

TA FTMC Activity Report

Volkan TUTAY¹, Samed DURMUS¹, Hatice CELIK¹, Muhammet Kursat SERCELI¹, Yakup SOYSAL¹, Furkan Kamil TUT¹, Burak IPLIKCI¹, Ipek CERSIL POLAT¹, Mustafa Melik GECGEL¹, Onur YORUK¹, Mahmut Kursad ARPACIOGLU¹

*¹Turkish Aerospace Inc. Fethiye Mah. Havacilik Bulvari No:16 Kahramankazan/Ankara/Turkiye
volkan.tutay@tai.com.tr, samed.durmus@tai.com.tr, hatice.celik@tai.com.tr,
muhammetkursat.serceli@tai.com.tr, yakup.soysal@tai.com.tr, furkankamil.tut@tai.com.tr,
burak.iplikci@tai.com.tr, ipek.cersilpolat@tai.com.tr, melik.gecgel@tai.com.tr, oyoruk@tai.com.tr,
mkarpacioglu@tai.com.tr*

Abstract:

Flight test campaigns within Turkish Aerospace are critical processes that require cost-effective and time-efficient management. Continuous monitoring and rapid identification of anomalies in both flight and ground systems—particularly telemetry systems and Flight Test Management Centers (FTMC)—are essential for ensuring data integrity and operational success. In this study, the FTMC Activity Report Software is introduced as a solution to enhance post-flight analysis. The software generates comprehensive assessment reports following each flight test by quantitatively evaluating telemetry losses across all test points and activities. Additionally, it visualizes key parameters from both airborne and ground-based equipment, enabling more effective interpretation of flight test data. By integrating and processing data streams from multiple subsystems in parallel, the system provides actionable insights into telemetry performance. The proposed approach reduces manual analysis effort, accelerates anomaly detection and resolution, and supports continuous improvement in telemetry systems.

Key words: flight test, telemetry systems, data analysis, anomaly detection, visualization

1. Introduction

Turkish Aerospace develops a wide range of indigenous platforms across fixed-wing (HURKUS, HURJET, KAN), rotary-wing (T-625 GOKBEY, T-129 ATAK), and unmanned aerial vehicle (ANKA, AKSUNGUR) categories. The speed of operations during test and data analysis activities of indigenously developed aircraft constitutes a critical factor in overall program success.

Flight test operations are inherently complex and require the coordination of multiple subsystems, including telemetry systems, ground networks, and airborne instrumentation. Ensuring the reliability and performance of these components is essential for the successful execution of test campaigns. In particular, continuous monitoring and rapid anomaly detection play a critical role in minimizing operational risks and improving efficiency.

A comprehensive evaluation of parameters such as telemetry system performance, ground network status, hardware conditions, and data quality metrics—including bandwidth utilization, equipment health, and data continuity—is

necessary for effective decision-making. However, conventional post-flight analysis methods often rely on manual processing, which can be time-consuming and prone to errors.

To address these challenges, the FTMC Activity Report Software has been developed. The system is designed to collect, process, and visualize data from multiple subsystems, including receiver systems, best source selectors, antenna control units, and differential global positioning systems. By generating a consolidated report after each flight test, the software enables efficient analysis of telemetry performance and supports improved planning of subsequent test activities. Through automation and enhanced visualization capabilities, the system significantly reduces analysis time while improving the accuracy and usability of flight test data.

2. TA FTMC Activity Report Summary

The "Activity Tag" table contains information pertaining to the aircraft utilized in a given activity and details related to the activity itself. This table facilitates the acquisition of data regarding equipment employed and the duration of the

activity. The "Responsible Personal" table lists the telemetry engineer and telemetry technician responsible for the activity. The "PCM Frame Summary" table specifies the packet size of data transmitted from the aircraft to the Flight Test Management Center (FTMC), denoted as the (TM Transfer Bitrate), and the size of the datawords containing data within that packet (Efficient TM Record Bitrate). This allows for the calculation of the (Efficient Percentage). Furthermore, by comparing the "Efficient TM Record Bitrate" data with the full capacity (xx MBPS – this data cannot be shared due to confidentiality restrictions), the percentage of the current telemetry data transmission capacity being utilized can be determined. The "Data Source Summary" table provides information on the data analysis equipment specifically used for each activity. The "Configuration Information Summary" table details the types and quantities of parameters found within the configuration file. Additionally, any changes made to the parameter list during testing can be viewed in the "Post-Test Change Qty." table. The "FTMC Software Information Summary" table provides information regarding the version of the data acquisition software used in the activity. Finally, the "Hardware Information Summary" table presents a concise overview of the capacity utilization of the hardware employed in the activity.

FTMC ACTIVITY REPORT

ACTIVITY TAG

PROJECT	:	HURKUS2	ACT. START DATE & TIME	:	
TAIL	:		ACT. END DATE & TIME	:	
ACTIVITY - CODE	:		ACT. DURATION	:	
SITE - TAKE-OFF	:		TEST START DATE & TIME	:	
SITE - LANDING	:		TEST END DATE & TIME	:	
SYSTEM TEST	:		TEST DURATION	:	
FTMC	:			:	
ANTENNA SET	:			:	

RESPONSIBLE PERSONNEL

ENGINEER(S)	TECHNICIAN(S)

PCM FRAME SUMMARY

TM TRANSFER BITRATE - GRB (Mbps)	EFFICIENT TM RECORD BITRATE - ETB (Mbps)	EFFICIENCY PERCENTAGE (ETB / GRB)	REAL CAPACITY USAGE (ETB / 20Mbps)
8.0 Mbps	6.01 Mbps	75.12	30.05

DATA SOURCE SUMMARY

Data Source Type	: LumistarDRSM	Device Name	:	Device IP	:
IRIGType	: B	CarrierFreq	: 1,000 Hz	Active Channel	: Channel 1

CDS COMPUTER	:	DESKTOP	CDS IP	:	
TMATS FILE	:			:	
CONFIGURATION FILE (B.T.)	:			:	
CONFIGURATION FILE (A.T.)	:			:	

CONFIGURATION INFORMATION SUMMARY

TYPE OF PARAMETERS	PRE-TEST QTY.	ADDED	DELETED	CHANGED
TPP	: 2293	0	0	0
DERIVED	: 4781	0	0	0
IAP	: 27	0	0	0

FTMC SOFTWARE INFORMATION SUMMARY

LICENCE TYPE	VER.	QTY. (3268s)	QTY. (6468s)
CDS-TPP	: 9.25.11.207	0	1
	: 9.25.11.207	0	14
	: 9.28.09.20	0	1

HARDWARE INFORMATION SUMMARY

CDS	CPU	:	14%
	PHYSICAL MEMORY	:	87%
	DISK USAGE	:	34%
CLIENTS	CPU	:	3%
	DISK USAGE	:	3%

Warning: > 90% - Red, Caution: > 50% - Yellow, RAM Max OS: Warning: > 90% - Red, Caution: > 50% - Yellow, Disk Usage: Warning: > 90% - Red, Caution: > 50% - Yellow

Export Date and Time:

Report Num:

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Fig. 1. Summary tables

The "Telemetry Status Summary" table provides an assessment of the percentage of valid data received from the aircraft during the activity. Within the "Test Points Data" table, telemetry valid data percentage analysis can be performed for the test points executed during the activity.



Fig. 2. TM Status summary

The graphs illustrate the aircraft's position during the activity and the status of the telemetry tracking antenna's ability to track the aircraft. A comparison is made between the elevation and azimuth angles the antenna is required to rotate to, based on the aircraft's position, and the actual elevation and azimuth angles the antenna rotates to. This allows for the analysis of telemetry losses potentially caused by the antenna's inability to track the aircraft.

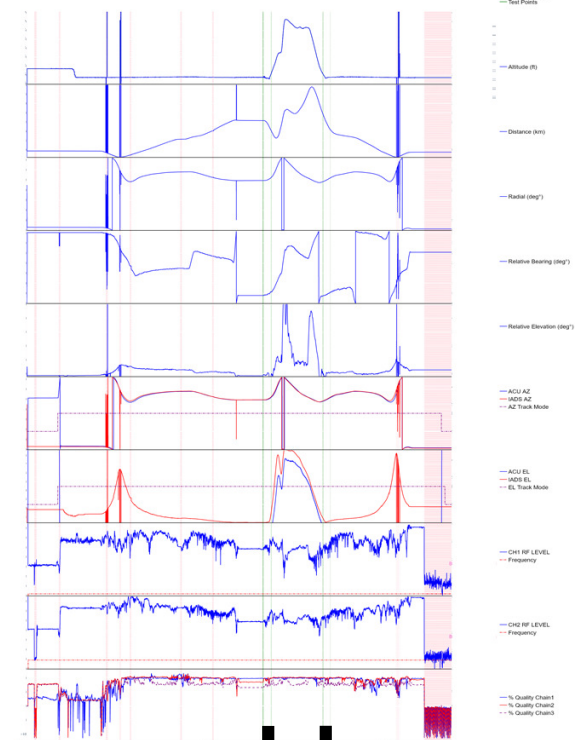


Fig. 3. Aircraft and antennas situation

3. TMATS File Analysis

Within the scope of the FTMC Activity Report Software, a dedicated analysis module has been developed for processing TMATS (Telemetry Attributes Transfer Standard) and PFConfig files. This module provides a comprehensive comparison between Flight Test Instrumentation (FTI) systems and telemetry systems, enabling detailed evaluation of parameter distribution, data rates, and bandwidth utilization efficiency.

TMATS FILE ANALYSIS			
TM SYSTEM AND FTI SYSTEM COMPARISON			
PARAMETER	TM	FTI	
NUMBER OF PARAMETERS	2,266.00	4,219.00	
BITRATE (Mbps)	6.51	16.79	
SPS	6,306,696.00	17,806,696.00	
KFPS	6,158.50	17,194.00	
MINOR FRAME	256.00	-	
ROW	300.00	-	
PACKET RATE	6.00	-	
SFD	0.00	-	
STNC WORD	-	-	
DATA BITS	912, 2048, 10756, 10364, 104876, 1024, 4096	16,52	
PCM FRAME BITRATE (Mbps)	9,832,400.00	-	
TOTAL DATA WORD COUNT	76,800.00	76,800.00	
USED DATA WORD COUNT (DATA)	66,536.00	-	
USED DATA WORD COUNT (FRAME)	66,536.00	-	
EMPTY WORD COUNT	9,264.00	-	
TM TRANSFER BITRATE - GRB (Mbps)	-	6.00	
EFFICIENT TRANSFER BITRATE - ETR (Mbps)	-	5.00	
EFFICIENCY PERCENTAGE (ETR/GRB)	-	75.12%	
REAL CAPACITY USAGE (ETB/GRB)	-	30.20%	
EFFICIENCY PERCENTAGE (ETR/GRB) = 5.00 / 6.51 * 100 = 76.96% < 75% < 70% < 60% < 50% < 40% < 30% < 20% < 10% < 5% < 0%			
REAL CAPACITY USAGE (ETB/GRB) = 1.65 / 5.41 * 100 = 30.31% < 30% < 25% < 20% < 15% < 10% < 5% < 0%			

Fig. 4. Tmats File Analysis

3.1 FTI and Telemetry System Comparison

A primary objective of the TMATS analysis is to compare the FTI and telemetry systems in terms of parameter count and bitrate allocation. By analyzing these metrics, the system quantifies how efficiently the available telemetry bandwidth is utilized. This comparison highlights discrepancies between generated data at the FTI level and transmitted data through the telemetry chain, providing insight into potential bottlenecks or underutilized capacity.

PACKAGE TYPE TM vs FTI RECORD RATE CONTROL									
TYPE	MEASUREMENT TYPE	NUMBER OF PARAMETERS IN FTI RECORD PACKET	FTI RECORD BITRATE (Mbps)	NUMBER OF PARAMETERS IN IRIG-106-CH-4 PCM FRAME	IRIG-106-CH-4 BITRATE (Mbps)	TM RECORD FTI RECORD	NUMBER OF PARAMETERS	BITRATE (Mbps)	
ADIC	ADIC - ACCELEROMETER/AC	132.00	4,131,840.00	84.00	2,462,208.00	63.64%	69.89		
ADIC	ADIC - BRIDGE	173.00	2,207,808.00	96.00	1,384,848.00	64.55%	104.7		
ADIC	ADIC - DIFFERENTIAL ENDED	252.00	4,807,168.00	168.00	954,880.00	66.67%	19.86		
ADIC	ADIC - MULTIPLEXING	252.00	133,120.00	132.00	58,260.00	50.50%	50.00		
ADIC	ADIC - TEMPERATURE - RTD	48.00	814,080.00	48.00	27,648.00	80.00%	3.45		
ADIC	ADIC - TEMPERATURE - THERMOCOUPLE	162.00	234,256.00	50.00	52,024.00	55.56%	23.29		
BCU	BCU - ETHERNET	64.00	12,424.00	32.00	16,384.00	97.14%	21.09		
BUS	BUS - ARINC-429	106.00	1,719,232.00	353.00	656,384.00	50.00%	36.27		
BUS	BUS - ETHERNET	188.00	588,024.00	188.00	89,256.00	100.00%	25.00		
BUS	BUS - MIL-STD-1553	1,978.00	2,864,576.00	588.00	561,152.00	80.00%	21.71		
VID	VID	1.00	1,648,576.00	2.00	1,060,624.00	200.00%	100.00		
GRAND TOTAL		4,095.00	17,129,472.00	2,179.00	6,273,784.00	56.41%	0.35		

Fig. 5. Tm vs FTI Rate Control

3.2 FTI Module and Parameter Analysis

The TMATS data extracted from the FTI system enables detailed identification of onboard equipment and modules. For each module, the system determines the number of associated parameters and their respective bitrate contributions. Furthermore, the analysis identifies how many of these parameters are mapped into the IRIG-106 Chapter 4 PCM frame structure, along with their corresponding data rates. This mapping provides a clear understanding of how raw sensor data are structured and transmitted within the telemetry framework.

3.3 Telemetry Data Structure Analysis

From telemetry TMATS files, the system extracts information regarding parameter distribution across transmission frequencies. This includes

identifying how many parameters are assigned to specific frequency channels and how bandwidth is allocated across the telemetry spectrum. Such analysis is critical for evaluating spectrum usage and ensuring optimal configuration of telemetry.

TM SYSTEM - CONFIGURATION FILE ANALYSIS										
PARAMETER RATE CONTROL DETAILS										
PARAMETER RATE	MAX/MIN ORIGIN	NUMBER OF PARAMETER	MIN RATE							
			1.0	10.0	32.0	50.0	128.0	1024.0	2048.0	4096.0
0.00	1.00	1867	0	0	755	4	945	5	157	1
32.00	3.20	1	0	1	0	0	0	0	0	0
128.00	4.00	4	0	0	4	0	0	0	0	0
128.00	12.80	4	0	4	0	0	0	0	0	0
128.00	128.00	32	32	0	0	0	0	0	0	0
Grand Total		1908	32	5	759	4	945	5	157	1

PARAMETER RATE CONTROL SUMMARY		PARAMETERS TYPE						
PARAMETER RATE	NUMBER OF PARAMETERS	TYPE	DERIVED	TPP	TM SYSTEM	USER DEFINED	IACS PARAMETERS	RECOVERED
SAME RATE	YES	1,924.00	2,291.00	2,648.00	1.00	4.00	288.00	0.00
SAME WITH MAX RATE	1,907.00							
SAME WITH MIN RATE	1,866.00							
OVER SAMPLING	1.00							
UNDER SAMPLING	0.00							

Fig. 6. TM System – Configuration File Analysis

3.4 FTI Configuration and Traceability

The FTI TMATS data also provide detailed configuration information for onboard data acquisition systems. The analysis determines the total number of parameters collected by each module, as well as how many of these parameters are actively linked to the telemetry system. Additionally, hardware-level details such as module identifiers and serial numbers are extracted, ensuring full traceability of the instrumentation setup.

FTI SYSTEM - INVENTORY LIST									
TYPE	NUMBER OF EQUIPMENT	NUMBER OF FTI PARAMETERS	NUMBER OF TELEMATICS PARAMETERS	EQUIPMENT NO	SERIAL NUMBER				
ADIC	32.00	1,371.00	616.00						
ADIC - ACCELEROMETER/AC	7.00	132.00	84.00	3.8, 4.10, 4.11, 4.12, 5.5, 5.4, 5.6	AJ0357, AJ0357, AJ0357, AJ0358, AJ0359, AJ0359, AJ0359				
ADIC - BRIDGE	2.00	173.00	96.00		AJ0350, 250712				
KADIADIC110B91	1.00	32.00	16.00	2.3, 5.7	AJ0321, AJ0323, AJ0328, AJ0341, AJ0352				
KADIADIC134	5.00	144.00	80.00	3.6, 4.14, 5.8, 5.9, 5.10					
ADIC - DIFFERENTIAL ENDED	7.00	252.00	168.00		AJ0343, AJ0343, AJ0370, AJ0370, AJ0378, AJ0342, AJ0375				
KADIADIC116	1.00	250.00	130.00	2.5, 2.6, 2.10, 3.3, 4.5, 4.6, 4.8					
KADIADIC102	1.00	250.00	130.00	2.4	AJ0316				
ADIC - TEMPERATURE - RTD	3.00	96.00	48.00						
KADIADIC113	0.00	96.00	48.00	2.11, 3.4, 5.5	YC3263, YC3265, AA1603				
ADIC - TEMPERATURE - THERMOCOUPLE	0.00	162.00	90.00						
KADIADIC102	0.00	162.00	90.00	2.7, 2.8, 2.9, 3.5, 4.3	AJ0353, AJ0317, AJ0318, AJ0354, AJ0355				
BCU - ETHERNET	4.00	96.00	32.00						
KADIADIC140	4.00	96.00	32.00	2.2, 3.2, 4.2, 5.2	AJ0385, AJ0386, AJ0388, AJ0389				
BUS - ARINC-429	1.00	796.00	353.00		AJ0315				
KADIADIC103	1.00	796.00	353.00	5.10					
BUS - ETHERNET	1.00	188.00	188.00		AJ0359				
KADIADIC102	1.00	188.00	188.00	4.3	AJ0318				
BUS - MIL-STD-1553	1.00	1,978.00	588.00						
KADIADIC102	1.00	1,978.00	588.00	5.10					
VID	1.00	1.00	2.00						
KADIADIC106	1.00	1.00	2.00	4.15	AA1200				
nan	0.00	0.00	nan						
Grand Total	48.00	4,095.00	2,179.00						

FTI SYSTEM - CHANNEL RANGE INFORMATION											
CH RANGE	RANGE1	RANGE2	RANGE3	RANGE4	RANGES	RANGES	RANGE7	RANGES	RANGES	RANGE10	RANGE11
RANGE MAX	0.00	0.03	0.10	1.00	10.00	125.00	1372.00	2.50	40.00	540.00	85.00
RANGE MIN	0.00	-0.03	-0.10	-1.00	-10.00	-55.00	-270.00	-2.50	-40.00	-540.00	-40.00
KADIADIC1103	708.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
KADIADIC109B91	0.00	2.00	0.00	12.00	18.00	0.00	0.00	0.00	0.00	0.00	0.00
KADIADIC112	0.00	0.00	0.00	0.00	180.00	0.00	0.00	0.00	72.00	0.00	0.00
KADIADIC113	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	96.00	0.00
KADIADIC116	0.00	0.00	0.00	0.00	132.00	0.00	0.00	0.00	0.00	0.00	0.00
KADIADIC134	0.00	0.00	144.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
KADIADIC140	56.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
KADIEB102	188.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
KADIB102	1976.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
KADIMC102	0.00	0.00	0.00	0.00	0.00	0.00	0.00	256.00	0.00	0.00	4.00
KADYD102	0.00	0.00	0.00	0.00	0.00	27.00	135.00	0.00	0.00	0.00	0.00

Fig. 7. FTI configuration analysis

3.5 Network Configuration Visualization

In addition to parameter-level analysis, the module visualizes the network topology of the FTI system. This includes mapping connections between switches, recorders, and other network components. The visualization enables identification of active communication paths, as well as unused or inactive ports, providing valuable insight into system configuration and potential optimization areas.

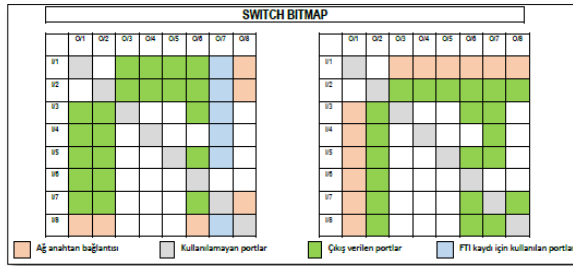


Fig. 8. Switch bitmap

3.7 Protocol-Based Parameter Analysis

The system further categorizes and analyzes parameters based on communication protocols, including iNET-X, RS-232, ARINC-429, and MIL-STD-1553. This classification allows evaluation of data distribution across different communication interfaces and supports a deeper understanding of system-level data flow.

PACKAGE INFORMATION						
PACKET TYPE	NUMBER OF PACKETS	NUMBER OF PARAMETERS	PACKET RATE (Hz)			
			1	32	128	256
INET-X	29	4223	0	1685	2102	422
ARINC-429-Word	173	173	173	0	0	0
MIL-STD-1553-Message	29	928	896	0	0	0
Generic	8	182	182	0	0	0
RS-232-Ch-4	2	2290	0	2286	0	0
FTI_RECORD	28	4219	0	1685	2102	422

Fig. 9. Package information

4. Differential Global Positioning System (DGPS) Assessment

The Differential Global Positioning System (DGPS) provides highly accurate positional data, which is primarily utilized in flight testing to calculate precise takeoff and landing distances and support specific test phases requiring exact distance measurements [1]. To support flight test operations, the ground segment utilizes a stationary DGPS base station. The analysis begins by verifying the base station's configuration, including its designated IP address and exact geographical coordinates (Latitude and Longitude). Ensuring these parameters are correctly established is critical, as they form the reference point for all differential corrections transmitted to the flight platform [2]. This initial verification confirms that the DGPS

unit was properly initialized and ready to provide reliable reference data.

4.1 Hardware Health and Diagnostic Monitoring

Continuous monitoring of the DGPS unit's physical and operational health is necessary to ensure uninterrupted service. The system tracks internal diagnostics, including CPU usage and device temperature. A sudden spike in CPU usage or a significant rise in temperature can indicate processing overload or environmental stress, potentially leading to a failure in calculating differential corrections. If thermal peaks or sustained high CPU loads are identified, engineers may perform technical inspections of the unit's cooling environment or analyze processing demands to prevent system degradation.

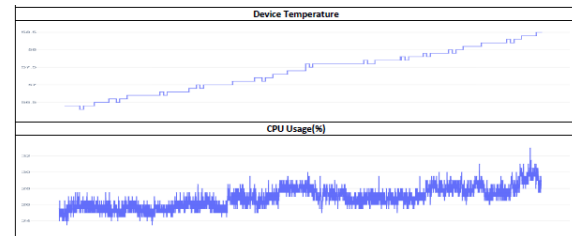


Fig. 10. Hardware health monitoring, including device temperature and CPU processing load of the DGPS unit.

4.2 Antenna Performance and Satellite Tracking

The accuracy of the DGPS corrections relies heavily on the antenna's performance and its ability to track multiple satellites. The analysis evaluates the GPS Antenna Voltage & Current to ensure the physical connection and power supply to the antenna remain stable. A sudden drop or irregularity in these electrical parameters can indicate a faulty cable, a damaged connector, or an internal antenna issue, which would directly compromise satellite reception.

Furthermore, the Number of Tracked Satellites is a critical metric for determining the quality of the positional solution. A higher number of tracked satellites generally results in a more robust and accurate differential correction. A significant drop in the number of tracked satellites could be caused by local RF interference, atmospheric conditions, or physical obstructions near the base station antenna. If a prolonged drop in satellite tracking is observed, engineers investigate the antenna's physical environment and check for potential sources of signal masking or interference to restore optimal satellite visibility.

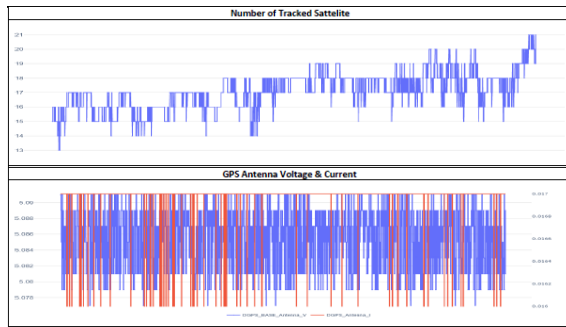


Fig. 11. Evaluation of satellite tracking performance and GPS antenna electrical stability.

5. Best Source Selector (BSS) Post-Test Analysis

The Best Source Selector (BSS) is a critical infrastructure component that ensures telemetry data continuity by aggregating multiple redundant streams[3]. To support concurrent flight test operations, the ground segment architecture at TUSAŞ incorporates multiple Flight Test Management Centers (FTMCs). Each center is assigned to a dedicated logical group within the BSS unit. This allows for independent configuration of selection algorithms and bitrate management tailored to specific mission needs. The system handles two types of connectivity based on receiver outputs: Ethernet (TMoIP) inputs for receivers with network capabilities and physical analog inputs for receivers with direct cable connections. The system architecture is monitored through an interface that tracks device identification and group configurations. Each group typically uses a "Weighted Majority Vote" algorithm to compare bitstreams in real-time [4]. The analysis includes verifying bitrate settings, matched filters, and output coding. Initial data integrity is confirmed by checking the Group BSS Status and baseline Data Quality Metric (DQM) levels.

5.1 Hardware Health and Diagnostic Monitoring

The reliability of the reconstructed telemetry stream is directly dependent on the physical health of the BSS hardware. The FTMC utilizes a multi-layered diagnostic approach, monitoring real-time alarm statuses including Board Detection, FPGA PCI integrity, and licensing health. These alarms serve as early warning indicators; for instance, a PCI alarm might signal a communication failure between internal modules, necessitating an immediate hardware check. Temperature monitoring across multiple sensors on the processing units (e.g., ADP modules) is also vital. A significant thermal peak is interpreted as a sign of environmental stress or cooling failure, prompting engineers to optimize processing loads or verify the ground

station's cooling infrastructure to prevent synchronization drifts.

BSS Health Alarm Status											
BSS NAME	ALARM BOARD DETECTED	ALARM LICENSE	ALARM SYSTEM CLOCK	ALARM SIGNAL NOISE	ALARM SIGNAL TSNP	ALARM SIGNAL TSNP	ALARM SIGNAL TSNP	ALARM SIGNAL TSNP	ALARM SIGNAL TSNP	ALARM SIGNAL TSNP	ALARM SIGNAL TSNP
BSS #1											

Fig. 12. Integrated hardware health dashboard showing thermal profiles and multi-point alarm monitoring.

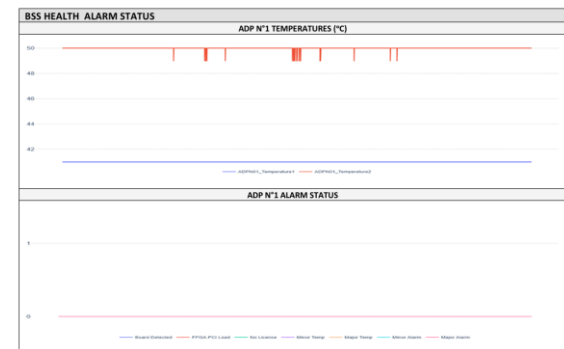


Fig. 13. ADP temperature and alarm status analysis

5.2 Multi-Input Signal Quality and Switching Validation

The performance evaluation follows a hierarchy, beginning with the overall output and then moving to individual sources. The Group DQM is the main metric, showing the total quality of the selected data. This value is checked against a limit to ensure the data is accurate. A stable Group DQM during source changes shows that the selection logic is working correctly across the assigned groups.

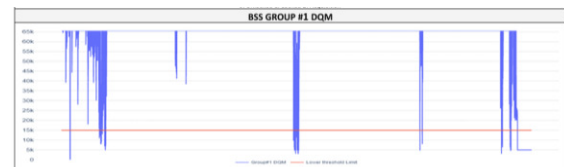


Fig. 14. DQM monitoring

Next, Ethernet (TMoIP) inputs are evaluated. For receivers with Ethernet outputs, the BSS utilizes TMoIP inputs. The TMoIP DQM serves as the primary quality indicator for these network streams and behaves similarly to the Group DQM. Packet Delay Variation (PDV) and DQE parameters help identify network problems. A peak in the PDV graph indicates network congestion or jitter, which can cause frame loss. When these peaks occur, engineers check network bandwidth or adjust buffer settings to stabilize the stream. Frame Synchronizer states (Search, Check, Locked, and Flywheel) are also tracked to ensure the data structure is preserved.

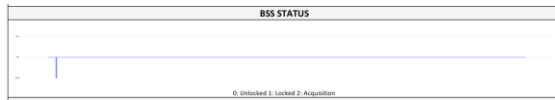


Fig. 15. Bss status monitoring

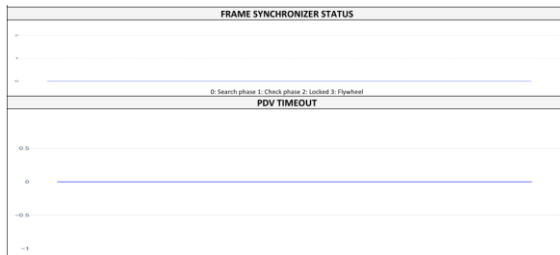


Fig. 16. Frame synchronizer status and PDV timeout graphs

Finally, physical analog inputs are evaluated for receivers connected via physical cables. The Signal-to-Noise ratio (E_b/N_0) is compared with the input-specific DQM. An E_b/N_0 peak indicates a strong signal, while sudden drops usually mean signal loss due to antenna shadowing or aircraft maneuvers. These events test the BSS switching speed. A successful switch occurs when the system moves to a better source without losing "Locked" status. If the analysis shows slow switching or data loss, engineers adjust the algorithm weights or re-tune the receivers to prioritize more stable links.

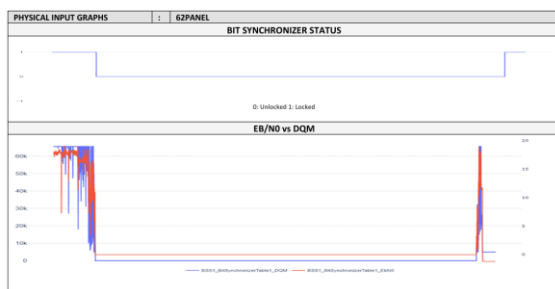


Fig. 17. Performance correlation between raw RF link quality and automated Data Quality Metric (DQM).

6. Telemetry Receiver Operational Architecture and Performance Analysis

The telemetry receiver is the core component responsible for demodulating RF signals into usable baseband data [5]. To support concurrent flight tests, the ground segment architecture utilizes multiple receivers assigned to specific tracking antennas. The analysis methodology begins by verifying the pre-test and post-test configurations, including channel frequencies (e.g., 2335 MHz and 2394 MHz), IF filter bandwidths, bitrates, and PCM output codes like NRZ-L. Receivers are typically configured in a Frequency Diversity mode to maximize signal reliability from multiple RF channels. This section verifies that the receivers were correctly initialized and maintained the required

demodulation parameters throughout the mission.

6.1 Hardware Health and Timing Synchronization

Continuous monitoring of the receiver's internal health ensures the reliability of the acquired data. The methodology tracks board temperatures and critical diagnostic alarms, such as FPGA status and System Clock integrity. Furthermore, timing precision is strictly verified through the IRIGB-1PPS lock status and 10 MHz reference alarms. An alarm or an "Unlocked" status in these timing parameters warns of potential timestamp corruption in the recorded telemetry packets. If thermal peaks or timing unlocks are identified, the standard procedure involves technical inspections of the cooling systems and external time-source connections to prevent synchronization failures in future operations.

	RECEIVER NAME	ALARM BOARD	ALARM EXTENSE	ALARM SYSTEM CLOCK	ALARM REMOTE UNLOCK	ALARM TEMPERATURE	MATCH ALARM SUM	MATCH ALARM SUM	HANDMADE TEMPERATURE	HANDMADE FPGAs TEMPERATURE	MONITORING CLIENTS
Rx1		0	0	0	0	-1	9	0	876	117	0
Rx2		0	0	0	0	0	9	0	881	117	0

Fig. 18. Integrated hardware health monitoring and timing synchronization status for the receiver units.

6.2 RF Performance and Signal Demodulation Analysis

The core of the performance evaluation focuses on the raw RF link and demodulation metrics. In the analysis graphs, measured RF Levels (dBm) are plotted against the calculated theoretical levels to assess the link budget. Under normal conditions, the measured signal should closely follow the calculated profile. A sudden, deep drop in the measured RF level while the theoretical calculation remains stable indicates a physical signal loss. This loss typically translates to a telemetry blackout event, meaning data packets are missing or corrupted. Such drops are primarily caused by physical issues, including severe antenna shadowing by the aircraft body during maneuvers, degradation in RF cables, or faults in the antenna's rotary joints.

In conjunction with RF levels, Channel Quality (dB) is evaluated as a critical indicator of data integrity [6]. While RF levels simply show the power of the received signal, Channel Quality reflects the Signal-to-Noise Ratio (SNR) and the actual usability of the baseband data. It is common to observe sufficient RF power but low Channel Quality, which implies that the signal is present but dominated by noise or interference. When the Channel Quality drops below the acceptable threshold, it directly correlates with unrecoverable Bit Error Rates (BER) and telemetry loss. If these degradations are

observed in post-flight analysis, engineers conduct a root cause investigation. Actions include analyzing the flight path to identify specific maneuvers that cause shadowing, inspecting the local RF environment for interference sources, or scheduling maintenance for the ground station's RF infrastructure.

Furthermore, the stability of the demodulation process is verified through the Carrier Detect and Bit Synchronizer statuses. These parameters must remain "Locked" to ensure continuous data extraction. A loss of lock, especially when accompanied by significant fluctuations in the Symbol Rate Offset, highlights severe synchronization issues. These fluctuations usually suggest excessive Doppler shifts during high-speed dives or instability in the airborne transmitter's oscillator. To mitigate these issues, technical teams may verify the aircraft transmitter's performance or optimize the receiver's Pre-D loop bandwidth settings to improve signal tracking during high-dynamic flight phases.

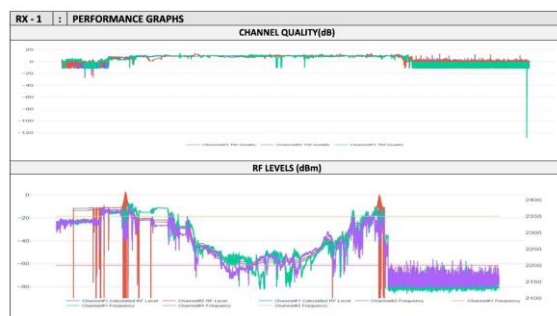


Fig. 19. Correlation between measured RF levels, calculated theoretical levels, and overall channel quality.

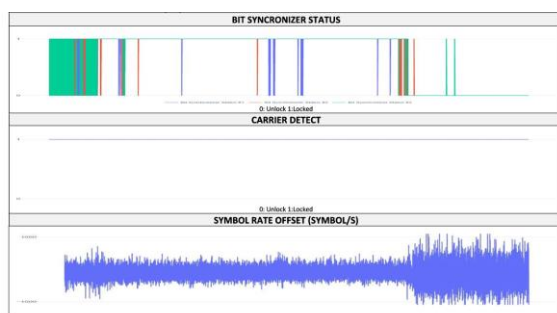


Fig. 20. Demodulator synchronization stability and symbol rate offset tracking.

7. Antenna Control Unit (ACU) Tracking Performance and Servo Analysis

The Antenna Control Unit (ACU) is responsible for maintaining a precise line-of-sight between the ground station and the flight platform. To support multiple concurrent flight tests, the ground segment architecture allows different tracking stations to be assigned to specific

mission groups. The system calculates target angles using Coordinate Transformation Functions (LLALookAngles) based on real-time aircraft GPS coordinates. These calculations integrate aircraft pitch, roll, and relative bearing to maintain high-precision pointing even during complex maneuvers. The system interface monitors the antenna's status to ensure it remains in the designated tracking mode, such as GPS or Auto-Track [7]. This section confirms that the ACU was correctly initialized and synchronized with the flight platform's navigation data for the mission.

7.1 Positioning Accuracy and Servo Dynamics

Tracking accuracy is evaluated by comparing the Calculated vs. Measured Azimuth and Elevation positions. The FTMC analyzes these overlapping graphs to identify any mechanical lag or servo-loop limitations [8]. A peak or a widening gap between the calculated and measured lines indicates a high angular rate maneuver where the antenna pedestal may be approaching its velocity or acceleration limits. Such deviations are interpreted as potential risks to link stability. If the measured position fails to follow the calculated path within the antenna's beamwidth, signal loss becomes imminent. In these cases, engineers take action by reviewing servo tuning parameters or refining the predictive tracking algorithms to improve the follow-up speed of the pedestal. Maintaining a precise overlap is the primary indicator of successful mechanical tracking.

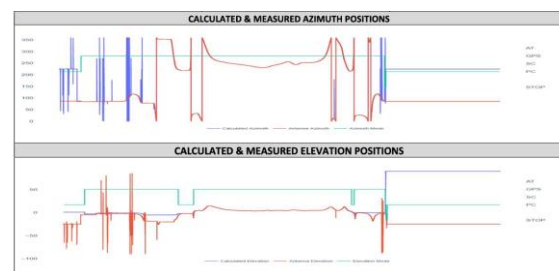


Fig. 21. Real-time comparison of theoretical tracking angles and actual antenna pedestal positions.

7.2 Signal Strength and Distance Correlation

The performance of the tracking receiver is evaluated by comparing its own RF levels (%) with the RF levels from the main telemetry receiver unit on a single graph. Under ideal conditions, these two values should move synchronously. A sudden drop in the tracking receiver signal while the main telemetry receiver level remains stable indicates an issue within the tracking RF path or hardware components. This deviation points to a system fault rather than a physical link loss, requiring technical inspections to determine the root cause.

Furthermore, the Aircraft-Antenna Distance is used in a separate analysis to evaluate signal quality. Signal levels are analyzed relative to the physical distance. Normally, signal strength decreases gradually as distance increases. However, sudden signal drops while the aircraft is within the operational range usually represent antenna shadowing caused by the aircraft body. When these losses are observed, the flight path is analyzed to verify coverage gaps, which helps optimize predictive tracking values to minimize data fragmentation.

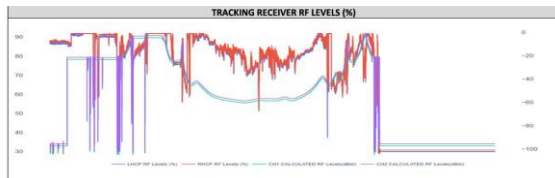


Fig. 22 Evaluation of signal integrity relative to the physical distance of the flight platform.

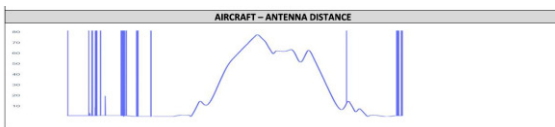


Fig. 23. Evaluation of signal integrity relative to the physical distance of the flight platform

7.3 Operational Interpretation and Mode Stability

The final stage of the ACU evaluation involves checking the stability of the tracking modes. The system must stay in "GPS" or "Auto-Track" modes without unexpected transitions to "Stop" or "Manual" states. By analyzing the correlation between distance, bearing, and signal levels, the FTMC validates the operational range and identifies any "blind spots" in the ground station's coverage. If tracking anomalies occur at specific coordinates, engineers investigate potential site obstructions or multipath effects. This rigorous methodology ensures that the ACU provides a stable and accurate pointing reference for the telemetry chain, guaranteeing the success of the data acquisition process.

7.4 Hardware Health and Tracking Alarms

Continuous hardware health monitoring ensures the mechanical and electronic stability of the pedestal. The analysis methodology involves tracking internal diagnostic states and proactive alarms, specifically the "Predictive Threshold" and "Sniffing" levels. These parameters determine how the antenna responds when the real-time RF link is compromised. An alarm peak in these metrics indicates that the signal dropped below a critical level, forcing the ACU to rely on predictive trajectory data [8]. This message tells engineers that the physical link was unreliable at a specific coordinate. In response, engineers

review the predictive settings or increase sniffing sensitivity to ensure the antenna follows the aircraft's path during signal dropouts.



Fig. 24. Alarm status

8. Post-Flight Data Analysis: Spatial Telemetry Drop-Out and Dynamic Trajectory Visualization

The overall success of flight test campaigns is directly correlated with the depth and accuracy of post-flight data analysis. In this context, the "Post-Flight Mapping and Analysis Tool" developed within the scope of this study is designed to generate a concrete analytical output that enables the spatial analysis of telemetry drop-outs, rather than merely providing a basic trajectory display.

This infrastructure accurately plots the aircraft's trajectory on a map during post-test evaluations. To enhance the efficiency of the analysis processes, a dynamic bounding box approach is implemented for visualization. A separate, high-resolution map view is dedicated to taxi operations and low-altitude flights (<3000 ft) encompassing ground movements. Once the aircraft departs the runway environment, the map boundaries are dynamically recalculated and adjusted based on the instantaneous position data of the aircraft. This ensures that the analyst is consistently provided with the optimal perspective and scale for each specific flight phase.

The most critical contribution of this tool to post-flight analysis is the management of data anomalies that occur during signal attenuation or telemetry loss. During a telemetry drop-out, the position data (GPS/INS) transmitted from the aircraft often becomes corrupted, yielding erroneous values or illogical spatial jumps. Plotting this raw data directly onto a map results in a distorted, unrealistic trajectory, which renders post-test positional analysis impossible.

Fig 25 shows, which encompasses operations above 3000 ft and expansive off-runway flight areas, visually highlights approximate telemetry drop-out regions directly on the aircraft's trajectory in red. By facilitating spatial analysis of signal losses immediately following every activity, this setup allows engineering teams to troubleshoot specific issues, such as antenna obscuration or terrain masking, rapidly making decisions and troubleshooting issues efficiently.

(Note: Due to confidentiality protocols and security restrictions, highly detailed, high-resolution map backgrounds are not provided in this visualization.)

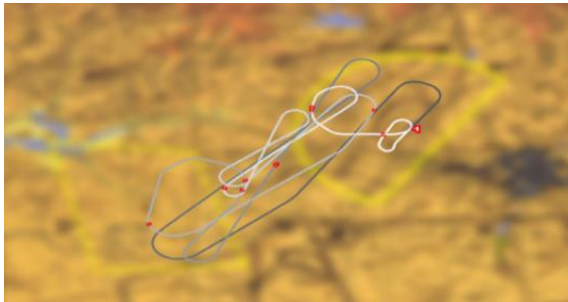


Fig. 25. Telemetry loss map for flight activity

To overcome this challenge and establish a consistent analysis environment, a "Condition Validation and Hold" algorithm is integrated into the system. The system ensures the validity of the incoming position data through the following methodology:

Continuous Comparison and Validation: Each newly acquired position data point is continuously compared against the previous valid position. Concurrently, the integrity of the current data is verified by monitoring a specific "status parameter" embedded within the telemetry packet.

Invalid Data Filtering (Latching/Hold): If the status parameter indicates that the data is corrupted, or if a physically anomalous positional jump is detected, the system rejects the erroneous data. Until a new, healthy data packet is received, the system continues to plot the trajectory by holding and utilizing the last known valid position stored in its memory [9].

By employing this filtering approach, the plotted flight trajectory reflects the actual path of the aircraft with a high degree of approximation, even in the presence of severe telemetry interruptions. The most valuable analytical output is then generated upon this corrected route: on this smoothed trajectory, the precise segments where telemetry loss occurred are highlighted in red.

8.1 Analytical Output and Regional Assessment

Mapping these drop-outs using filtered, positionally accurate data provides test engineers with crucial analytical material immediately available post-flight. This visual output facilitates a detailed investigation of regional telemetry losses. It allows analysts to clearly diagnose on the map whether the drop-outs were caused by geographical obstacles (terrain masking), specific flight maneuvers (aircraft structure shadowing the antenna), or

ground station antenna tracking limitations. Consequently, this infrastructure serves as a fundamental evaluation tool for the spatial verification of telemetry system performance and the optimization of future flight test planning.

Fig 26 visualizes the exact path traversed by the aircraft on the ground for operations below 3000 ft. By overlaying telemetry drop-outs on this high-resolution runway and taxiway data, precise spatiotemporal losses can be identified. These detailed analytics are directly utilized to evaluate current antenna placements and inform future telemetry RF infrastructure improvement projects.



Fig. 26. Telemetry loss map for runway

9. Activity Report of UAV Systems

In manned flight test platforms, the foundation of the telemetry data acquisition architecture is the PCM Frame structure [10]. All components used to generate and transmit flight test data in PCM Frame format on board the aircraft, capture and decommutate it on the ground side, and visually present it to the relevant system engineers constitute the telemetry system architecture. In addition to flight tests of the in-house developed manned aircraft projects at Turkish Aerospace (TA), flight tests of the in-house developed unmanned aerial vehicle platforms such as ANKA, AKSUNGUR and ANKA-III are also monitored through telemetry. Since UAV systems already incorporate link systems, telemetry data acquisition is performed by routing the messages downlinked to the ground over the network [11], [12]. For this reason, telemetry data control differs from conventional PCM Frame data acquisition control. Within this scope, telemetry data acquisition success metrics were created for UAV project flight test activities and reflected in the Activity Report.

9.1 Gathered Messages List & Activity Status Summary

In UAV test operations, telemetry data verification is conducted specifically at the message (label) level. A comprehensive list and the status information of all messages for which data acquisition has been performed – contingent upon the specific test activity – are summarized under this heading. By reviewing this list, a rapid analysis of telemetry activities can be performed on a per-message basis. For a more granular evaluation, the dedicated analysis page for the respective message should be consulted.

MESSAGE NAME	MESSAGE TYPE	P / A	INT. UPDATE RATE (Hz)	MESSAGE PERIOD (ms)	TRANSMITTED (SPKs)	DELAY RATE (%)	ORIGIN COUNT AND DATA LOSS (PERCENTAGE)	VALID MESSAGE RATE (%)	VALID MESSAGE RATE WITHOUT LINK LOSS (%)	FRAME COUNT PER SECOND
Msg 1	TELECOMMAND	P	20.0	10.0	130	36.13	nan	98.3	98.3	5.0
Msg 2	TELECOMMAND	P	10.0	5.0	95	24.38	nan	98.31	98.31	5.0
Msg 3	TELECOMMAND	P	2.0	1.0	94	17.56	nan	98.32	98.32	1.0
Msg 4	TELECOMMAND	A	2.0	0.0	96	12.54	nan	0.0	nan	1.0
Msg 5	TELECOMMAND	A	2.0	0.0	43690	0.0	nan	0.0	nan	1.0
Msg 6	TELECOMMAND	P	10.0	5.0	99	26.44	nan	98.3	98.3	5.0
Msg 7	TELECOMMAND	P	2.0	1.0	81	6.55	nan	98.32	98.32	1.0
Msg 8	TELECOMMAND	A	2.0	0.0	98	30.13	nan	0.0	nan	0.0
Msg 9	TELECOMMAND	A	2.0	0.0	43690	0.0	nan	0.0	nan	0.0
Msg 10	TELECOMMAND	P	2.0	1.0	266	18.52	nan	98.33	98.33	1.0
Msg 11	TELECOMMAND	A	2.0	0.0	43690	0.0	nan	0.0	nan	0.0
Msg 12	TELECOMMAND	A	2.0	0.0	43690	0.0	nan	0.0	nan	0.0
Msg 13	TELECOMMAND	A	2.0	0.0	91	8.75	nan	0.0	nan	1.0
Msg 14	TELECOMMAND	P	2.0	1.0	94	12.49	nan	98.32	98.32	1.0
Msg 15	TELECOMMAND	A	2.0	0.0	43690	0.0	nan	0.0	nan	0.0
Msg 16	TELECOMMAND	A	2.0	0.0	107	0.0	nan	0.0	nan	0.0
Msg 17	TELEMETRY	P	20.0	10.0	178	99.82	nan	97.67	97.67	10.0
Msg 18	TELEMETRY	P	20.0	5.0	182	75.46	nan	97.8	99.53	5.0
Msg 19	TELEMETRY	P	20.0	10.0	270	53.26	nan	93.58	nan	10.0
Msg 20	TELEMETRY	P	10.0	2.0	130	75.75	nan	99.42	99.68	1.0
Msg 21	TELEMETRY	P	10.0	5.0	152	54.67	nan	93.54	nan	5.0
Msg 22	TELEMETRY	P	10.0	2.0	199	78.16	nan	99.44	99.67	1.0
Msg 23	TELEMETRY	P	10.0	5.0	205	55.74	nan	95.53	nan	5.0
Msg 24	TELEMETRY	P	10.0	2.0	95	124.19	nan	99.61	99.79	1.0
Msg 25	TELEMETRY	P	20.0	10.0	87	71.61	nan	95.4	nan	10.0
Msg 26	TELEMETRY	P	20.0	5.0	187	113.47	nan	97.75	98.96	5.0
Msg 27	TELEMETRY	P	4.0	1.0	102	87.59	nan	97.05	97.74	1.0
Msg 28	TELEMETRY	P	4.0	1.0	800	146.56	nan	97.64	98.03	1.0

Fig. 27. Gathered messages list

Message-specific control parameters are color-coded based on their limit values:

- If the relevant parameter value is within the expected range, no coloring is applied.
- If the relevant parameter value is within the range of caution limit values, the cell is colored yellow.
- If the relevant parameter value is within the range of warning limit values, the cell is colored red.
- If the relevant message was not received at all during the test, the entire row is colored gray.

The parameters monitored for each specific message are detailed below:

- P/A: Indicates whether the message is transmitted on a periodic or aperiodic basis.
- IADS Update Rate: Specifies the sampling frequency on the data acquisition unit.
- Message Frequency: Represents the reference frequency value broadcast by the platform
- Frame Size: Provides the message length as calculated by the data acquisition unit.

- Delay Average: The arithmetic mean of instantaneous message latency values recorded throughout the test duration.
- Valid Message Rate: The percentage of messages received without data loss, calculated as: 100% - Message Loss Rate.
- Valid Message Rate without Link Loss: The ratio calculated by excluding message losses specifically resulting from link failures.
- Frame Count per Second: Specifies the total number of messages captured per second.

9.2 UAV Downlink Status Parameters and Analysis

The UAV Downlink Status page shows which links (LOS and BLOS) are active in the relevant test, and which links are used for data acquisition on the UAV and Flight Test Management Center (FTMC) sides.

The first section lists the parameters used. Listing the parameters helps identify any configuration problems when analyzing output. The intermediate section contains graphs, respectively:

- Link selected by UPA and UPA Auto LOS output
- Link selected by UAV and Auto LOS output
- LOS and BLOS links activity status

The final section shows the activity percentages of the link selected by UPA and other available links.



Fig. 28. UAV downlink status analysis

9.3 Telemetry & External Interface Messages

Telemetry messages transmitted from the aircraft are analyzed in the Telemetry & External

Interface Messages section. Messages summarized in the Gathered Messages List are presented here in detail and graphs are created. For telemetry packets, losses arising from aircraft link health are designated as Link Loss, while the remaining losses are designated as Packet Drop. By disregarding losses caused by Link Loss, the Valid Message Rate Without Link Loss parameter has been defined. This is because, in UAV test activities, there is no action that the telemetry engineer can take regarding link health. The status information of the UAV communication links is recorded simultaneously. Based on this message information, an inference is made as to whether the message loss is due to link health. One graph indicates whether the instantaneous data loss is due to link loss or packet drop, while the other shows message latency and the number of packets captured per second.

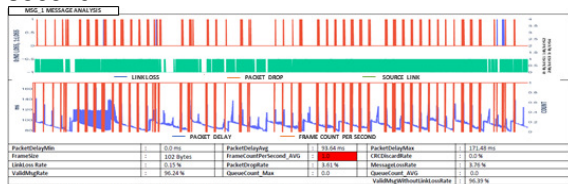


Fig. 29. TM message analysis

9.4 UAV Uplink Status Parameters and Analysis

The UAV Uplink Status page shows which links (LOS and BLOS) were active in the relevant test and which links were used for data acquisition by the UAV. Although this page is not directly used for telemetry data acquisition analysis, it has been included for awareness purposes.

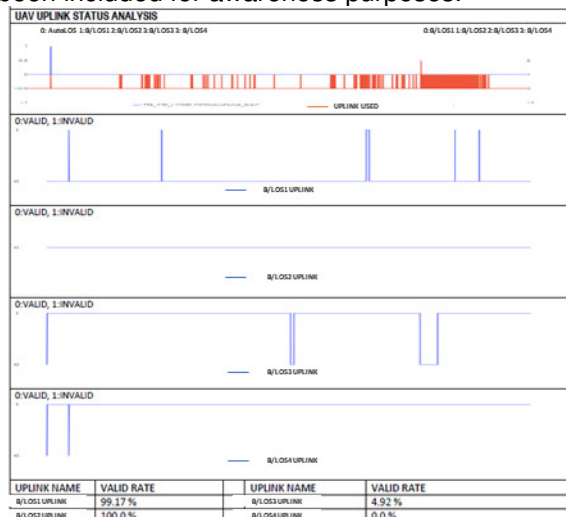


Fig. 30. UAV uplink status analysis

9.5 Telecommand & Link Management Messages

Telecommand messages transmitted from the Ground Control Station are analyzed in this section. Messages summarized in the Gathered

Messages List are presented here in detail and graphs are created. Since telecommand messages are ground messages, there is no loss associated with the link. For this reason, the data loss experienced in telecommand messages is just classified as Packet Drop.

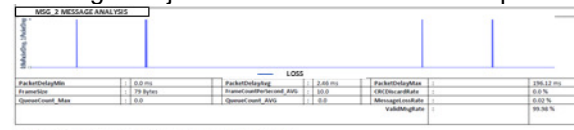


Fig. 31. TC message analysis

10. Meteorological Data Processing and Analysis

Within the FTMC Activity Report Software, a dedicated meteorological module has been developed to evaluate environmental conditions affecting flight test operations, particularly their impact on ground telemetry systems and antenna performance. The module supports both real-time monitoring and post-flight analysis by transforming raw sensor data into structured outputs integrated into the final report.

10.1 Data Acquisition and Parameter Definition

Meteorological data are acquired from ground-based sensors via network interfaces (e.g., Modbus/TCP) and processed in their native units, including temperature ($^{\circ}\text{F}$), wind speed (mph), wind direction (degrees), and barometric pressure (inHg). Derived units (e.g., $^{\circ}\text{C}$, knots, mBar) are calculated through internal conversions. High-frequency sampling (e.g., 100 Hz) ensures accurate representation of transient environmental conditions. In addition to raw measurements, key derived parameters such as minimum, maximum, and average values are computed [13].

10.2 Derived Metrics and Threshold Analysis

A core functionality of the module is the evaluation of wind conditions against predefined antenna operational limits. For each antenna type, operating and survival thresholds are defined. When wind speed exceeds these limits, the system generates condition indicators (caution or warning) and calculates cumulative exceedance durations. This enables quantification of environmental exposure over time rather than relying solely on peak values. Additional metrics, such as wind direction at extreme speeds, provide further context for system performance analysis.

10.4 Statistical Summary Generation

The system automatically produces statistical summaries for all meteorological parameters over the test duration. These summaries include maximum, minimum, and average values

derived from high-resolution data, ensuring accurate representation of both steady-state and transient conditions. The results are directly embedded into the FTMC Activity Report, enabling rapid assessment and correlation with telemetry system behavior.

10.5 Time-Series Visualization

Time-series plots are generated for key parameters, including wind speed, wind direction, temperature, and pressure. These visualizations support detailed analysis of temporal variations, allowing identification of sudden gusts, fluctuations, and long-term trends. Combined visualization of wind speed and direction further enhances the interpretation of atmospheric dynamics and their potential effects on antenna tracking and telemetry stability.

10.6 Geospatial Visualization

A geospatial visualization layer presents wind characteristics using map-based representations. This includes the location of the meteorological station and vector-based visualization of wind magnitude and direction. Critical conditions such as extreme values are highlighted to improve situational awareness and support intuitive interpretation [14].



Fig. 32. Vector Representation of Wind Direction and Magnitude.

11. Hardware Status

During flight test activities, CPU values from all computers within the Flight Test Management Center (FTMC) are extracted from log files. This data is then analyzed to assess computer performance. Separate graphical visualizations are generated for the CDC (presumably referring to a specific system or component) and all client computers.

Figure 33 illustrate the capacity utilization of the client used during the activity throughout its duration. This enables the analysis of performance degradation potentially attributable to hardware capacity limitations.

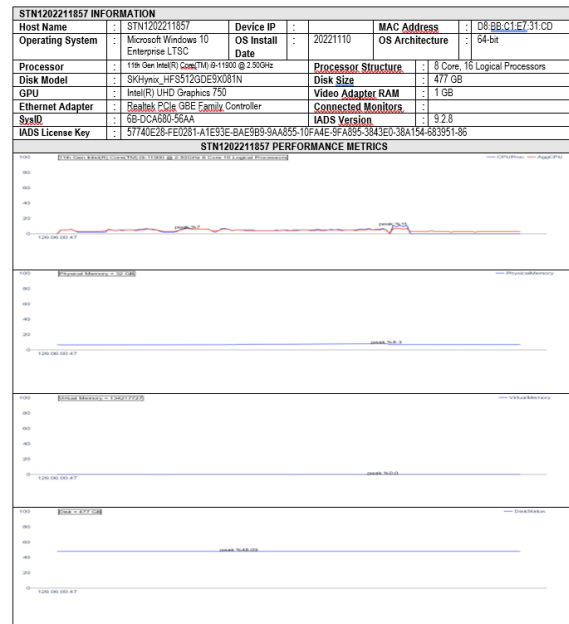


Fig. 33. Hardware status graphics

Separate pages are generated displaying individual performance metrics for both the CDS and client computers. Alongside this, Figure 34 presents a summary table outlining the performance metrics of all computers utilized throughout the activity. To facilitate rapid identification of potential issues, the table employs color-coding – warnings and cautions – when metrics exceed predefined threshold values. This allows for the swift detection of computers exceeding limits and enables prompt action to be taken.

HARDWARE PERFORMANCE SUMMARY									
No	Desktop	CPU Model	%Max OS	Duration(min)	RAM Size	%Max OS	Disk Size	Usage	Mon Qty
1	DESKTOP-RSRMVI0	4 C8 LP @ 3.60GHz	%36	0.0	X0	32.0 GB	%17	476.34 GB	%54
2	CLIENT-4	4 C8 LP @ 3.40GHz	%9	0.0	X0	4.0 GB	%63	931.4 GB	%7
3	CLIENT-S-10	4 C8 LP @ 3.40GHz	%9	0.0	X0	16.0 GB	%15	230.93 GB	%45
4	CLIENT-S-12	4 C8 LP @ 3.40GHz	%9	0.0	X0	16.0 GB	%14	236.1 GB	%46
5	CLIENT-S-2	4 C8 LP @ 3.40GHz	%9	0.0	X0	16.0 GB	%12	238.38 GB	%75
6	CLIENT-S-6	4 C8 LP @ 3.40GHz	%9	0.0	X0	16.0 GB	%16	220.93 GB	%60
7	CLIENT-S-7	4 C8 LP @ 3.40GHz	%2	0.0	X0	4.0 GB	%29	119.96 GB	%85
8	CLIENT-S-8	4 C8 LP @ 3.40GHz	%7	0.0	X0	16.0 GB	%16	226.1 GB	%57
9	CLIENT-S-9	4 C8 LP @ 3.40GHz	%20	0.0	X0	16.0 GB	%14	220.93 GB	%61
10	CLIENT-10	4 C8 LP @ 3.40GHz	%9	0.0	X0	16.0 GB	%12	226.1 GB	%70
11	Client-1	4 C8 LP @ 3.40GHz	%9	0.0	X0	16.0 GB	%12	226.1 GB	%53
12	Client-8	6 C12 LP @ 3.40GHz	%9	0.0	X0	32.0 GB	%45	237.54 GB	%59
13	DESKTOP-GHPPJ02	4 C8 LP @ 3.40GHz	%8	0.0	X0	16.0 GB	%19	237.83 GB	%31
14	DESKTOP-TA4DPUR	4 C8 LP @ 3.60GHz	%58	2370.0	X39	16.0 GB	%29	930.44 GB	%8
15	STN1202211846	8 C16 LP @ 2.50GHz	%9	0.0	X0	32.0 GB	%16	476.56 GB	%47
16	STN1202211857	8 C16 LP @ 2.50GHz	%7	0.0	X0	32.0 GB	%7	476.56 GB	%48

* C: Core, LP: Logical Processor, OS: Operating System, CPU: Max OS: Warning: > %40 - Red, Caution: > %30 - Yellow, RAM: Max OS: Warning: > %40 - Red, Caution: > %30 - Yellow, Disk Usage: Warning: < %75 - Red, Caution: < %50 - Yellow.

Fig. 34. Hardware status graphics

12. Software Architecture and Algorithm Design

Within the scope of this project, the FTMC Activity Report Software has been developed using the Python programming language, with a focus on scalability, automation, and efficient data processing. The software architecture is designed to handle large volumes of flight-test data and to generate structured, repeatable reports with minimal manual intervention.

Flight-test data are acquired from the IADS (Integrated Analysis and Display System) environment through a dedicated Dynamic Link

Library (DLL) interface. This integration enables direct access to all recorded flight activity data, including thousands of parameters associated with telemetry systems, navigation sources, and ground-based subsystems. The acquired data are processed and structured to ensure consistency across different report sections.

For data analysis and interpretation, extensive use of visualization libraries is employed to transform raw telemetry and system parameters into graphical representations. Hundreds of plots are generated for each test activity, enabling rapid assessment of system performance, anomaly detection, and trend evaluation. To address the computational cost associated with large-scale visualization, parallelization techniques are implemented. These methods significantly reduce processing time by distributing graph-generation tasks across multiple execution units.

In addition to visualization processes, parallel computing approaches are also applied to the analysis of large TMATS (Telemetry Attributes Transfer Standard) files. Parallel loops are utilized to accelerate parsing and parameter extraction, ensuring that even high-volume configuration datasets can be processed efficiently within the reporting workflow.

A modular report-generation structure is adopted through the use of Jinja templating. Separate Jinja templates are defined for each subsystem and report section, allowing flexible customization and independent updates without affecting the overall system. This approach enables cost-effective maintenance and rapid adaptation to evolving reporting requirements.

Finally, the report assembly process is completed by combining section-specific document templates in a predefined sequence. Each subsystem report is generated independently and then merged into a unified document, resulting in a comprehensive and structured final report. This modular and automated pipeline enhances consistency, reduces manual workload, and significantly improves the efficiency of post-flight analysis.

13. Conclusion and Future Work

Within the scope of the FTMC Activity Report, data acquired from all telemetry subsystems – both ground-based and airborne – alongside data derived from TMATS files and observations of human behavior, are presented to users via visualization tools post-activity. Anomalies within the visualized data are readily identifiable on the generated graphs, facilitating efficient bandwidth utilization and maximizing telemetry quality throughout the operational period.

Currently, reports are disseminated within two hours of activity completion. Future development plans for the software prioritize the real-time generation of the graphical representations included in the report, rather than post-activity processing. The target is to deliver reports within one minute of activity termination. This shift aims to enhance operational responsiveness and provide stakeholders with timely insights.

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