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AZERSPACE-1 46°E
User's Handbook

GSVT and Satellite Access Procedures

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ABBREVIATIONS

AZ - Azimuth

BW - Bandwidth

CW - Clockwise

CCW - Counter Clockwise

CSM - Communication System Monitoring

EL - Elevation

EIRP - Equivalent Isotropic Radiated Power

CGSUT - Customer's Ground Station Under Test

GSVT - Ground Station Verification Test

HPA - High Power Amplifier

PNOC - Payload and Network Operations Centre

SAF - Satellite Access Form

SAP - Satellite Access Procedure

SSPA - Solid State Power Amplifier

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INTRODUCTION

• To ensure the performance of each satellite link is maintained at a high level, and a high quality of service is delivered to every customer, Azercosmos requires the customers to test and register their equipment and links with PNOC. • This handbook details these procedures:

• Ground Station Verification Tests (GSVT): The tests customers are required to conduct to register a Ground Station with PNOC

• Satellite Access Procedures (SAP): The procedures customers are required to follow to register or modify their links with PNOC. • Any questions regarding these procedures should be directed towards the PNOC

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1. OVERVIEW AND CUSTOMER RESPONSIBILITIES

- 1. Overview and Customer Responsibilities
- This section describes the mandatory tests customers are required to conduct to register a Ground Station with PNOC. These tests should be done before the Ground Station accesses the Azercosmos system.
- Customers are required to complete and send the GSVT Form, via email or fax, to PNOC to request a test date. This should be undertaken at least two [2] working days prior to the intended test date. PNOC will confirm with the customer on the tests set up and the PNOC engineer in-charge of co-coordinating the tests.
- All tests should be performed with the active participation of an PNOC engineer.
- Customers are required to submit all measurements taken at the Ground Station for PNOC to compile and verify. Test results will be sent to the customer within one [1] working day after all the measurements are received.
- Every Ground Station that has passed all compulsory tests will be registered with Azercosmos and a unique Ground Station ID assigned. Customers are required to mention the Ground Station ID in all communications with the PNOC.

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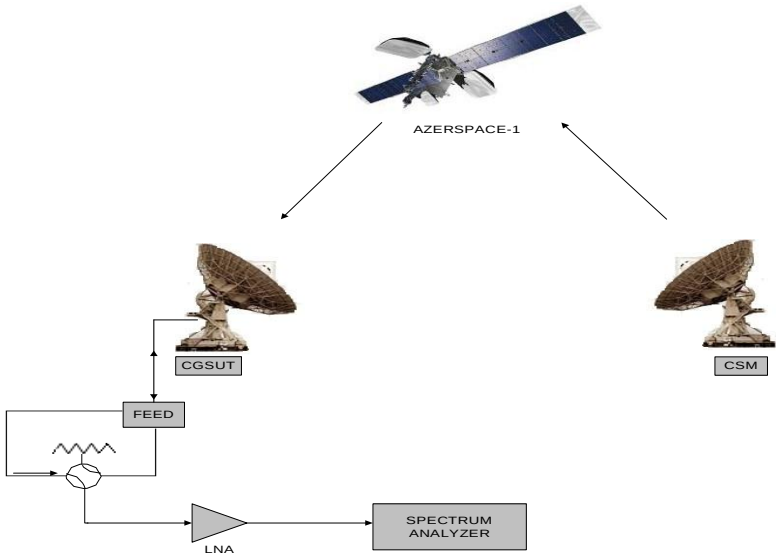
2. ANTENNA POINTING VERIFICATION

2.1 Antenna Alignment Procedure

Step 1: Calculate the EL and AZ angles for the CGSUT. Adjust the CGSUT ground antenna towards the satellite based on the calculated EL and AZ angles.

- El = arctg{[$\cos(Lo_S - Lo_{SAT})\cos(La_S) - 0{,}15126]/\sqrt{[1 - \cos^2(Lo_S - Lo_{SAT})]}\cos^2(La_S)$}
- Az = 180 + arctg [$tg(Lo_S - Lo_{SAT})/\sin(La_S)$].
- Lo_S - longitude of station, Lo_{SAT} - longtitude of satellite, La_S – latitude of station, La_S – latitude of station

Step 2: Set up the test equipment as shown in Figure 1 below.



Step 3: Set the Spectrum Analyzer to the following settings: Parameter Settings

Centre Frequency Beacon frequency

- Span 5 MHz
- Res. Bandwidth 10 kHz
- Amplitude Scale 10 dB/Div.

Upon completion, if correctly setup, the CGSUT should be able to receive Azerspace-1 beacon signals in C-band (4195.0 MHz/4196.3 MHz) with RHCP or in Ku-band (10950.1 MHz) with LHCP.

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2.2 AZ and EL ANGLE ADJUSTMENT PROCEDURE

- Step 1: Check the C-Band or Ku-Band beacon signals; if they are not visible, repeat the steps in Section 2.1 until the signals are visible.
- Step 2: Adjust the CGSUT antenna AZ and EL angles to maximize the signal level; record the corresponding AZ and EL angles.
- Step 3: Rotate the CGSUT antenna polarization to maximize the signal level and record the polarizer angle.
- Step 4: Adjust the CGSUT antenna AZ in the CW direction starting from the position determined in Step 2 above until the peak of the first side lobe is reached. This is indicated by the beacon signal level decreasing as the antenna pattern passes through the first pattern null, increasing again until it peaks at the first side lobe, and then begins to decrease again. Note that this first side lobe peak is smaller than the main lobe. Record the antenna pointing angle for this side lobe peak.
- Step 5: Normalize the antenna pointing back to the peak of the main lobe.
- Step 6: Repeat Step 4 for the CCW direction AZ. If no other higher peak is observed, lock the AZ axis at the highest peak of the main lobe as determined in Step 2.
- Step 7: Adjust the CGSUT antenna EL in the upward direction starting from the position determined in Step 2 above, until the peak of the first side lobe is reached. This is indicated by the beacon signal level decreasing as the antenna pattern passes through the first pattern null, increasing again until it peaks at the first side lobe, and then begins to decrease again. Note that this first side lobe peak is smaller than the main lobe. Record the antenna pointing angle for this side lobe peak.
- Step 8: Normalize the antenna pointing back to the peak of the main lobe.
- Step 9: Repeat Step 7 for the downward direction EL. If no other higher peak is observed, lock the EL axis at the highest peak of the main lobe as determined in
- Upon completion of the above and provided no higher peak is observed during the adjustments, the antenna pointing is verified on the main lobe with regards to AZ and EL.

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2.3 POLARIZER ADJUSTMENT PROCEDURE

- Step 1: Check the C-Band or the Ku-Band test signals are visible; if they are not visible, repeat the steps in Section 2.1 until the beacon signals are visible.
- Step 2: Receive test signal with co-polarization receive antenna feed; record the received signal level.
- Step3a: If the CGSUT is equipped to receive a cross-polarized downlink signal (antenna with two receiving ports, one for each polarization), measure the signal level at the output of the cross-polarization feed port. Adjust the polarizer angle so that a signal null is achieved at the output of the cross-polarization feed port; record the received level and the polarizer angle.
- Step3b: If the CGSUT is not equipped to receive the cross-polarized downlink signal (antenna with only one receiving port), adjust the polarizer so that a signal null is achieved at the output of the co-polarization feed port; record the signal level and the polarizer angle. Rotate the polarizer by 90° from the recorded Null angle and lock it there. Verify the received signal is the same or better than that of Step 2.
- Upon completion of the above, the polarizer is adjusted to the correct setting.

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3. CROSS-POLARIZATION ISOLATION TESTS

- Test Objective
- The CGSUT meets Azercosmos's requirement if the cross-polarization isolation is at least 30 dB or more. However, under certain circumstances, if the result falls below the 30 dB requirement, it will be further analyzed. The acceptance of the result is subjected Azercosmos's discretion.
- Test Setup
- For the cross-polarization isolation tests, the Spectrum Analyzer should be set to the following settings: Parameter Setting
    - Centre Frequency Test Frequency
    - Span 200 kHz
    - Resolution BW 300 Hz
    - Video BW 300 Hz
    - Amplitude 10 dB/Div
- The polarization isolation measurements described here do not characterize the Ground Station antenna alone; the measurements also include the effects of the satellite and propagation medium

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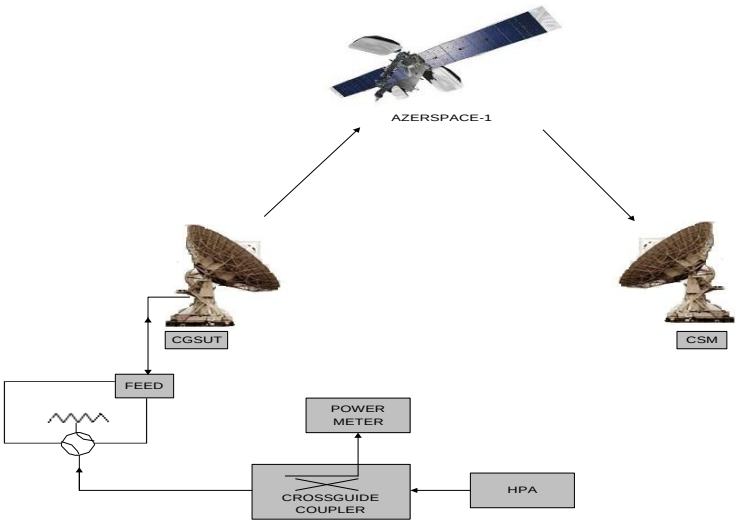
3.1. TRANSMIT CROSS-POLARIZATION ISOLATION TEST

- Step 1: Set up the test equipment as shown in Figure 2 below.

Figure 2: Transmit Antenna Side lobe Pattern / Cross-Polarization Isolation Measurement Setup



- Step 2: Contact the PNOC engineer and, under his/her direction, transmit an unmodulated carrier from the CGSUT at reduced power.
- Step 3: Slowly increase the uplink power level until the PNOC engineer reports the satellite downlink EIRP carrier is 15 dB below the saturation level of the operating transponder.
- Step 4: Verify the linearity of the system by reducing the uplink by 1 dB; this should reduce the measured downlink signal by 1 dB; the PNOC engineer will record the co-polarization signal level.
- Step 5: Rotate the polarizer waveguide switch, or the feed, by 90º to transmit on the cross-polarization port; the PNOC engineer will co-ordinate with the CGSUT personnel to fine tune the polarizer angle to null the receive signal; record the cross-polarization signal level and the polarizer angle.
- Step 6: Confirm with the PNOC engineer that all the measurements have been recorded.
- Step 7: Rotate the polarizer waveguide switch, or the feed, by 90º from angle recorded in Step 6 and verify the receive co-polarization signal level is the same or better than that recorded in Step 4. Bring down the carrier.

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3.2. RECEIVE CROSS-POLARIZATION ISOLATION TEST

- Note: While, the receive cross-polarization isolation test is not compulsory it is strongly recommended that the customer measure the receive characteristic of the CGSUT
- Step 1: Set up the test equipment as shown in Figure 1 above.
- Step 2: Contact the PNOC engineer and arrange for an unmodulated carrier to be transmitted from PNOC.
- Step 3: Track the satellite for the maximum downlink co-polarization signal.
- Step 4: Record the signal level on the spectrum analyzer and verify the linearity of the system when the PNOC engineer reduces the uplink by 1 dB; this should reduce the measured downlink signal by 1 dB.
- Step 5: Rotate the polarizer waveguide switch, or the feed, by 90º and fine tune the polarizer angle to null the receive signal; measure the cross-polarization signal level and the polarizer angle.
- Step 6: Record and plot the difference between the co-polarization and the cross-polarization signal levels.
- Step 7: Rotate the polarizer waveguide switch or the feed, by 90º from angle recorded in Step 5 and verify the receive co-polarization signal is the same or better than that recorded in Step 3. Inform PNOC to bring down the carrier.

Upon completion of the above, customer should send the results in Step 5 together with other test results to PNOC for compilation.

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4. ANTENNA SIDE LOBE PATTERN TESTS

- Test Objective
- The CGSUT meets Azercosmos's test requirement if 90% of the antenna transmit side lobe peaks do not exceed the 29 – 25 log (ɵ) [dB] over 1°≥ Iɵl ≥ 6°.
- Test Setup
- For the antenna side lobe pattern tests, the Spectrum Analyzer should be set to the following settings:
- Centre Frequency Test Frequency
- Span 0
- Resolution BW 100 Hz
- Video BW < 1 kHz (30 Hz)
- Sweep time Slew Time
- Amplitude 10 dB/Div.
- Trace A Max Hold, Single Sweep

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4.1. TRANSMIT ANTENNA SIDE LOBE PATTERN TEST

- Note: For antenna between 1.8m and 4.5m, and non-motorized antennas, this test can be replaced by submitting the manufacturer's datasheet, or previously conducted test results, to PNOC for consideration. For antenna 4.5m and above this test is compulsory.
- Do not allow the antenna to point toward neighbouring satellite while transmitting.
- Step 1: Set up the test equipment as shown in Figure 2 above.
- Step 2: Contact the PNOC engineer and, under his/her direction, transmit an unmodulated carrier from the CGSUT at reduced power.
- Step 3: Slowly increase the uplink power level until the PNOC engineer reports the satellite downlink EIRP carrier is 15 dB below the saturation level of the operating transponder.
- Step 4: Verify the linearity of the system by reducing the uplink by 1 dB; this should reduce the measured downlink signal by 1 dB; the PNOC engineer will record the received signal level.
- Step 5: Slew the CGSUT antenna off the satellite by 6º (corrected angle) in AZ (ΔAZcorrected) in a CCW direction at a constant rate (e.g. 0.02º/sec), while timing the movement. Record the time taken and provide the information to the PNOC engineer
- ΔAZcorrected = 2 sin-1 [sin (ΔAZ/2) . cos (EL)] where
- ΔAZ = Indicated Azimuth angle from boresight
- EL = Indicated elevation angle above true horizon
- Step 6: At the same slew rate, while co-coordinating with the PNOC engineer, move the main lobe of the CGSUT antenna through the satellite in the CW direction over a 12º (corrected) range from its previous position.
- Step 7: Confirm with the PNOC engineer the pattern plot has been recorded. Return the antenna to the beam peak and bring down the carrier.
- Step 8: Repeat Step 5 and Step 6 for the elevation axis over a range of ± 6º from the main lobe centre.
- Step 9: Confirm with the PNOC engineer the antenna patterns over the required range on both AZ and EL have been recorded and then bring down the carrier.

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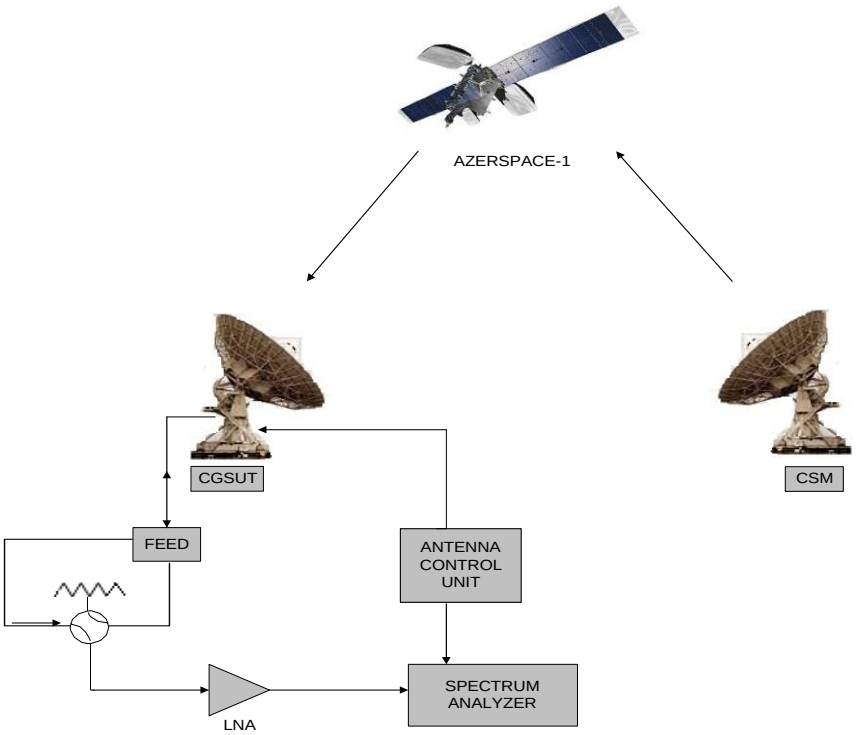
4.2. RECEIVE ANTENNA SIDE LOBE PATTERN TEST

- Note: While this test is not compulsory it is strongly recommended that the customer measure the receive characteristic of the CGSUT. If the carrier used originates from the customer's hub, this operation still needs to be co-ordinated with PNOC engineer.
- Step 1: Set up the test equipment as shown in Figure 3 below.



- Step 2: Contact the PNOC engineer and request them to uplink an unmodulated carrier to the Azerspace-1 transponder at a power level 15 dB below saturation level of the operating transponders.
- Step 3: Set the spectrum analyzer to the appropriate downlink frequency and reduce the resolution bandwidth to 10 kHz; set the plotter to record the receive pattern.
- Step 4: Slew the CGSUT antenna off the satellite by 6º (corrected angle) in AZ (ΔAZcorrected) in a CCW direction at a constant rate (e.g. 0.02º/sec), while timing the movement. Record the time taken.

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- Step 5: At the same slew rate, move the main lobe of the CGSUT antenna through the satellite in a CW direction over a 12º (corrected) range from its previous position.
- Step 6: Calculate the corrected AZ angle using the following equation
- ΔAZ corrected = 2 sin-1 [sin (ΔAZ/2) . cos (EL)]
- where,
- ΔAZ = Indicated Azimuth angle from boresight
- EL = Indicated elevation angle above true horizon
- Step 7: Repeat the above steps for the elevation axis over a range of ± 6º from the main lobe centre and plot the received antenna side lobe pattern

- Step 8: Draw the 29 - 25 Log θ [dB] curve on the plot for $1^0 \geq |\theta| \geq 6^0$
- Where, θ is the off-axis angle from satellite.
- Upon completion of the above, customer should send the plots together with other test results to PNOC for compilation.

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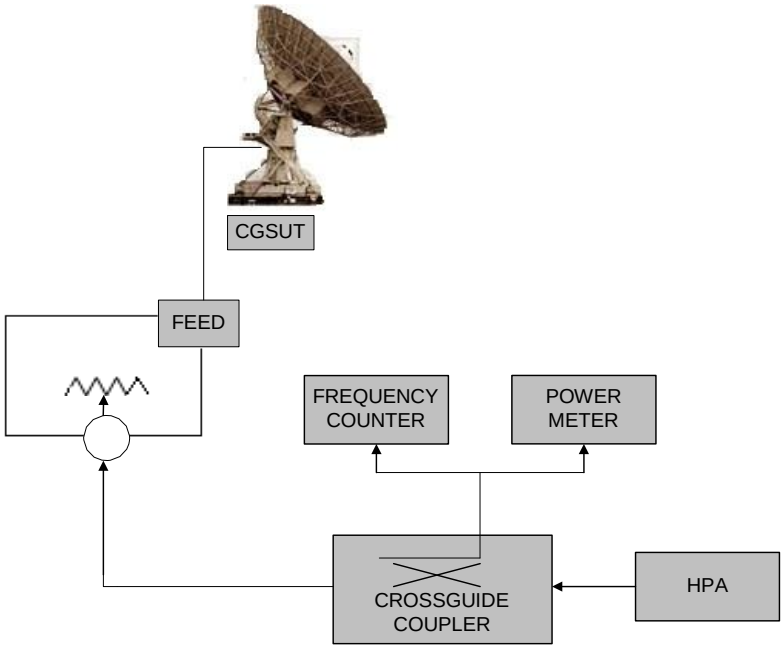
5. POWER AND FREQUENCY STABILITY TESTS

- Note: This test is not compulsory for antenna < 4.5m.
- Test Objective
- The CGSUT meets Azercosmos's requirement if the variation in power is less than ±0.5dB and the variation in frequency is less than ±1kHz over 24 hrs period.
- Test Setup
- Step 1: Connect a power meter and a frequency counter through a directional coupler to the HPA as shown in Figure 4 below.

Figure 4: Power and Frequency Stability Measurement Setup



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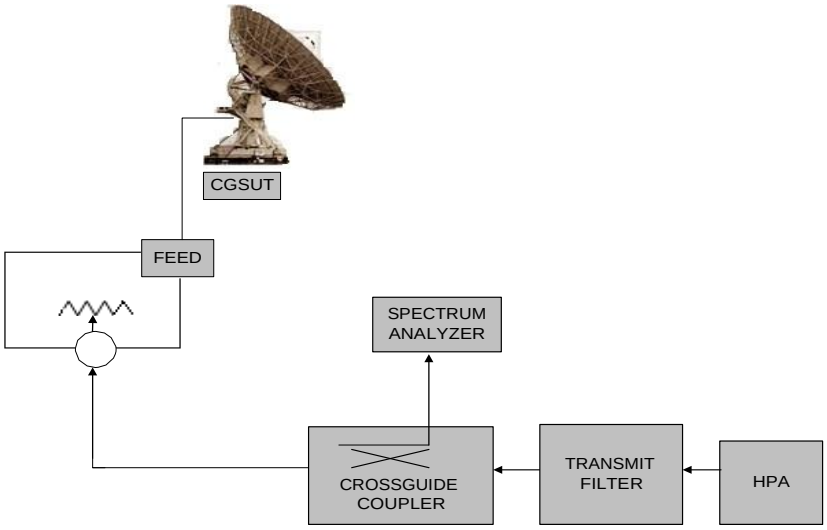
6. OUT OF BAND EMISSION TESTS

- Note: This test is not compulsory for Ground Station antenna < 4.5m. It is compulsory for Ground station, using KHPA.
- Test Objective
- The CGSUT meets Azercosmos's requirement if out of band emission of the uplink chain does not exceed 4 dBW/4 KHz outside of the assigned Transponder bandwidth.
- Step 1: Connect a power meter and a frequency counter through a directional coupler to the HPA as shown in Figure 4 below Connect a spectrum analyzer through a directional coupler to the HPA as shown in Figure 5 below.

Figure 5: Out of Band Emission Measurement Setup



- Step 2: Set the spectrum analyzer to the following settings: Parameter Settings
- Centre Frequency — Test Frequency
- Span 100 MHz — (±50 MHz from Centre Freq.)
- Resolution BW — 3 kHz
- Video BW — 3 kHz
-

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- Step 3: Transmit an unmodulated carrier to the dummy load, without uplinking to the satellite; measure the out-of-band emission of the uplink chain displayed on the spectrum analyzer.
- Step 4: Repeat the above procedure for any redundant uplink equipment.
- Step 5: Plot the out-of-band emission and fax to PNOC.
- Upon completion of all the tests, customers are required to submit the measurements to PNOC to be compiled and verified.

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1. OVERVIEW AND CUSTOMER RESPONSIBILITIES

- This section describes the procedures customers are required to follow to register or modify their links with PNOC.
- Customers should complete and send the SAF, via email or fax, to PNOC to request a date/time to activate or modify a link. This process should be completed at least two [2] working days prior to the intended link activation/ modification date. The PNOC will confirm with the customer on a date/time to complete the set up process.
- Prior to activating a link, the customer should ensure their Ground Station is registered on the Azercosmos system. This can be achieved by conducting the Azercosmos GSVT with the PNOC. The GSVT registration procedures are described in Section A of this handbook.
- Note: Azercosmos reserves the right to interrupt and/or terminate any operational transmission or test broadcast which are detrimental to, or may jeopardize and/or interfere with, the integrity and/or operation of Azercosmos, and/or other carriers or users of Azercosmos.

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2. LINK ACTIVATION PROCEDURE

- Step 1: Set Ensure the Ground Station is properly aligned to the intended satellite in AZ, EL and Polarizer using Azercosmos satellite's beacon signals. Instructions for aligning the Ground Station antenna are available in Section 2.1, 2.2 and 2.3 of this handbook.
- Step 2: Set the SSPA/HPA to “Standby Mode”. Ensure all uplink equipment is warmed up and stable. Tune the equipment to the proper power level and frequency range and set the modulator to its maximum attenuation level. It is advisable to set this power level at the centre of the dynamic range of the modulator.
- Step 3: Call the PNOC Hotline Number to inform the PNOC engineer the Ground Station is ready to transmit.
- Step 4: When advised by the PNOC engineer, transmit an unmodulated carrier at the lowest possible level. If instructed, fine tune the pointing of the Ground Station by moving the AZ, EL and Polarizer.
- Step 5: Increase the power level slowly while PNOC monitors the carrier, to the level indicated in the SAF and modulate the signal.
- Step 6: Verify the performance (C/N, Eb/No or BER) at the receiving site and fine tune power level as instructed by PNOC engineer.

Upon completion of these steps, the carrier has been validated and is registered in the Azercosmos CSM database for immediate and continuous monitoring

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3. LINK MODIFICATION PROCEDURE

- Step 1: Call PNOC engineer at the allocated time and verify permission to adjust transmission parameters; change the transmission of the Ground Station to the new parameters.
- Step 2: Verify the performance (C/N, Eb/No or BER) at the receiving site and fine tune the power level as instructed by PNOC.
- Upon completion of these steps, the modified carrier has been validated and is registered in the Azercosmos CSM database for immediate and continuous monitoring.

4. LINK SHUTDOWN PROCEDURE

- Step 1: Inform PNOC via email or telephone, at least one [1] working day prior to the intended time of shutdown. PNOC will reconfigure the CSM system accordingly.
- Step 2: After the carrier is shutdown, switch the output of the SSPA/HPA to the dummy load, or put the unit on STANDBY mode, to avoid noise or other unwanted signal from being transmitted. There should be no RF transmission from the Ground Station to Azercosmos satellite.

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PROBLEM REPORTING

Customers shall report all problems to the PNOC at the earliest possible opportunity. The PNOC is manned 24/7. When reporting a problem, the customer shall:

- Identify their company;
- Provide associated Ground Station ID and carrier description;
- Provide an accurate description of the trouble with as much detail as practical.

The PNOC will record the customer's contact information and details of the problem and, where appropriate, open a trouble ticket and provide the customer with the ticket number.The PNOC will troubleshoot the problem to resolution in conjunction with the service providing earth station, and provide timely updates to customer. Customers should immediately report any instances of interference to their transmissions to the PNOC. The PNOC will assist in trying to identify the source of interference and will contact any likely potential interferers. It should be recognized, however, that it is sometimes very difficult to identify the source of interference.Suspected degradation or outages in the space segment shall be reported to the PNOC, which will coordinate investigation of the problem and testing. Suspected degradation of transponder performance may require the customer to release the transponder at a mutually acceptable time to allow Azercosmos time for performance testing. The contact details for the PNOC are provided in the next section.

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CONTACT DETAILS and ESCALATION

- In case of service interruption, the customer should report the problem immediately to an PNOC engineer by contacting the Azercosmos Hotline.
- Depending of the nature of problem the PNOC may escalate the problem to other groups within Azercosmos. Azercosmos PNOC will follow its internal procedure for escalation.

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24x7 customer HOTLINE: +994 12 565 00 65
Email: PNOC@azercosmos.az

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