TELECOM INFRA PROJECT

NTCS Technical Requirements Document

Non-Terrestrial Connectivity Project Group

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Introduction and Scope

1. Introduction & Scope

The telco industry is focusing its deployment in regions with a higher density of inhabitants – main cities. Consequently, telco network vendors have concentrated R&D efforts on designing technology that is more efficient and can deliver more capacity in dense areas. As a result of this, networks are not designed to deliver a sustainable business in places with a very low number of inhabitants/km2 as the cost per inhabitant covered is higher.

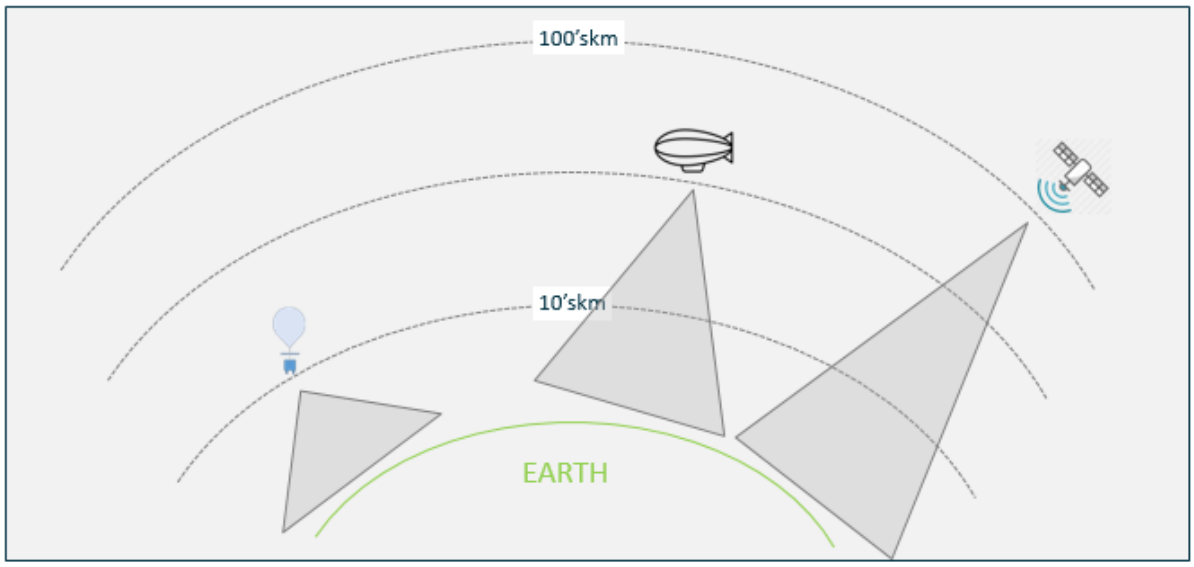
Beyond technology, commercial offering(s) must be considered. A mobile network operator´s offer is homogeneous; mobile data packet costs the same across a country. Price plans are designed to capture clients and create a profitable business in the urban business as it is considered of most value. However, current market dynamics are putting increasing pressure on reducing this price. As the price of connectivity is reduced the incentives to deploy in less dense areas decrease as the unitary cost gets lower and the margins are null or negative.

Today, traditional terrestrial technologies are profitable in locations with over 10.000 inhabitants and are normally covered organically by operators. Operators innovating with specific technologies and designs optimized for low-density areas can also build a sustainable business in locations with thousands of inhabitants. However, the biggest challenges come when covering places with under 1.000 inhabitants or disperse nucleus of population (scattered houses).

To cover this segment, we need to radically reinvent the way we deploy, serve and operate connectivity –disruption is required. This is a global pending challenge. It is estimated that globally there are 3 billion people without internet services, of which 750 million needs a disruptive solution, so it represents 25% of the whole opportunity.

Many new innovators are looking to solve this problem from the sky. The advantage of being deployed in the sky provides the capacity of covering

extremely broad areas from one single point. These new solutions can take a variety of shape in terms of platforms (drones, zeppelins, drones or balloons) and operate at different altitudes, but they have one thing in common: delivering connectivity directly from the sky to a standard smartphone.



These sky platforms are perfect for covering ultra-low density areas, minimizing the cost/inhabitant covered by maximizing the number of inhabitants covered by each vehicle. This enables providing mobile coverage in places where the density of inhabitants can be tens of people per square km. The position in the sky also provides the advantage of avoiding complex terrain orography such as dense jungles or mountains.
New sky platforms are bringing the best of two worlds: the ability of satellite to provide extensive coverage wherever it is needed – even in a dynamic manner redistributing capacity adhoc - with the capacity of terrestrial networks of having low latency and being able to concentrate throughput.

Although the immediate use case is covering the unconnected, applications can go beyond this initial use case. This document focuses on mobile coverage for rural communities and emergency responses as the initial use case, but applications can go well beyond mobility, FWA, private comms, etc.

This document explains the service requirements required for sky platforms providing coverage directly to smartphones, focusing on two initial use cases: connecting the unconnected and emergency response. These requirements include general service description on the capacity required and also additional capabilities required to ensure that this service can complement and co-exist with traditional terrestrial connectivity. These service requirements will be used to design the communications solutions that will be fitted on the sky platforms to provide this service.

2

Service Requirement

2. Service Requirement

The purpose of this section is to define the requirements of the non-terrestrial network to provide the initial service for a proof of concept (PoC) and for potential commercial deployment. The rationale build starts with defining from the service and experience required from the end-user – which will help ensure the market-fit for the solutions. From this initial definition, that document will define KPIs to describe features and capacity required. Some of the KPIs have been left as a ratio per square km, as the total area covered can vary between different types of solutions.

a. Service provided

The service is defined as direct LTE coverage from the sky platform directly to end users' standard smartphones for PoC and potential commercial deployment. Through this coverage, the network shall provide data and voice services (VoLTE). Future service considerations will also include 5G.

A minimum area of coverage of 15 km radius is considered – although some platforms may be able to provide more extensive coverage.

b. User experience for PoC

Even in remote and unconnected areas users are familiar with mobile broadband and expect to use the same services available in urban areas, including but not limited to social networks, web services, video streaming, gaming, etc.

Users have to be able to consume at least these services – although the minimum service quality level can be lowered compared to terrestrial – as the reason they will buy and use this connectivity is solely to consume them similarly to any other network.

The next KPIs are defined as the minimum acceptable so the services

before mentioned could work properly.

- **Throughput.** Defined as effective average throughput that end-users will experience. This shall exclude sessions close-to-zero transmitted information during the averaging window. Calculated as the relation between all the data transmitted in a considered period and the sum of all the transmitting time of all the UEs in the considered period.
  - 10 Mbps Average DL user experience
  - 1,5 Mbps Average UL user experience
- **Latency.** Defines as the round-trip time to reach the internet.
  - < 100ms
- **Availability.** Defined as the percentage of the time the service is accessible by end-users.
  - >95%
- **Data session setup drop.** Defined as data sessions that are setup successfully. Calculated as the relation between E-RAB unsuccessful setup attempts and total E-RAB setup attempts.
  - < 3%
- **Data session drop.** Defined as data sessions that do not end correctly. Calculated as the relation between E-RAB dropped connections and total E-RAB connections.
  - < 3%
- **VoLTE setup drop.** Defined as VoLTE sessions that are setup successfully. Calculated as the relation between VoLTE unsuccessful setup attempts and total VoLTE setup attempts.
  - < 3%
- **Data session drop.** Defined as VoLTE sessions that do not end correctly. Calculated as the relation between VoLTE dropped connections and total VoLTE connections.
  - < 3%

c. User experience for potential commercial deployment.

Even in remote and unconnected areas users are familiar with mobile broadband and expect to use the same services available in urban areas, including but not limited to social networks, web services, video streaming, gaming, etc.

Users have to be able to consume at least these services – although the

minimum service quality level can be lower compared to terrestrial – as the reason they will buy and use this connectivity is solely to consume them similarly to any other network.

The next KPIs are defined as the minimum acceptable so the services before mentioned could work properly.

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  - 10 Mbps Average DL user experience
  - 2,0 Mbps Average UL user experience
- **Latency.** Defines as the round-trip time to reach the internet.
  - < 100ms
- **Availability.** Defined as the percentage of the time the service is accessible by end-users.
  - >95%
- **Data session setup drop.** Defined as data sessions that are setup successfully. Calculated as the relation between E-RAB unsuccessful setup attempts and total E-RAB setup attempts.
  - < 3%
- **Data session drop.** Defined as data sessions that do not end correctly. Calculated as the relation between E-RAB dropped connections and total E-RAB connections.
  - < 3%
- **VoLTE setup drop.** Defined as VoLTE sessions that are setup successfully. Calculated as the relation between VoLTE unsuccessful setup attempts and total VoLTE setup attempts.
  - < 3%
- **Data session drop.** Defined as VoLTE sessions that do not end correctly. Calculated as the relation between VoLTE dropped connections and total VoLTE connections.
  - < 3%

d. Demand considerations for commercial deployment

Demand considerations have been set based on the experience of Telefonica and Vodafone in terrestrial when deploying terrestrial

coverage in rural and remote areas in their footprint. Minimum and maximum values are estimated to consider different scenarios of demand.

- **Inhabitant density.** The service is defined to provide coverage in areas with @20 inhabitants per square km. This KPI applies to the total area of coverage under the sky platform.
- **SIM penetration.** Defined as the relation between the total number of SIMs and the total number of inhabitants covered.
  - 80% -100%
- **User adoption.** Defined as the total number of users that are subscribed to the network provided by the sky platform. The service assumes that there will be at least two MNOs subscribed.
  - 50% -75
- **Device compatibility.** Not all devices are compatible with LTE coverage and specifically, they may not be compatible with the specific band that the platform will use (sub 1GHz). This will limit the total number of users connected – especially in the short and mid-term.
  - 40% -60%
- **Concurrent users.** Defined as the relation between the concurrent users using the service at one moment in time and the total number of users
  - the 10%

*Note: Demand considerations are not considering travelling users; ie. Users that do not live within the coverage footprint. In some specific scenarios, this may be the main source of traffic and a deep-dive study will have to be made.

e. Service density for commercial deployment

Characteristics of different platforms will involve being able to serve different areas of coverage. For the service, a minimum area of 20km of radius is considered – but this is not applied in a restrictive manner, platforms may be able to cover bigger extensions. To abstract this capability, many of the following KPIs are provided as a density/km.

With these premises, we can estimate the client density and concurrent client density for the cases we defined before.

- **Client density.** Defined as the total number of served clients per km2.
  - o Neutral: 3,2 clients/km2
  - o Optimistic: 9,0 clients/km2

Calculated by multiplying the inhabitants/km2 (20inhab/km2), SIM penetration, user adoption and device compatibility.

- **Concurrent client density.** Defined as the total number of concurrent served clients per km2. This factor is relevant to size the capacity of the access solution.
  - o Neutral: 0,32 Concurrent client/km2
  - o Optimistic: 0,9 Concurrent client/km2

Calculated by multiplying the client density with client concurrency.

- **Throughput density.** Defined as the minimum throughput density to be provided to deliver the user experience defined above.
  - o Neutral: 0,32 * 5Mbps =1,6 Mbps/km2
  - o Optimistic: 0,9 *5Mbps = 4,5 Mbps/km2

This estimation is the result of multiplying concurrent client density with the throughput.

To provide a reference comparison with urban LTE service:

- Average spectral efficiency of 3bps/Hz in LTE
- Carrier bandwidth: 20Mhz carrier (not considering carrier aggregation)
- Site distance: 200mts sector radius

With these considerations, the throughput density would be 461Mbps/Km2. Showing that the requirement has been relaxed by two orders of magnitude to create a solution optimized for low-density scenarios.

f. Spectrum consideration

The bandwidth allocated to the sky platform will be 10MHz in a sub 1GHz band – to facilitate propagation. Specific band used may vary between operators and/or country where the service is provided.

g. Supporting features for PoC

For live PoC it will be a subset of the features require for potential commercial deployment.

#	Component	Description
1	Access	Directive antenna with possibility to dynamically define area of coverage
2	Access	LTE protocols stack with software customization to adapt to large propagation delays of up to 40ms (Round Trip Time (RTT)).
5	Access	Solution follows and is compliant with LTE security requirements (IPSec encapsulation, authentications, encryption, etc.)
7	Access	Solution supports voice over LTE.
9	Access	Dynamic change in neighboring cells. Sky platforms will be deployed ad-hoc in different scenarios of ground coverage – especially in emergency scenarios. Neighboring configuration should be simple and fast.
10	Backhaul	Wireless backhaul used to take traffic back to the ground.
11	Backhaul	Backhaul link supports a horizontal Distance between the ground station and sky platform of over 50km without deteriorating or being a bottleneck to the access service.
12	Management	The Operations Support System should support standard functionalities like software management, performance management, and fault management. In addition. Communications KPIs and alarms integrated in the existing OSS platforms of telcos.
13	System	The solution works with standard LTE devices and the SIM cards of the MNOs delivering the service.

15	System	Resilience in terms of security and stability in varying weather conditions.
18	System	Non-Terrestrial solution will integrate with test core of the MNO. A specific intermediate can be used to facilitate this integration and the support of the rest of the features described.

h. Supporting features for potential commercial deployment

The following table provides and initial list of minimum features required for the communications solutions to guarantee: (i) service requirements, (ii) business requirements, (iii) coexistence with terrestrial connectivity.

#	Component	Description
1	Access	Directive antenna with possibility to dynamically define area of coverage – beam management for scenarios of multiple beams.
2	Access	LTE protocols stack with software customization to adapt to large propagation delays of up to 40ms (Round Trip Time (RTT)).
3	Access	Interference handling features. With extensive areas of coverage, solutions will overlap with terrestrial networks. Dedicated spectrum for sky platform is not anticipated. In this scenario, interference handling features are critical for both networks to co-exist. This feature should be independent to the terrestrial vendor used.
4	Access	Sync supported in the Non-Terrestrial solutions, as it is needed to coordinate features between macro and Non-Terrestrial layers (1588 or GPS). Delivered according to

		ITU standard.
5	Access	Solution follows and is compliant with LTE security requirements (IPSec encapsulation, authentications, encryption, etc.)
6	Access	Solution supports different forms of sharing agreements: MORAN. MOCN and roaming.
7	Access	Solution supports voice over LTE.
8	Access	Solution supports IoT technologies (NB-IoT and Cat-M)
9	Access	Dynamic change in neighboring cells. Sky platforms will be deployed ad-hoc in different scenarios of ground coverage – especially in emergency scenarios. Neighboring configuration should be simple and fast.
10	Backhaul	Wireless backhaul used to take traffic back to the ground.
11	Backhaul	Backhaul link supports a horizontal Distance between the ground station and sky platform of over 50km without deteriorating or being a bottleneck to the access service.
12	Management	The Operations Support System should support standard functionalities like software management, performance management, and fault management. In addition. Communications KPIs and alarms integrated in the existing OSS platforms of telcos.
13	System	The solution works with standard LTE devices and the SIM cards of the MNOs delivering the service.
14	System	Energy optimization features to minimize energy usage
15	System	Resilience in terms of security and stability

		in varying weather conditions.
16	System	Complement legacy terrestrial service. This includes: -.Handovers integration with terrestrial service -.Load balancing policies -.Prioritization between terrestrial ground carriers and non-terrestrial carriers. This feature should be independent to the terrestrial vendor used.
17	System	Manageable, flexible installation and operation of the Non-Terrestrial Solution, with target to deliver an efficient and seamless multi-technology network. Dynamic changes in bands used and self-optimization for these bands is required.
18	System	Non-Terrestrial solution will integrate with the public core of the MNO. A specific intermediate can be used to facilitate this integration and the support of the rest of the features described.
19	System	All the information on the users connected to the service will be owned by the operator. No other player can access, store or process the user information or the traffic being generated.

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