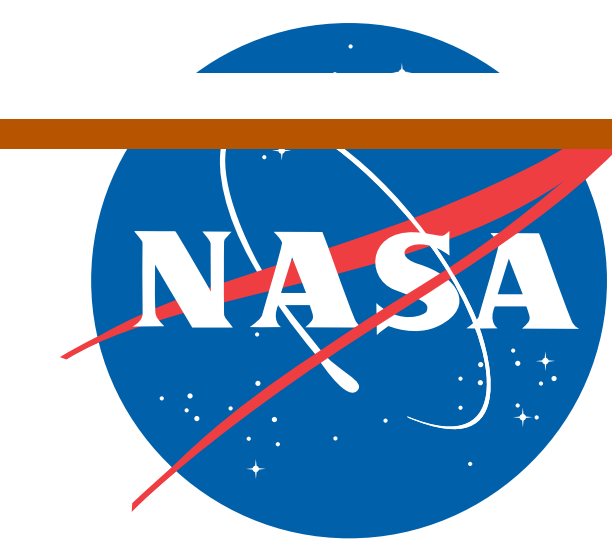
LINK ANALYSIS OF HIGH THROUGHPUT SPACECRAFT COMMUNICATION SYSTEMS FOR FUTURE SCIENCE MISSIONS

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I. INTRODUCTION

- In the next ten years NASA plans to launch several spacecraft into Low Earth Orbit (LEO) for remote sensing of the Earth with instruments that will accumulate several hundred gigabits of data per orbit
- The ability to handle such a large volume of science data per orbit far exceeds the capabilities of NASA's current space and ground assets
- The paper proposes two solutions: first, a high data rate link between the LEO spacecraft and ground via relay satellite in geostationary orbit (GEO). Second, a high data rate direct to ground link from LEO

II. KA-BAND SPACE-TO-SPACE LEO-TO-GEO LINK

The relay satellites are located in GEO. The LEO-to-GEO link is designated as the return link (RL) to the relay satellite and operates at Ka-band (25.25 to 27.0 GHz) frequencies. The GEO-to-LEO forward link (FL) operates at K-band (22.55 to 23.55 GHz) frequencies.
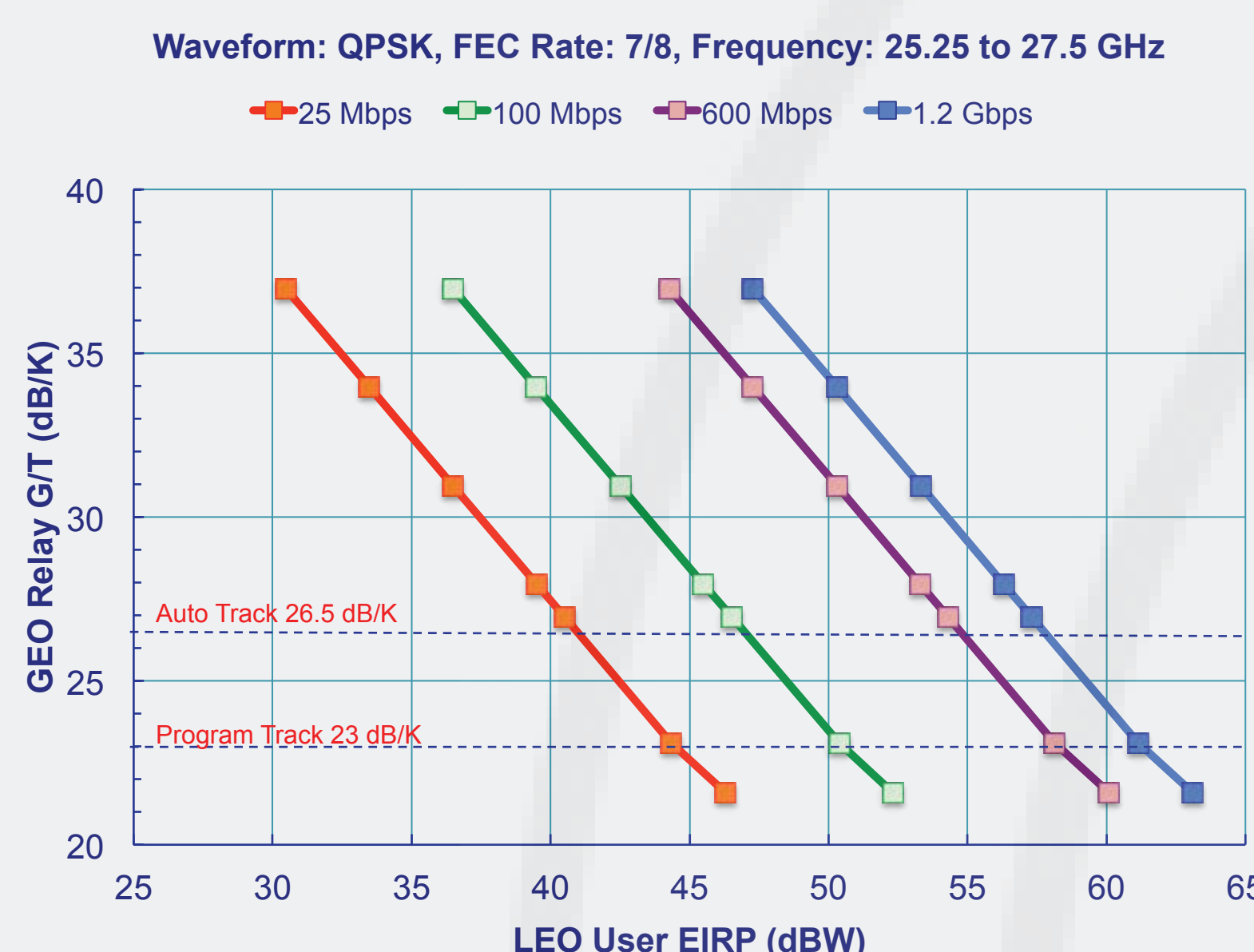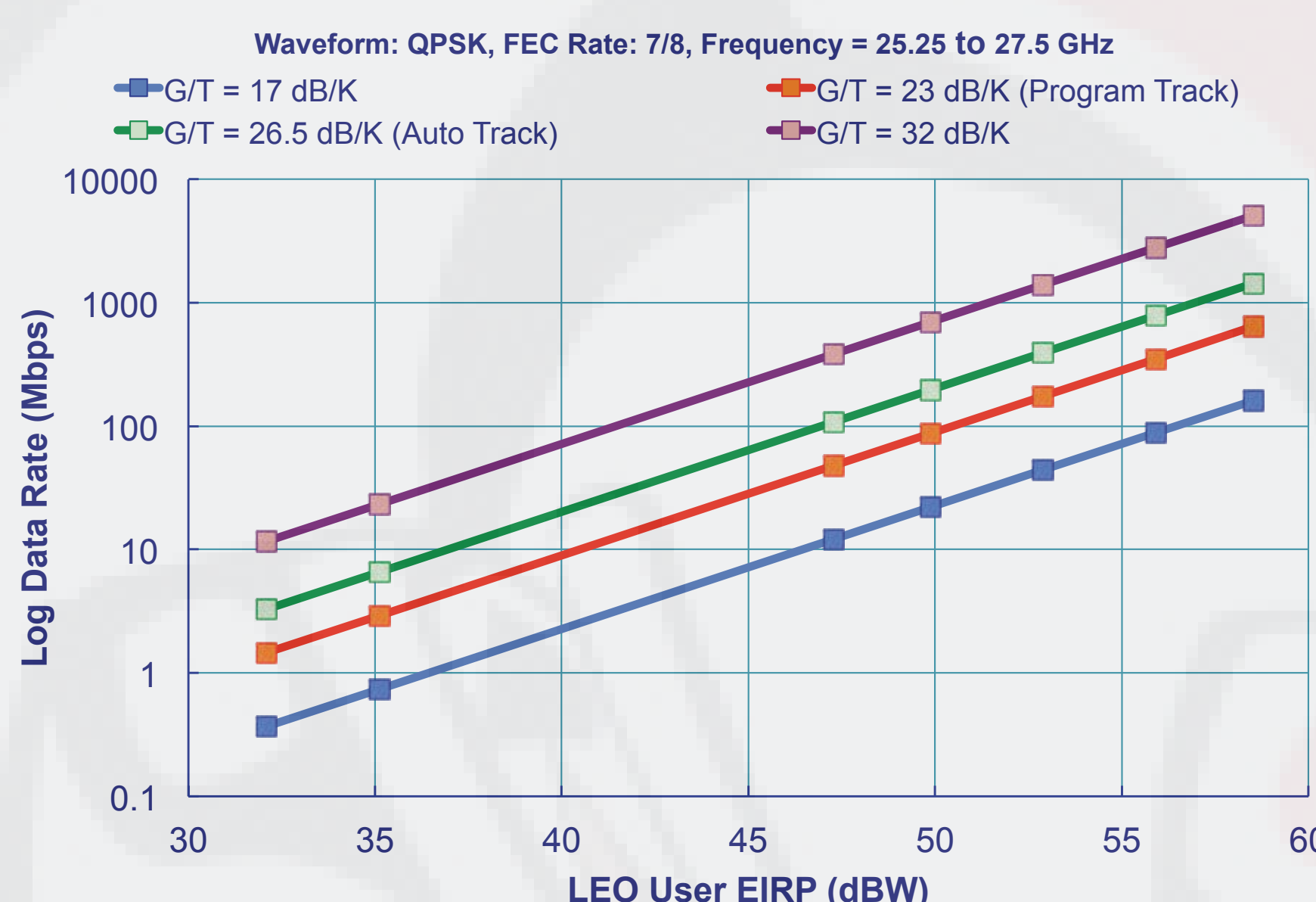
LEO-TO-GEO RELAY SATELLITE LINK
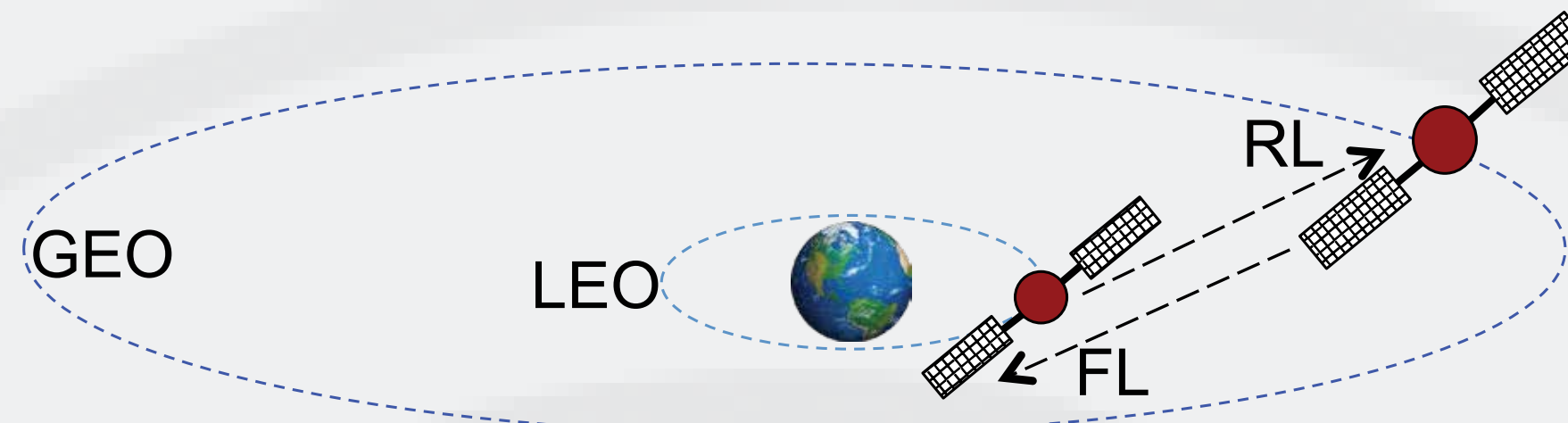
### SPACE-TO-SPACE LINKS AND SPACE-TO-GROUND LINKS VIA RELAY SATELLITE
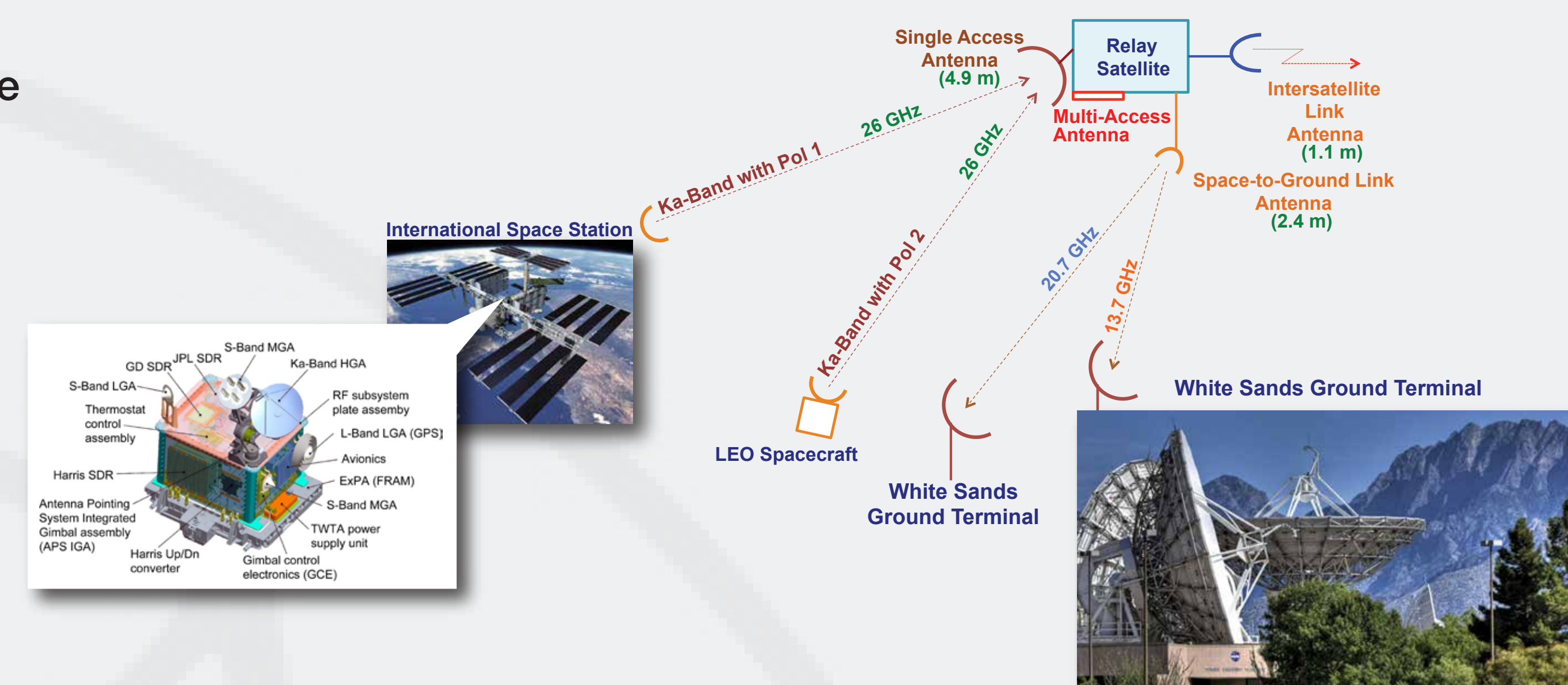
RELAY SATELLITE G/T VS. LEO SPACECRAFT EIRP (LEO-TO-GEO Kₐ-BAND SINGLE ACCESS RETURN LINK)

Waveform: QPSK, FEC Rate: 7/8, Frequency: 25.25 to 27.5 GHz

ACHIEVABLE DATA RATES VS. LEO SPACECRAFT EIRP (LEO-TO-GEO Kₐ-BAND SINGLE ACCESS RETURN LINK)

Waveform: QPSK, FEC Rate: 7/8, Frequency: 25.25 to 27.5 GHz

RELAY SATELLITE EIRP VS. LEO SPACECRAFT G/T (GEO-TO-LEO Kₐ-BAND SINGLE ACCESS FORWARD LINK)

Waveform: QPSK, FEC Rate: 7/8, Frequency: 22.55 to 23.55 GHz
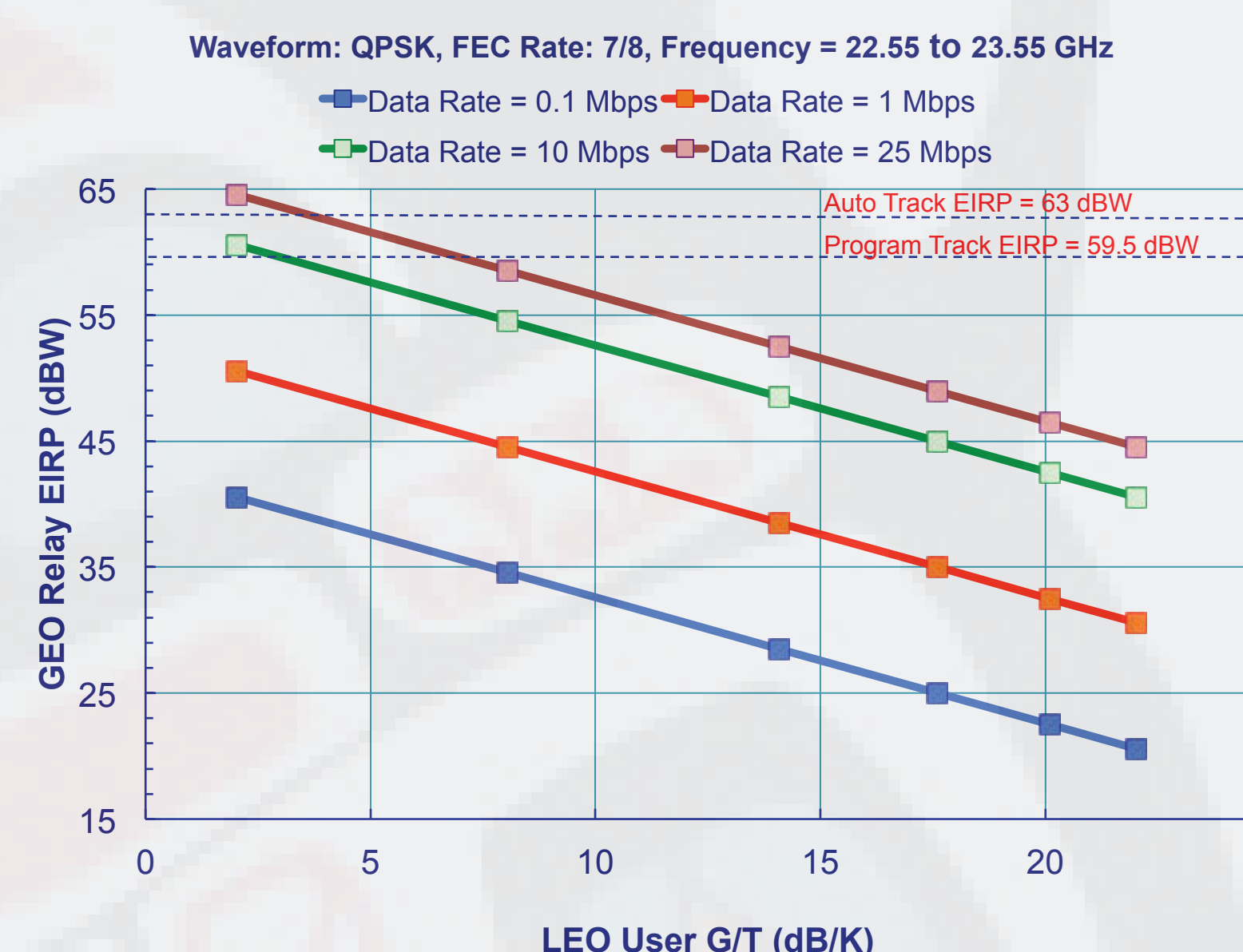
ACHIEVABLE DATA RATE VS. LEO SPACECRAFT G/T (GEO-TO-LEO Kₐ-BAND SINGLE ACCESS FORWARD LINK)

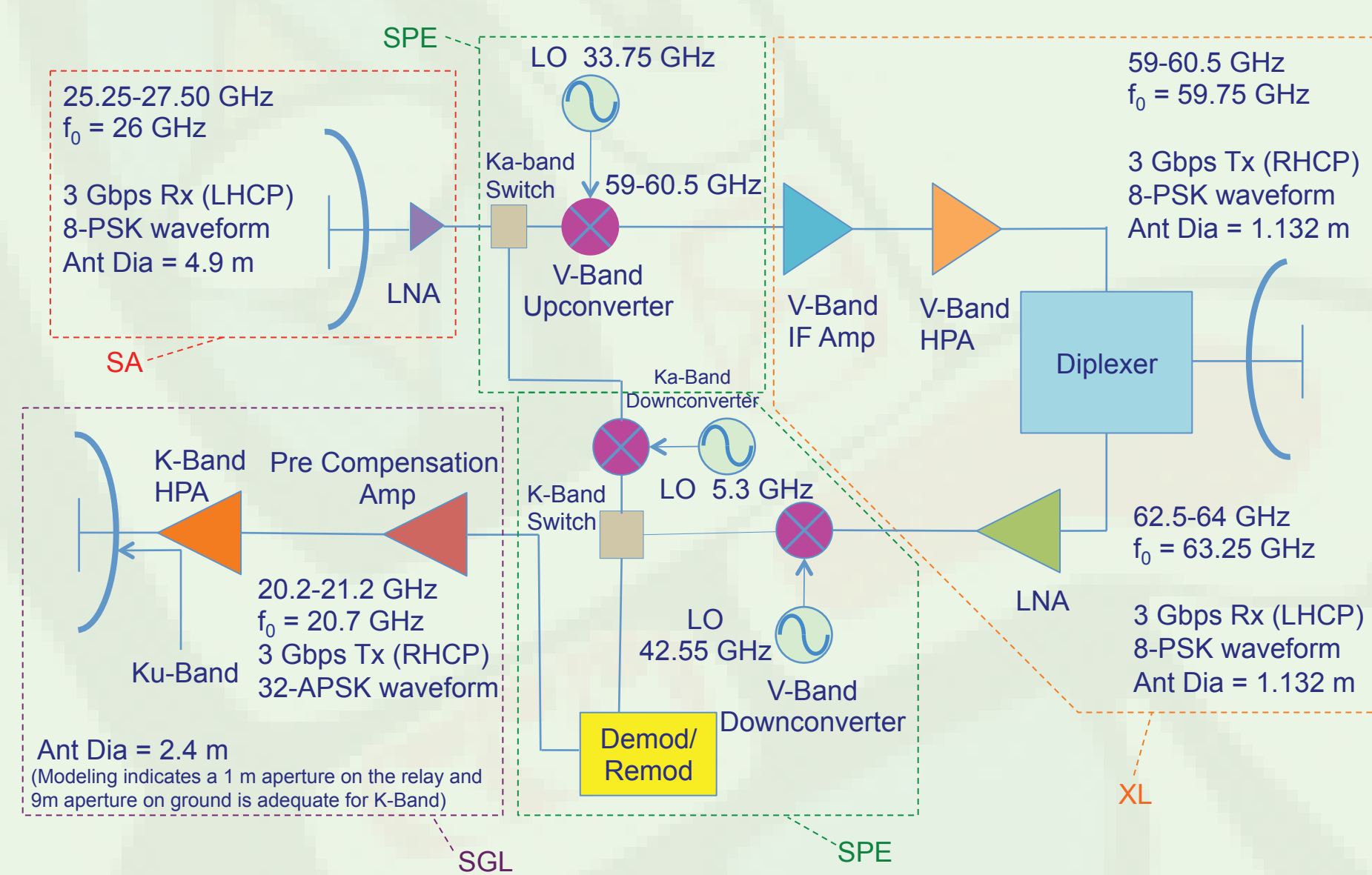Waveform: QPSK, FEC Rate: 7/8, Frequency: 22.55 to 23.55 GHz
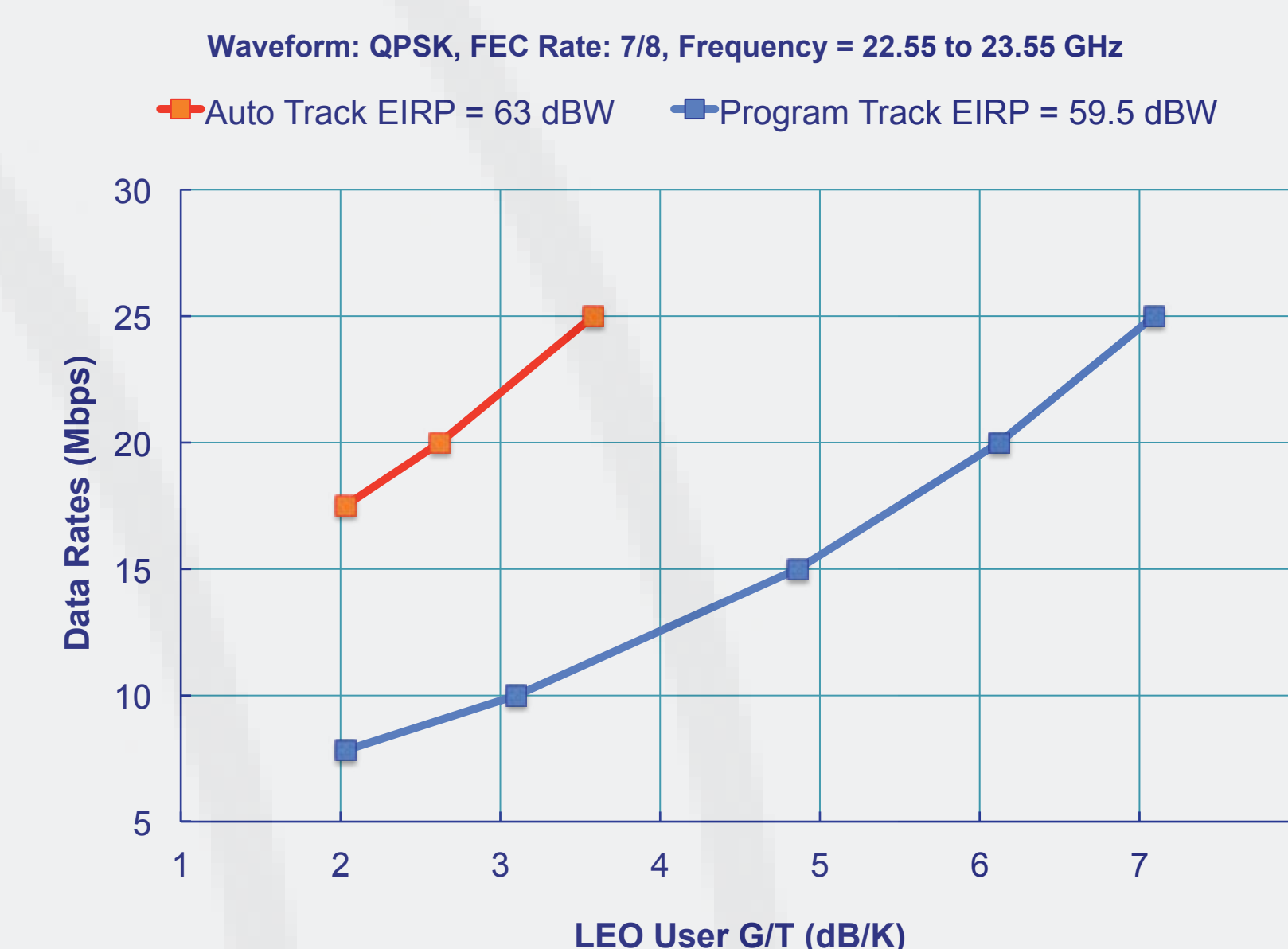
III. V-BAND GEO-TO-GEO INTERSATELLITE LINKS

The forward (FL) and return (RL) links operate at V-band frequencies (59 to 64 GHz), but with opposite sense of polarization to minimize interference
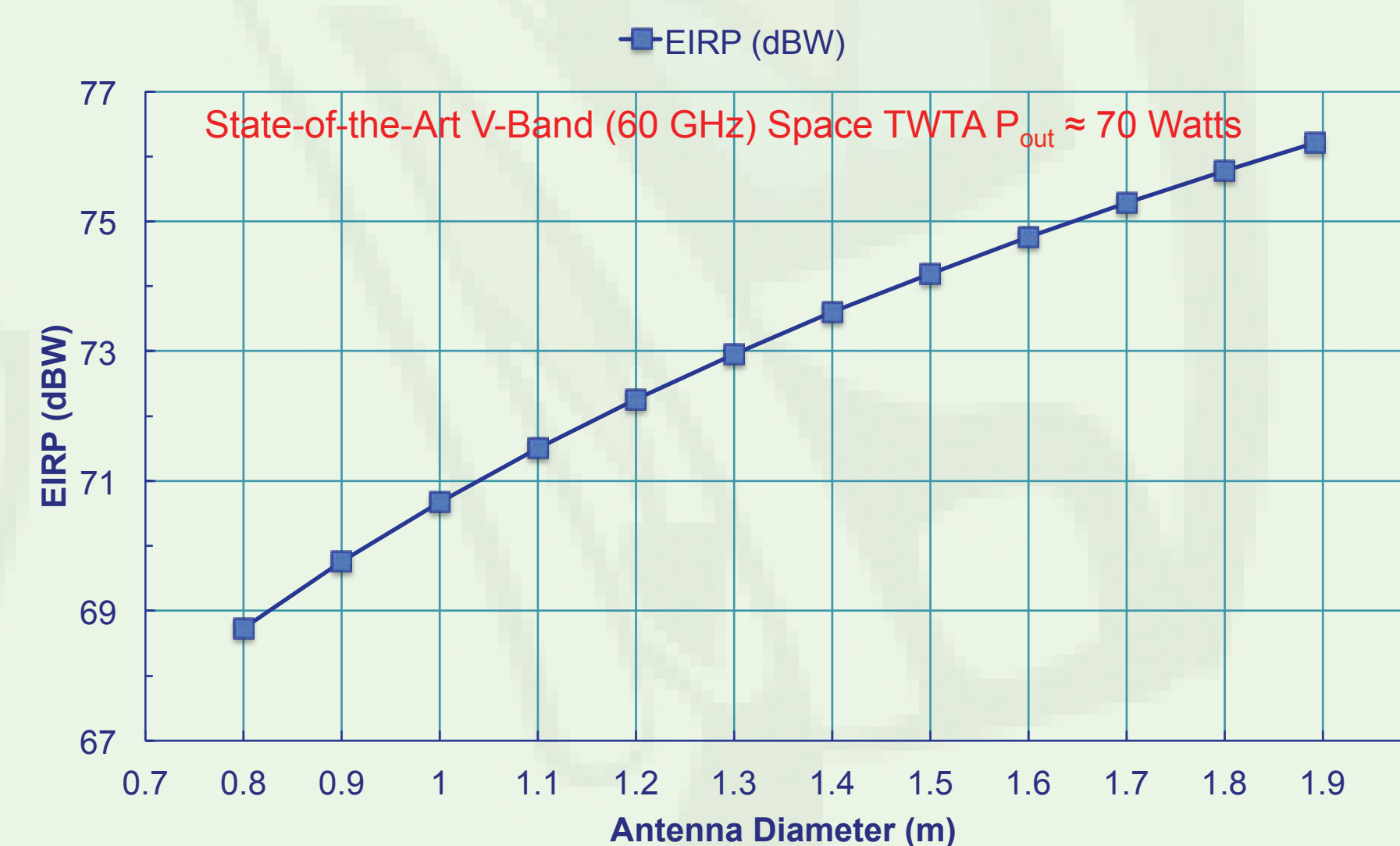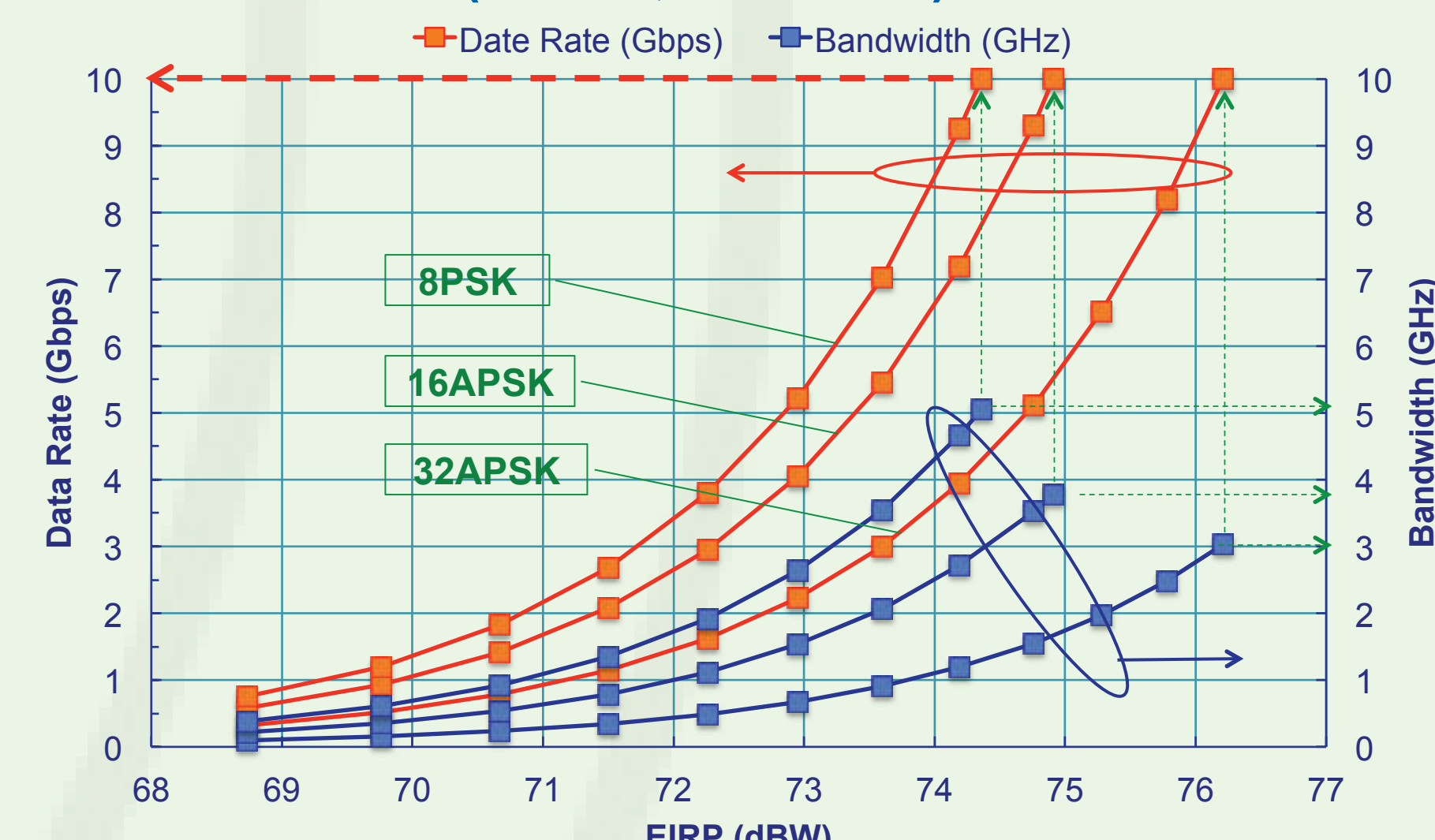
GEO-TO-GEO INTERSATELLITE LINKS
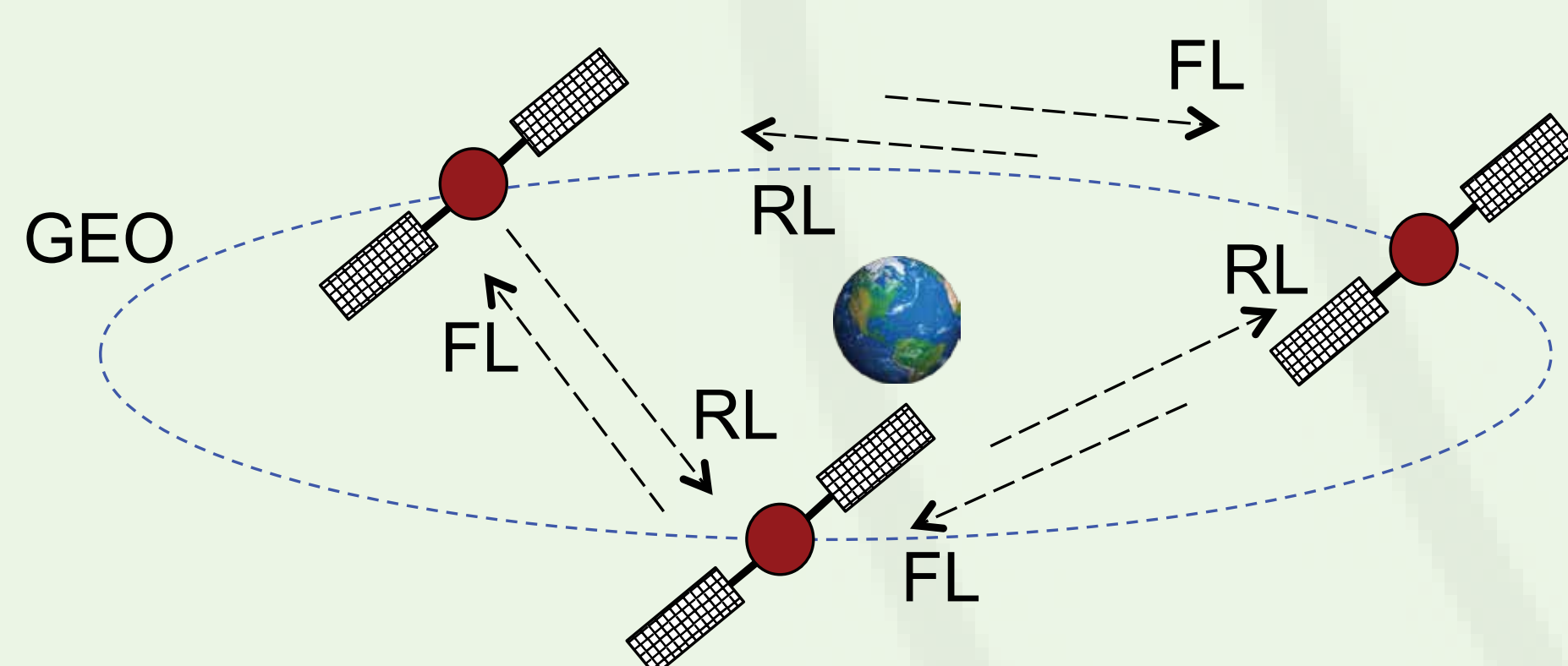
TX AND RX CHAIN ONBOARD THE RELAY SATELLITE FOR SPACE-TO-SPACE LINKS AND SPACE-TO-GROUND LINKS

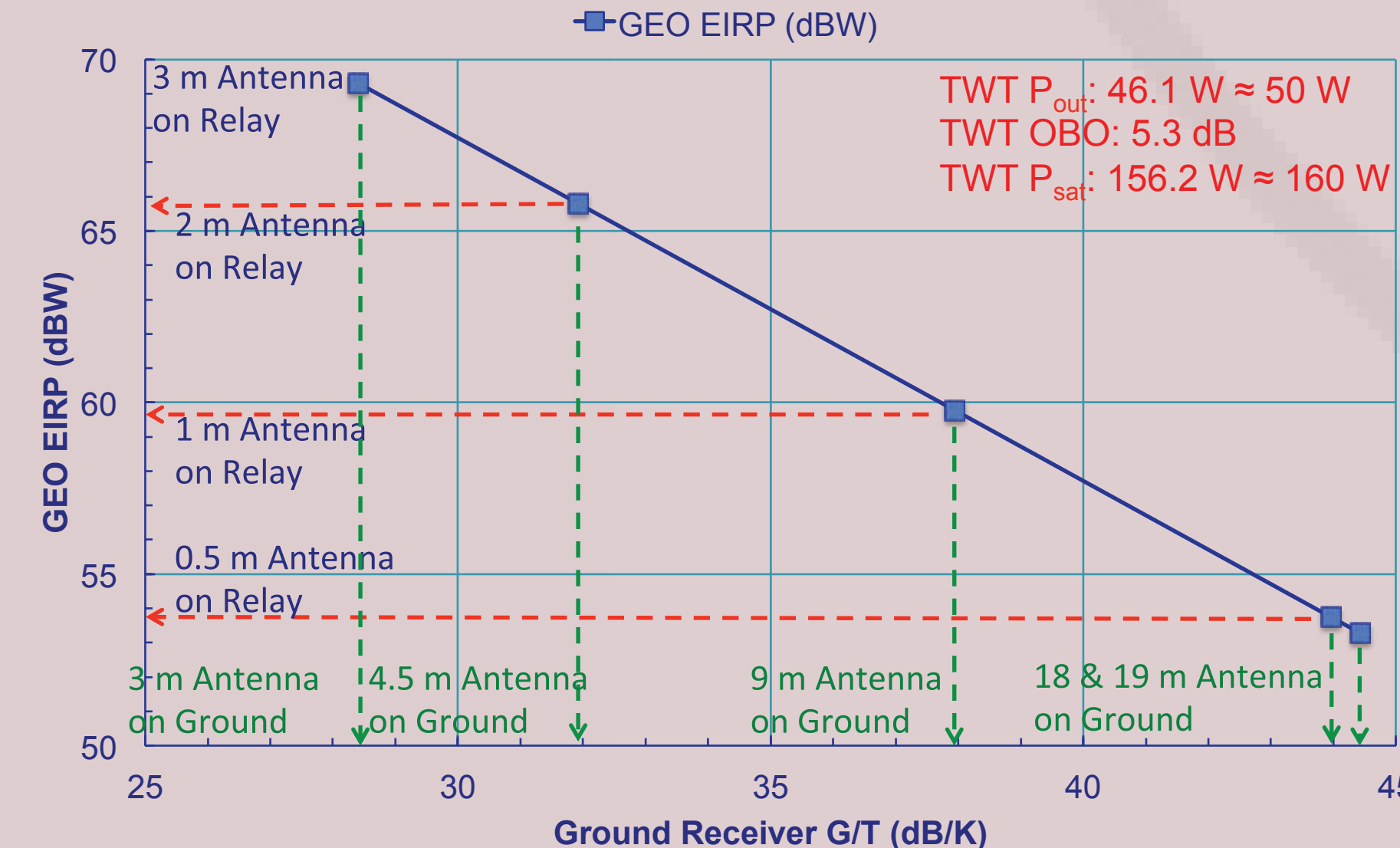### RELAY SATELLITE EIRP VS. ANTENNA DIAMETER

DATA RATE AND BANDWIDTH VS. RELAY SATELLITE EIRP (60 GHZ, LDPC 9/10)

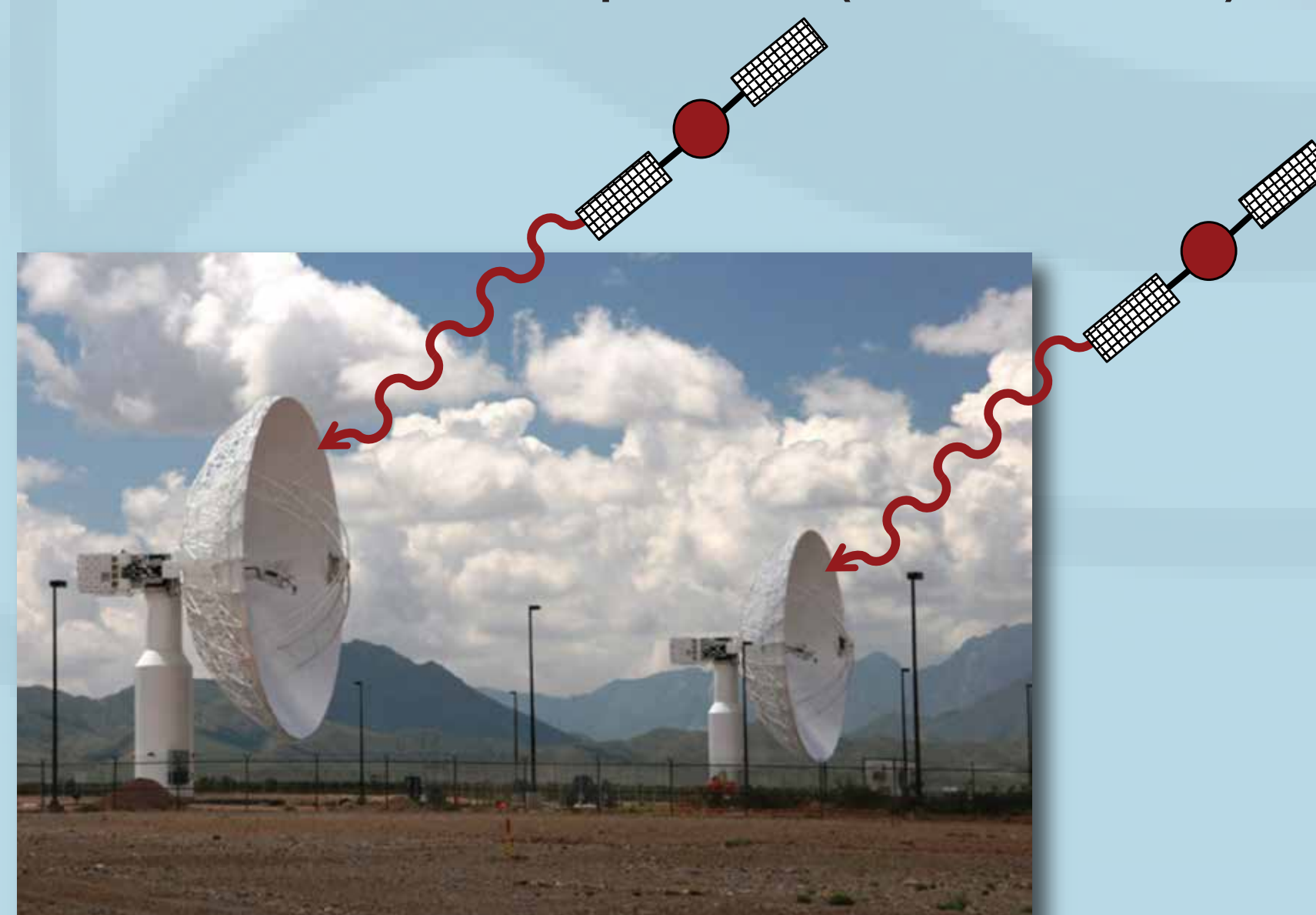

IV. K-BAND GEO-TO-GROUND LINK

The relay satellite to ground station down link operates at K-band frequencies (20.2 to 21.2 GHz)

RELAY SATELLITE EIRP VS. GROUND RECEIVER G/T

V. KA-BAND LEO-TO-GROUND LINK

The LEO spacecraft to a ground station down link operates at Ka-band frequencies (25.5-27.0 GHz)
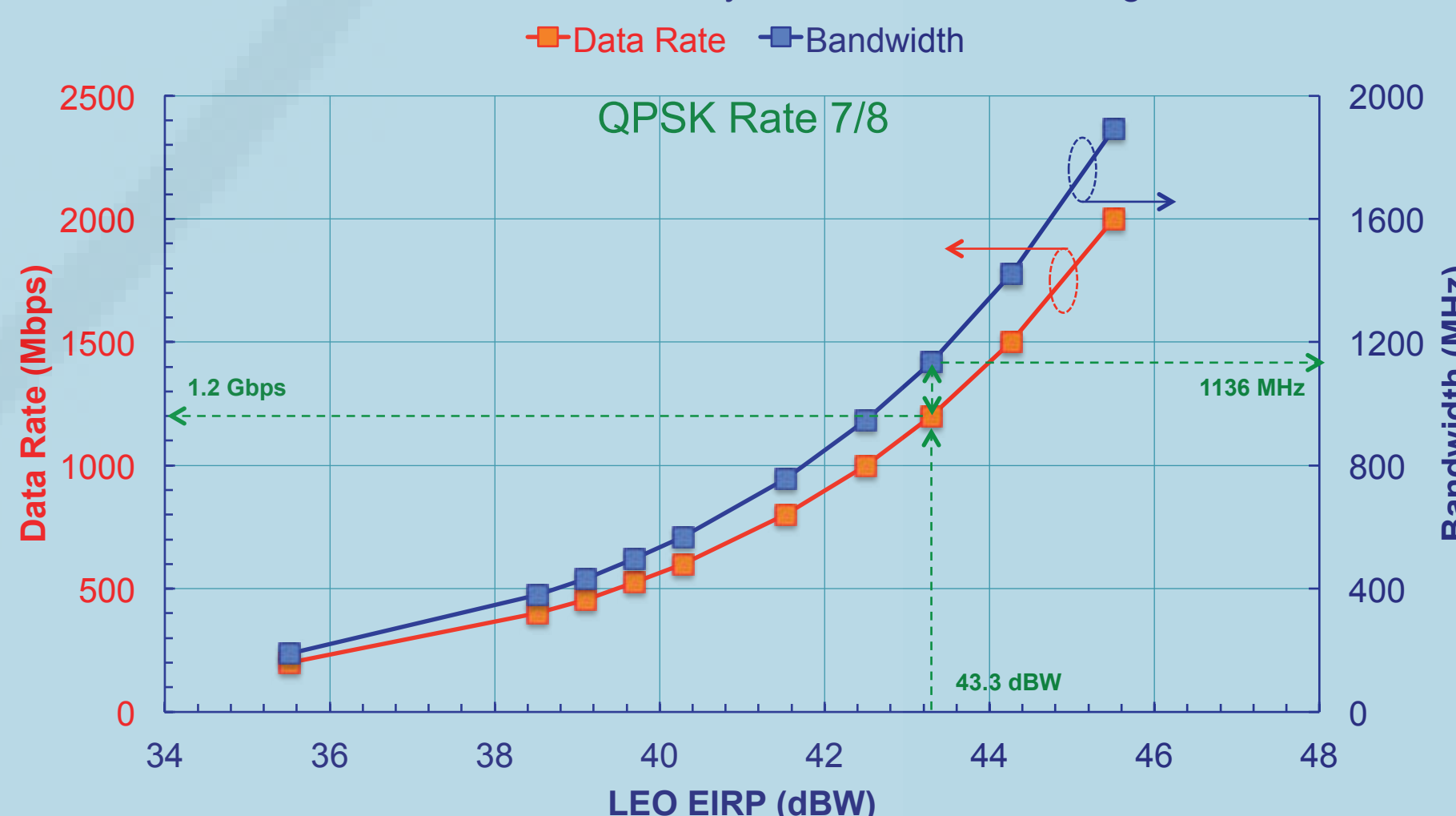

HIGH POWER HIGH EFFICIENCY TRAVELING-WAVE TUBE AMPLIFIER (TWTA) FOR SPACE-TO-GROUND LINKS

DATA RATE AND BANDWIDTH VS. LEO SPACECRAFT EIRP (LEO USER TERMINAL TO GROUND (WSC))

LEO User Tx Ant Dia: 0.5 m, Tx Frequency: 26 GHz, User Ant Dia: 0.5 m, G/T: 14.8 dB/K, 99% Availability at WSC, Elevation Angles: ≈15°
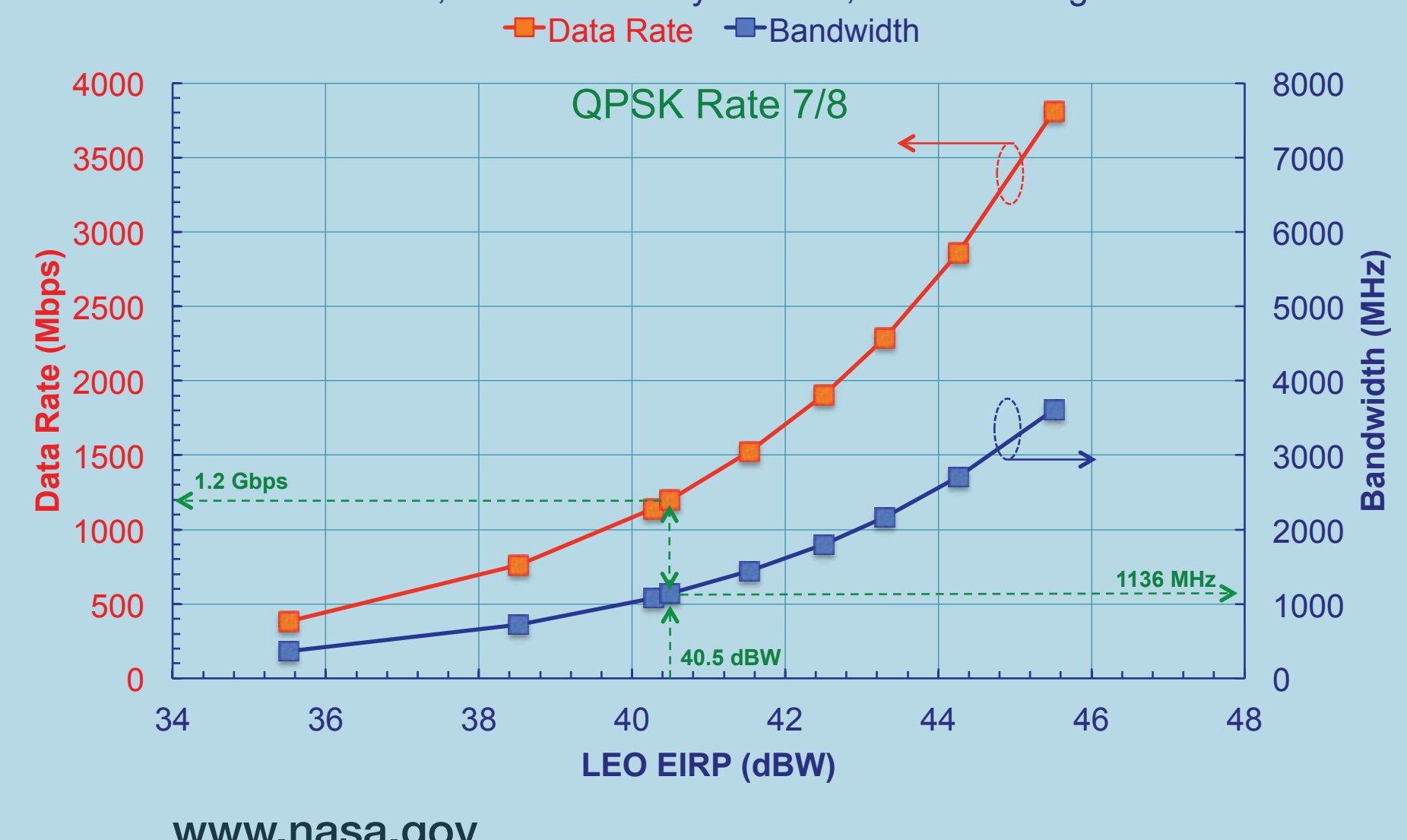

DATA RATE AND BANDWIDTH VS. LEO SPACECRAFT EIRP (LEO USER TERMINAL TO GROUND (WSC))

LEO User Tx Ant Dia: 0.5 m, Tx Frequency: 26 GHz, User Ant Dia: 0.5 m, G/T: 14.8 dB/K, 99% Availability at WSC, Elevation Angles: ≈30°
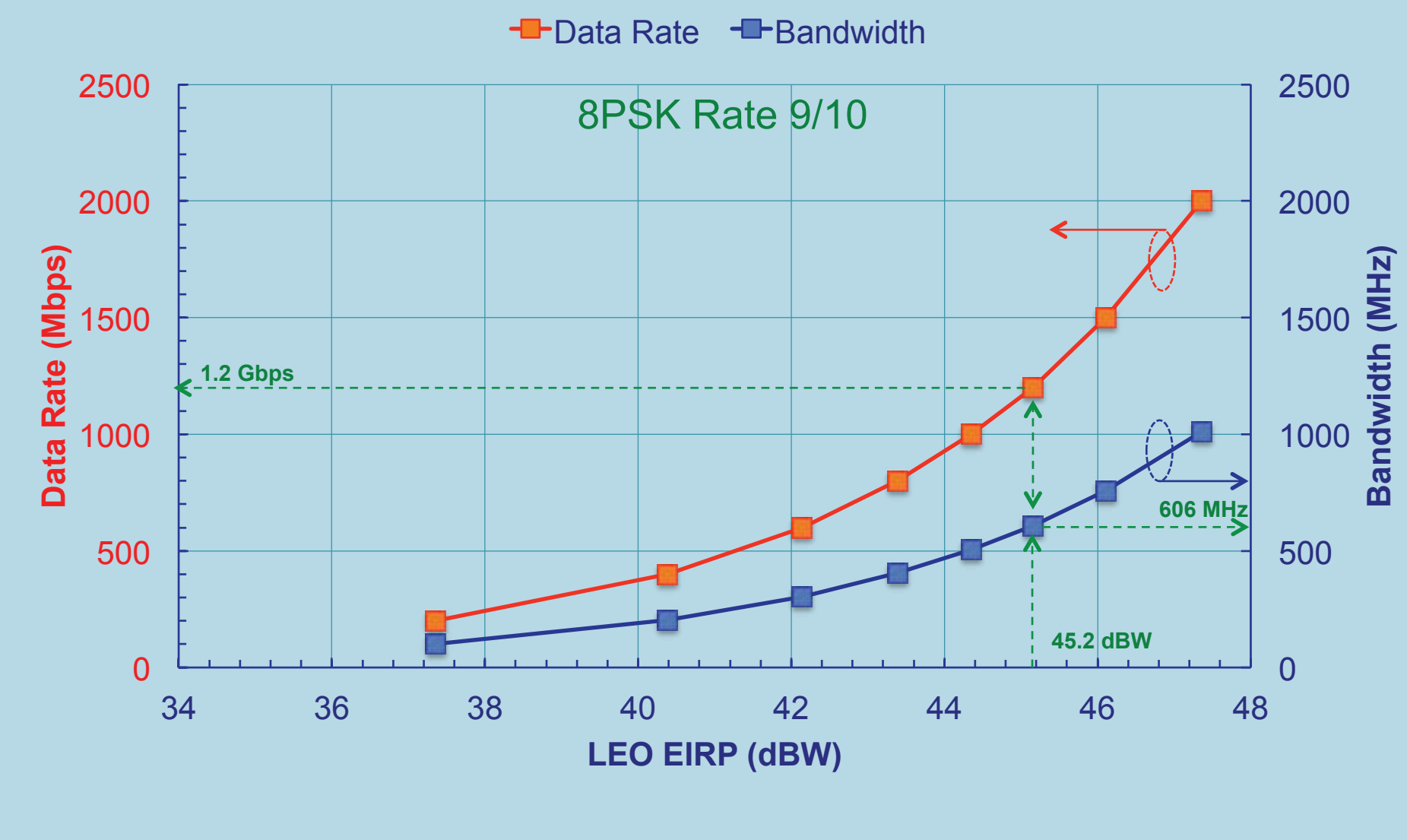

DATA RATE AND BANDWIDTH VS. LEO SPACECRAFT EIRP (LEO USER TERMINAL TO GROUND (WSC))

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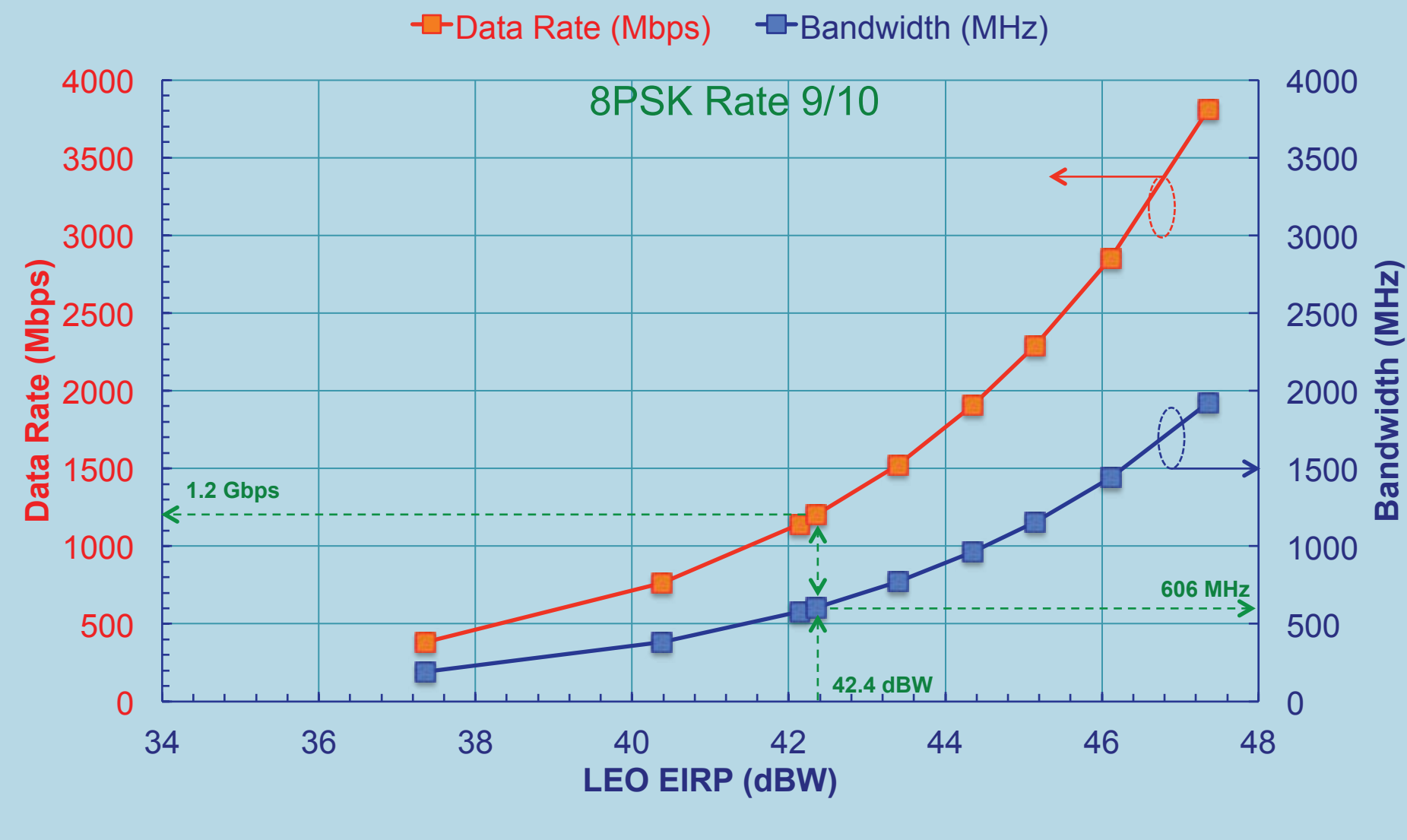

DATA RATE AND BANDWIDTH VS. LEO SPACECRAFT EIRP (LEO USER TERMINAL TO GROUND (WSC))

LEO User Tx Ant Dia: 0.5 m, Tx Frequency: 26 GHz, User Ant Dia: 0.5 m, G/T: 14.8 dB/K, 99% Availability at WSC, Elevation Angles: ≈30°

VI. CONCLUSIONS

Results from computer simulations carried out for high-data-rate LEO-to-GEO, GEO-to-GEO, GEO-to-ground, and LEO-to-ground links to down load large volume of science data are presented

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