ATTACHMENT (B)

WAC-23/067
[NOTE: This document was forwarded on a non-consensus basis]

UNITED STATES of AMERICA

Proposals for the work of the conference

Agenda Item 10

10 to recommend to the Council items for inclusion in the agenda for the next WRC, and to give its views on the preliminary agenda for the subsequent conference and on possible agenda items for future conferences, in accordance with Article 7 of the Convention,

Draft Proposal for a WRC-27 Agenda Item
Spectrum allocations and associated regulatory provisions to support lunar and cislunar communications in specific frequency bands

Background Information:

The need urgently exists to accommodate the planned communications and data transmission requirements of long-term and continuous commercial and scientific operations on and around the moon. Operations on the moon's surface are lunar operations, and operations in the vast void between Earth orbits and the moon are known as cislunar operations.

This proposal is for studies to support multi-component end-to-end communications for lunar and cis-lunar operations. The core element is a draft new resolution that directs and focuses the ITU-R studies. This resolution includes the specific frequency bands and services to be considered and the interservice interference cases to be addressed in the studies. It is highly focused on the regulatory measures, including allocation additions or revisions, that are needed to meet very well-defined requirements. The resolution also calls for a report from the ITU-R to WRC-27 on the results of those studies and potential regulatory changes.

Administrations in all three ITU Regions have announced and are pursuing lunar missions, with remote unmanned exploration already underway, and with human visits to the Moon set to occur as early as 2025. From there, permanent bases and regular space travel (both crewed and remote-controlled) will be established by the end of this decade or in the early 2030s. This is not speculation. Technological and business model development is underway, and much of this development will transcend the scientific arena and include substantial commercial activity.

The Radio Regulations include some provisions (*see, e.g.,* Section **V** of Article **22**) that specifically apply to services on the moon, and the Master International Frequency Register (MIFR) includes a number of assignments from several administrations. Today, however, there are no established commercial options for multi-use lunar/cislunar communications or data storage. Entities around the world have started the

effort to address this imminent need. In the United States, for example, a comprehensive proposal has been made for a commercial lunar communications relay service – anticipating early use by NASA as well as others with commercial lunar far side and south polar region missions.[1] Other business initiatives will follow.[2] Again, with lunar and cislunar mission planning underway for activities that will begin within the next few years, this is neither a theoretical nor academic exercise. [3]

It is of utmost importance to the successful exploration and conduct of continuous operations on the Moon for there to be a reliable, understandable, usable, and available communications and data architecture in place to handle the communication and data transmissions services such exploration and operation services will require. The timely and effective development of this architecture is essential to the advancement of lunar exploration, scientific research, and the broader commercial lunar economy.

The architecture for how the communications requirements for operations in lunar/cislunar space (i.e., cislunar communications relay and data services for missions on the lunar surface and in lunar orbit) and beyond will be structured is rapidly taking shape. Systems, such as Parsec, have been designed to be compatible with NASA's LunaNet initiative, and create an internet-like architecture to support lunar missions.[4] The LunaNet system requirements are intended to promote maximum interoperability and to enable use by a broad range of operators. LunaNet will include networking services capable of moving data between nodes; positioning, navigation, and timing services for orientation and velocity determination; and time synchronization and dissemination and science services providing situational alerts and scientific measurements. Other space agencies around the world are developing similar initiatives, and some space agencies are encouraging commercial development of lunar and cislunar communications systems in the form of public/private partnerships that are now characterizing significant aspects of space activities – from launch services to space habitats and more.

The envisioned lunar and cislunar communications system is being designed to enable communications to and from Earth (Earth station) for lunar assets (service user) through lunar orbiting relay satellites (space stations). Surface-to-surface communications would be enabled through the satellite relay link in lunar orbit for surface assets. Communications links, coupled with radiometric navigation techniques to provide location, velocity, and time information to assets on the lunar surface and in lunar orbit, will also be used. The planned system will provide real-time relay capabilities when both ends of the link (Moon and Earth) are visible.

Some core elements are likely to be included in all architectures. These elements include:

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[1] The U.S. Federal Communications Commission is considering an application seeking the establishment of a lunar communications system called "Parsec™". *See* FCC File No. SAT-LOA-20220218-00020, Q43 Full Narrative § 4 (filed Feb. 18, 2022) https://bit.ly/3RaqyO3 ("Parsec Application")

[2] The U.S. Federal Communications Commission is considering an application seeking authority for a lunar lander. *See* FCC File No. SAT-AMD-20220510-00049, Narrative (filed May 10, 2022), https://bit.ly/3OyIMXz; FCC File No. SAT-LOA-20210423-00055, Narrative (filed Apr. 23, 2021), https://bit.ly/3Ov4Pyz ("IM Application").

[3] *See generally* Parsec Application; IM Application.

[4] *See* David Israel et al., LunaNet: a Flexible and Extensible Lunar Exploration Communications and Navigation Infrastructure and the Inclusion of SmallSat Platforms, Presentation and Paper before Technical Session XII: Communications at Utah State University Small Satellite Conference, SSC20-XII-03, at Table 1 (2020), https://bit.ly/3LCI3n0
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- **Lunar surface communications** (functionally similar to terrestrial mobile services that are provided on the Earth's surface) that are used for robotic vehicles to/from a lunar base, and such lunar node-to-node links as space suits and radio handsets.
    - *Potential frequencies include*
      390-405 MHz, 406-406.1 MHz, 410-420 MHz, 435-450 MHz,
      2400-2480 MHz, 2503.5-2650 MHz, 3400-3700 MHz,
      5150-5350 MHz, 5470-5725 MHz, 5850-5925 MHz
    - The selection of frequency bands used on Earth for land mobile and/or RLAN applications enables these operations to leverage existing products, designs, and chip sets that have already addressed technical challenges in Earth-based applications and are considered good candidates to be space hardened. The other potential bands on the list above have properties that make them desirable for lunar-surface operations. While aligning well to promote technical achievability, this approach also significantly lowers future costs for development and deployment for all potential lunar operators. Additionally, pre-launch testing is simplified when using bands allocated on the Earth's surface.
    - Given free space path loss and separation distances, no potential interference into Earth-based land mobile and RLAN services is expected.
    - For the lunar-surface uses, there is no current allocation that fully covers this element.

- **Lunar surface to/from lunar-orbiting satellites** (similar to Earth-to-space/space-to-Earth links, but using the Moon in place of the Earth.)
    - *Potential frequency bands include 390-405 MHz (cislunar space-to-lunar surface), 435-450 MHz (lunar surface-to-cislunar space), 23.15-23.55 GHz (cislunar space-to-lunar surface) and 27-27.5 GHz (lunar surface-to-cislunar space), and space research service bands at 2025-2110 MHz (cislunar space-to-lunar surface) and 2200-2290 MHz (lunar surface-to-cislunar space).*
    - The allocation to the space research service (space-to-space) in the 2025-2110 MHz and 2200-2290 MHz bands for lunar surface stations communicating with non-satellite space objects in cislunar space covers the intended use and appears to be consistent with RR Nos. **1.8** and **1.64**. The inter-satellite service for the 23.15-23.55 GHz and 27.0-27.5 GHz bands are limited to communications between artificial satellites, so its use for this element may not be achievable.
    - No current allocation for space research (space-to-space) in the 390-405 MHz, 435-450 MHz, 23.15-23.55 GHz and 27.0-27.5 GHz bands. Space research in these bands would need to include links between artificial satellites and stations on the moon. It is important to confirm that there is no distinction between functionally-equivalent links involving stations on artificial satellites versus those involving stations on space objects on the moon.
    - Given free space path loss and separation distances from Earth-centric operations (including ISS and fixed-satellite service Earth-to-space links), no potential interference into Earth-centric services is expected, and there will be no need to revisit any prior allocation actions or conditions in the potential bands listed for this element.

- **Lunar-orbiting satellite inter-satellite links**
    - *Potential frequency bands are 23.15-23.55 GHz and 27-27.5 GHz.*
    - This use fits nominally within the ISS definition.
    - Given free space path loss and separation distances from Earth-centric operations (including ISS and fixed-satellite service Earth-to-space links), no potential interference into Earth-centric services is expected, and there will be no need to revisit any prior allocation actions or conditions in the potential bands listed for this element.

- **Lunar surface-to/from-Earth communications** (including telemetry, telecommand, telematics, data transfer, and contingency uses with a limited number of specific Earth stations).
    - *Potential frequency bands include 7190-7235 MHz (Earth-to-lunar surface), 8450-8500 MHz (lunar surface-to-Earth), 22.55-23.15 GHz (Earth-to-lunar surface), and 25.5-27 GHz (lunar surface-to-Earth).*
    - The space research service (Earth-to-space or space-to-Earth) allocation for earth stations communicating with lunar surface space objects applies and appears to be consistent with RR Nos. **1.8**, **1.63**, and **1.64**. It is important to confirm that there is no distinction between functionally-equivalent links involving stations on artificial satellites versus those involving stations on space objects on the moon.

- **Lunar-orbiting satellites to/from ground stations on Earth** (similar to Earth-to-space/space-to-Earth) but the spacecraft are in orbit around a natural satellite of the Earth).
    - *Potential frequency bands include space research service bands at 7190-7235 MHz (Earth-to-space), 8450-8500 MHz (space-to-Earth), 22.55-23.15 GHz (Earth-to-space), and 25.5-27 GHz (space-to-Earth).*

The frequency bands identified above are technically well suited to accommodate the requirements developed to date. Changes to the Radio Regulations may be necessary in some cases only to accommodate some of the types of traffic, services, and functional capabilities. While new allocations to the space research service (space-to-space) could be a possible outcome of the ITU-R studies, it is important to confirm in all of the new or existing SRS cases that the communications applications fit or can be accommodated within the SRS.
Preliminary ITU-R studies have identified factors to be considered in assessing the compatibility of the envisioned lunar and cislunar operations with incumbent services in the specified frequency bands. Continued development and completion of these studies will permit the development of appropriate ITU-R regulatory text to define the cases in which such transmissions may be provided, and allow for a determination of whether the recognition of compatible links can be made via appropriate modifications to Article **5** of the Radio Regulations (where warranted), and provisions for the coordination, notification, and recording of frequency assignments.
The specific proposals for this WRC-27 agenda item are provided below:

Proposals

SUP USA/10 (LUNAR/CISLUNAR)/1

RESOLUTION 812 (WRC-19)

Preliminary agenda for the 2027 World Radiocommunication Conference*

Reasons: This Resolution must be suppressed, as WRC-23 will create a new Resolution that will include the agenda for WRC-27.

ADD USA/10 (LUNAR/CISLUNAR)/2

RESOLUTION [A10] (WRC-23)

Agenda for the 2027 World Radiocommunication Conference

The World Radiocommunication Conference (Dubai, 2023),

considering

a) that, in accordance with No. 118 of the ITU Convention, the general scope of the agenda for a world radiocommunication conference (WRC) should be established four to six years in advance and that a final agenda shall be established by the ITU Council two years before the conference;

b) Article 13 of the ITU Constitution relating to the competence and scheduling of WRCs and Article 7 of the Convention relating to their agendas;

c) the relevant resolutions and recommendations of previous world administrative radio conferences (WARCs) and WRCs,

recognizing

a) that this conference has identified a number of urgent issues requiring further examination by WRC-27;

b) that, in preparing this agenda, some items proposed by administrations could not be included and have had to be deferred to future conference agendas,

resolves

to recommend to the Council that a WRC be held in 2027 for a maximum period of four weeks, with the following agenda:

1 on the basis of proposals from administrations, taking account of the results of WRC-19 and the Report of the Conference Preparatory Meeting, and with due regard to the requirements of existing and future services in the frequency bands under consideration, to consider and take appropriate action in respect of the following items:

1.1 to consider, based on the results of ITU-R studies, spectrum allocation and associated regulatory provisions to support lunar and cislunar communications in specific frequency bands in accordance with Resolution **[A10-LUNAR] (WRC-23)**;

. . .

invites the ITU Council

to finalize the agenda and arrange for the convening of WRC-27, and to initiate as soon as possible the necessary consultations with Member States,

instructs the Director of the Radiocommunication Bureau

1 to make the necessary arrangements to convene meetings of the Conference Preparatory Meeting (CPM) and to prepare a report to WRC-27;

2 to submit a draft report on any difficulties or inconsistencies encountered in the application of the Radio Regulations referred in agenda item 9.2 to the second session of the CPM and to submit the final report at least five months before the next WRC,

instructs the Secretary-General

to communicate this Resolution to international and regional organizations concerned.

Reasons: To provide for urgent studies in the specified frequency ranges of the possibility of accommodating lunar and cislunar communications on a basis other than under No. **4.4** of the Radio Regulations.

ADD USA/10 (LUNAR/CISLUNAR)/3

DRAFT NEW RESOLUTION [A10-LUNAR] (WRC-23)

Spectrum allocations and associated regulatory provisions to support lunar and cislunar communications in specific frequency bands

The World Radiocommunication Conference (Dubai, 2023),

considering

a) that scientific and commercial operations on the moon and between the moon and Earth are increasing, and will be robust by later in this decade and into the 2030s;

b) that operations on the moon are considered to be lunar operations, and operations in the vast void between the moon and where Earth-orbiting satellites operate (and the Earth itself) are considered to be cislunar operations;

c) that the operations referred to in *considering a)* above will need a reliable, understandable, usable, and available communications and data architecture in place to handle the substantial communication and data transmissions services that support such scientific and commercial operations;

d) that the ITU-R has begun preliminary studies on the technical issues associated with lunar and cislunar communications,

considering further

a) that the architecture envisioned for the operations referred to in *considering a)* include the following components:

i) Lunar surface communications (similar to terrestrial mobile services on the Earth's surface) that are used for lunar robotic vehicles to/from a lunar base, and such lunar node-to-node links as space suits and radio handsets – with potential frequencies that include:

a. frequency bands that are used on Earth for applications in the mobile service at 390-399.9 MHz, 440-450 MHz, 2400-2480 MHz, 2503.5-2650 MHz, 3400-3700 MHz, 5150-5350 MHz, 5470-5725 MHz, and 5850-5925 MHz;

b. the space research service (space-to-space) band at 410-420 MHz (also allocated to the mobile service); and

c. the frequency bands at 399.9-405 MHz, 406-406.1 MHz, and 435-440 MHz (allocated to services other than mobile, but which have properties that make them desirable for lunar-surface-only operations);

ii) Lunar surface to/from lunar-orbiting satellites (similar to Earth-to-space/space-to-Earth links, but using the Moon in place of the Earth) – with potential frequency bands that include 23.15-23.55 GHz (cislunar space-to-lunar surface) and 27-27.5 GHz (lunar surface-to-cislunar space), and space research service bands at 2025-2110 MHz (cislunar space-to-lunar surface) and 2200-2290 MHz (lunar surface-to-cislunar space), as well as the frequency bands 390-405 MHz (cislunar space-to-lunar surface) and 435-450 MHz (lunar surface-to-cislunar space) that have allocations as described in *considering further a) i)* above;

iii) Lunar-orbiting satellite inter-satellite links (already covered within the definition of inter-satellite service (ISS)) – with potential frequency bands that include the ISS bands at 23.15-23.55 GHz and 27-27.5 GHz;

iv) Lunar surface-to/from-Earth communications (including telemetry, telecommand, telematics, data transfer, and contingency services involving a limited number of stations on Earth) – with potential frequency bands that include 7190-7235 MHz (Earth-to-lunar surface), 8450-8500 MHz (lunar surface-to-Earth), 22.55-23.15 GHz (Earth-to-lunar surface), and 25.5-27 GHz (lunar surface-to-Earth);

v) Lunar orbiting satellites to/from ground stations on Earth (similar to Earth-to-space/space-to-Earth but the spacecraft are in orbit around a natural satellite of the Earth) – with potential frequency bands that include space research service bands at 7190-7235 MHz (Earth-to-cislunar space), 8450-8500 MHz (cislunar space-to-Earth), 22.55-23.15 GHz (Earth-to-cislunar space), and 25.5-27 GHz (cislunar space-to-Earth);

b) that lunar missions requiring access to the communications architecture described in *considering further a) i)* through *v)* will already be underway before WRC-27;

c) that the communications architecture described in *considering further a)* above could also provide the starting point for consideration of communications on, to, and from celestial bodies in our solar system other than the moon,

recognizing

a) that the distance between the Earth and the moon will likely mean that low power operations similar to terrestrial mobile operations but performed on the lunar surface, and other non-Earth-centric operations, pose no threat of unacceptable or harmful interference to terrestrial service operations on Earth;

b) that the nature of the activities on and around the moon that the envisioned communications architecture will support makes it untenable to rely on No. **4.4**, and appropriate allocation and associated regulatory actions are needed to ensure international recognition of the operations and provide certainty and growth opportunities for the long term;

c) that there is no current allocation in the frequency bands identified in *considering further a) i)* above that can accommodate the described lunar surface communications;

d) that space research service (space-to-space) allocations in the frequency bands identified in *considering further a) ii)* above involve communications between artificial satellites and stations on the moon and there is no current space research service (SRS) (space-to-space) allocation in the 23.15-23.55 GHz and 27-27.5 GHz bands that encompasses the described communications between the lunar surface and lunar-orbiting artificial satellites;

e) that there is an allocation to the ISS in the 23.15-23.55 GHz and 27-27.5 GHz frequency bands identified in *considering further a) iii)* above that can accommodate the described communications links between satellites in lunar orbit, with reference to Nos. **5.536, 5.536A, 5.536B, 5.536C,** and **5.537** of the Radio Regulations;

f) that confirmation that space research (Earth-to-space) and (space-to-Earth) communications can include communications to/from non-satellite space objects would ensure that the current allocation in the frequency bands identified in *considering further a) iv)* above encompasses the described communications between the lunar surface and ground stations on the Earth's surface;

g) that the current allocation to the SRS in the frequency bands identified in *considering further a) v)* above has appropriate directionality that can accommodate the described communications between the lunar-orbiting satellites and earth stations on the Earth's surface;

h) that confirmation is needed that the uses of the space research service as envisioned here fit within the "scientific or technological research purposes" component of the definition of the SRS in No. **1.55** of the Radio Regulations;

i) that the Radio Regulations already address some communications matters involving lunar and cislunar operations, such as Section V of Article **22**, and the Master Register already includes a number of lunar-related assignments;

j) that it is desirable to achieve the objective of putting a reliable, understandable, usable, and available communications and data architecture in place, and to keep the number of associated regulatory

changes to the fewest necessary to provide that framework for the operations referred to in *considerings a)* and *c)* above;

k) that the purpose of the communications architecture being developed may make it appropriate to consider including regulatory provisions and potential exceptions to current allocations and use cases in a WRC Resolution that can be periodically updated as requirements and experiences change, and minimize or avoid definitional or other changes that could have unintended or farther-reaching consequences,

recognizing further

a) that the frequency bands at 390-405 MHz, 406-406.1 MHz, 410-420 MHz, 435-450 MHz, 2400-2480 MHz, 2503.5-2650 MHz, 3400-3700 MHz, 5150-5350 MHz, 5470-5725 MHz, and5850-5925 MHz include primary allocations (in some or all Regions) to the fixed and mobile services, fixed-satellite service, meteorological aids, meteorological satellite, space operation, mobile-satellite service, radiolocation, radiodetermination-satellite service, broadcasting-satellite service, Earth exploration-satellite (passive), radio astronomy, space research (including the limitations on space-to-space applications in the 410-420 MHz band in No. **5.268**), standard frequency and time signal-satellite, and/or aeronautical radionavigation service;

b) that the frequency bands 23.15-23.55 GHz and 27-27.5 GHz include primary allocations to the fixed, mobile, fixed-satellite service (27-27.5 GHz only), and inter-satellite services, and the space research service bands at 2025-2110 MHz and 2200-2290 MHz include allocations to the space operation service, Earth exploration-satellite service, and fixed and mobile services;

c) that the ISS frequency bands at 23.15-23.55 GHz and 27-27.5 GHz include primary allocations to the fixed and mobile services, and Fixed-Satellite Service (Earth-to-space), Earth exploration-satellite service, and space research service, and there are intra-service considerations to be examined for the ISS;

d) that the frequency bands at 7190-7235 MHz and 22.55-23.15 GHz envisioned for Earth-to-moon communications include primary allocations to the fixed, mobile, ISS (22.55-23.15 GHz only), Earth exploration-satellite service (Earth-to-space) (7190-7235 GHz only), and space research (Earth-to-space) services; and the frequency bands 8450-8500 MHz and 25.5-27 GHz envisioned for moon-to-Earth communications include primary allocations to the fixed, mobile, ISS (25.5-27 GHz only), Earth exploration-satellite (space-to-Earth) (25.5-27 GHz only), and space research (space-to-Earth) services;

e) that No. **1.23** defines space operations service as a "radiocommunication service concerned exclusively with the operation of spacecraft, in particular space tracking, space telemetry and space telecommand";

f) that No. **1.55** defines space research service as a "radiocommunication service in which spacecraft or other objects in space are used for scientific or technological research purposes";

g) that No. **1.8** defines space radiocommunication as "any radiocommunication involving the use of one or more space stations or the use of one or more reflecting satellites or other objects in space and No. **1.64** defines space station as "a station located on an object which is beyond, is intended to go beyond, or has been beyond, the major portion of the Earth's atmosphere";

h) that No. **1.63** defines an earth station as "a station located either on the Earth's surface or within the major portion of the Earth's atmosphere and intended for communication:

- with one or more space stations; or
- with one or more stations of the same kind by means of one or more reflecting satellites or other objects in space";

i) that Resolution **750 (Rev.WRC-19)** applies to the Inter-Satellite Service allocation in the 22.55-23.55 GHz band to protect Earth-Exploration Satellite Service (passive) in the 23.6-24.0 GHz band from unwanted emissions;

emphasizing

that despite the allocation and other regulatory actions that may be needed, the spectrum uses described in *considering further a)* above are designed to be compatible with and complementary to the uses of the identified frequency bands that are being made or planned today in one or more ITU-R regions,

resolves to invite ITU-R

1 to study and develop, as a matter of urgency, the technical and operational characteristics of a lunar/cislunar communications architecture in the frequency bands and for the purposes identified in *considering further a)* above;

2 to study, as a matter of urgency, sharing and compatibility between stations functioning in the manner described in *considering further a)* above and current and planned stations of the existing services allocated in the same frequency bands, while ensuring the protection of primary services referred to in *recognizings further a)* through *d)* above, and taking into account *recognizings a) and e)* above;

3 to develop, for the different types of stations functioning in the manner described in *considering further a)* above, the technical conditions and regulatory provisions necessary to implement the envisioned communications architecture in the specified frequency bands, including new or revised allocations, as warranted, and new or revised associated regulatory provisions, taking into account the results of the studies above;

4 to complete these studies by the 2027 World Radiocommunication Conference,

invites administrations

to participate in the studies and to provide input contributions,

resolves to invite the 2027 World Radiocommunication Conference

to consider the results of the above studies and take necessary regulatory actions, as appropriate.

Reasons: To provide a roadmap for the detailed studies that will be required in the conceptually-compatible frequency bands identified for the implementation of the developing architecture. The studies will endeavor to minimize changes to the RR where possible, while establishing a framework for lunar/cislunar communications systems to receive international recognition and have the flexibility to accommodate inevitable future developments.

ATTACHMENT

PROPOSAL FOR FUTURE AGENDA ITEM FOR [XXX]

Subject: Proposed Future WRC Agenda Item for WRC-2027 to consider, based on the results of ITU-R studies, spectrum allocation and associated regulatory provisions to support lunar and cislunar communications in specific frequency bands in accordance with Resolution **[A10-LUNAR] (WRC-23)**;
Origin: United States of America

Proposal: to enable the establishment of spectrum allocation and associated regulatory provisions to support lunar and cislunar communications in specific frequency bands, on a basis other than under No. **4.4**, taking into account the necessary protection of existing services; in accordance with Resolution **[A10-LUNAR] (WRC-23)**;

Background/reason:
To provide a means for recognizing in the Radio Regulations transmissions on and near the moon (lunar and cislunar), as well as between the moon and the Earth, to support upcoming crewed and unmanned lunar operations in the scientific commercial realms. This study would address technical and regulatory issues in the identified bands.

Radiocommunication services concerned:
Inter satellite service, Earth exploration satellite, Space research, Space operations.

Indication of possible difficulties: None foreseen

Previous/ongoing studies on the issue: Studies have been initiated in Working Party 7B during the 2019-2023 ITU-R Study Cycle

Studies to be carried out by: ITU-R Study Group 7	*with the participation of:* SGs 4 and 5

ITU-R Study Groups concerned: SG 7, SG 4, and SG 5

ITU resource implications, including financial implications (refer to CV126): Minimal

Common regional proposal: Yes/No ***Multicountry proposal:*** Yes/No
Number of countries:

Remarks