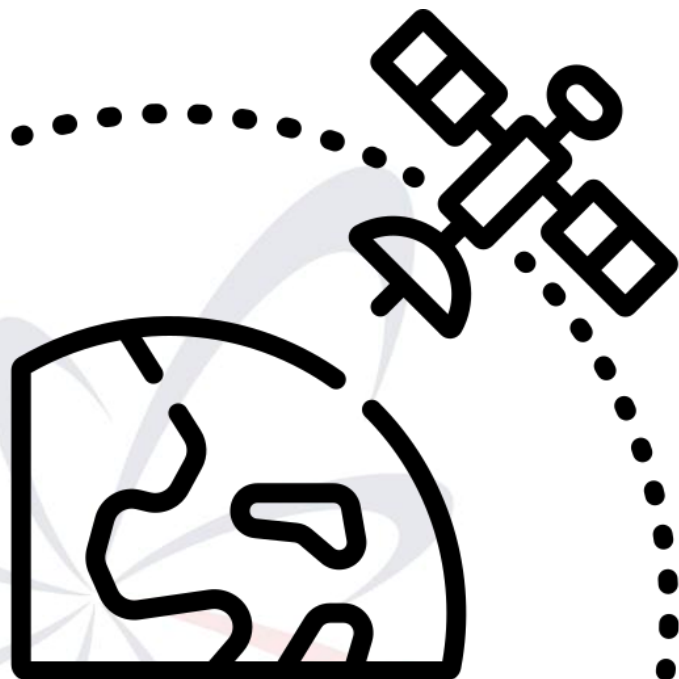


# Uloga Low Earth Orbit (LEO) satelitskih mega konstelacija u 5G ekosistemu

Aleksandar Borić

# LEO, MEO, GEO satelitiski sistemi



- GEO (Geostationary Equatorial Orbit)
  - Orbitalna visina 35.786 km
  - Kašnjenje (Latency)  $\approx 500 \div 800$  ms
- MEO (Medium Earth Orbit)
  - Orbitalna visina  $2.000 \div <35.786$  km
  - Kašnjenje (Latency)  $\approx 125 \div 325$  ms
- LEO (Low Earth Orbit)
  - Orbitalna visina  $500 \div 2.000$  km
  - Kašnjenje (Latency)  $\approx 25 \div 50$  ms

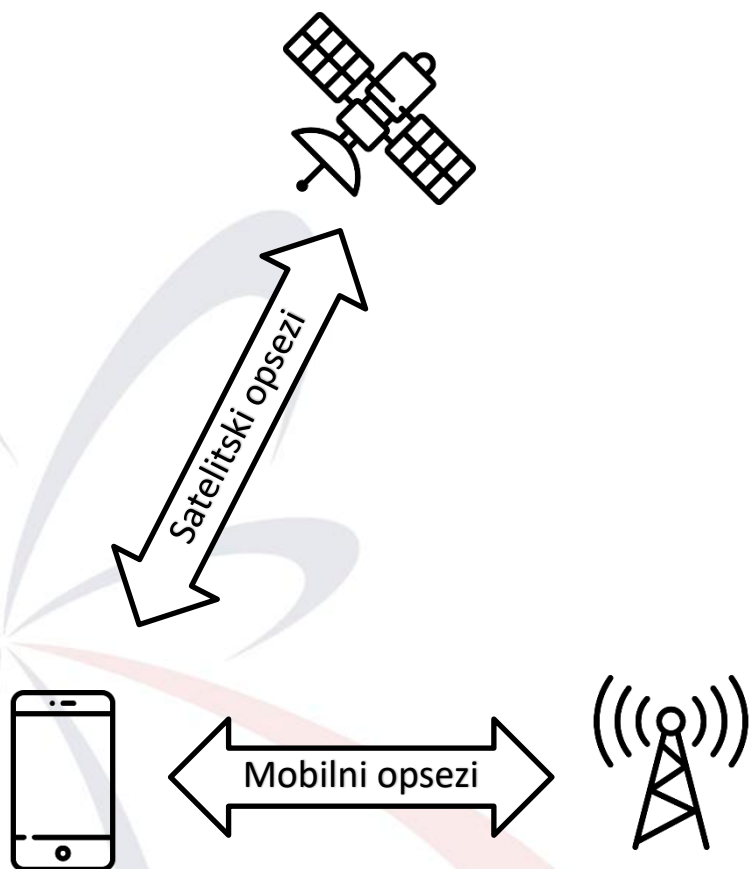
# Starlink

- 10.000 korisnika (Februar 2021)
- 1.500.000 korisnika (Maj 2023)
- 4.000 aktivnih satelita
- FCC dozvola za 7.500 novih satelita
- Planirani broj satelita 42.000

Vrsta usluge	Cena opreme (\$)	Mesečna pretplata (\$)	Internet brzina (Mbps)
Residential	600	120	50 – 150 (pros. 87)
Roam/Mobility	600	145	Best effort
Business	2.500	500	150 - 500
Maritime	10.000	5.000	350

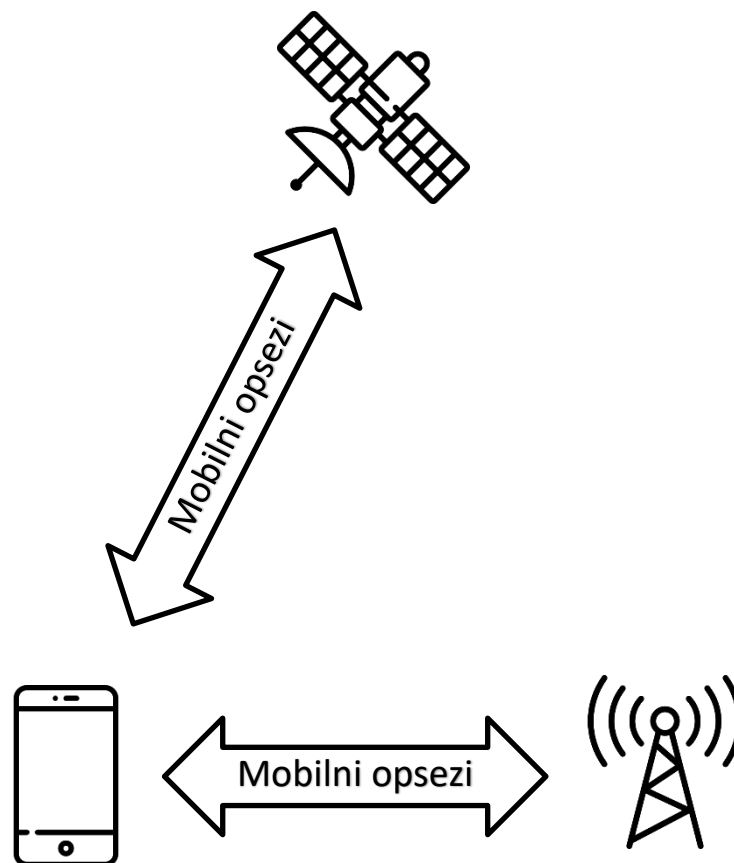
# Direct to Device (D2D)

Rad u satelitskim opsezima



Mobilni telefon  
(3GPP release  $\geq 17$ )

Rad u mobilnim opsezima?



Mobilni telefon

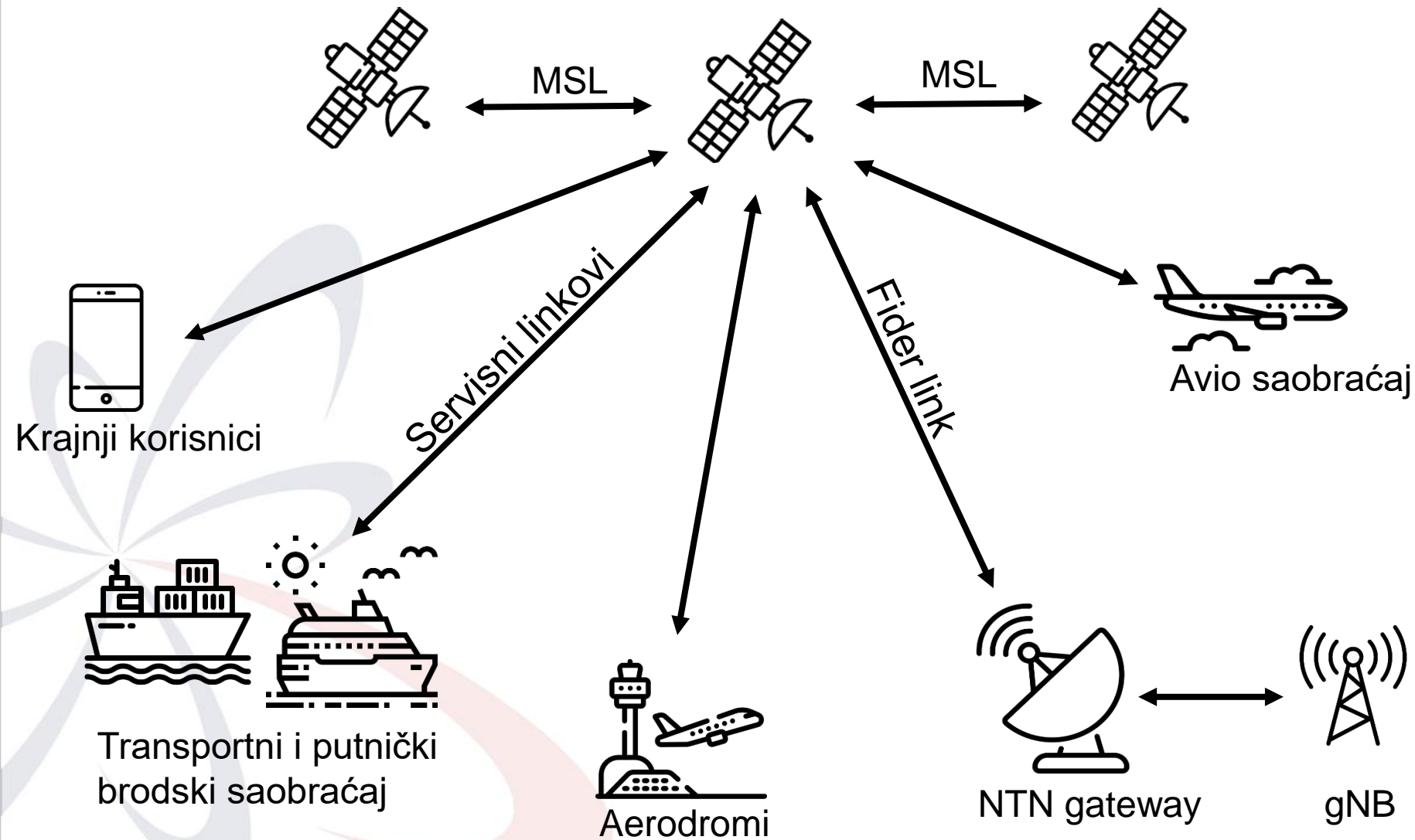
# 3GPP Release 17 i 18

## 5G NTN Frekvencijski spektar

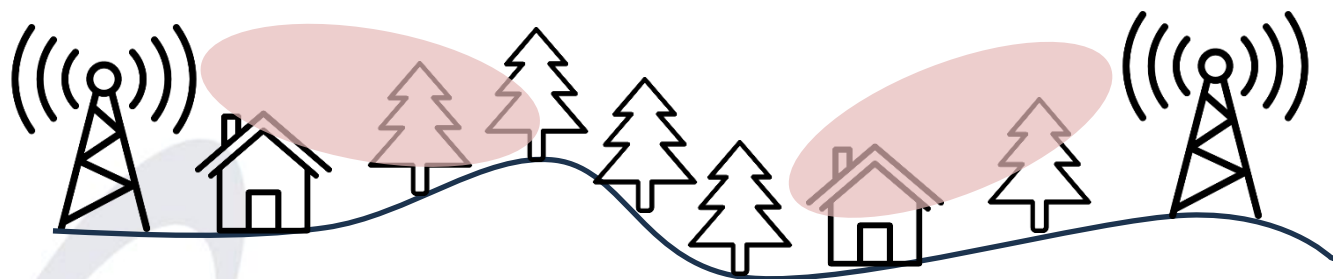
Phase	FR	Advantages	Challenges	NTN Band	Uplink (Earth to Space)	Downlink (Space to Earth)	Duplex
<b>3GPP, 1<sup>st</sup> bands for NTN (R17)</b>	<b>FR1</b>	<ul style="list-style-type: none"> <li>Lower path attenuation</li> <li>Already be used in legacy communication (components are available)</li> </ul>	<ul style="list-style-type: none"> <li>Spectrum crunch (bands are densely occupied) --&gt; up to 40MHz bandwidth is usable</li> </ul>	n256 (S-Band)	1980 MHz – 2010 MHz	2170 MHz – 2200 MHz	FDD
				n255 (L-Band)	1626.5 MHz – 1660.5 MHz	1525 MHz – 1559 MHz	FDD
<b>3GPP, 2<sup>nd</sup> bands proposed for NTN (R18)</b>	<b>FR2</b>	<ul style="list-style-type: none"> <li>Broadband service offering</li> </ul>	<ul style="list-style-type: none"> <li>Introduction of FDD in FR2 may probably cause interference btw FDD &amp; TDD</li> </ul>	Ku-band	12.75 GHz – 13.25 GHz & 13.75 GHz – 14.5 GHz	10.7 GHz – 12.75 GHz	FDD
				Ka-band (GEO)	27.0 GHz – 30.0 GHz	17.3 GHz – 20.2 GHz	FDD
				Ka-band (non-GEO)	27.0 GHz – 29.1 GHz & 29.5 GHz – 30.0 GHz	17.7 GHz – 20.2 GHz	FDD

( Izvor: 3GPP TR 38.811, 3GPP RP-212144, R&S, Nokia)

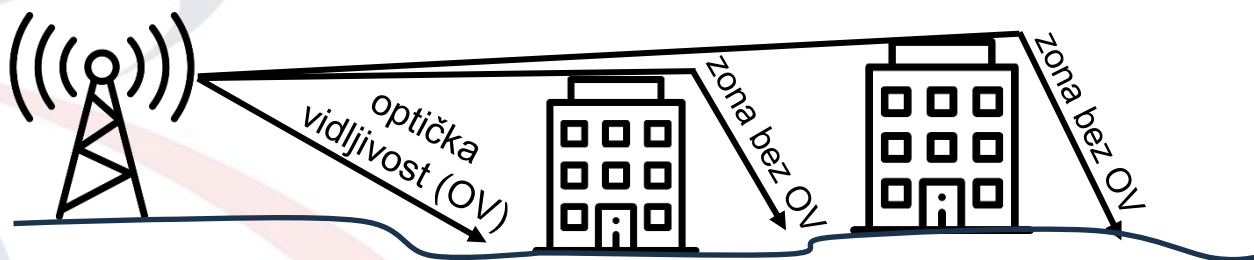
# Non-Terrestrial Network



# Terrestrial Networks zone bez pokrivanja

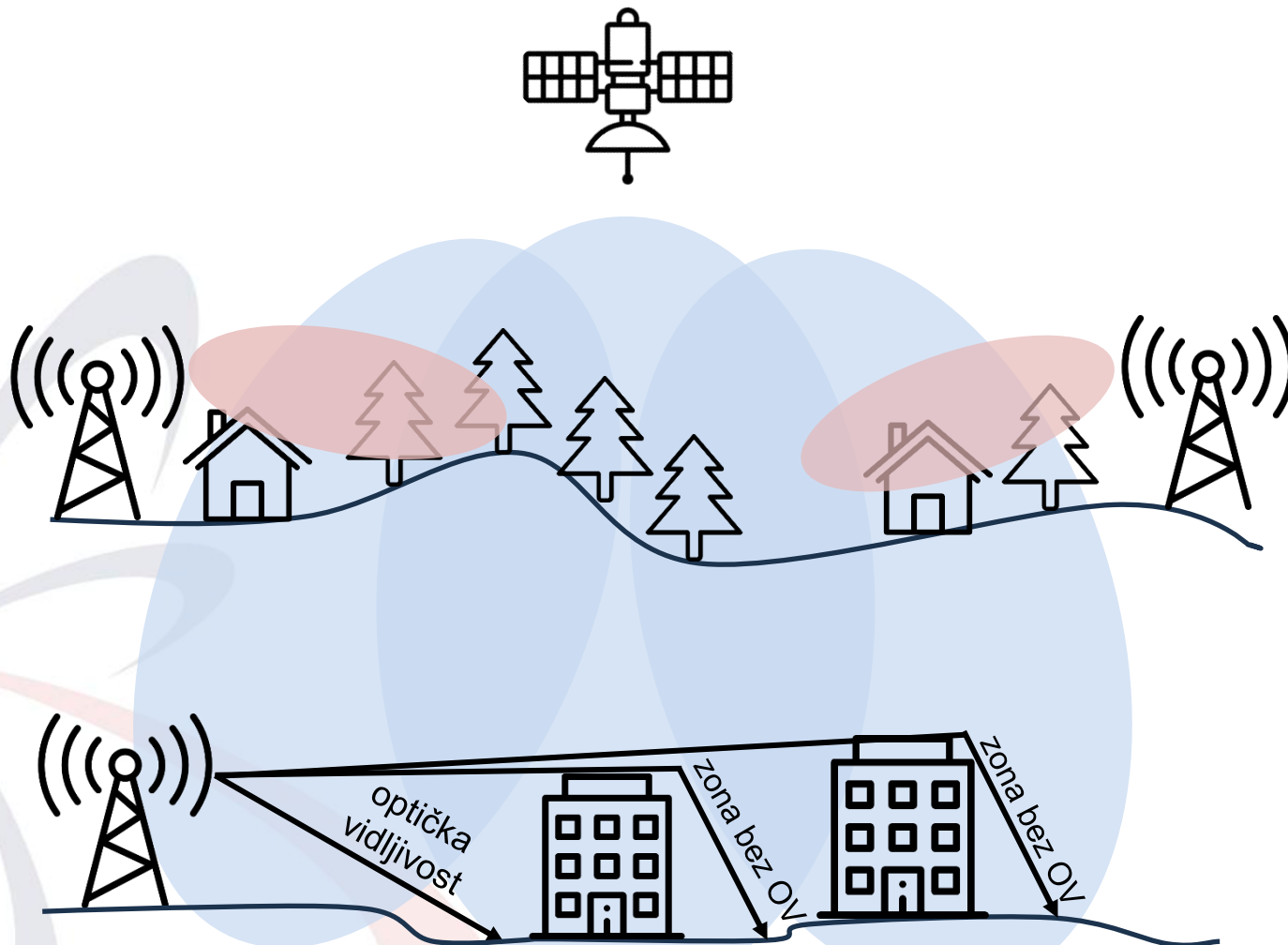


Ruralna područija



Urbana područija

# NTN dodatno pokrivenje





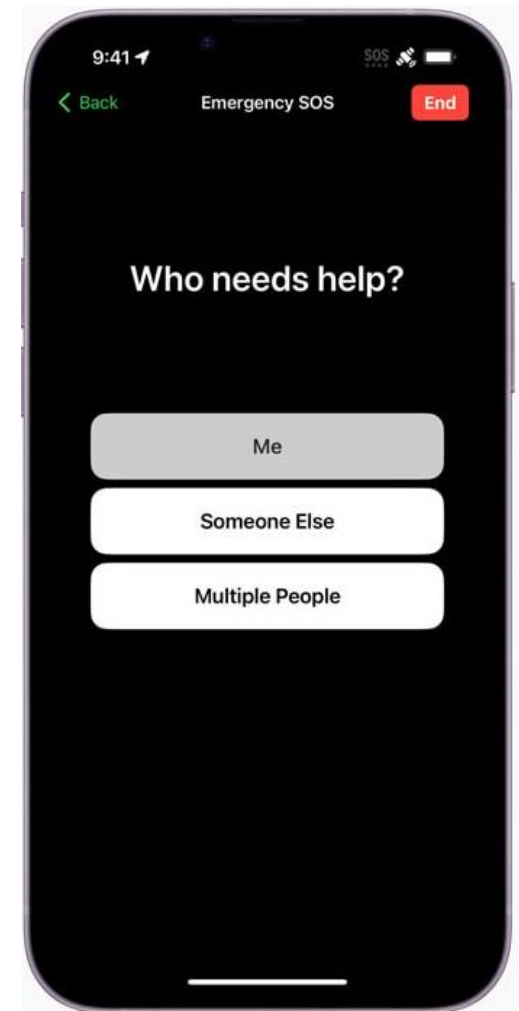
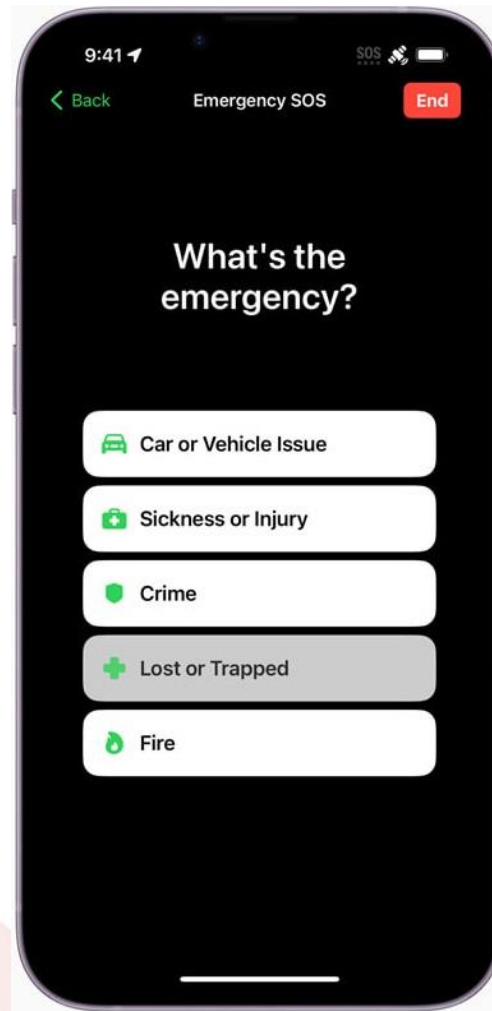
# Trenutno dostupne i buduće usluge u satelitskim opsezima



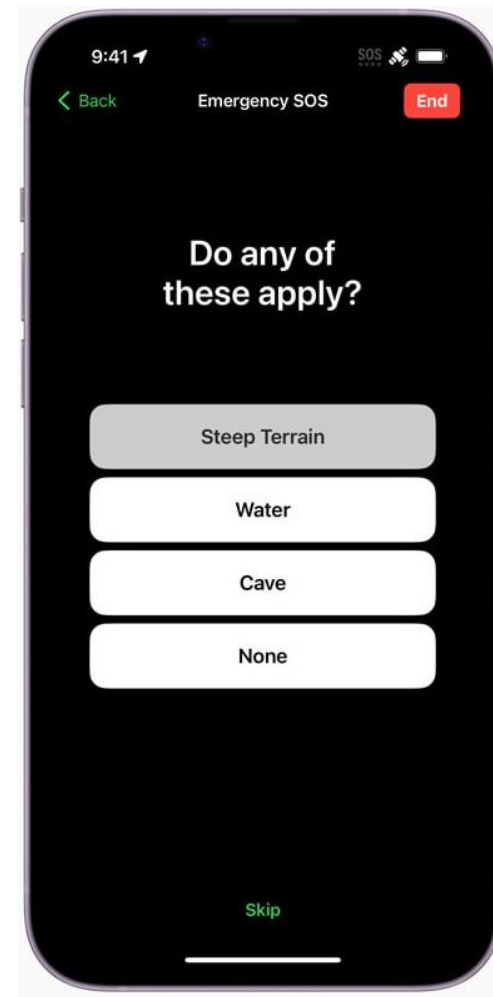
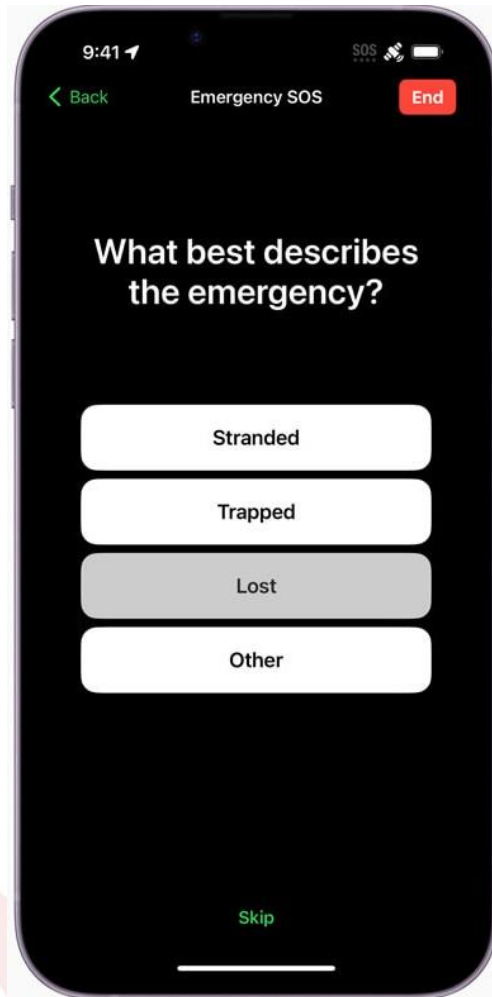

	Apple	Qualcomm	MediaTek	Samsung	Huawei
Phone Availability	iPhone 14 series (Now available)	Honor, Motorola, Nothing, OPPO, vivo, Xiaomi (To be available in 2023 H2)	Motorola Defy 2 (Available in 2023 Q1), CAT S75	?	<ul style="list-style-type: none"> <li>• 2-way: P60 series, Mate X3 series, nova11 Ultra;</li> <li>• 1-way: Mate 50 series, Mate Xs series (Now Available)</li> </ul>
Features	One-way SOS messaging	Two-way SOS messaging	Two-way SOS messaging	Two-way SOS messaging	One & Two-way SOS messaging
Satellite Operator	Globalstar	Iridium	Inmarsat Skylo	?	Deidou
Constellation	LEO	LEO	GEO	LEO	GEO
Implementation	Proprietary	Proprietary	3GPP R17 NTN standard	3GPP R17 NTN standard	Proprietary

Izvor : R&S, Apple, Qualcomm, MTK, Samsung, Huawei)

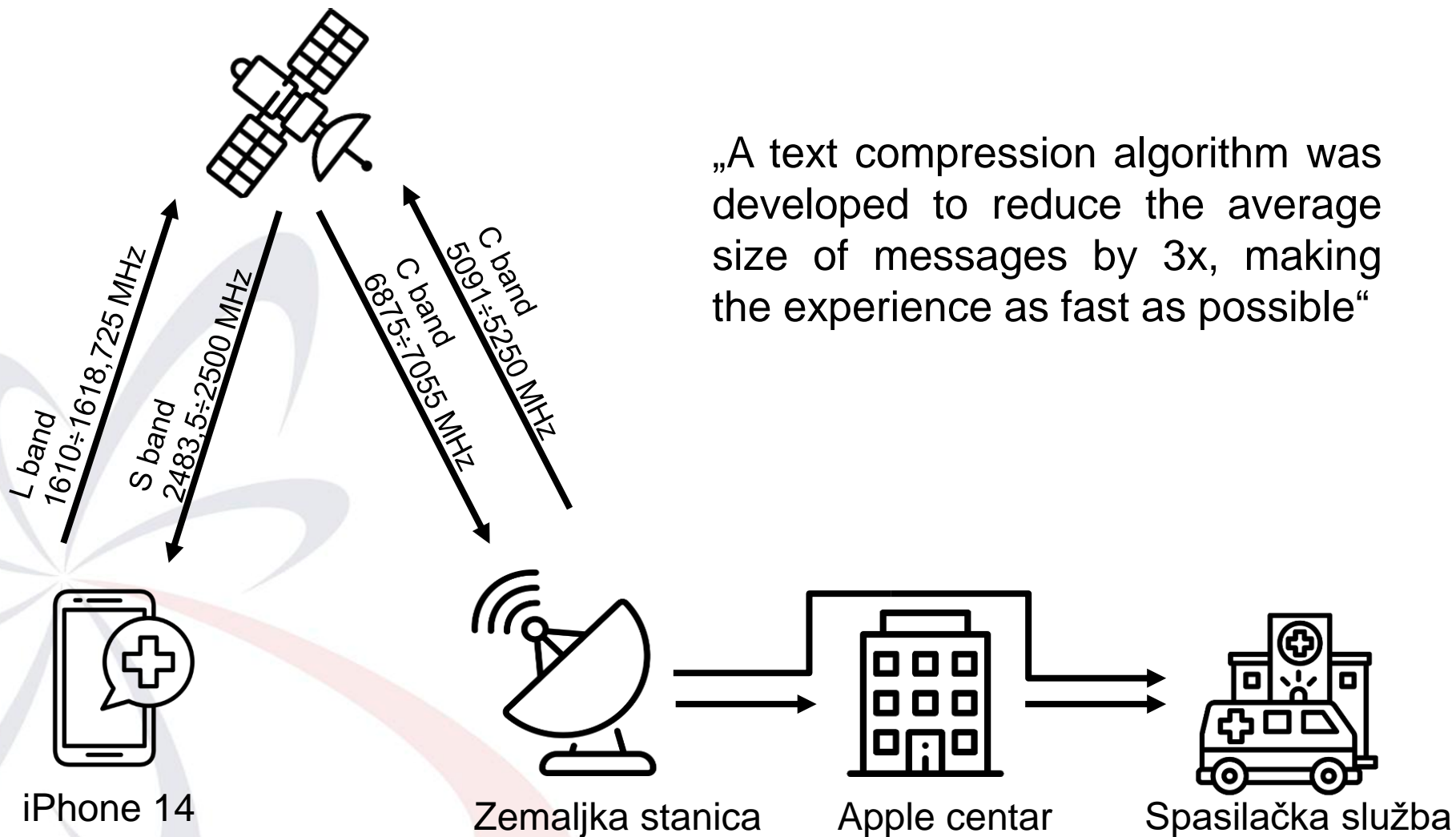
# Apple Emergency SOS usluga



# Apple Emergency SOS usluga



# Apple Emergency SOS usluga



# Buduće usluge u mobilnim opsezima Starlink i T-Mobile

„Coverage Above and Beyond“

- T-Mobile, Mid Range opseg 1.910 – 1.995 MHz
- Starlink sateliti druge generacije
- Testiranje sistema, krajem 2023 godine u ograničenim zonama (Havaji, Aljaska, Puerto Rico)
- Faza I: SMS, MMS, Tekstualne aplikacije
- Faza II: Telefonija, Internet

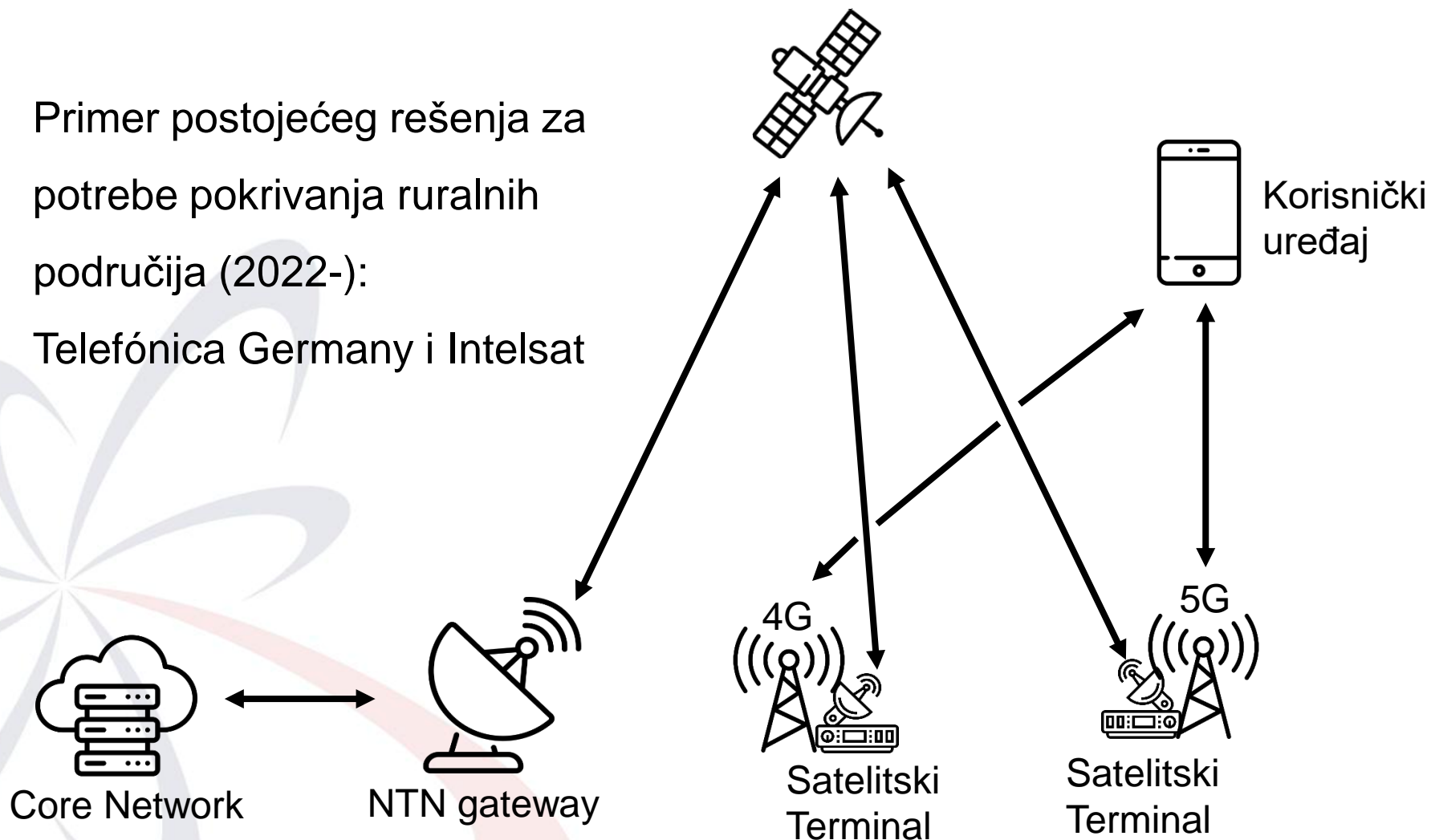
# Regulatorni izazovi

- Harmonizacija opsega
- Roaming sporazumi
- Učešće satelitskih operatera na aukcijama za dodelu spektra
- Numeracija u satelitsko-mobilnim mrežama
- Interoperabilnost korisničkih uređaja
- Presretanja podataka u satelitskim mrežama sa Mesh topologijom

# Fallback rešenje za kritičnu infrastrukturu

Primer postojećeg rešenja za potrebe pokrivanja ruralnih područja (2022-):

Telefónica Germany i Intelsat



# Univerzalni servis

- „The European Commission recognises the potential of Satcom solutions and has taken first steps towards a European space-based connectivity initiative“  
(BEREC Report on Satellite Connectivity for Universal Services, 2022)
- Usluga Univerzalnog servisa je tehnološki neutralna
- Parametri kvaliteta usluge satelitskih servisa su uporedivi sa parametrima postojećih terestričkih mrežama
- Jedino rešenje u ruralnim područjima bez mobilnog pokrivanja
- Cena kao otežavajući faktor



# Hvala na pažnji!

## Pitanja?