Drone Network Workshop

Aston University

Non-terrestrial Network based Seamless Communication Solution for High-Connectivity and Sustainability

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Dr. Zhengjia Xu is a passionate aerospace researcher with extensive multidisciplinary R&D experience specialising in ***wireless communication, space-service based localisation and navigation, signal processing with scientific AI models for data analysis.***

Dr. Xu has successfully led, developed, and supervised a number of research projects sponsored by ESA and EPSRC, collaborating with leading industry partners such as Telespazio UK, GMV, and OneWeb. His industry experience includes prototyping and deployment of innovative passive radar systems and IoT solutions, developed in partnership with companies like Drone Defence Services Ltd, ASH Wireless Ltd (Captec), and London Defence.

His practical engineering experience as a Senior RF Engineer and Embedded Systems Engineer has equipped him with comprehensive skills in hardware implementation, Software-Defined Radio (SDR) application development, embedded C programming (ARM-based platforms), and Python programming.

Wireless Comm, Nav, and Positioning, and Autonomous Systems

All-Inclusive Service for Sustainable Connectivity on the Move

To address the lack of reliable connectivity in coastal surveillance, environmental monitoring, **maritime safety**, **search and rescue**, and **critical infrastructure inspection** in cell-sparse or no-coverage environments, we are developing and field-prototyping Non-Terrestrial Network (NTN) communications (e.g., LEO satellite connectivity such as Starlink) to deliver wide-area, resilient links and materially reduce operational and safety risks caused by communications blackspots.

StellarCube Sustainable Solutions

4G/5G, Wi-Fi / Satellite → Customer oriented compact design → Automatic link selection and fusion → Seamless connectivity

HIGH PERFORMANCE, Plug&Play, AFFORDABLE & COMMUNICATION SUSTAINABILITY

- **Multi-Bearer Aggregation - Combine 4G/5G, Wi- Fi, LEO satellite**
- **Seamless Aggregation - Zero-interruption among multi-networks**
- **Edge Intelligence - Local processing & traffic optimization**
- **Secure by Design – E2E encryption, VPN support**

StellarCube Specifications

Form Factor 235×165×23mm, 850g

Power 12V DC, 36W (cellular)

Temperature -10°C to +50°C

Throughput 500 Mbps

Dual 4G/5G modems + Wi-Fi 6 **+** Ethernet to LEO and much more (4×GbE, USB 3.0)

CHEDDAR

Demonstration of UAV-Based Emergency Response Using Non-Terrestrial Networks (NTN)

Durham University | Department for Science, Innovation, & Technology | EPSRC Engineering and Physical Sciences Research Council

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1. Introduction

In **disaster** scenarios where terrestrial base stations are unavailable, a Non-Terrestrial Network (NTN) solution aims to be investigated to demonstrate the coordination between users, Unmanned Aerial Vehicles (UAVs) and Low Earth Orbit (LEO) satellite communications.

The provision of high-throughput, low-latency, and resilient communication services in response to Public Protection and Disaster Relief (PPDR) operations, as well as in temporary and unplanned events, remains a persistent **challenge**. In this regard, the deployment of a mobile NTN architecture, augmented by UAV integration, presents a promising solution. **Such a platform facilitates rapid establishment of provisional communication infrastructure, enabling emergency connectivity restoration with notable advantages including enhanced mobility & flexibility, independence from terrestrial networks, and near-global coverage.**

Current research on NTNs remains largely theoretical, with limited customisation for real-world applications and insufficient grounding in practical scenarios to identify critical research challenges. **Demonstrating 3D multi-layered NTN network to enable emergency response capabilities requires system-level integration and incremental innovation to establish a coherent architecture that supports application-oriented deployment.**

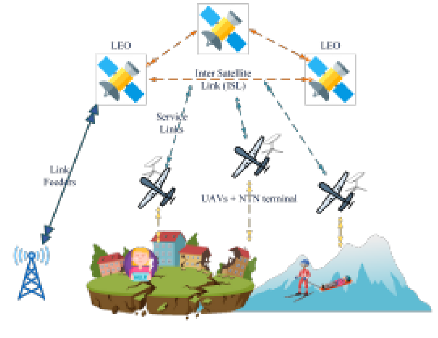
The general objectives of this project include:

- demonstrating 3D multi-layered communication services to ground users over UAV based NTN,
- user-tracking based communication optimisation following Integrated Sensing and Communications (ISAC) principle.

2. Use Scenario

3D Multi-layered NTN Architecture

In the envisioned NTN architecture, each UAV is integrated with a NTN terminal, functioning as an aerial relay node to support user-terminal association in areas where terrestrial infrastructure is unavailable or has been compromised. These UAV-mounted terminals establish service links with proximal LEO satellites to facilitate efficient information exchange.



This hierarchical NTN framework supports the rapid deployment of disaster-resilient communication services, offering high mobility, wide-area connectivity, and link diversity under extreme or unstructured conditions. **The system is particularly well-suited for mission-critical operations such as search-and-rescue missions, emergency response coordination, and temporary communication restoration in post-disaster environments (e.g., earthquakes, landslides, or remote mountainous regions).**

3. ISAC Integration

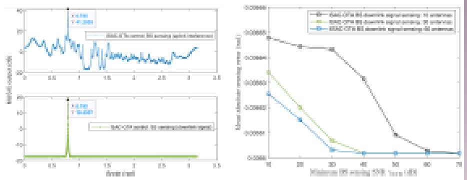
Assuming that user signals are unknown and must be identified through an RF sensing mechanism within the ISAC framework, the localisation accuracy serving as an indicator of sensing performance is estimated using the classical MUSIC algorithm, enabled by the deployment of a MIMO antenna array.

Communication Objective Function with SNR Constraints:

$\min_{\mathbf{W}_T, \mathbf{v}, a} \frac{1}{3} \sum_{t=1,2,3} \mathbb{E}_{\sim s, \epsilon_k} \left[\| a \cdot \mathbf{z}_k[t] - \tilde{\mathbf{u}}_k[t] \|_2^2 \right]$

s.t.

$\mathrm{SNR}^{(\text{dl-echo})} \geq \gamma_{\mathrm{SNR}}, \| [\mathbf{W}_T]_{m,:} \|_2^2 + |v_m|^2 \leq P_{\mathrm{BS}}, 1 \leq m \leq N_t$

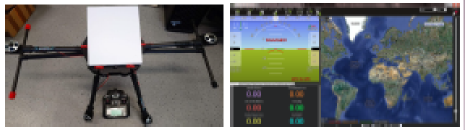


(a) MUSIC Angle Estimation (b) Sensing Performance Eval.

Fig. (a) demonstrates the feasibility of angle estimation using the classical MUSIC algorithm within an ISAC-OTA base station sensing framework, validating the algorithm's resolution and robustness across interference scenarios. As shown in Fig. (b), sensing accuracy improves notably with increasing SNR and larger-scale MIMO configurations. This highlights the advantages of higher spatial degrees of freedom in enhancing angular resolution and estimation precision.

4. Ongoing Real Demonstration

The demonstrated UAV platform adopts a 6-axis airframe, enabling stable flight with heavy payloads. A Starlink Mini terminal is integrated as a satellite communication module, serving as a relay to facilitate bidirectional data exchange between ground users and Low Earth Orbit (LEO) satellites. The system is supported by the Mission Planner software, which provides capabilities for health monitoring, autonomous mission planning, and in-flight system diagnostics.



Further system integration and validation will be carried out through additional flight trials in real-world scenarios, aiming to demonstrate the feasibility of the proposed 3D multi-layered NTN communication architecture in practical deployments.

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Thank you for your attention

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