412TW-TP-19-62

AIRBUS A330 MULTI ROLE TANKER TRANSPORT (MRTT) AND USAF RECEIVER SIMULATION TOOL (RST) GROUND TEST PLAN

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Project Engineer

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SEPTEMBER 2019

TEST PLAN

Controlling Office: Aerial Refueling Certification Agency (ARCA), Wright-Patterson AFB, Ohio 45433-7142.

412TH TEST WING
EDWARDS AIR FORCE BASE, CALIFORNIA
AIR FORCE MATERIEL COMMAND
UNITED STATES AIR FORCE

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14. ABSTRACT

This test collects USAF Receiver Simulation Tool (RST) fuel system data during ground test with an Airbus A330 Multi Role Tanker Transport (MRTT). The data will be used by the Aerial Refueling Certification Agency (ARCA) when providing aerial refueling (AR) certifications between the A330 MRTT and USAF receivers. It will also support a fuel system compatibility analysis to allow the A330 MRTT to refuel to full (top-off) USAF receivers at 50 ±5 pounds per square inch gauge. Testing was requested by ARCA, Wright-Patterson AFB, Ohio. The lead developmental test organization is the Air Force Test Center (AFTC), Edwards AFB, California. The executing test organization is the 412th Test Wing/418th Flight Test Squadron, Edwards AFB, California. The participating test organization is the Airbus Defense & Space, Getafe (Madrid), Spain. Testing will be executed by a combined USAF/Airbus Company team at Getafe, Spain in September 2019 and will consist of approximately 20 ground test hours.

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Aerial refueling; boom ground test; fuel system; A330; A330 MRTT; surge pressure; RST(receiver simulation tool)

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1.0 INTRODUCTION

1.1 General

This test plan collects USAF receiver simulation tool (RST) fuel system data during ground test with an Airbus A330 Multi Role Tanker Transport (MRTT). The fuel system data includes fuel temperature, fuel pressure, fuel flow rate, and closure valve position. The data will be used by the Aerial Refueling Certification Agency (ARCA) when providing aerial refueling (AR) certifications between the A330 MRTT and USAF receivers and will support a fuel system compatibility analysis to allow the A330 MRTT to refuel to full (top-off) USAF receivers at 50 ±5 pounds per square inch gauge (psig).

Testing was requested by ARCA, Wright-Patterson AFB, Ohio. The lead developmental test organization is the Air Force Test Center (AFTC), Edwards AFB, California. The executing test organization is the 412th Test Wing/418th Flight Test Squadron, Edwards AFB, California. The participating test organization is the Airbus Defense & Space, Getafe, Spain. Testing will be executed by a combined USAF and Airbus Company team. Testing is expected to be conducted at the Airbus Military Conversion Centre located in Getafe in September 2019 and will consist of approximately 20 ground test hours. The 412 TW job order number for this test effort is AKMC0L00.

1.2 Background

The 412TW completed AR certification testing with the A330 MRTT variant, RAAF KC-30A, and the A-10C, B-1B, C-17A, E-7A, F-16C, F-22, F-35A, and KC-30A aircraft. All but 2 (F-35, KC-30A) tanker/receiver pairs were restricted from performing top-offs at 50 ±5 psig because of the lack of receiver aircraft instrumentation and are operationally restricted as well per their AR clearance.

1.2.1 RST

Similar RST testing with KC-10A and KC-135R aircraft to provide the baseline RST fuel pressure data was previously conducted IAW 412 TW-TP-17-45, *KC-10 and KC-135 Surge Pressure Data Collection Using the USAF Fuel Surge Pressure Test Tool* (reference 1). The KC-10A test is approximately 80 percent complete but is on hold due to test aircraft availability. The KC-135R test is complete. ARCA has confirmed that the RST performed properly and provided accurate data with sufficient fidelity to meet the evaluation criteria.

1.2.2 A330 MRTT

ARCA has restricted the Airbus A330 MRTT from topping-off USAF receivers at the nominal AR fuel pressure of 50 ± 50 psig due to the lack of instrumented receiver aircraft fuel pressure data. This test is intended to provide ARCA with data to possibly rescind this restriction and eliminate the need to instrument USAF receivers during future AR test efforts.

Fuel pressures in the tanker and receiver aircraft typically surge during closure of receiver aircraft fuel valves. The RST is intended to simulate surge pressures (typically experienced during fuel top-off and rapid disconnect) by testing permutations of four different fuel line diameters, two different fuel valve closure rates, and different fuel flow rates.

1.3 Test Item Description

The test items are the Airbus A330 MRTT and the RST.

1.3.1 Airbus A330 MRTT Tanker

The Airbus A330 MRTT shown in figure 1 is a modified Airbus A330-200 with an advanced refueling boom system (ARBS) and two Cobham Mk-32B-905E underwing refueling pods. The A330 MRTT is the newest variant of the KC-30A. The A330-200 MRTT can carry a maximum of 108,800 kilograms (240,000 pounds) of fuel. The A330 MRTT is powered by two 320,000 Newton (72,000 pounds of force) RR Trent 772B-60 turbofan engines.

Figure 1 AIRBUS A330 MRTT Aircraft

The A330 MRTT military modifications for AR, include:

- A refueling boom mounted at the rear of the aircraft to enable in-flight boom refueling operations. ARBS at boom upgrade 3 (BUG III) Loop 6.1 (Boom Control Unit SW 7.3.7) or subsequent configuration.
- A 3-D boom-enhanced vision system (BEVS) to enable the monitoring and control of wing pod and boom refueling operations from the aerial refueling operator (ARO) station.
- An aft-facing mission console in the cockpit that allows conduct of in-flight dispensing operations from the ARBS and hose and drogue.

1.3.1.1 A330 MRTT Advanced Refueling Boom System

The A330 MRTT boom is approximately 18 meters (60 feet) long at maximum extension. The boom is operated with fly-by-wire controls and uses electrically actuated ruddervators as the control surfaces and electric motors for telescoping. Control of the boom is conducted utilizing two side stick controls at both the ARO and mission control officer stations; the flight control stick on the right, and the telescoping control stick on the left.

The ARO may command two types of disconnects by depressing the disconnect trigger on the flight control stick. The first detent will trigger a disconnect by transmitting an electrical signal through the nozzle signal coil, and will also trigger the independent disconnect system (IDS), which allows a disconnect even if the receiver’s toggles are in the latched position. The second detent will actuate the IDS and uses an electrical path that bypasses the boom control unit. The IDS is electrically controlled and actuated, causing the toggle latch trays on each side of the nozzle to collapse inward and allow the ARO to separate the boom from the receiver aircraft.

The boom is automatically retracted 0.6 to 1.2 meters (2 to 4 feet) during the first 0.5 second following all disconnects to achieve approximately 0.9 meters (3 feet) of separation. The retraction function considers longitudinal rate of receiver motion at disconnect. When enabled, an automatic retract is performed to zero extension following the expiration of the disconnect delay setting time.

1.3.1.2 Fuel System

The total fuel capacity of the A330 MRTT is 110 Tons (240,000 pounds). The boom is designed to offload at rates up to 3,369 kilograms per minute (kg/min) (1,230 gallons per minute [gpm]) at 50 ±5 psig, depending on receiver capability. The proof pressure is 120 psig, the limit pressure and surge pressure are both 240 psig, and the ultimate (burst) pressure is 360 psig.

There are six AR pumps, of which a maximum of four can be used for simultaneous operation. The A330 MRTT CG is automatically managed by the Flight Management Guidance and Envelope Computer by controlling the AR computers to manage pumps for fuel transfer to receivers. When operating in AUTO mode, either one, two or four AR pumps are operating depending on the receiver.

An internal surge boot assembly is installed within the boom assembly of which consists of an inner and outer synthetic rubber compound boot, to absorb any surge pressures during fuel delivery. Each boot section is a pressurized/inflated nitrogen bladder formed around a perforated section of the liner tube. The pressure disconnect function will initiate a pressure disconnect when a fuel pressure greater than 75 psig is sensed in the nozzle for more than 48 milliseconds.

The ARO can program an offload amount into the multifunction controller display prior to initiating a fuel transfer. The AR system regulates to 50 ±5 psig until within 500 kilograms (1,100 pounds) of the programmed offload amount at which point the system is commanded to regulate down to 20 ±5 psig. A manual override function to override preselected offload settings may be activated by a button on the boom flight control stick.

1.3.2 Receiver Simulation Tool

The RST is a ground test tool designed to generate and record surge pressures created by closing fuel line valves during simulated boom refueling operations. It consists of two major components: a fuel rig element (FRE) and a mobile control room (MCR) trailer. Below is a brief description of each component of the RST, see *RST System User Manual* (reference 2) for full setup, operating, and cleanup procedures. The RST is an ARCA asset that is stored and maintained by the 412 TW.

The FRE shown in figure 2 consists of three modules: the boom receptacle stand (BRS), the multiline fuel manifold assembly (MFMA), and the fuel deposit module (FDM). All FRE functions are controlled by personnel in the MCR trailer.

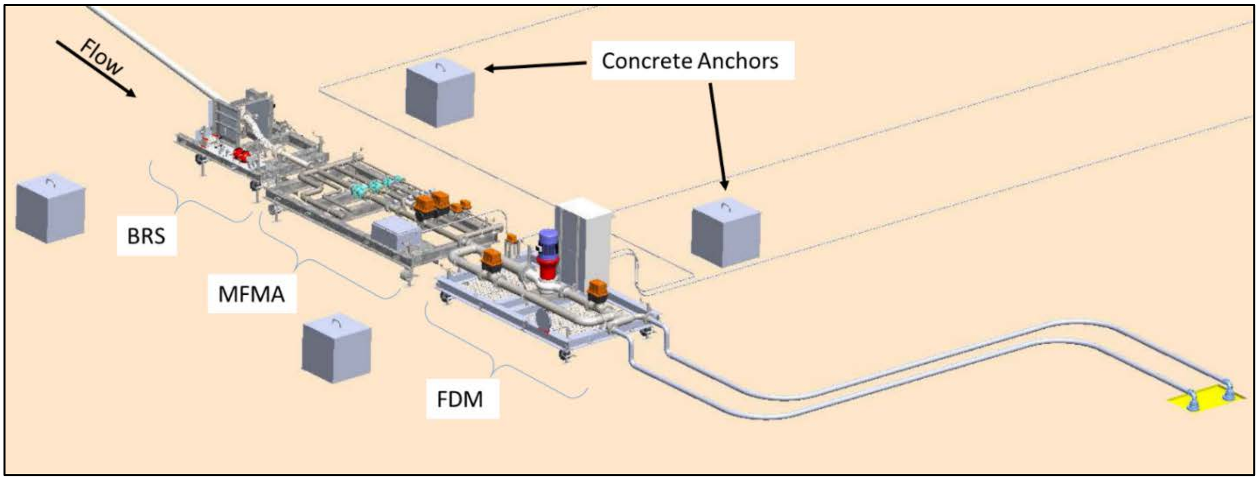

Figure 2 FRE Modules

The BRS shown in figure 3 has a universal aerial refueling receptacle slipway installation (UARRSI) (P/N 2775561) that mates with the tanker boom nozzle. The UARRSI is mounted on a spring loaded rail system designed to rapidly separate the BRS from the boom nozzle during disconnects. The UARRSI latches are hydraulically actuated. The BRS control panel in the MCR trailer indicates ready, contact, and disconnect signals, and can disconnect the receptacle from the boom on command. A flexible spill containment basin placed under the BRS will catch and contain any fuel spillage.

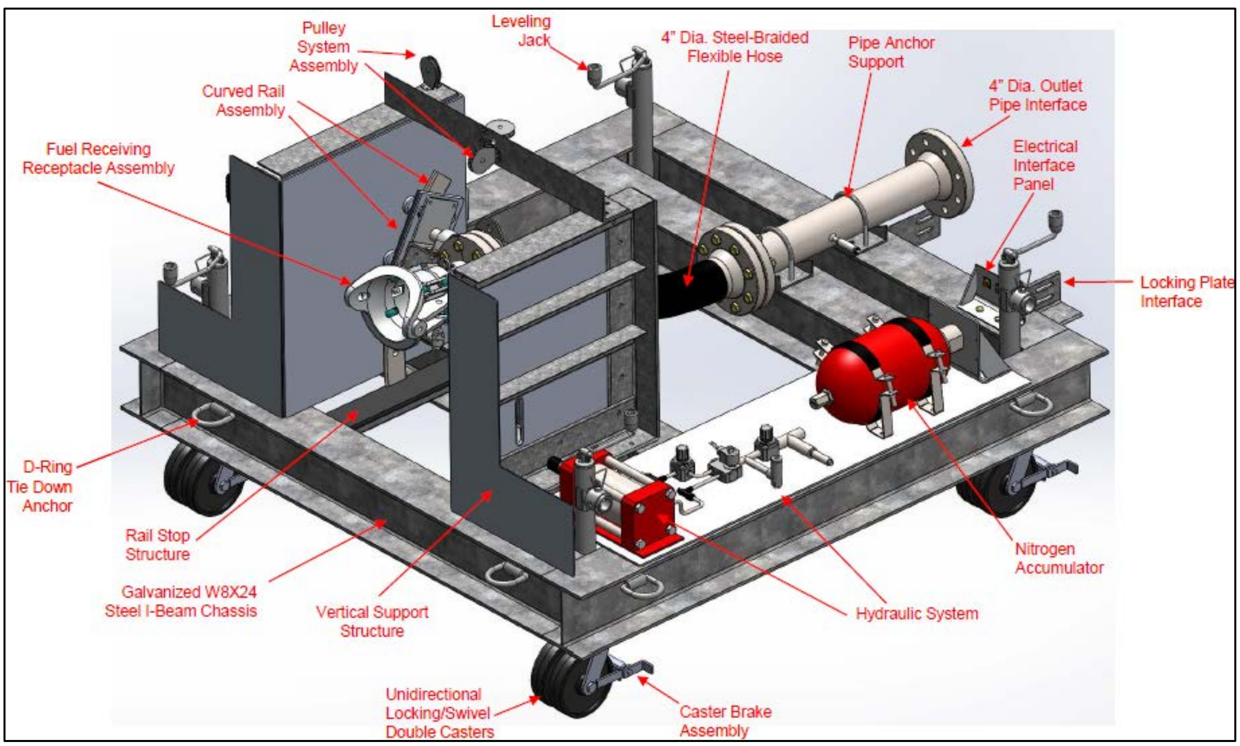

Figure 3 Boom Receptacle Stand

The MFMA shown in figure 4 is designed to simulate typical fuel line diameters found in various fighter- and heavy-type receiver aircraft. Fuel passed through the BRS is routed through 4-inch, 3-inch, 2-inch, and/or 1-inch diameter pipes in the MFMA as directed by the test plan. Each pipe has a pressure transducer, closure valve, throttling valve, and flowmeter. The electrically controlled, hydraulically actuated closure valves are closed at predetermined rates while fuel is flowing at different volumetric flow rates to generate surge pressures in individual lines. The fuel flow through the closure valve is automatically adjusted via the throttling valves to modify the backpressure in the system and achieve the desired flow rates. The throttling valves in the 4-inch and 3-inch lines are butterfly valves and in the 2-inch and 1-inch lines are ball valves. The MFMA enclosure houses and protects all FRE internal electronics from adverse testing/weather elements and provides the electrical interface between the MCR trailer and FRE modules for data monitoring/control, AC/DC power distribution, and emergency 'shutdown power' capabilities.

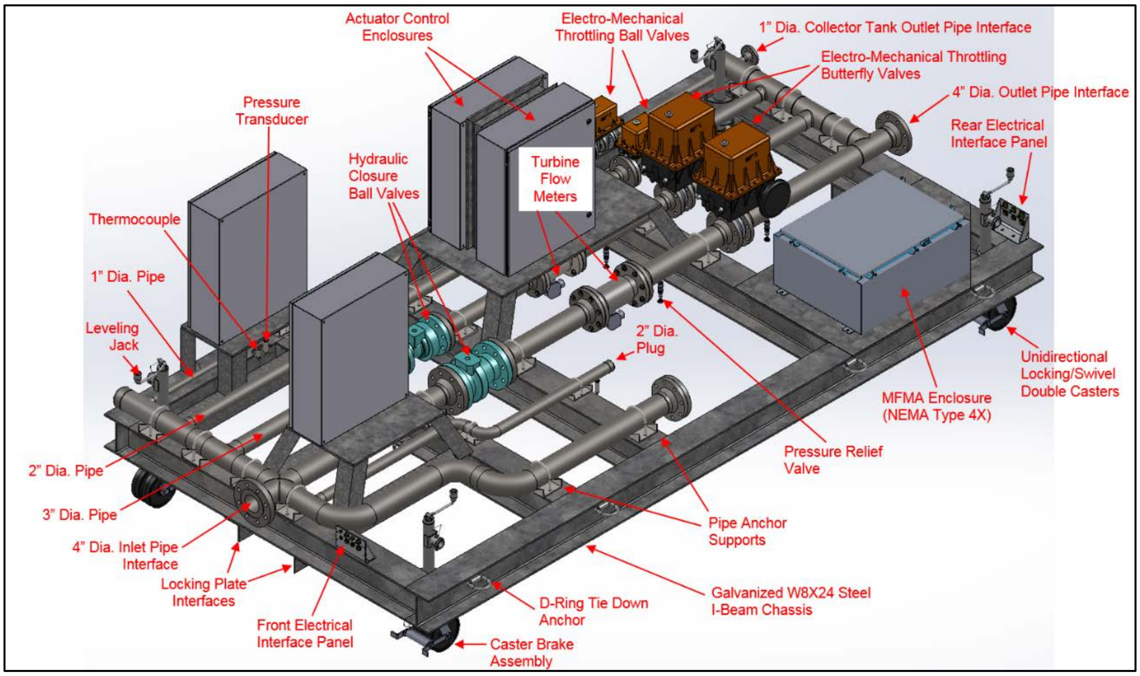

Figure 4 Multiline Fuel Management Assembly

The FDM shown in figure 5 is the interface between the MFMA and the fuel collection systems (fuel hydrant pits, fuel trucks, collector tanks). The FDM is capable of depositing fuel at a rate of 4,921 kg/min (1,300 gpm) and is compatible with fuel hydrant systems and fuel trucks commonly used on military installations. The FDM includes two 4-inch hoses that can be fitted with hydrant couplers to be compatible with hydrant pit systems, fuel nozzles for compatibility with fuel trucks, and a single 1-inch hose to deposit fuel into a collector tank.

For most test cases, the pump bypass line is utilized; however, for the test conditions that require higher flow rates the booster pump must be used to overcome the backpressure and achieve the desired flow rate. A sealed, fuel-rated, 40-horsepower, 3-phase electric motor drives the centrifugal booster pump and is controlled by a closed-loop controlled variable frequency drive (VFD).

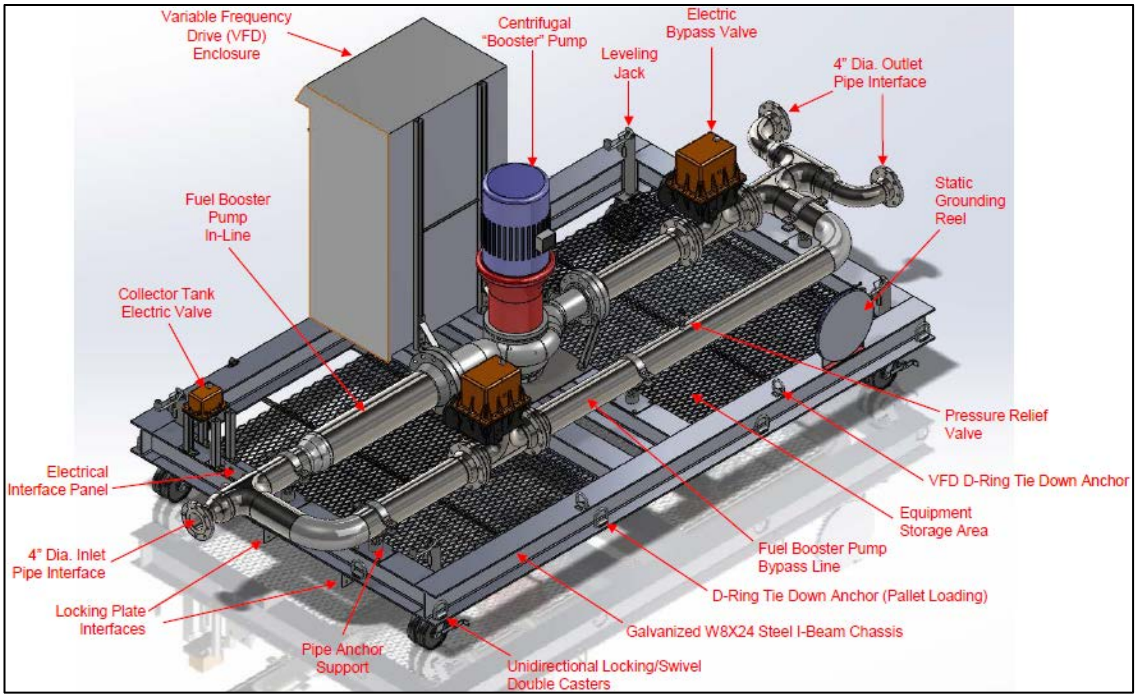

Figure 5 Fuel Deposit Module

Fuel from the FDM can be deposited into fuel hydrant pits, fuel trucks, or collector tanks. This test will use the existing fuel hydrant pit system, which can accept fuel flow rates up to 3,358 kg/min (1,200 gpm).

The MCR shown in figure 6 is a small, reduced height trailer with exterior cameras for monitoring the FRE and test aircraft with workstations for four test personnel. It is powered by a diesel generator mounted on the tongue or by shore power. It has four computer workstations for controlling, monitoring, and recording of all RST instrumentation and function and has an emergency shutoff button that immediately shuts down the FRE. A wireless communication network is provided between multiple MCR operators, ground test personnel, and tanker aircrew during ground offloading operations.

Figure 6 Mobile Control Room

1.4 Overall Test Objective

The overall test objective is to collect RST fuel system data during ground test with an Airbus A330 MRTT. The fuel system data includes fuel temperature, fuel pressure, fuel flow rate, and closure valve position.

1.5 Constraints and Limitations

No constraints or limitations have been identified at this time.

1.6 Test Resources

1.6.1 Test Facilities

Testing will be conducted at the Airbus Military Conversion Centre in Getafe, Spain. The test setup (A330 and RST) will be located at the Airbus Getafe airfield at a ramp location that is used for dedicated Airbus Company fuel testing.

1.6.2 Test Aircraft

The test aircraft will be an Airbus A330 MRTT. The MRTT boom will make contact and disconnect, as testing dictates, with the RST and be restrained with a boom sling and/or boom stand per Airbus procedures. USAF government personnel will not be aboard the A330 MRTT when testing is in progress.

1.6.3 Instrumentation Requirements

Instrumentation requirements for the RST and A330 MRTT are detailed in table 1. See appendix C for a complete list of instrumentation that will be recorded during testing. The RST instrumentation is required for data collection; however, the A330 MRTT instrumentation is desired but not required.

Table 1 Instrumentation Requirements

Test Item	Parameter Name	Parameter ID	Location	Units	Expected Range	Expected Accuracy	Expected Sample Rate (samples/sec)
RST	BRS Inlet Pressure Sensor--Spool Insert	PT09	RST	psig	100 psig	±1%	200
	Surge Pressure Measurement	PT01 PT02 PT03 PT04	RST, directly upstream of closure valve in each line	psig	500 psig	±0.25%	1,000
	Ball Closure Valve Position	CV01 CV02 CV03 CV04	RST	deg	180 deg	N/A	N/A
	IRIG Time on RST	Timestamp	MCR	Time	N/A	±30 ns	1,000
	Fuel Temperature	TC02 TC03 TC04 TC05	RST	deg F	N/A	±0.2%*	N/A
A330 MRTT	Boom Delivery Pressure	N/A	Boom Nozzle	psig	100 psig	N/A	20
	Boom Fuel Flow	N/A	Boom	kg/min	3,600 kg/min	N/A	20
	Hydraulic Power Carts Pressure	N/A	Test Perimeter	psig	3,000 psig	Unknown	Unknown
	Hydraulic Power Carts Flow Rate	N/A	Test Perimeter	kg/min	Unknown	Unknown	Unknown

* Or 0.2 degrees Celsius, whichever is greater

1.6.4 Test Support Facilities and Equipment

The 412 TW will provide support personnel and equipment as required, including but not limited to:

- The USAF RST
- 6 kW Flood Light Cart (FL-1D), 120 volts AC, 30 amps, at 60 Hz
- Personnel to fill the roles of: program manager, test conductor, data analysis, discipline engineer, RST maintenance

The Airbus Military Conversion Centre will provide support personnel and equipment as required, including but not limited to:

- A330 test aircraft and support equipment for a non-engine running ground test
- A parking spot on the airfield ramp equipped with a fuel hydrant system
- Fire department, if A330 MRTT engines are run
- Method of communication between the test team (frequencies, LMRs, etc.)
- 30 kW Diesel Engine Generator (MEP-809B), 240 volts AC, 60 amps, at 50 Hz
- Self-generating Nitrogen Cart, Fill 2.5-gallon bottle to 1,500 psig
- 10,000-pound capacity forklift
- Flatbed gooseneck trailer (for any long distance movements)
- Fuel bowser (side connection tank) for fuel draining
- Fuel truck with universal aerial refueling receptacle ground tester
- Truck with a 2-5/16" ball hitch (move the MCR if needed)
- Ballast to hold RST during testing
- Fluids (diesel, engine oil)
- Adapters/Fuel lines (4-inch-to-6-inch, 150-pound class flange adapter, 6-inch fuel line)
- Facility area for USAF personnel to include desk space, internet connection, restroom access

1.7 Safety Requirements

A separate Safety Plan will be developed in accordance with AFTCI 91-203, *AFTC Test Safety Review Policy* Edwards AFB (reference 3). Documentation of safety and operating procedures at the host facility, Airbus Military Conversion Centre, will be required before USAF government personnel are allowed to participate on-site.

1.8 Security Requirements

All test planning, procedures and data handling will be at the UNCLASSIFIED level. Standard operations security will be utilized. USAF government personnel will travel on government orders. On-site clearance to the Airbus facility will be coordinated as required.

1.9 Test Project Management

The Global Reach Combined Test Force is responsible for test management. Table 2 lists key personnel with responsibilities essential to the implementation of test execution. The 412 TW test team personnel will travel to the Airbus facility via commercial or military transportation.

Table 2 Test Planning Personnel

Name	Function	Organization	Contact Information
Lt Col Zachary Schaffer	Commander	418 FLTS	661-275-7600 zachary.schaffer@us.af.mil
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Ms. Jamie Smith	AR Lead Engineer	418 FLTS	661-275-3642 jamie.smith.27@us.af.mil
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Mr. Hans Lambrecht	Project Engineer	JT4	661-277-8346 hans.lambrecht.ctr@us.af.mil

1.10 Environmental Impact Assessment

An environmental impact assessment will be completed by the host facility if required.

2.0 TEST AND EVALUATION

2.1 General

The purpose of this test is to collect RST fuel system data during ground test with an Airbus A330 MRTT. The data will be used by ARCA when providing AR certifications between the A330 MRTT and USAF receivers.

Testing is scheduled for execution between September and October of 2019 and will require approximately 1 week of ground test. The test team should prepare for an additional three days of setup and three days of tear down for a total of 2 weeks at the test location.

2.2 Test Approach

The test data will be evaluated by ARCA and may be used to relieve the fuel pressure restrictions imposed on the A330 MRTT during AR operations with USAF receivers. The test point sequence may be adjusted during execution based on engineering judgement, tanker aircraft, RST, and/or other resource availability.

Testing will occur at various fuel offloads, AR pump configurations, MFMA fuel line sizes, and closure valve rates. The following build-up sequence is required for technical adequacy:

1. Testing will start at an initial fuel flow of 75 kg/min (25 gpm) as a safety buildup and progress through preplanned flow rates until the maximum fuel rate is achieved for each pipe diameter.
2. Test points may be added if the test team determines buildup should be performed in smaller increments.
3. Test conditions may be changed to match KC-10A and KC-135R baseline test conditions when that data becomes available.

Fuel will flow at varying rates through fuel lines of the different diameters RST fuel lines to approximate the generic characteristics of different receiver types. The RST will disrupt steady state fuel flow using closure valves that will be commanded to close at two different rates. Steady state fuel flow is defined as 30 seconds of constant flow within ±5 gpm of desired fuel flow rate or as determined by the test team if desired flow rate cannot be achieved. The closure valves will be commanded to close in 0.5 or 2.0 seconds. The maximum fuel pressure generated by the closure valve will be measured by multiple transducers at both the RST (required) and the tanker aircraft boom (desired). A330 MRTT boom fuel pressures will be recorded if available.

2.3 Test Objective

The overall and specific test objective is to collect RST fuel system data during ground test with an Airbus A330 MRTT.

2.4 Specific Test Objective 1 – RST Fuel Pressure Data Collection

The specific objective is to collect RST fuel system data during ground test with an Airbus A330 MRTT.

2.4.1 MOP 1.1 – RST Fuel System Data

The fuel system data includes fuel temperature, fuel pressure, fuel flow rate, and closure valve position. The RST fuel pressure is recorded upstream of the RST closure valves. The RST fuel flow rate is recorded downstream of the RST closure valve.

2.4.1.1 Success Criteria

The test will be considered successful when the required data are collected within the tolerances that are specified in appendix B.

The closure valve must exhibit a smooth closure profile for the test point to be considered successful and the valve position must be within ±5 percent from an ideal linear closure during the entire profile.

2.4.1.2 Evaluation Criteria

None – data collection only.

2.4.1.3 Final Data Products

RST fuel temperature, fuel pressure, fuel flow rate, and closure valve position time history plots for each test condition will be included in the data package. General observations made during test conduct will be included in the test complete letter.

2.4.1.4 Data Requirements

The following data are required:

- Fuel temperature, pressure, and flow rate data recorded from RST instrumentation
- Valve closure rates, line size, and valve position on the RST
- Number of AR pumps used during each test point
- Engineering comments for each test condition
- Test setup photographs (desired)

2.4.1.5 Test Methodology

The A330 MRTT fuel system will be powered by hydraulic power carts and with the fuel transfer pumps in AUTO mode. Fuel will be transferred through the boom using the test setup shown in figure A1 or similar. Once the flow rate is regulated to the desired condition per the tables in appendix B, the closure valve on the RST will be closed at a rate according to the test point, generating a surge pressure in the RST. The pressure transducers installed on the RST will measure fuel pressures including the maximum surge pressure. Detailed test procedures are in appendix B.

The A330 MRTT fuel management software will automatically determine which pumps to operate based on aircraft CG management and the fuel flow required for the fuel transfer. The system will automatically re-configure fuel location or cease dispense if a CG limit is close to being exceeded. Changing pumps during a fuel transfer can cause the fuel pressure to decrease momentarily.

After a test point has been run, data analysis will be performed to determine whether the flow rate and valve closure profile were within tolerances. The data analysis will be performed using a method described in the Data Analysis Plan (appendix E).

2.4.1.6 Expected Test Results

The required data will be recorded with sufficient fidelity to meet the test objective. The surge pressures should increase as the fuel flow rate increases, RST line diameter decreases, or valve closure rate increases, but should never exceed 240 psig.

3.0 TEST PROCEDURES

The combined 412th TW/418 FLTS and Airbus Company Test Team will execute this test plan IAW the responsibilities and procedures specified in Edwards AFBI 99-105, *Test Control and Conduct* (reference 4), and Edwards AFBI 99-101, *412 TW Test Plans* (reference 5).

3.1 Pretest Briefings/Test Readiness Review (TRR)

In addition to a TRR, scheduled a week prior to the first test, a pretest briefing will be conducted among participating personnel. The briefings will include, but will not be limited to:

- System under test – status
- Instrumentation – status
- Adjacent ramp activity
- Test Objective
- Test card review and crew procedures
- Safety
- Success criteria
- Go/No-Go Criteria
- Real Time data requirements to include format, algorithms, and data definitions
- Final data requirement to include format, algorithms, and data definitions

3.2 Test Execution

Test execution will follow the procedures outlined in the test plan. The 418 FLTS will be responsible for producing test cards that meet the requirements of this test plan and GR CTF Operating Instruction (OI) 99-105, *Test Safety Planning* (reference 6). All test points will be ground tests. Testing will be broken into two distinct parts, detailed in appendix D.

3.3 Posttest Briefing

All personnel associated with the test execution will attend a posttest briefing to discuss:

- System under test – status
- Instrumentation status and performance
- Review and discussion of test events
- Data requirement review
- System under test performance review
- Lessons learned
- Contractor equipment performance

3.4 Post Mission Data Processing

Tanker data will be recorded during each ground test. The 412 TW will provide a data package to ARCA for applicable dissemination to the NATO Support and Procurement Agency.

4.0 TEST REPORTING

4.1 Daily Flight Report

At the conclusion of each ground test, the 418 FLTS will complete a daily flight report, compiling information from all participants. The daily reports are informal documents intended to quickly and succinctly record results of the ground test mission, test points completed, and recommendations for the next day's testing. Significant issues will be communicated to the next test crew. All daily ground reports will be distributed to the USAF government test team members. Reports will contain the following:

- Aircraft configuration
- Applicable ground squawks
- Crew/team comments
- Test team names
- Ground test duration
- Test number, aircraft tail number, and date of test
- Test summary
- Test event log (a table listing of key test events)
- Test start/test complete times
- Watch items
- Discussion of test points that require further analysis prior to test progression

4.2 Results and Recommendations

A test completion letter will be generated by the 418 FLTS detailing the results and recommendations of the test program. The letter, signed by 412 TW, will be sent to ARCA. A compilation of all daily ground test reports and any requested data may also be sent with the report.

4.3 Technical Report

In accordance with Edwards AFBI 99-103, *412 TW Technical Report Program* (reference 7), a test complete letter and data package will be provided by the 412 TW.

5.0 LOGISTICS SUPPORT

5.1 General

A combined 412 TW/JT4 Maintenance team will travel to Getafe with the test team in order to set up, maintain, and break down the RST ground test unit.

Airbus Military Conversion Centre will maintain the A330 MRTT aircraft located in Getafe, Spain. Airbus will provide test instrumentation components and will be responsible for their respective operation and maintenance.

6.0 REFERENCES

1. *KC-10 and KC-135 Surge Pressure Data Collection Using the USAF Fuel Surge Pressure Test Tool*, 412 TW-TP-17-45, 412th Test Wing, Edwards AFB, California, August 2017.

2. *Receiver Simulation Tool (RST) System User Manual Revision 'B'*, JT3-AFC-SMNL-17221-0002, USAF TW TENG/ENI, Edwards AFB, California, September 2018.

3. Edwards AFTCI 91-203, *AFTC Test Safety Review Policy*, Edwards AFB, California, February 2015.

4. Edwards AFBI 99-105, *Test Control and Conduct*, 412th Test Wing, Edwards AFB, California, January 2014.

5. Edwards AFBI 99-101, *412 TW Test Plans*, 412th Test Wing, Edwards AFB, California, August 2013.

6. GR CTF OI 99-105, *Test Safety Planning*, 412th Test Wing, Edwards AFB, California, January 2014.

7. Edwards AFBI 99-103, *412 TW Technical Report Program*, 412th Test Wing, Edwards AFB, California, August 2013.

8. *Receiver Simulation Tool (RST) System Interface Control Document (ICD) Revision 'B'*, JT3-AFC-SICD-16245-0020, USAF TW TENG/ENI, Edwards AFB, California, April 2018.

APPENDIX A – DETAILED TEST ITEM DESCRIPTION

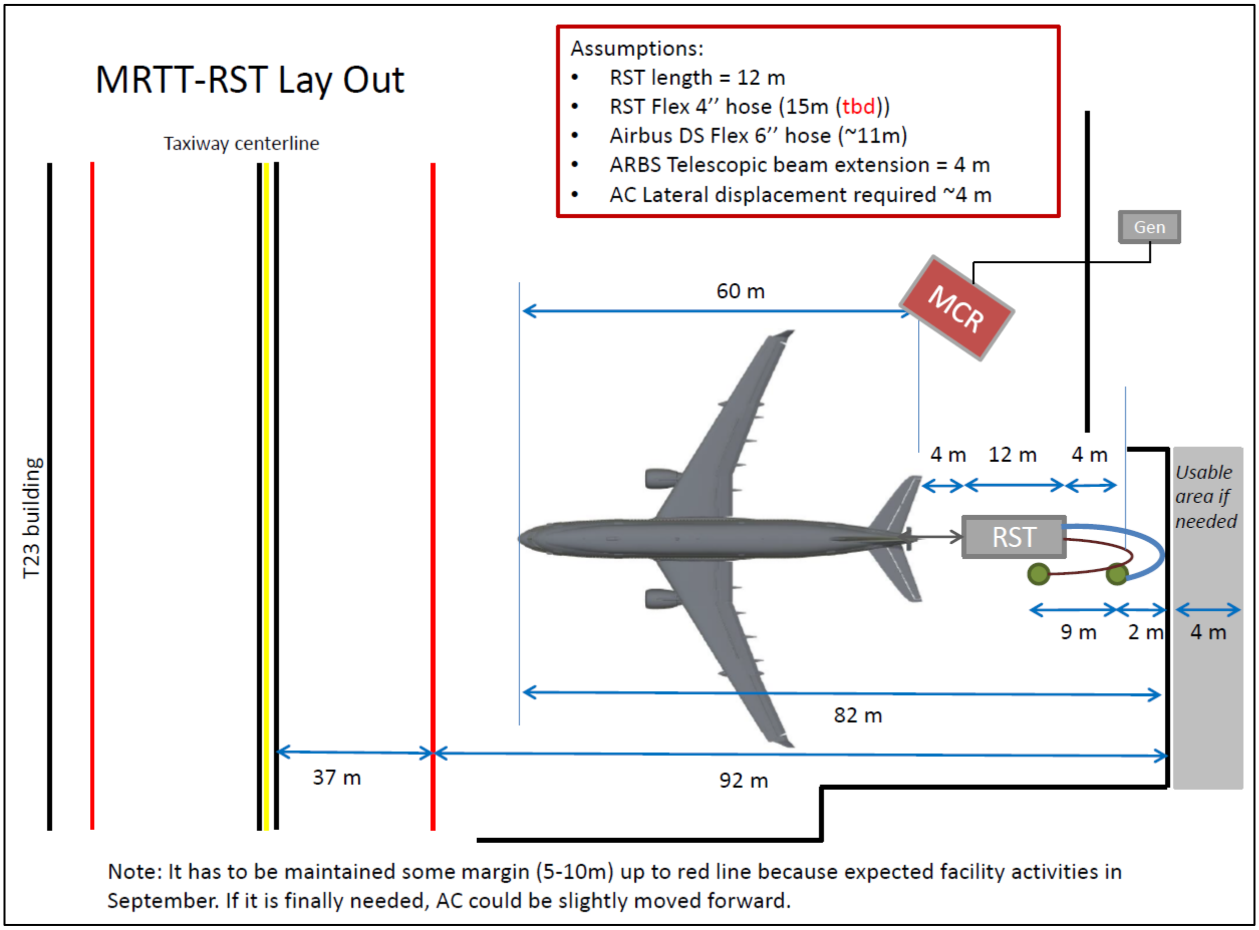

Figure A1 Test Setup (image provided by Airbus)

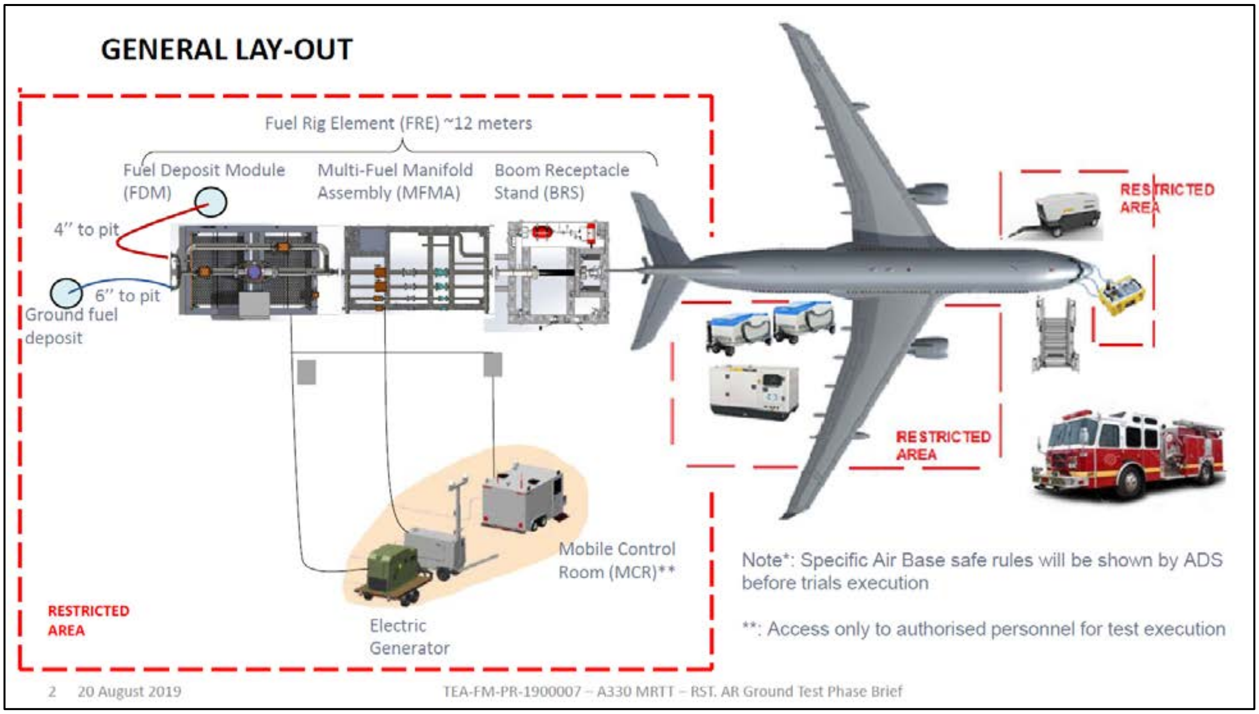

Figure A2 Test Setup with Support Equipment (image provided by Airbus)

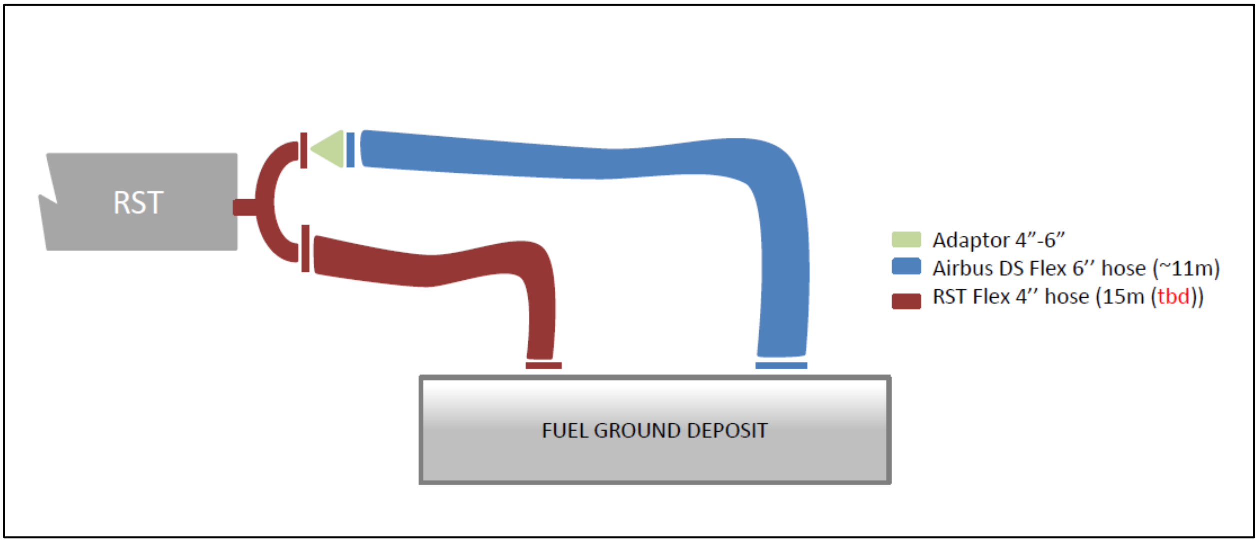

Figure A3 Fuel Pit Layout (image provided by Airbus)

APPENDIX B – TEST CONDITION MATRIX

The data band for the test points listed are below and may be changed at the discretion of the test team as long as data fidelity is maintained:

- Flow Rate: Larger of ±2% or ±5gpm
- Closure Rate ±5%

The tables below contain all test points that are planned to be executed. Engineering judgement will be used to add or remove test points based on real-time results. For example, test points may be added if the test team determines build up should be performed in smaller increments. Additionally, test points will be configured to match the test conditions of the baseline data when the baseline data becomes available.

Table B1 A330 MRTT One Pump, 1-Inch Line

Test Point No.	Aircraft	No. of Pumps	Line Size (in)	Flow Rate (gpm [kg/min])	Valve Closure Rate (sec)
1	A330 MRTT	1	1	25 (75)	2.0
2	A330 MRTT	1	1	25 (75)	0.5
3	A330 MRTT	1	1	50 (150)	2.0
4	A330 MRTT	1	1	50 (150)	0.5
5	A330 MRTT	1	1	75 (225)	2.0
6	A330 MRTT	1	1	75 (225)	0.5

Table B2 A330 MRTT Two Pumps, 1-Inch Line

Test Point No.	Aircraft	No. of Pumps	Line Size (in)	Flow Rate (gpm [kg/min])	Valve Closure Rate (sec)
7	A330 MRTT	2	1	25 (75)	2.0
8	A330 MRTT	2	1	25 (75)	0.5
9	A330 MRTT	2	1	50 (150)	2.0
10	A330 MRTT	2	1	50 (150)	0.5
11	A330 MRTT	2	1	75 (225)	2.0
12	A330 MRTT	2	1	75 (225)	0.5

Table B3 A330 MRTT One Pump, 2-inch Line

Test Point No.	Aircraft	No. of Pumps	Line Size (in)	Flow Rate (gpm [kg/min])	Valve Closure Rate (sec)
13	A330 MRTT	1	2	100 (300)	2.0
14	A330 MRTT	1	2	100 (300)	0.5
15	A330 MRTT	1	2	150 (450)	2.0
16	A330 MRTT	1	2	150 (450)	0.5
17	A330 MRTT	1	2	200 (600)	2.0
18	A330 MRTT	1	2	200 (600)	0.5
19	A330 MRTT	1	2	250 (750)	2.0
20	A330 MRTT	1	2	250 (750)	0.5
21	A330 MRTT	1	2	300 (900)	2.0
22	A330 MRTT	1	2	300 (900)	0.5

Table B4 A330 MRTT Two Pumps, 2-inch Line

Test Point No.	Aircraft	No. of Pumps	Line Size (in)	Flow Rate (gpm [kg/min])	Valve Closure Rate (sec)
23	A330 MRTT	2	2	100 (300)	2.0
24	A330 MRTT	2	2	100 (300)	0.5
24	A330 MRTT	2	2	150 (450)	2.0
26	A330 MRTT	2	2	150 (450)	0.5
27	A330 MRTT	2	2	200 (600)	2.0
28	A330 MRTT	2	2	200 (600)	0.5
29	A330 MRTT	2	2	250 (750)	2.0
30	A330 MRTT	2	2	250 (750)	0.5
31	A330 MRTT	2	2	300 (900)	2.0
32	A330 MRTT	2	2	300 (900)	0.5

Table B5 A330 MRTT Four Pumps, 2-inch Line

Test Point No.	Aircraft	No. of Pumps	Line Size (in)	Flow Rate (gpm [kg/min])	Valve Closure Rate (sec)
33	A330 MRTT	4	2	200 (600)	2.0
34	A330 MRTT	4	2	200 (600)	0.5
35	A330 MRTT	4	2	250 (750)	2.0
36	A330 MRTT	4	2	250 (750)	0.5
37	A330 MRTT	4	2	300 (900)	2.0
38	A330 MRTT	4	2	300 (900)	0.5

Table B7 A330 MRTT One Pump, 3-inch Line

Test Point No.	Aircraft	No. of Pumps	Line Size (in)	Flow Rate (gpm [kg/min])	Valve Closure Rate (sec)
39	A330 MRTT	1	3	300 (900)	2.0
40	A330 MRTT	1	3	300 (900)	0.5
41	A330 MRTT	1	3	350 (1,050)	2.0
42	A330 MRTT	1	3	350 (1,050)	0.5
43	A330 MRTT	1	3	400 (1,200)	2.0
44	A330 MRTT	1	3	400 (1,200)	0.5

Table B8 A330 MRTT Two Pumps, 3-inch Line

Test Point No.	Aircraft	No. of Pumps	Line Size (in)	Flow Rate (gpm [kg/min])	Valve Closure Rate (sec)
45	A330 MRTT	2	3	300 (900)	2.0
46	A330 MRTT	2	3	300 (900)	0.5
47	A330 MRTT	2	3	400 (1,200)	2.0
48	A330 MRTT	2	3	400 (1,200)	0.5
49	A330 MRTT	2	3	500 (1,500)	2.0
50	A330 MRTT	2	3	500 (1,500)	0.5
51	A330 MRTT	2	3	600 (1,800)	2.0
52	A330 MRTT	2	3	600 (1,800)	0.5
53	A330 MRTT	2	3	700 (2,100)	2.0
54	A330 MRTT	2	3	700 (2,100)	0.5

Table B9 A330 MRTT Four Pumps, 3-inch Line

Test Point No.	Aircraft	No. of Pumps	Line Size (in)	Flow Rate (gpm [kg/min])	Valve Closure Rate (sec)
55	A330 MRTT	4	3	300 (900)	2.0
56	A330 MRTT	4	3	300 (900)	0.5
57	A330 MRTT	4	3	400 (1,200)	2.0
58	A330 MRTT	4	3	400 (1,200)	0.5
59	A330 MRTT	4	3	500 (1,500)	2.0
60	A330 MRTT	4	3	500 (1,500)	0.5
61	A330 MRTT	4	3	600 (1,800)	2.0
62	A330 MRTT	4	3	600 (1,800)	0.5
63	A330 MRTT	4	3	700 (2,100)	2.0
64	A330 MRTT	4	3	700 (2,100)	0.5

Table B11 A330 MRTT One Pump, 4-inch Line

Test Point No.	Aircraft	No. of Pumps	Line Size (in)	Flow Rate (gpm [kg/min])	Valve Closure Rate (sec)
65	A330 MRTT	1	4	350 (1,050)	2.0
66	A330 MRTT	1	4	350 (1,050)	0.5
67	A330 MRTT	1	4	400 (1,200)	2.0
68	A330 MRTT	1	4	400 (1,200)	0.5

Table B12 A330 MRTT Two Pumps, 4-inch Line

Test Point No.	Aircraft	No. of Pumps	Line Size (in)	Flow Rate (gpm [kg/min])	Valve Closure Rate (sec)
69	A330 MRTT	2	4	350 (1,050)	2.0
70	A330 MRTT	2	4	350 (1,050)	0.5
71	A330 MRTT	2	4	400 (1,200)	2.0
72	A330 MRTT	2	4	400 (1,200)	0.5
73	A330 MRTT	2	4	500 (1,500)	2.0
74	A330 MRTT	2	4	500 (1,500)	0.5
75	A330 MRTT	2	4	600 (1,800)	2.0
76	A330 MRTT	2	4	600 (1,800)	0.5
77	A330 MRTT	2	4	700 (2,100)	2.0
78	A330 MRTT	2	4	700 (2,100)	0.5

Table B13 A330 MRTT Four Pumps, 4-inch Line

Test Point No.	Aircraft	No. of Pumps	Line Size (in)	Flow Rate (gpm [kg/min])	Valve Closure Rate (sec)
79	A330 MRTT	4	4	350 (1,050)	2.0
80	A330 MRTT	4	4	350 (1,050)	0.5
81	A330 MRTT	4	4	400 (1,200)	2.0
82	A330 MRTT	4	4	400 (1,200)	0.5
83	A330 MRTT	4	4	500 (1,500)	2.0
84	A330 MRTT	4	4	500 (1,500)	0.5
85	A330 MRTT	4	4	600 (1,800)	2.0
86	A330 MRTT	4	4	600 (1,800)	0.5
87	A330 MRTT	4	4	700 (2,100)	2.0
88	A330 MRTT	4	4	700 (2,100)	0.5
89	A330 MRTT	4	4	800 (2,400)*	2.0
90	A330 MRTT	4	4	800 (2,400)*	0.5
91	A330 MRTT	4	4	900 (2,700)*	2.0
92	A330 MRTT	4	4	900 (2,700)*	0.5
93	A330 MRTT	4	4	1,000 (3,000)*	2.0
94	A330 MRTT	4	4	1,000 (3,000)*	0.5

* These test points have been deemed optional by all responsible parties

APPENDIX C – TEST PARAMETER LIST

Table C1 RST Test Parameter List (Reference 7)

Element	Parameter	Reading Type	Description	Bits	Data Type
0	Main Data Loop Timestamp	Timestamp	Count of seconds since 12AM, January 1 1904	64	Double
1	Main Data Loop Count	Count	Count of timed data loop within RT.	32	U32
2	Boolean Array 1	Boolean	See Boolean Array 1 Table	32	U32
3	Boolean Array 2	Boolean	See Boolean Array 2 Table	32	U32
4	PT01 SI+	Pressure	Micro Amp (4000 to 20000), 0 to 1.0KGI	16	U16
5	PT02 SI+	Pressure	Micro Amp (4000 to 20000), 0 to 1.0KGI	16	U16
6	PT03 SI+	Pressure	Micro Amp (4000 to 20000), 0 to 1.0KGI	16	U16
7	PT04 SI+	Pressure	Micro Amp (4000 to 20000), 0 to 1.0KGI	16	U16
8	PT05 SI+	Pressure	Micro Amp (4000 to 20000), 0 to 1.0KGI	16	U16
9	PT06 SI+	Pressure	Micro Amp (4000 to 20000), 0 to 1.0KGI	16	U16
10	PT07 SI+	Pressure	Micro Amp (4000 to 20000), 0 to 1.0KGI	16	U16
11	PT09 SI+	Pressure	Micro Amp (4000 to 20000), 0 to 1.0KGI	16	U16
12	PT10 SI+	Pressure	Micro Amp (4000 to 20000), 0 to 2.5KGI	16	U16
13	TC02 SI+	Temperature	Micro Amp (4000 to 20000), 32 to 212°F	16	U16
14	TC03 SI+	Temperature	Micro Amp (4000 to 20000), 32 to 212°F	16	U16
15	TC04 SI+	Temperature	Micro Amp (4000 to 20000), 32 to 212°F	16	U16
16	TC05 SI+	Temperature	Micro Amp (4000 to 20000), 32 to 212°F	16	U16
17	TV01 XMTR SI+	Position Feedback	Micro Amp 4000(closed) to 20000(open)	16	U16
18	TV02 XMTR SI+	Position Feedback	Micro Amp 4000(closed) to 20000(open)	16	U16
19	TV03 XMTR SI+	Position Feedback	Micro Amp 4000(closed) to 20000(open)	16	U16
20	TV04 XMTR SI+	Position Feedback	Micro Amp 4000(closed) to 20000(open)	16	U16
21	FM01 IOUT SI+	Flow Reading	Micro Amp 4000 to 20000, Flow (gpm) = (6.2502*Reading/1000)-25.001	16	U16
22	FM02 IOUT SI+	Flow Reading	Micro Amp 4000 to 20000, Flow (gpm) = (28.125*Reading/1000)-112.5	16	U16
23	FM03 IOUT SI+	Flow Reading	Micro Amp 4000 to 20000, Flow (gpm) = (46.876*Reading/1000)-187.51	16	U16
24	FM04 IOUT SI+	Flow Reading	Micro Amp 4000 to 20000, Flow (gpm) = (93.752*Reading/1000)-375.03	16	U16
25	CV01_XMTR SI+	Position Feedback	Micro Amp 4000(open) to 20000(closed)	16	U16
26	CV02_XMTR SI+	Position Feedback	Micro Amp 4000(open) to 20000(closed)	16	U16
27	CV03_XMTR SI+	Position Feedback	Micro Amp 4000(open) to 20000(closed)	16	U16
28	CV04_XMTR SI+	Position Feedback	Micro Amp 4000(open) to 20000(closed)	16	U16
29	MFMAE TEMP SENSOR SI+	Temperature Reading	Micro Amp (4000 to 20000), 0 to 125°F	16	U16
30	CRIO_Temp	cRIO Temperature	°F	16	U16
31	TV05 IND/TV05 COMMAND	Tri-State	Open = 0, Closed = 1, Transit = 2	8	U8
32	TV06 IND/TV06 COMMAND	Tri-State	Open = 0, Closed = 1, Transit = 2	8	U8
33	TV07 IND/TV07 COMMAND	Tri-State	Open = 0, Closed = 1, Transit = 2	8	U8

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APPENDIX D – TEST PROCEDURES

Test procedures described in this appendix provide a general overview to the reader. The specific steps to configure the RST and A330 for testing are provided in the *RST System User Manual*, Revision 'B' (Reference 2). The procedures are subject to redline changes pending the test card review process.

1. Measure and mark where the A330 MRTT and FRE modules are going to be placed.
2. Park A330 MRTT at predetermined location on ramp.
3. Transport FRE modules and place them in relative areas for mating.
4. Fine tune position of FRE modules, adjust height and level with jacks, then fasten them together at the flanges and locking plates.
5. Place the hydraulic mules, MCR, and generators in their specific locations around the FRE.
6. Layout fuel hoses, route and mate umbilical cables, and attach grounding reel leads to the correct earth grounding points on the ramp.
7. Bring up power in the MCR and on the FRE.
8. Perform a communication check and a unit/sensor status check.
9. Pilot and Boom Operator perform applicable items in the normal preflight checklist.
10. Pilot and Boom Operator perform applicable items in the preparation for aerial refueling checklist.
11. Lower boom per appropriate A330 MRTT maintenance T.O.
12. Ensure surge boots are properly serviced and pressurized.
13. Extend boom to mid-length per appropriate aircraft maintenance T.O.
14. Make contact with BRS and ensure boom is latched.
15. Start the fuel priming sequence/process.

The following is a step by step process used to collect the data. These steps will be provided on the test cards and will be subject to change upon test team review.

1. Ensure A330 fuel tanks have necessary fuel load for the test point without exceeding CG or requiring pump swaps.
2. RST engineers configure RST per the test point, see Appendix B.
3. A330 Tanker crew activates proper number of AR pumps per the test point, see Appendix B.
4. RST Discipline Engineer verifies fuel flow and pressure reach steady state for approx. 30 seconds.
5. RST Instrumentation Engineer will toggle the gui to close the closure valve in order to generate a surge within the RST.
6. Hand record the surge pressure measured in the RST as well as the valve closure rate. This will clear the test team to the next test point.
7. A330 Tanker crew disengages AR pumps.
8. Repeat steps #1-7 for all test points

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APPENDIX E – DATA ANALYSIS PLAN

This data collection plan will utilize a software program to assess data quality and allow progression to the next data point. The time-history pressure plots produced by the graphical user interface (GUI) will be reviewed to ensure that no limits were exceeded during each test event. Figure E1 shows a sample screen shot of a single parameter GUI tab and Figure E2 shows a sample screen shot of the multi-parameter GUI tab.

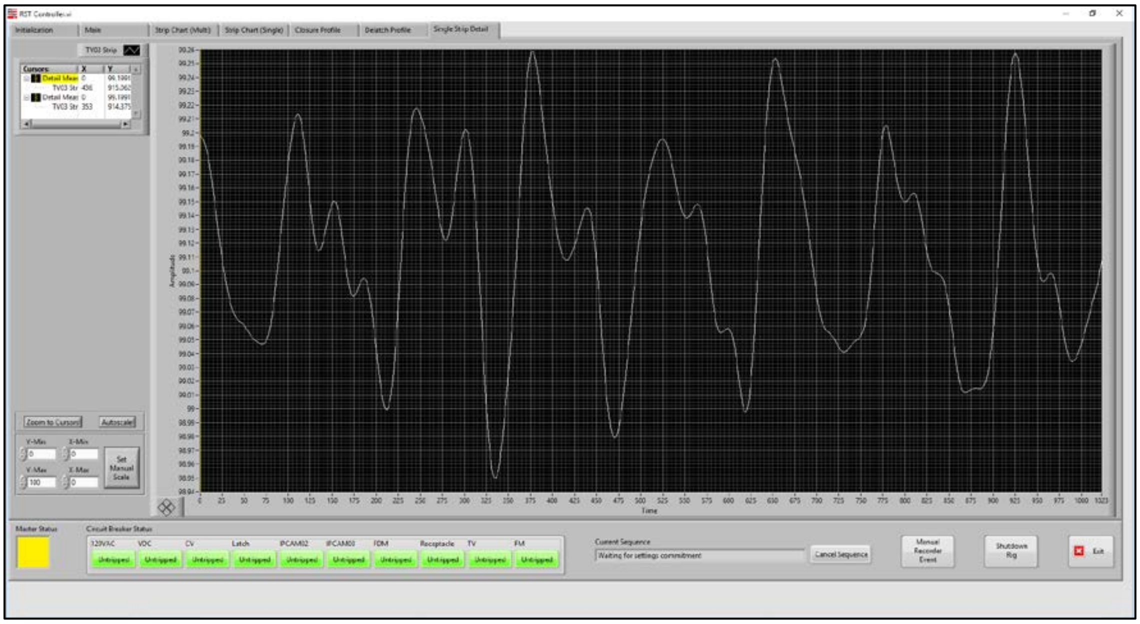

Figure E1 Single Parameter GUI Tab

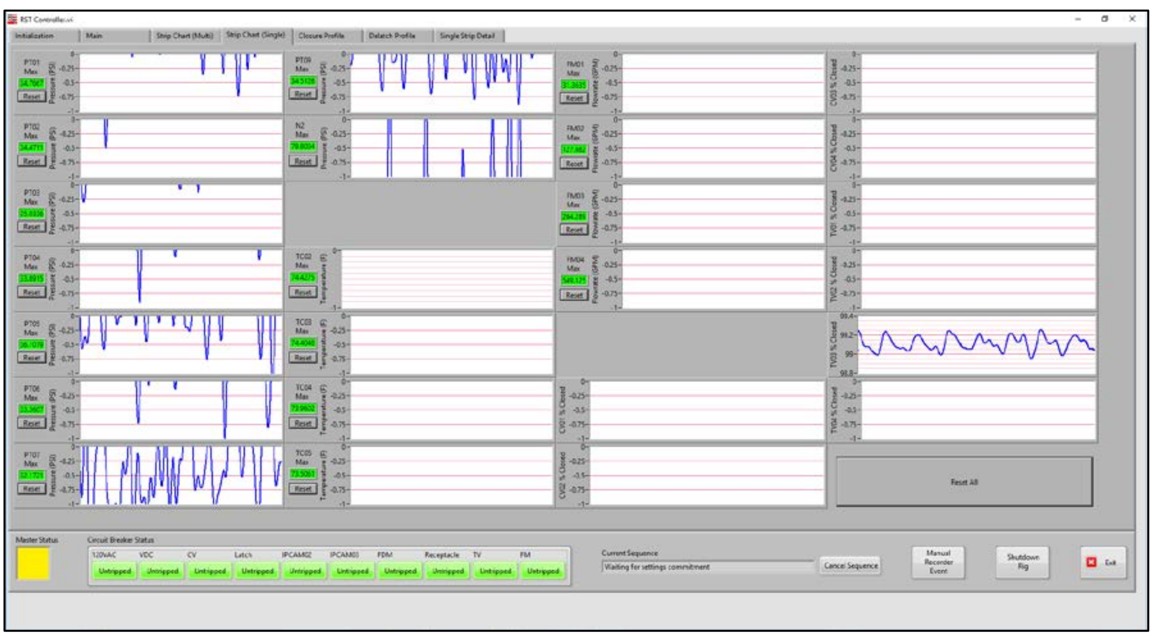

Figure E2 Multiple Parameter GUI Tab

Also, to ensure data quality, the time-history plot in Figure E3 of the valve position will be reviewed to ensure that valve closure was linear and within tolerances. Engineering judgement will be used to assess the validity of the data collected before the test conductor is notified that it is clear to proceed to the next test point.

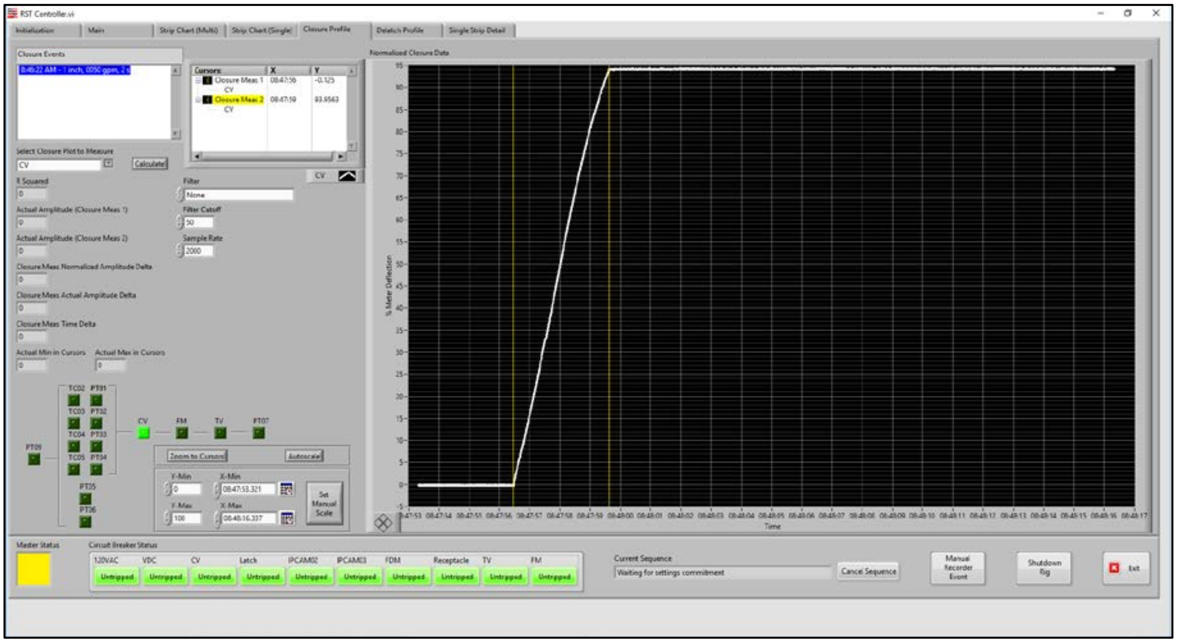

Figure E3 Closure Profile GUI Tab

Filtering will be applied on a condition by condition basis to the tanker data. The filter will be selected to eliminate high frequency noise while preserving the surge pressure characteristics.

APPENDIX F – ABBREVIATIONS, ACRONYMS, AND SYMBOLS

Abbreviation	Definition
3-D	three-dimensional
AC/DC	alternating current/direct current
AFB	Air Force Base
AFI	Air Force Instruction
AFTC	Air Force Test Center
AFTCI	Air Force Test Center Instruction
AR	aerial refueling
ARBS	advanced refueling boom system
ARCA	Aerial Refueling Verification Agency
ARO	aerial refueling operator
BEVS	boom-enhanced vision system
BRS	boom receptacle stand
BUG III	boom upgrade 3
CG	center of gravity
CTF	combined test force
DOD	Department of Defense
DR	deficiency report
DTIC	Defense Technical Information Center
FDM	fuel deposit module
FLTS	Flight Test Squadron
FRE	fuel rig element
gpm	gallon(s) per minute
GR	Global Reach
Hz	Hertz
IAW	in accordance with
IDS	independent disconnect system
in	inch(es)
kg/min	kilogram(s) per minute
kW	kilowatt(s)
MCR	mobile control room
MFMA	multiline fuel manifold assembly
MOP	measure of performance

Abbreviation	Definition
MRTT	Multi Role Tanker Transport
NATO	North Atlantic Treaty Organization
ns	nanosecond(s)
OI	operating instructions
P/N	part number
psig	pounds per square inch gage
RST	receiver simulation tool
sec	second(s)
SOT	safety of test
T.O.	technical order
TP	test plan
TRR	test readiness review
TW	Test Wing
UARRSI	universal aerial refueling receptacle slipway installation
U.S.	United States
USAF	United States Air Force
VFD	variable frequency drive

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