SAGIN-4C-6G: A Space-Air-Ground Integrated Network for Enhanced Communication, Computation, Caching and Control in 6G

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Motivation

- **Space-air-ground integrated networks (SAGINs) hold great promise in delivering ubiquitous access, effectively meeting the 6G demands for large-coverage on-demand services.**
- **Various components like unmanned aerial vehicles (UAVs), high-altitude platforms (HAPs), satellites, and terrestrial networks face distinct limitations and integration challenges.**

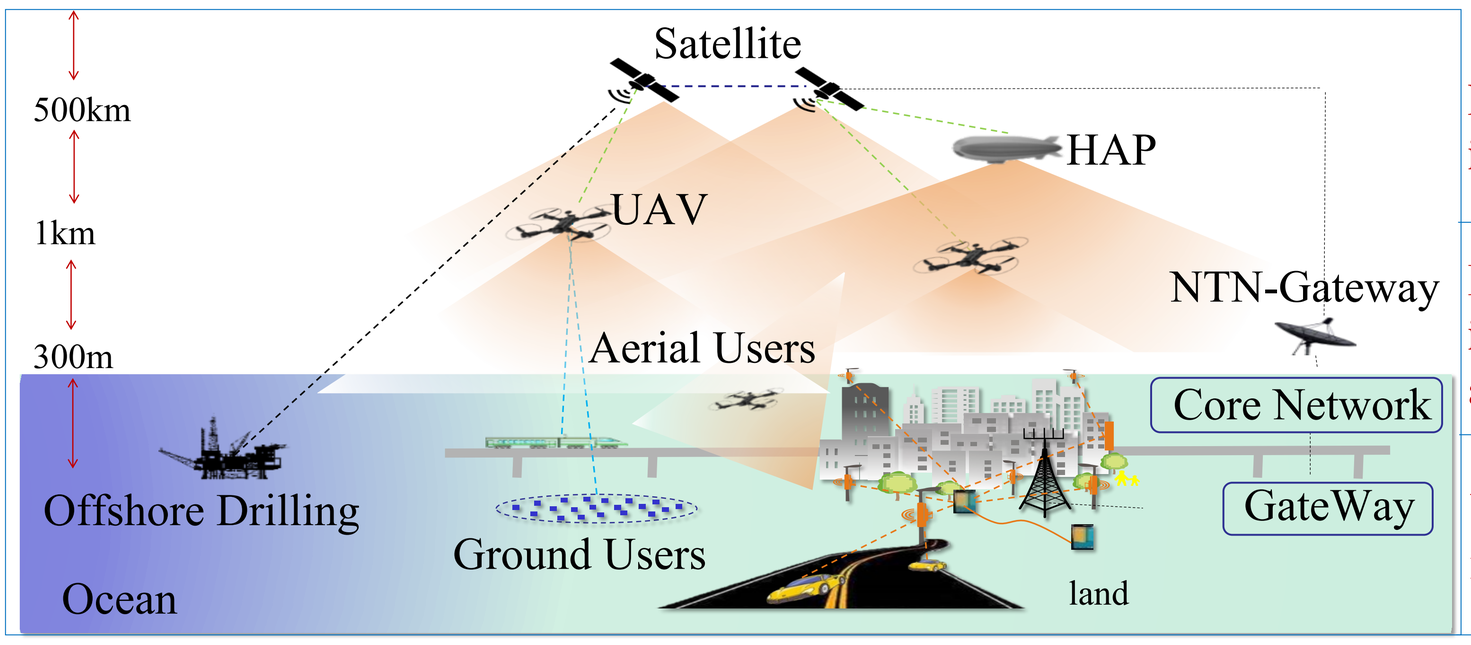
Our Demo Contributions

- **This demo presents the world's first SAGIN-4C-6G platform, which has been successfully deployed and tested within commercial networks (China Mobile).**
- **It designs an Integrated 4C module (I4CM), that sets a new benchmark for the integration of multi-dimensional networks in the evolution toward 6G.**

Introduction

6G Ubiquitous Communication: Wireless coverage enabled by SAGINs is a key issue.

Goals: Three-dimensional seamless global coverage, on-demand services for various application scenarios.

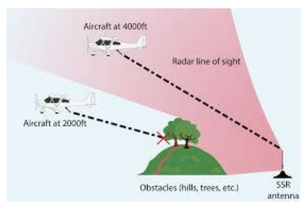


Issues to be addressed

No coverage in specific areas

e.g. Starlink: coverage differentiation

Lack of coverage in low altitude areas



e.g. UAV system: communication coverage blind spots

Weak coverage in dense areas

e.g. Milan cell phone call map: non-uniform service coverage

Demo Description

① Ad-Hoc Network Module

② Flight Control Module

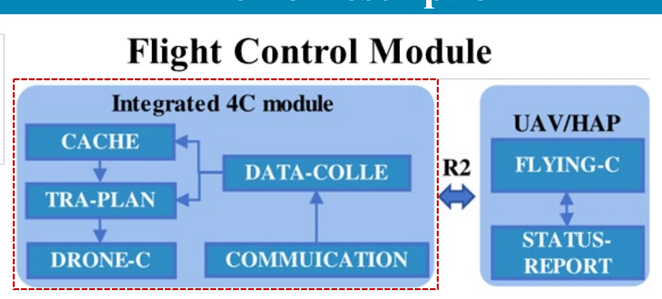
③ Backhaul Module

④ AAP Equipment

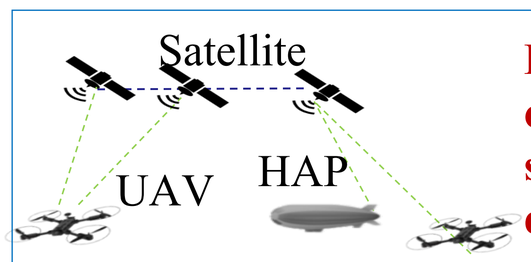
⑤ Core Network

⑥ Backhaul Equipment

⑦ Satellite Module



I4CM is designed to enable stable coverage according to the distribution of ground users and coverage demand.



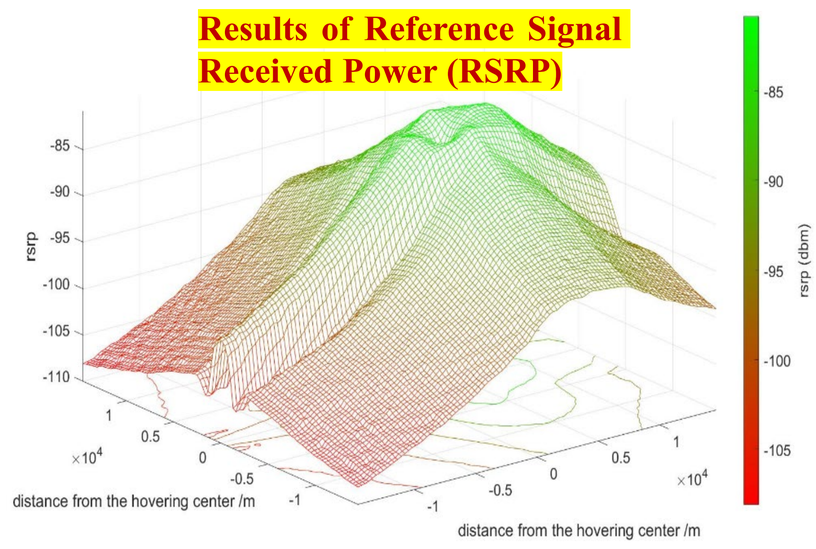
Inter-satellite handover challenges in UAV/HAP-accessed satellite mega constellations with diverse requirements

No. of satellite layers	Orbital number	No. of satellites per orbital	Total No. of satellites	No. of satellites per orbital /total stars	Orbital inclination (°)	Orbital height (km)
LEO-1	18	21	378	23/414	85	1345
LEO-2	36	21	756	23/828	89	1100
LEO-3	45	48	2160	53/2385	60	375
LEO-4	47	50	2350	55/2585	50	370
LEO-5	46	52	2392	57/2622	40	365
LEO-6	24	28	672	31/744	30	445
LEO-7	24	28	672	31/744	30	455
10322 (after 10% backup of single orbital)						

With constant connection requirements, approximate 40% increase in resource efficiency.

Demonstration Results

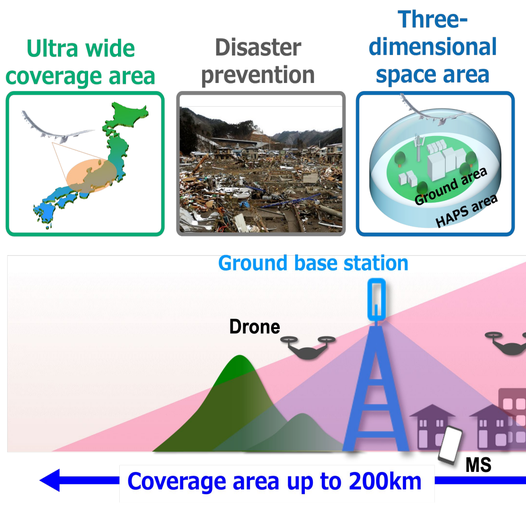
AAP flight altitude upper bound	1,000 m
Power supplement	160 W
5G backhaul frequency	4.9 GHz
Satellite backhaul frequency	Ka-band
Radio access frequency	2.6 GHz



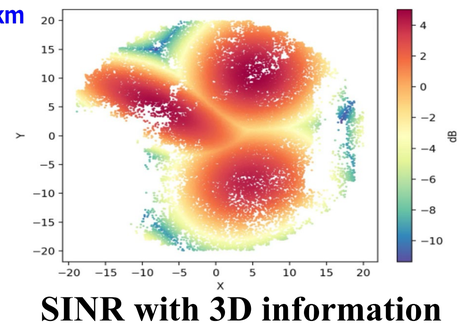
The coverage area, where the RSRP of the ground user exceeds the threshold (-100 dBm), is greater than 100 km².

HAP over Tokyo Area

Three HAPs with beamforming can adapt according to UE-Dense Areas

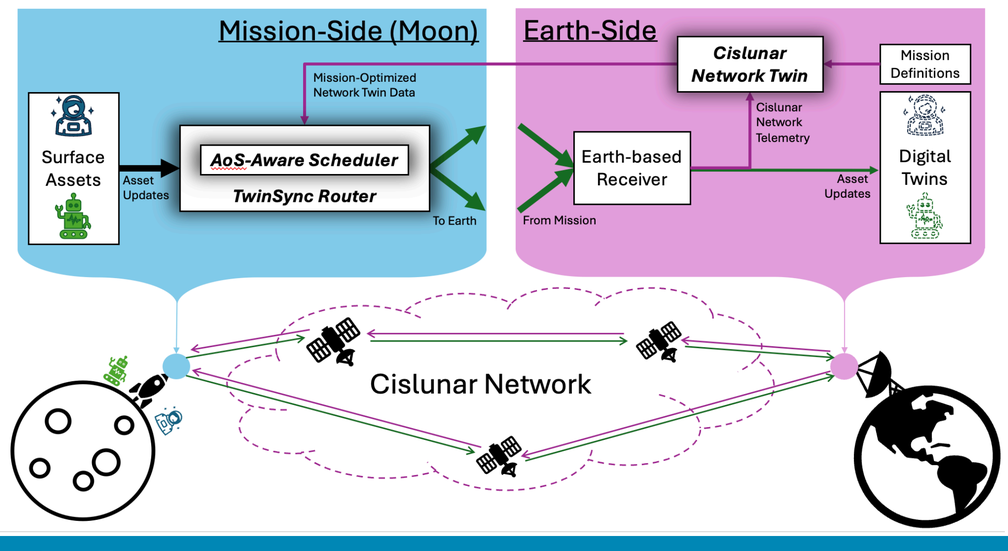


Transmission power	43 dBm/cell	Bandwidth	18 MHz
Number of cells	3 cells/HAPS	Communication Link	Downlink
Transmission frequency	2 GHz	Propagation	System design on page 7



Future Outer Space Integration

A Framework for Syncing Digital Twins over Dynamic Cislunar Networks



Industrial Acceptance and Broader Impact

- **This demo is already partially deployed in the commercial networks of China Mobile, providing coverage assurance for emergency incidents.**
- **The SAGIN-4C-6G platform integrating the I4CM enables high-speed A2G coverage over 100 km², supporting low-altitude economy applications and stable connectivity for emergency response.**