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Input paper for the following Committee(s):	check as appropriate	Purpose of paper:
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Agenda item [2] (from agenda)	3
Workplan Task Number / Technical Domain [2]	……
Working Group	WG 3
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VDE-SAT Spectrum Allocation Plan with TDD

1 SUMMARY

Either frequency plan Alternative 1 or Alternative 2 for VDE-SAT employs FDD transmission mode, which relies on *frequency separation* for uplink and downlink isolation. Nevertheless, neither Alternative 1 nor Alternative 2 for VDE-SAT provides sufficient separation between uplink and downlink channels, which potentially leads to excessive interference from the output of the transmitter leaked directly into the input of the receiver of a VDES transceiver operating in FDD full duplex mode, especially for LEO satellites with very limited payload and dimension. The solution by VDE-SAT to this problem is to resort to FDD half-duplex which *forces* the time separation between uplink and downlink transmissions to prevent the cross-link interference. This type of transmission mode, however, cuts down the already-low VDE-SAT spectral efficiency to HALF. It is detrimental to VDE-SAT, which has been struggling in spectral efficiency due to low link budget. We propose the TDD transmission mode that naturally introduces the *time separation* between uplink and downlink transmission without loss of spectral efficiency is advantageous in terms of cross-link interference for the VDE-SAT frequency plan. The adoption of the TDD transmission mode is therefore recommended for VDE-SAT no matter which frequency plan is selected.

1.1 Purpose of the document

The input document aims to propose a TDD transmission mode for VDE-SAT in place of the FDD.

1.2 Related documents

[1] Radiocommunication Study Groups, Working Document towards a preliminary draft new report ITU-R. M.[VDES-SAT], 2018.

[2] IALA Guideline G1139, The Technical Specification of VDES, Working Draft, 201812, Edition 2.

[3] ITU, Technical characteristics for a VHF data exchange system in the VHF maritime mobile band, Rec. ITU-R M.2092-0, 2015.

[4] eNAV23, UTC-based VDE-SAT Uplink Transmission Timing Advance.

1 Input document number, to be assigned by the Committee Secretary
2 Input papers should be assigned to a work task as listed in the Committee work plan which is available in input papers. Leave open if uncertain but consider how the paper is to be processed if not relevant to a work task

2 BACKGROUND

As for VDE-SAT, currently, there are three frequency utilization plans proposed for ITU final approval in WRC-19 [1]. In the frequency plan alternative 1 [1], paired channels 26 and 86 are dedicated to VDE-SAT with the lower leg channels 1026 and 1086 to uplink, and upper leg channels 2026 and 2086 to downlink. Four channels 1024, 1084, 1025 and 1085 are shared between VDE-TER uplink and VDE-SAT uplink services. Four channels 2024, 2084, 2025 and 2085 are shared among VDE-TER downlink, ship to ship and VDE-SAT downlink services.

The alternative 2 frequency plan allows for utilization of paired channels 24, 84, 25 and 85 primarily for VDE-TER, while paired channels 26 and 86 (i.e., both lower legs 1026, 1086 and upper legs 2026 and 2086) exclusively reserved for VDE-SAT uplink. VDE-SAT uplink is also possible in paired channels 24, 84, 25 and 85, but the VDE-SAT uplink in these channels does not impose constraints on VDE-TER. Furthermore, this frequency plan opens up a new frequency band from 160.9625 to 161.4875 MHz from the non-channelized spectrum, which is a 525-kHz worth of bandwidth exclusively allocated for VDE-SAT downlink as shown [1].

3 DISCUSSION

3.1 ISSUES WITH VDE-SAT FDD

As aforementioned, neither alternative 1 nor alternative 2 frequency plan for VDE-SAT provides sufficient RF isolation between uplink and downlink under FDD full duplex transmission mode. The FDD with half-duplex (HD) transmission mode is thus enforced shown in VDE-SAT as shown in Figure 1 (top), in which the control station (i.e., satellite) and mobile station (e.g., ship) take turns to transmit on the downlink and uplink, respectively, which avoids the simultaneous transmissions for a station transceiver. Although the leakage from the transmitter to the receiver is prevented, the duty cycle per channel is halved. The enforcement of HD thus in effect cuts down the spectral efficiency into half. For instance, there are only 40% spectrum usage for uplink and 60% for downlink under 4:6 uplink and downlink partition – very inefficient in spectrum usage!

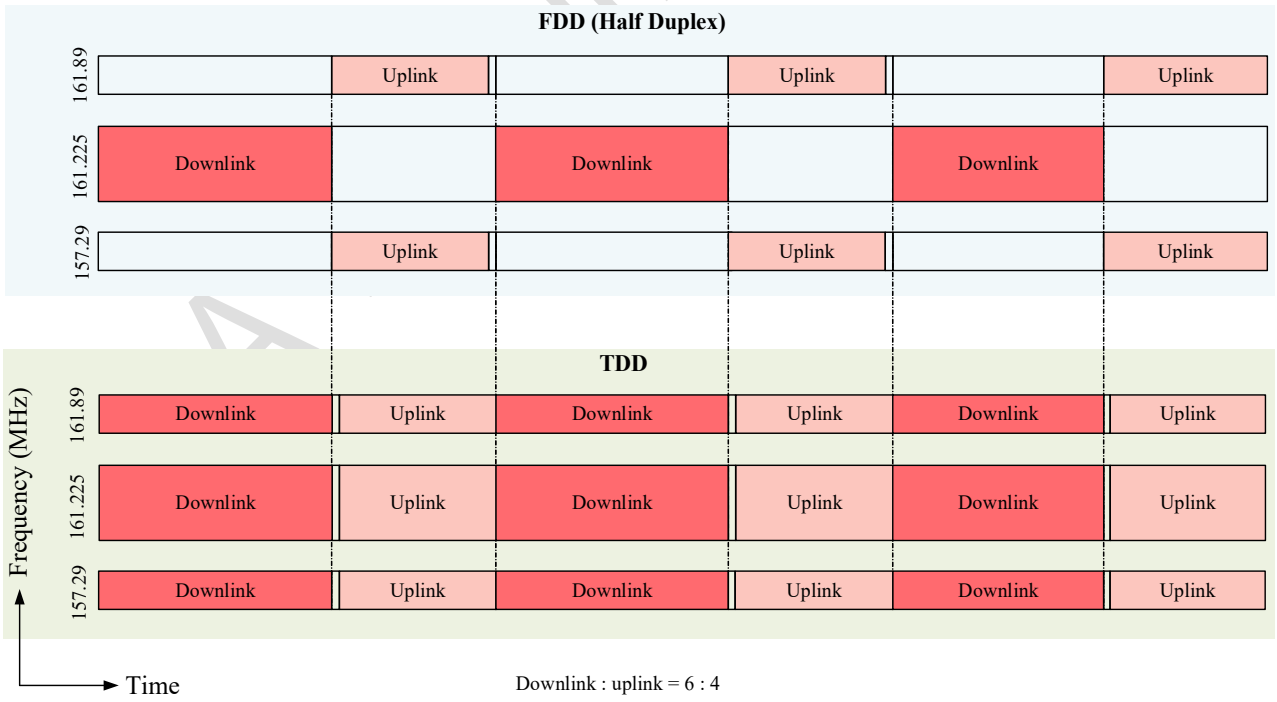

Figure 1 Illustration of the transmission structure for VDE-SAT FDD (HD) and the proposed TDD, where the alternative 2 frequency utilization plan is used as example.

3.2 PROPOSED TDD

The proposed solution is to retain the time separation as in FDD HD mode without sacrificing the spectral efficiency is to employ the time division duplex (TDD) transmission mode as shown in Figure 1 (bottom), in which a VDE-SAT channel is used as a duplex channel, i.e., downlink and uplink transmissions are time-multiplexed onto the same channel. In this mode, the transceiver of a station never needs to transmit and receive at the same time but still maintains full channel utilization.

Figure 1 shows an example of the transmission structure operating in TDD transmission mode with the upper link timing advance scheme [4]. Figure 2 shows the spectral efficiency of the VDE-SAT with the FDD HD and TDD transmission modes. It is not surprising to see that TDD mode has much higher spectral efficiency.

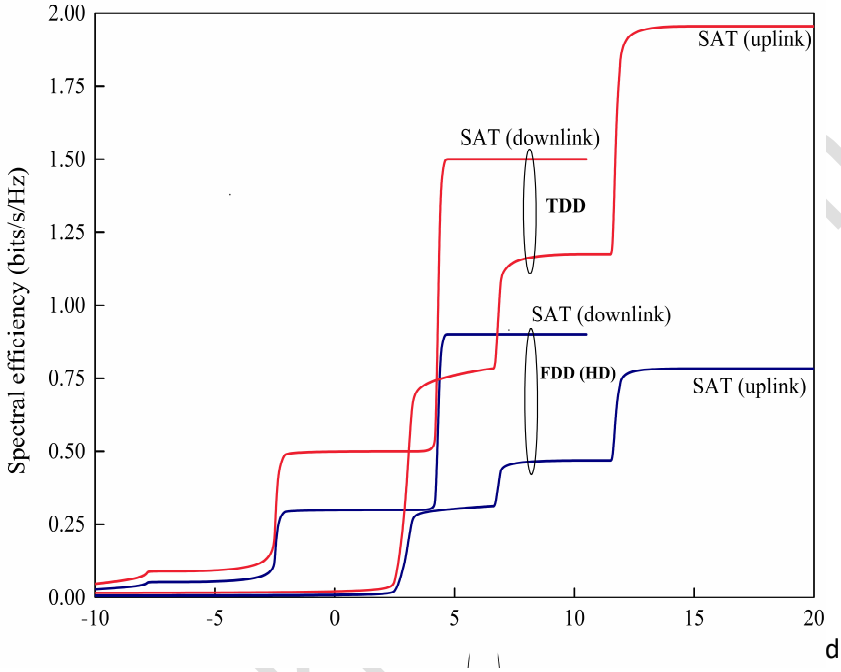

Figure 2 Spectral ef d TDD transmission modes for VDE-SAT, given the link configurations in [2] and downlink SNR limited by the PFD in [3].

4 REFERENCES

5 ACTION REQUESTED OF THE COMMITTEE

The Committee is requested to note the information and take appropriate action.