



WRC-23 AI 1.8
CONTROL AND NON-PAYLOAD
COMMUNICATION (CNPC) OF
UNMANNED AIRCRAFT SYSTEMS
USING THE FIXED-SATELLITE SERVICE

BACKGROUND, ANSWERS AND KEY ELEMENTS

2023



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**Control and Non-Payload Communications (CNPC) / Command and Control (C2)
of Unmanned Aircraft System (UAS) / Remotely Piloted Aircraft System (RPAS)
in non-segregated airspaces using primary allocations
of the fixed-satellite service (FSS)**

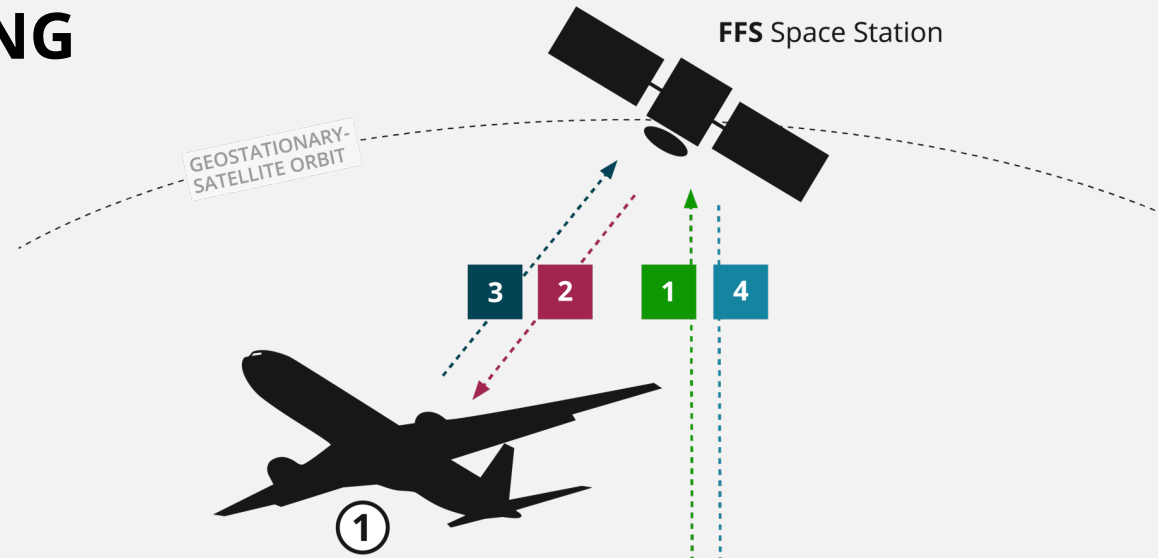
This presentation collects
key elements, background information and **answers**
for the **safe and reliable operation of UAS / RPAS**

GOALS OF REGULATIONS AND AIRWORTHINESS CERTIFICATIONS



- ✓ **Provision of a regulatory framework and procedural guidance for the safe and reliable operation of UAS/RPAS**
in non-segregated airspaces using primary allocations of the FSS under its already regulated conditions
→ **use-as-is principle**
- ✓ **Paving the way for using of the huge amount of existing satellite capacity in the FSS**
being the only existing technical solution for long-range applications, especially of medium to high altitudes
- ✓ **Use of the experiences on UAS/RPAS flights in segregated airspaces gained over the last decade**
and transfer of operational, and technical achievements into the use of the non-segregated airspaces
under clear regulatory and operational rules
- ✓ **Guaranteeing a safe UAS/RPAS operation without the need for new developments of satellite technology**
Existing resources could be used right away for supporting worldwide UA/RPA operations

TECHNICAL UNDERSTANDING



1+2: Forward link (Remote pilot to UA)

- 1 **FORWARD UPLINK (E-S)**
as a **particular FSS** uplink
- 2 **FORWARD DOWNLINK (S-E)**
as **standard FSS** downlink received by an aircraft earth station

3+4: Return link (UA to remote pilot)

- 3 **RETURN UPLINK (E-S)**
as **standard FSS** uplink
- 4 **RETURN DOWNLINK (S-E)**
as **standard FSS** downlink



UACS/RPS*

REMOTE PILOT

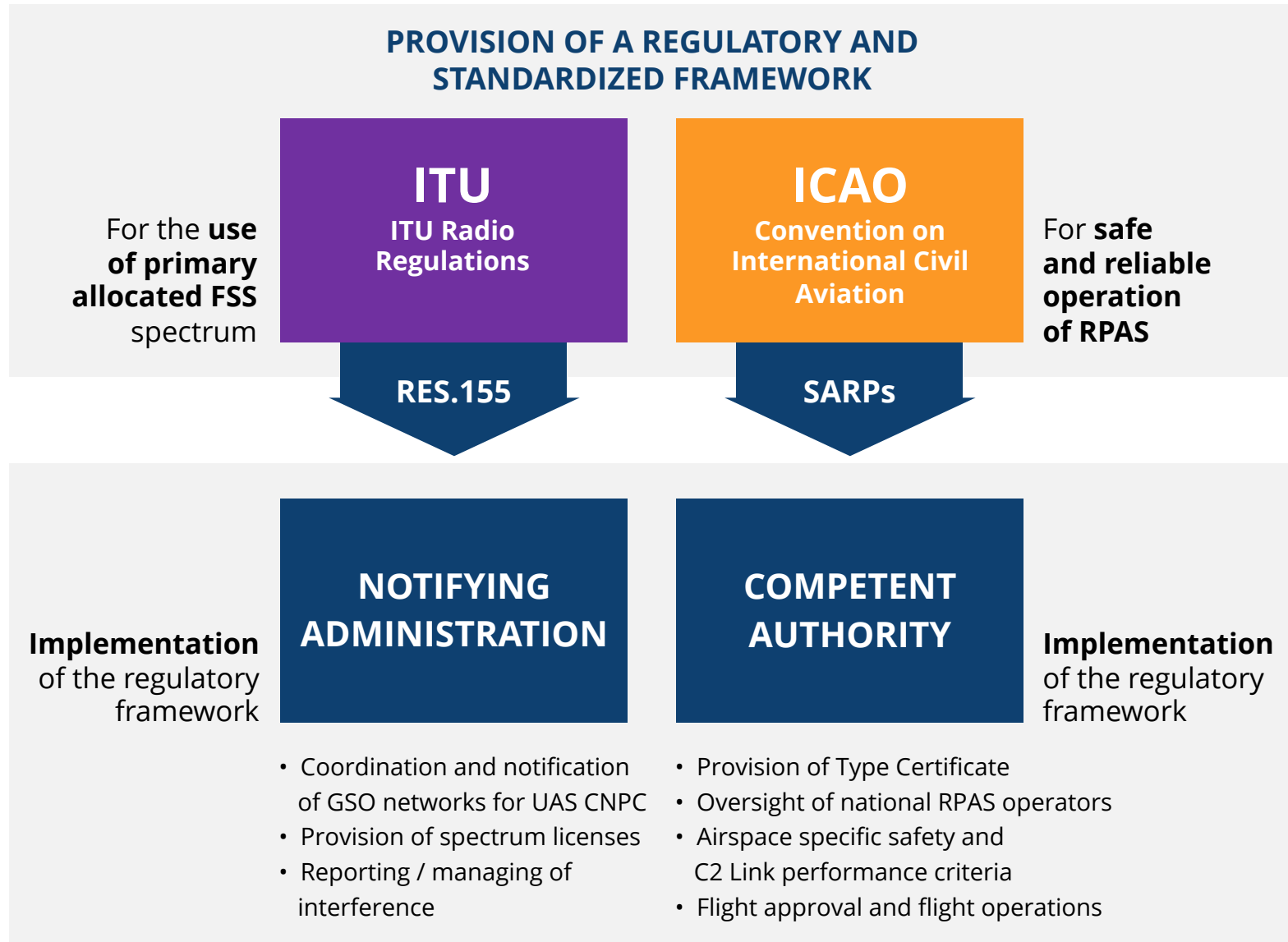
EARTH STATION
(FIXED ON THE GROUND)

① „ONE PILOT, ONE PLANE“ POLICY

* UACS = Unmanned Aircraft Control Station | RPS = Remote Pilot Station

UAS CPNC / C2 LINKS

RESPONSIBILITIES



FOLLOWING

- **the adoption of Resolution 155**
- **setting the rules** for its implementation and
- **the endorsement of SARPs** with guidelines for the Required Link Performances

Responsibility is transferred to the state and administration level

KEY ELEMENTS

Overview **ITU** and **ICAO**



ITU

Res.155

- I. **Determines a regulatory framework of how to use the FSS for UAS CNPC links**
- II. **Protects incumbent co-primary radiocommunication services**
- III. **Provides guidance for interference management**
- IV. **Enables veto rights for ADMs on licensing RPS and/or UAS CNPC earth stations to be operated in/over their territory**

ICAO

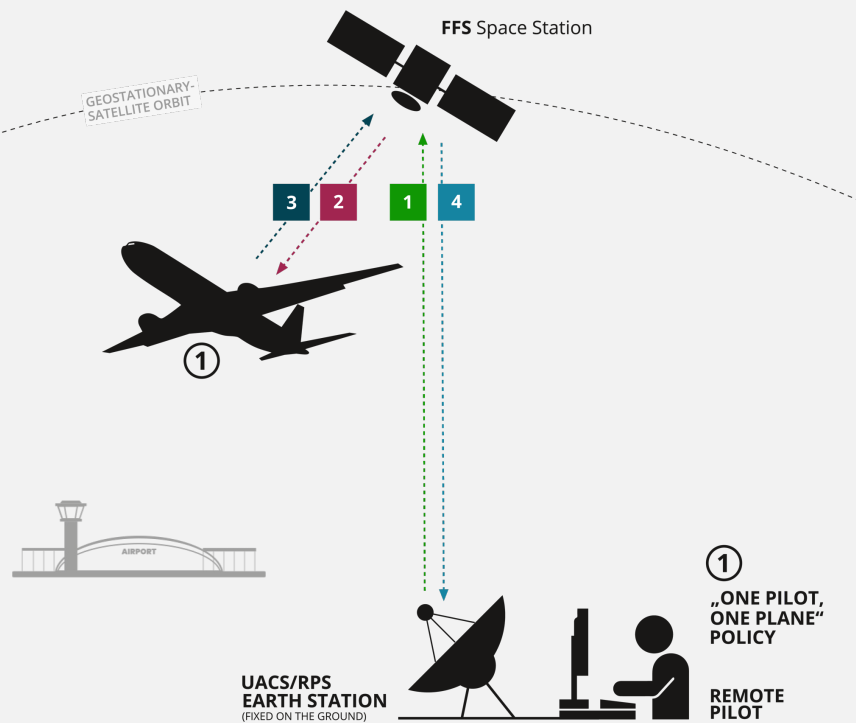
SARPs
(+ Manual)

- I. **Ensure C2 Link performance and safety of flight for RPAS / Instrument Flight Rules (IFR) operations**
- II. **Define responsibilities for operations, service provision and certifications**
- III. **C2 Link procedures and guidelines for service provision**
- IV. **System SARPs as C2 Link technology agnostic requirements**

ITU

RES.155

I. FSS FRAMEWORK



FREQUENCY BANDS ALLOCATED TO THE FSS TO BE USED BY UAS CNPC LINKS:

Ku band:

14-14.47 GHz and **10.95-11.2 GHz, 11.45-11.7 GHz** (in all ITU Regions)

11.7-12.2 GHz on a worldwide basis as (Region 2 only)

12.2-12.5 GHz (Region 3 only)

12.5-12.75 GHz (Regions 1 and 3)

Ka band:

29.5-30 GHz and **19.7-20.2 GHz** on a worldwide basis

RESOLUTION 155

- **CNPC links** are an **application of the primary FSS**
- **“Use-as-is” principle:**
No regulatory change of the FSS – like every other FSS application:
 - Links 1 and 4** as **standard links of FSS** to and from fixed (mostly specific) earth stations
 - Link 2** as a **standard FSS downlink** received by an earth station on board UA. Mitigation measures should be in place to reduce the impact of interference caused by incumbent terrestrial radiocommunication services.
 - Link 3** as an **application of the FSS uplink** from an earth station on board UA. PFD masks are established for the protection of co-primary terrestrial radiocommunication services in Ku band over territories of affected ADMs
- **No adverse impact** on exiting existing and future frequency coordination process (no safety of life argumentation in coordination / no safety status according to **ITU RR Article 4.10** for FSS-based CNPC)
- **Use of notified GSO networks (MIFR)** with recorded parameter ranges of **the FSS satellite network and its particular coordination agreements**

II. PROTECTION OF TERRESTRIAL SERVICES

Only applicable for **Link 3** in **Ku band** in countries identified in **Article 5 of ITU-RR** for certain frequency bands

5.505 ADDITIONAL ALLOCATION:

in Algeria, Saudi Arabia, Bahrain, Botswana, Brunei Darussalam, Cameroon, China, Congo (Rep. of the), Korea (Rep. of), Djibouti, Egypt, the United Arab Emirates, Eswatini, Gabon, Guinea, India, Indonesia, Iran (Islamic Republic of), Iraq, Israel, Japan, Jordan, Kuwait, Lebanon, Malaysia, Mali, Morocco, Mauritania, Oman, the Philippines, Qatar, the Syrian Arab Republic, the Dem. People's Rep. of Korea, Singapore, Somalia, Sudan, South Sudan, Chad, Viet Nam and Yemen, **the frequency band 14-14.3 GHz is also allocated to the fixed service on a primary basis.** (WRC-19)

5.508 ADDITIONAL ALLOCATION ("limited to some countries in **ITU Region 1**" only): in **Germany, France, Italy, Libya, North Macedonia** and the **United Kingdom**, the frequency band **14.25-14.3 GHz is also allocated to the fixed service on a primary basis.** (WRC-19)

REGIONAL ALLOCATION:

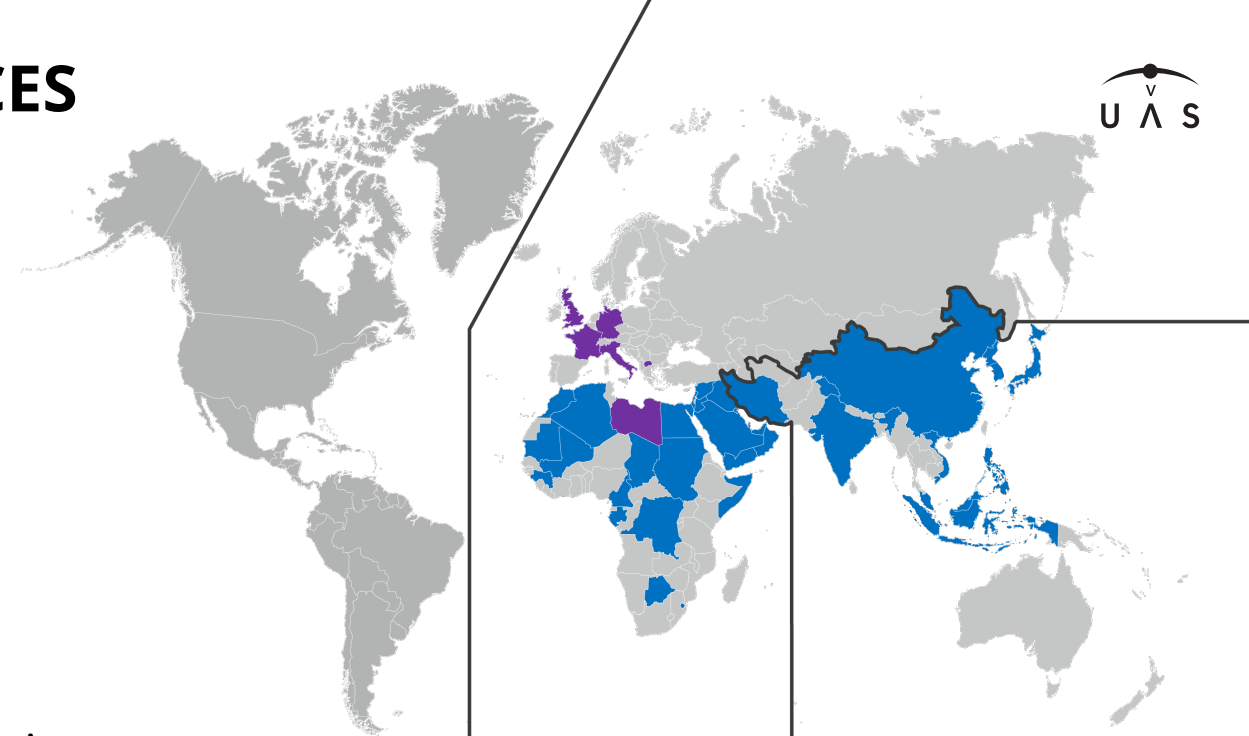
in **ITU Regions 1, 3** the frequency band **14.3-14.4 GHz is allocated to the fixed service on a primary basis**

WORLDWIDE ALLOCATION:

the frequency band **14.4-14.47 GHz is allocated to the fixed service on a primary basis**

No protection of terrestrial radio services is required over the oceans

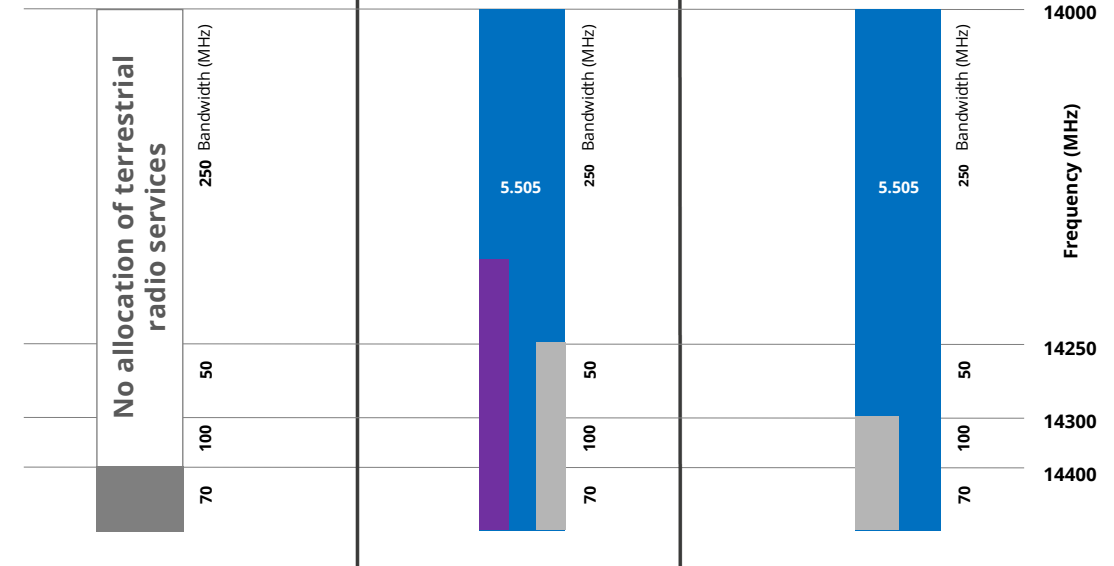
PFD masks are proposed in Res. 155 Annex 2 b) as a hard limit



ITU Region 2

ITU Region 1

ITU Region 3



II. PROTECTION OF TERRESTRIAL SERVICES

Two examples of PFD masks have been developed for the protection of terrestrial services

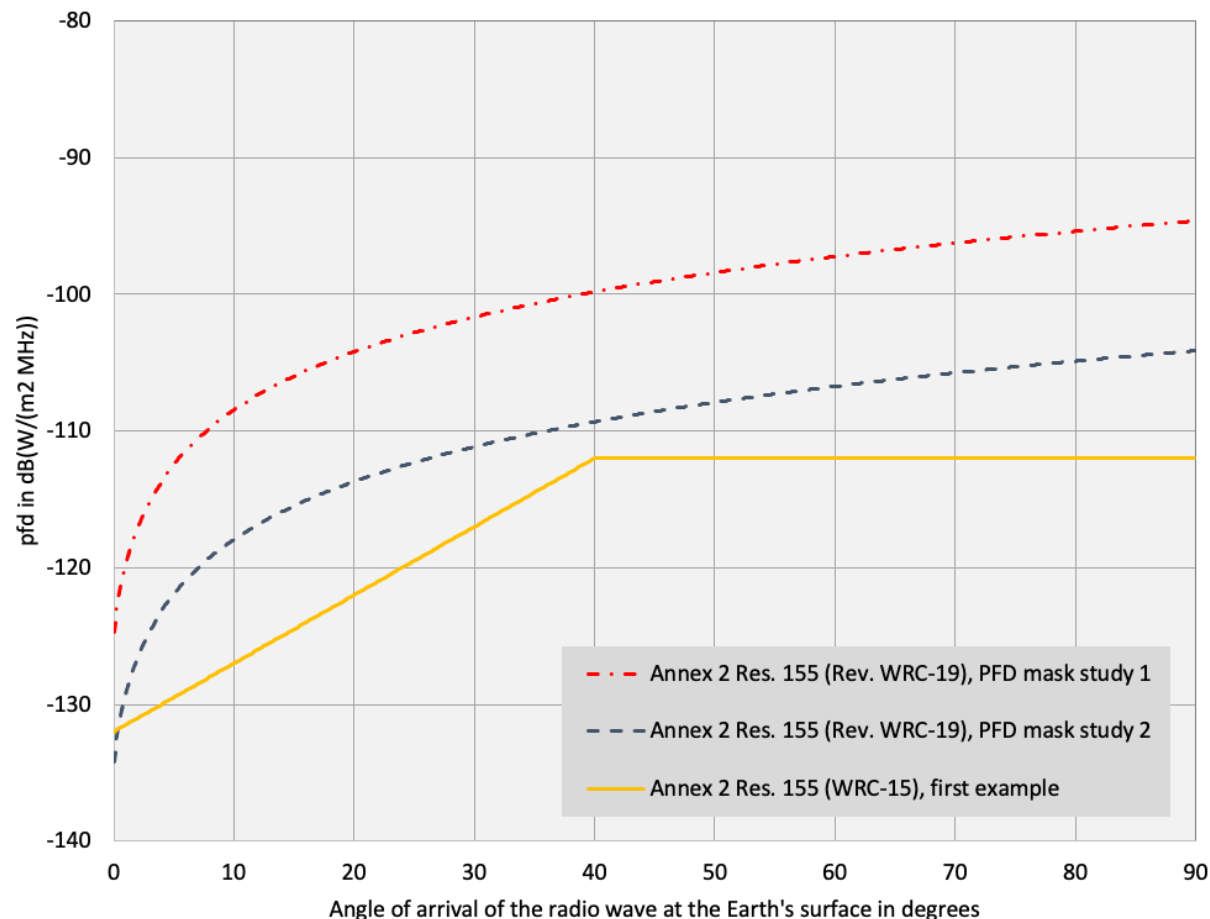
Multiple altitudes and FS characteristics

have been studied to show full protection for the anticipated FS characteristics by fulfilling

- the **short-term** protection criteria of FS
- the **long-term** protection criteria of FS
- the **Fractional Degradation of Performance (FDP)** criteria of FS for frequencies below 15 GHz

Examination / Implementation of PFD masks

could be similar to **Res. 169 (WRC-19), WRC-23 AIs 1.15** and **1.16**.



III. INTERFERENCE MANAGEMENT

Operational measures shall be established to overcome most of the interference cases,

- within the coordination results of the used FSS systems
- under the responsibility of the notifying administration

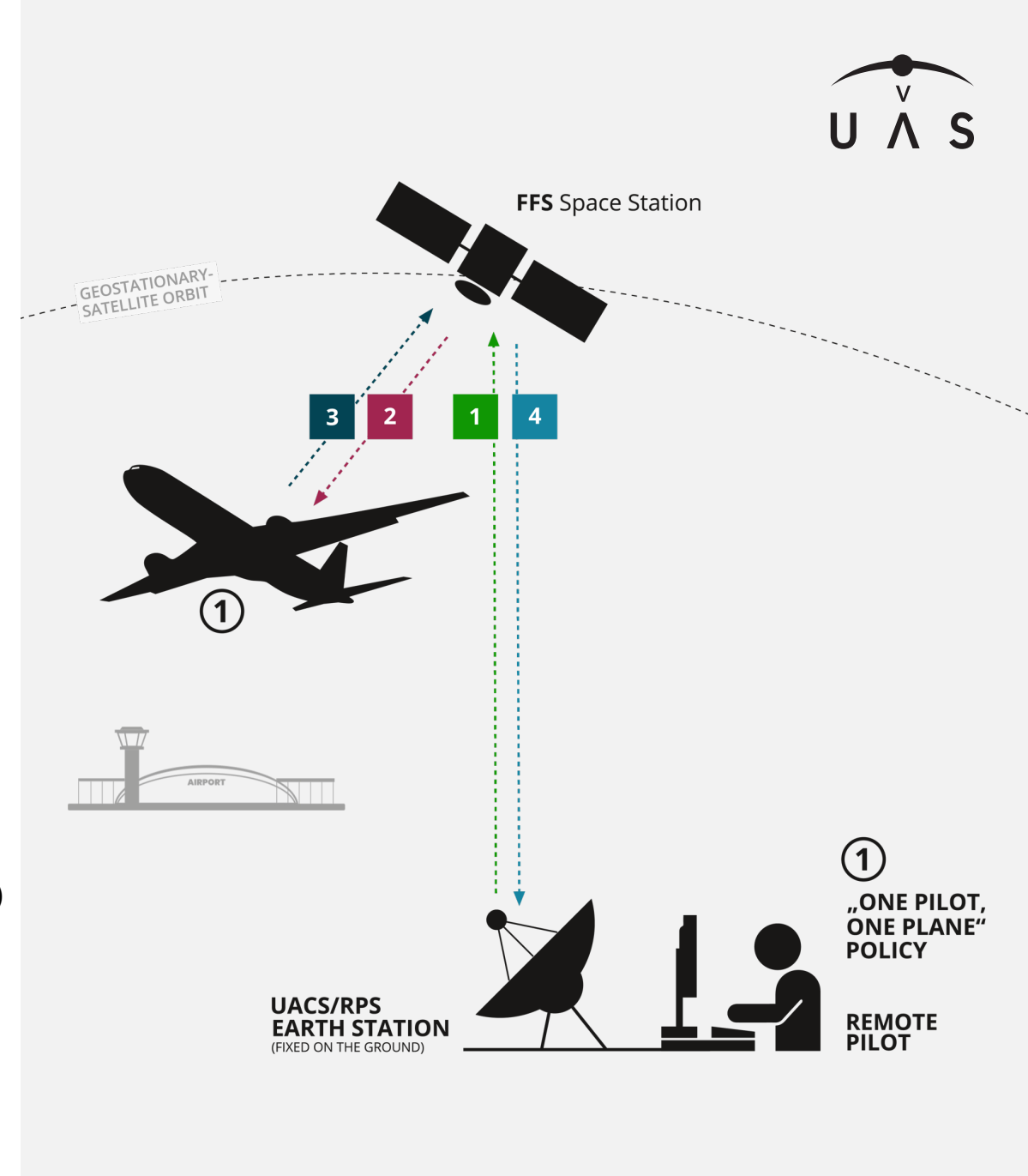
ICAO SARPs establish procedures to ensure the safety of flight including emergency procedures in case of a lost link

New interference environment for **link 2** only

Mandatory monitoring, prediction, and estimation of FS interference by the UAS/RPAS operator

Tools and methods are available to improve interference mitigation and prediction (e.g. cognitive systems, reinforcement learning)
 → Could be covered in a future Recommendation in ITU-R

Links **1**, **3** and **4** are standard FSS links whose interference environment is well-known by the respective satellite operator



IV. LICENSING AND VETO RIGHTS OF NOTIFYING ADM

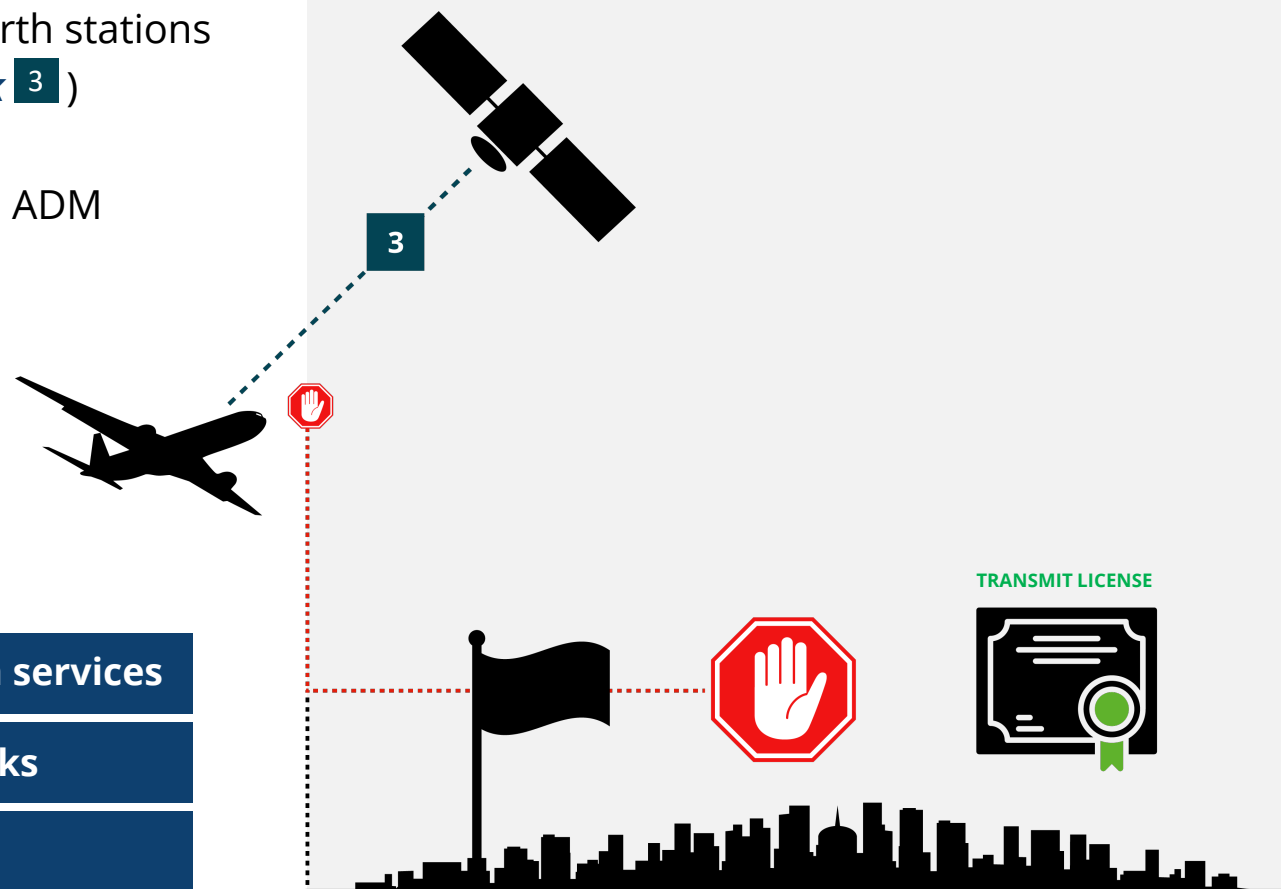
FSS operator **requires a transmit license** for UAS CNPC earth stations when operating in / flying over the territory of an ADM ([Link 3](#))

FSS operator **needs to apply for transmit licenses** in each ADM following the national licensing rules and processes

Prerequisite for such licensing:
ITU notification of the satellite network

National licensing **requires** in most cases, i.a.

- ✓ **Proof of protection of terrestrial radiocommunication services**
- ✓ **Complete coordination with national satellite networks**
- ✓ **Compliance with resolves and provision Res. 155**
- ✓ **Proprietary requirements which might be specific to Res. 155 or generic to all transmitting satellite terminals**



ICAO

SARPs

I. ENSURE C2 LINK PERFORMANCE AND SAFETY OF FLIGHT FOR RPAS

- For the safety of flight, several planning and operational procedures as well as special measures are required
- Certification and supervision of the RPAS operator and licensing of the Remote Pilots, implementation of a Safety Management System (SMS), and a collection of regulatory, operational and infrastructure measures to be implemented
- Guidelines for developing the Required Link Performances (RLPs) and definition of airspace-specific performance indicators (Availability, Continuity, and Integrity)
- Guidelines for operational responsibilities including Service Level Agreements (SLAs) between C2CSP(s) and RPAS Operator(s)
- Type Certificates, guaranteeing the airworthiness of the UAS equipment

The RPAS Designer specifies the, RPAS design dependent, C2 Link Specification

The RPAS Operator contracts, through a Service Level Agreement with the C2CSP, for a QoS for their planned operation

RLP developed by Aviation Safety Regulators

C2 Link standardized by SARPs

PERFORMANCE

Performance based RLP, high level concept and process, actual values in Manual

MANAGEMENT

Performance based, response to commands to Establish/Terminate, Switchover, Handover and Report Status, actual values in Manual

COMPATIBILITY

Performance based, management of interference and protection of systems, actual values in Manual

SECURITY

Performance based security controls, actual values in Manual

II. SECURE INDIVIDUAL COUNTRY VETO RIGHTS / OVERFLIGHT RIGHTS

The freedoms of the air are a set of 9 commercial aviation rights in respect of scheduled international air services, granted by one State to another State, or States including the country's airlines to

- fly across its territory
- land in its territory
- to put down and to take on traffic coming from or destined to the home state of the carrier
- etc.

The freedoms of the air are the fundamental building blocks of the international commercial aviation route network.

▶ Mandatory basis for the ICAO work:

- **Chicago Convention** stipulates in **Annex 2, Appendix 4** that **also a 'pilotless aircraft' requires permission of the State** planned to be flight over.

III. C2 LINK SERVICE PROVISIONION

SARPs

Required Link Performance (RLP) and safety of flight to be fulfilled inside the FSS boundary conditions for the RPAs command and control in non-segregated airspaces

End-to-end responsibility for guaranteeing the safety of flight in the hand of the RPAS operator, beforehand certified by the responsible/competent authority

Satellite-based C2 Link via service provisioning concept C2 Communication Service Provider (C2CSP) based on SLAs to fulfill the RLP guarantees that the QoSD (Quality of Service Delivered) be **commensurate / at least as good as QoSR** (QoS Required) based on the **exclusive use of the allocated satellite resource for that specific link**

RPAS
MANUAL

Technology agnostic system performance characteristics for compliance with the RLPs

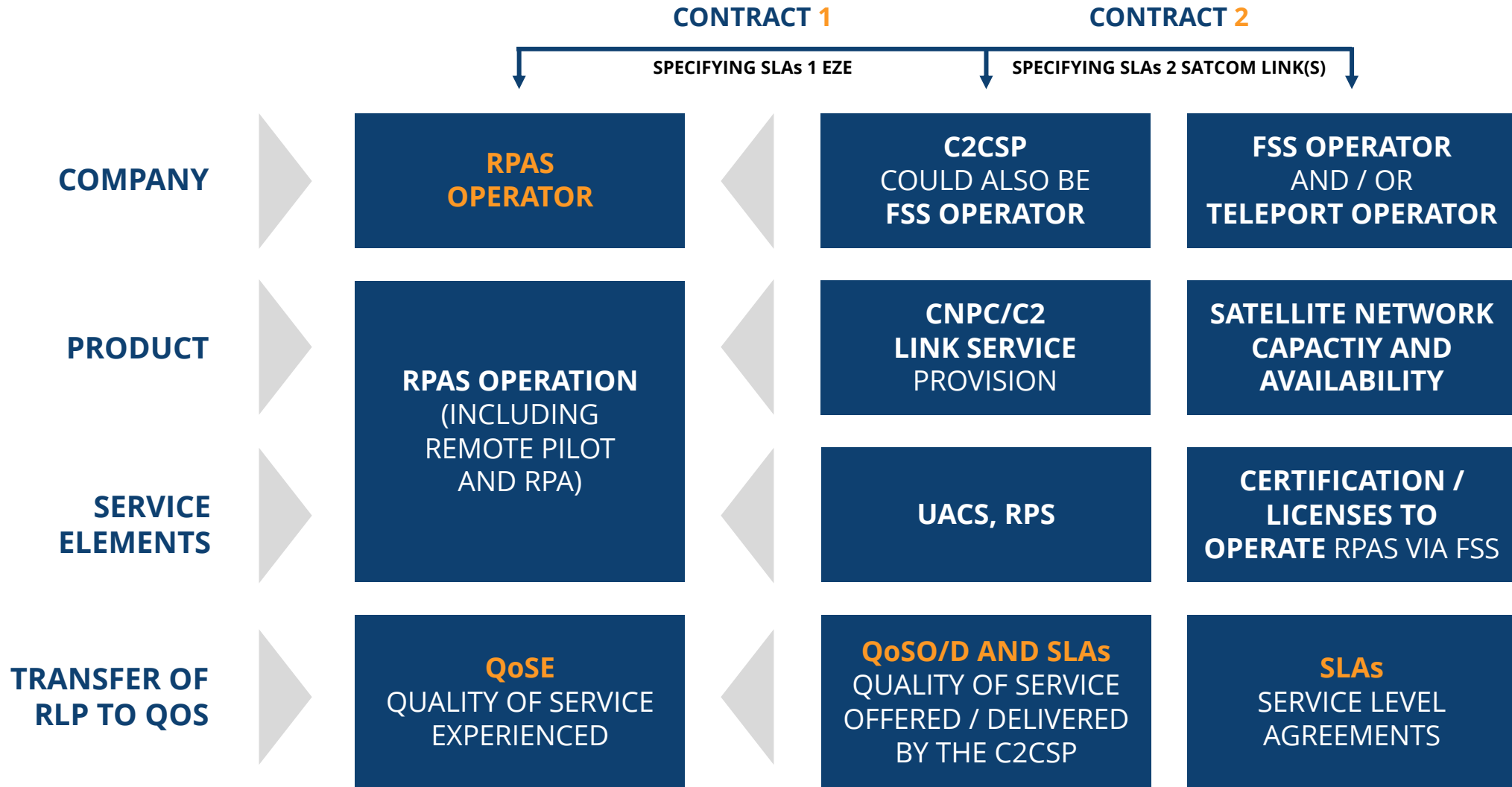
Definition and international harmonization of C2 Link technologies

Guidelines for developing the RLPs and concept for its transfer towards C2 Link specifications and the required QoS (QoSR)

QoSR-compliant specific selection of the appropriate technical solution

- FSS service provider(s) with its satellites/coverages/beams
- UAS control station (UACS)/Remote Pilot Station (RPS)

PROCESS FOR AN RPAS OPERATOR



C2 LINK PLANNING PROCESS FOR AN RPAS OPERATOR

QoS_D / QoS_E are fixed in SLAs between RPAS and C2CSP for selected FSS satellites



Technical, regulatory and operational constraints and boundary conditions for C2 Link provision

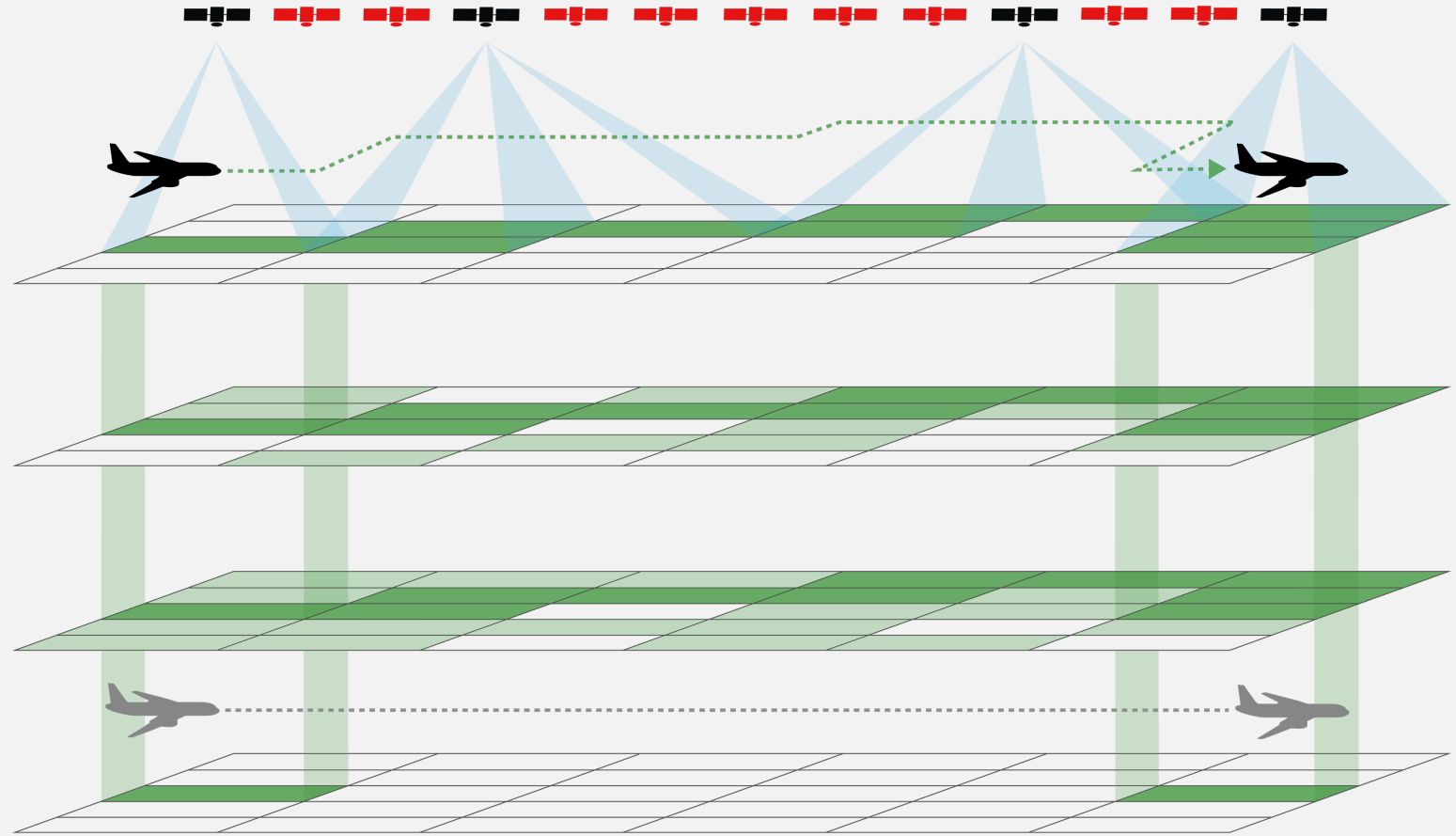
4 FSS QoS_D / QoS_O under existing coordination agreements

3 UA earth station transmit licenses in *Link 3*

2 Service area(s) of the notified FSS filing(s)

1 Freedom of the air

Usable SLA-compliant satellite coverages and resulting exclusions zones for the flight path above different territories





SUMMARY AND CONCLUSION

SUMMARY

Completed key elements



- ✓ **Safety of Flight** → Necessary performance and safety aspects cleared for safe operation of UAS / RPAS
- ✓ **Responsibilities** → Clear distinction of responsibilities defined
- ✓ **SARPs development** → SARPs endorsed in 2022, on time for WRC-23's decision on Resolution 155
- ✓ **Protection of incumbent radio services** → Protection based on country specific conditions is established
- ✓ **Framework on how to use the FSS** → All necessary aspects are clarified for FSS compliant UAS / RPAS operations
- ✓ **Veto right after WRC-23 still available** → National sovereignty / veto rights still in place even when Res.155 is implemented

- ✓ **SARPs and Resolution 155 pave the way for the safe and reliable use of FSS for CNPC / C2 Links** under the developed regulatory and procedural framework
- ✓ **Resolution 155 provides the rules and boundary conditions of regulatory provisions for use of FSS for UAS CNPC /RPAS** but does **not provide a blanket set** and is **not bypassing national rights**
- ✓ **UAS CNPC via FSS is a valid and SARPs-compliant technology, but needs to be evaluated on a flight-by-flight basis in terms of SLA and Resolution 155 compliance** as its performance and (non-) suitability depends on geographic, regulatory, and national boundary conditions
- ✓ **Both, the ICAO SARPs and the ITU-R Resolution 155 define and provide the international framework and general rules for FSS-based CNPC / C2 Links** but the States / ADMs have the rights and the possibility to define their own set of rules inside these frameworks for the operation of UAS/RPAS or even restrict operation in non-segregated airspace



**Support Resolution 155
for the use of FSS for UAS CNPC links!**

PLEASE SCAN QR CODE FOR FURTHER UAS INFORMATION

