

User Manual

RMTS Industries

Rocket Motor Test Stand

Program Manager Signature: _____

Client Procuring Officer Signature: _____

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Acromyns

Rocket Motor Test Stand **RMTS**

University of Alaska Fairbanks **UAF**

Engineering Analysis Package **EAP**

Failure Modes and Effects Analysis **FMEA**

Direct Current **DC**

High Power Rocketry **HPR**

Student Rocketry Program **SRP**

List of Figures

Fig 1 Page X

1 General

1.1 Document purpose

The Rocket Motor Test Stand (RMTS) User Manual provides operational guidance, safety requirements, and procedural instructions for the setup, testing, transportation, and maintenance of the RMTS system. The purpose of this document is to ensure that all operators can safely and effectively use the RMTS to test rocketry motors.

1.2 Introduction

The RMTS was designed and built by RMTS Industries and is intended for use in testing High Power Rocketry (HPR) motors ranging from 1/8-A model rocket motors to I-class HPR motors. The RMTS was designed to meet the safety requirements of the Tripoli Rocketry Association safety code [6] for an HPR launch platform, with some requirements changes to accommodate the differences between a test stand and a launch platform.

1.3 System Overview

The RMTS is a modular rocket engine test stand that measures the thrust force generated by rocket motors ranging from model rocketry 1/8A to HPR I-class motors. The core of the system comprises two sections: RMTS Control Suitcase and the RMTS Test Stand. The RMTS is built for all-weather operations in Alaska, the test stand can be disassembled and packed into three transport containers, allowing for rapid deployment by a single person within 30 minutes. [2]

1.3.1 Control Suitcase

The Control Suitcase is the controller for all systems on the RMTS. The heart of the system is a Raspberry Pi 4 which is responsible for initiating measurements, processing the data, and displaying the results. The suitcase contains a portable monitor and keyboard for user interaction with the pi, an ignition switch and button for triggering the motor, and a battery backup system for providing several hours of power in the absence of main power.

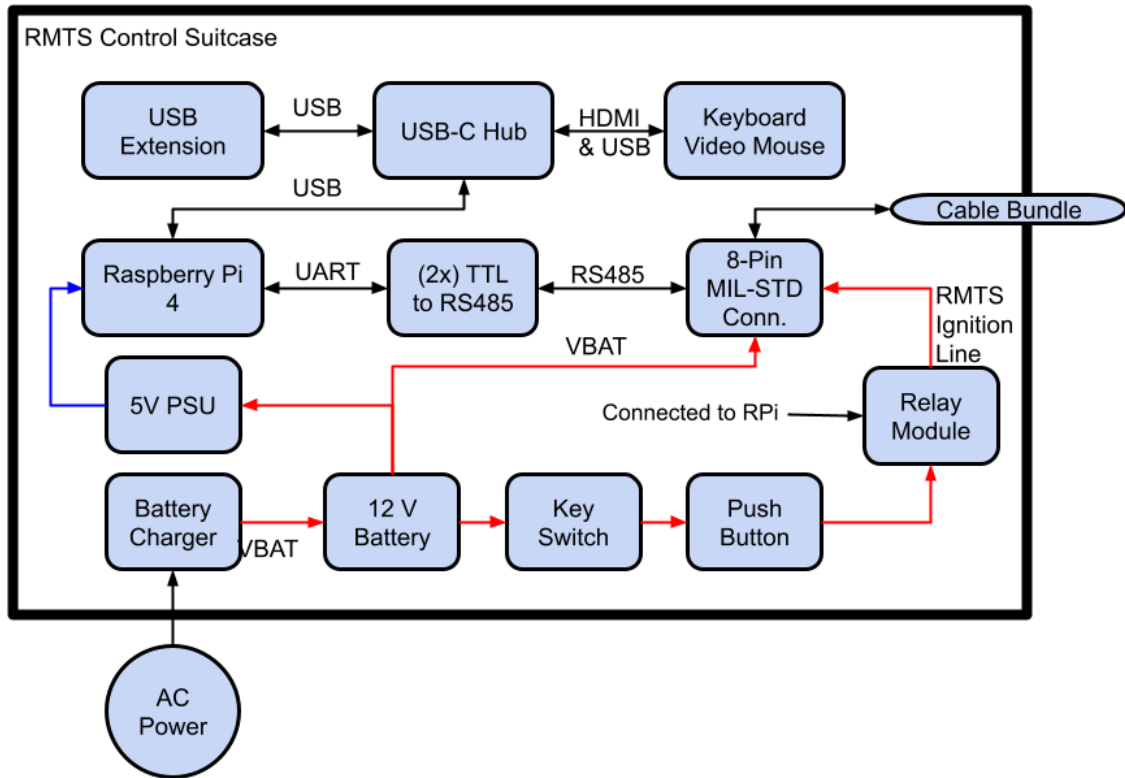


Figure 0X: I feel we should have an image(or more) here

1.3.2 Test Stand

This unit consists of 2 major parts: the Motor Mount Frame & Test Jig, and the Sampling Electronics Box. The Motor Mount Frame is the steel structure that holds all the components securely together, while the Test Jig is a removable assembly that includes a lathe chuck for holding the rocket motor, three load cells, and a blast deflector plate.

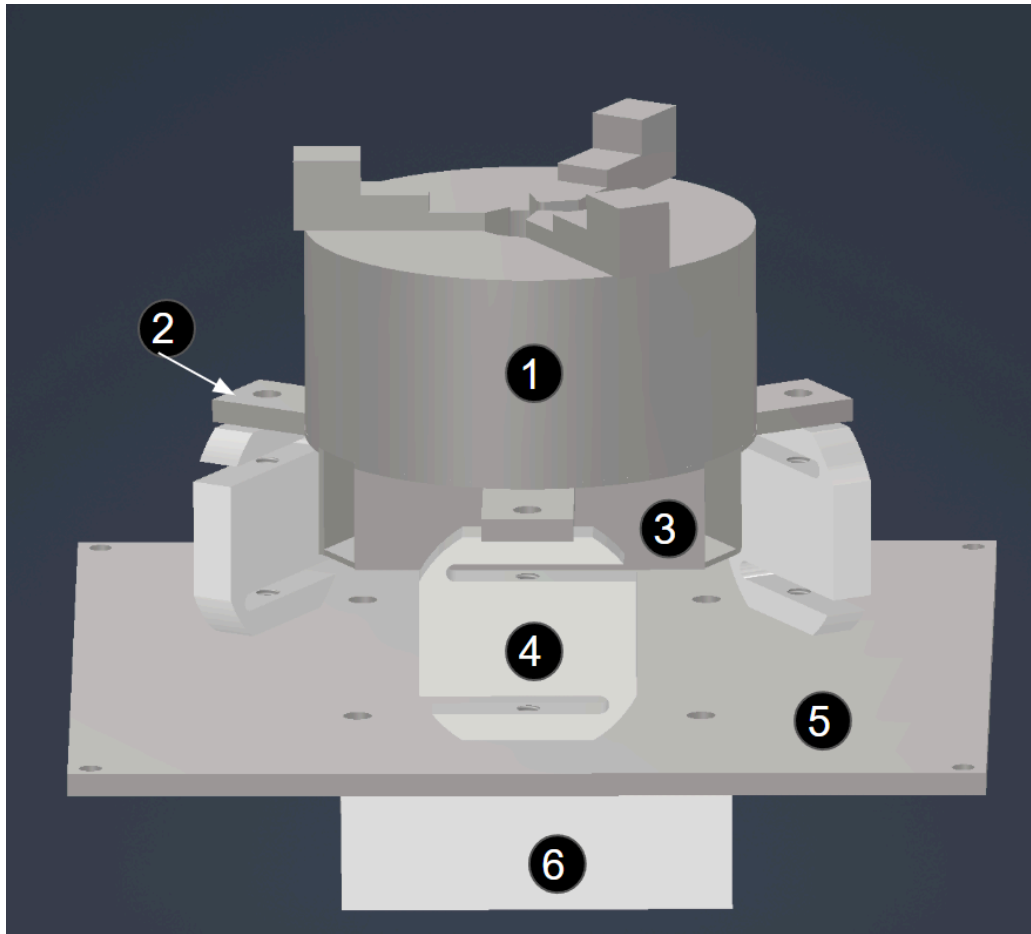


Figure 0X: Motor Mount Assembly: 1.Lathe chuck 2.Load cell spacers 3. Ejection catch
4.Load cells 5.Base plate 6.Load cell splitter

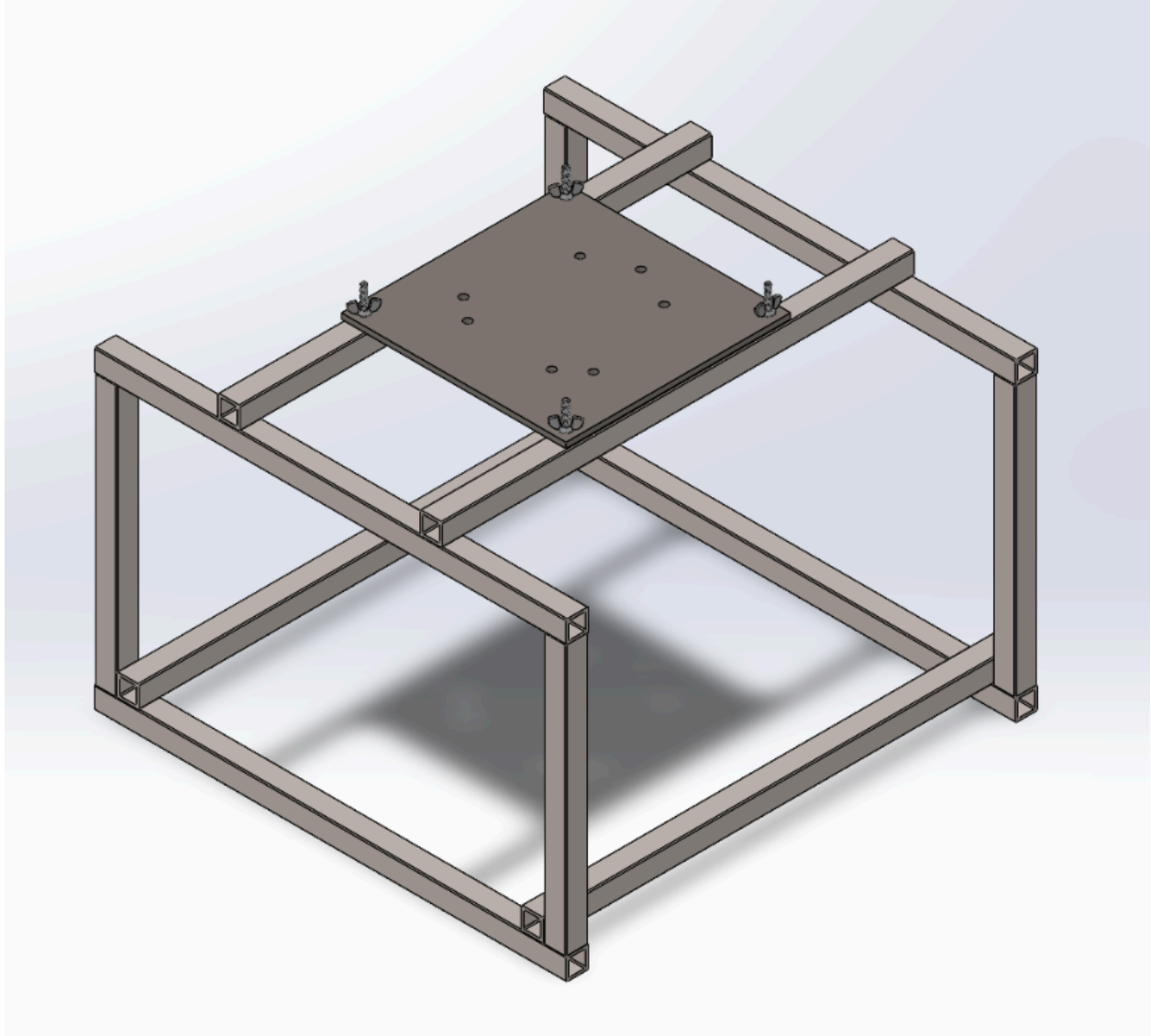


Figure 0X: Main Frame(include the base plate)

The Sampling Electronics Box is a metal container that houses the electronics necessary for measuring the load cells on the Test Jig and transmitting the data to the suitcase. Specifically, the box houses an arduino that controls the siren, measures the signal from the load cell amplifier, and transmits the data to the control suitcase.

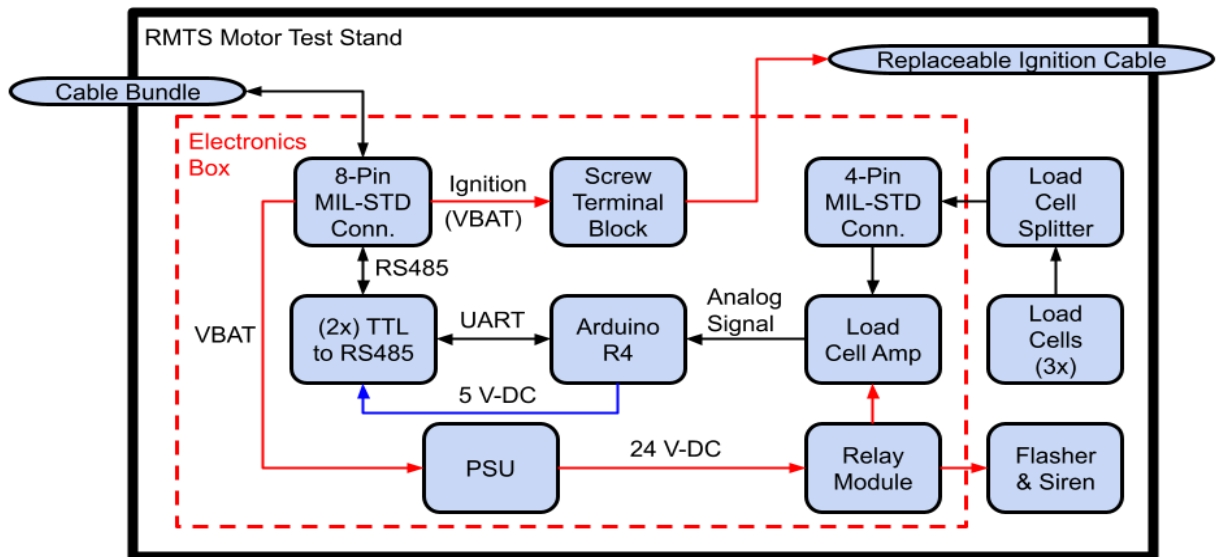


Figure 0X: Block Diagram of Electronics Box

2 Safety Precautions

To ensure personnel safety during the installation, and testing, minimum personnel requirements must be met at each test site. Failure to meet these minimum personnel requirements could result in serious consequences.

Please refer to the appendix "Minimum Required On-Site Personnel" for requirements and their responsibilities.

2.1 Emergency Procedures

The following are general procedures for handling some possible emergencies.

Occurrences	Actions
Engine explosion	<ul style="list-style-type: none"> -Wait at least 60s before approaching the stand -If the motor remains burning, do not approach -Once safe, inspect the structural frame and load cell mount
Personal injury	<ul style="list-style-type: none"> -Immediately stop all testing activities

	-Provide first aid only if trained -Call emergency service if you need -Do not resume the operation if the area is declared a safe
Early firing	- Do not approach until the motor has fully burned out -Confirm ignition relay status and disable ignition power -Inspect wiring File an incident report
Poor air ventilation	-Staying upwind
Fire	-Use only class ABC extinguishers placed near the stand-off perimeter -Do not extinguish burning motors -After burnout, inspect for smoldering debris and hot surfaces

2.2 Stand off/clear area

According to the National Rocket Association's minimum distance table (Appendix 1), the minimum cleared area diameter for I, H-class and below rocket motors is 50 ft. The minimum personal distance is 100 ft.

Motor size	Stand-off Distance	Clear Area Distance
1/8 A - A	100 ft	50 ft
B - C	100 ft	50 ft
D - E	100 ft	50 ft
F - G	100 ft	50 ft
H	100 ft	50 ft
I	100 ft	50 ft
Public or untrained personnel	100 ft	100 ft

2.3 Building precautions

Under normal circumstances, RMTS shall not be operated inside any building, unless the building is a test bay that was specifically designed for rocket motor testing and passed a safety inspection. All risks of indoor operation are for the user to consider and mitigate beforehand.

2.4 Control station lock out

A strict logout-tagout procedure during setup and before ignition is required by the RMTS. The following table explains this:

Procedures	Description
Key Switch	The ignition key must remain off during setup, wiring, installation, and calibration. This ensures there is no power reaching the relay prior to launch readiness.
Software lockout	The system may not proceed until the software actuates a relay and provides power to the launch button.
Physical lockout	The motor igniter lead cable (the two wire output from the test stand ignition terminals must remain disconnected from the motor until the area is clear, stand-off zone is enforced, and warning siren has been tested

2.5 Fault Detection and diagnosis

The RMTS system includes multiple subsystems and there might be identifiable failure modes.

The following table explains this:

Fault Name	Description
Electrical Faults	Low battery voltage, shorted ignition line, PSU overheating, loose cable bundle connection
Sensor and load cell faults	Damaged wiring, amplifier saturation, loose load cell mounting hardware
Software faults	Loss of communication, freezing of GUI
Mechanical faults	Vibration anomalies during earlier tests due to loosened frame screws, misalignment or deformation

Required actions

- Maintenance log could be used to take the record of any fault.
- Replacing damaged components before continuing

3 System Procedures

This section describes recommended procedures for the conduct of normal operations of the RMTS.

3.1 Limitations

The RMTS is unable to accommodate forces in excess of 250 N or 1400 N for the 3x10 kg and the 3x50 kg motor jigs respectively. Exceeding these force measurement values could result in permanent damage to the load cells on the jig. **xx/xx**

3.1.1 Outdoor operational constraints

The RMTS is not designed for indoor use. The RMTS is capable of operating in outdoor conditions of -40C - 40C, strong winds, etc. Due to motor orientation the RMTS is unable to operate in conditions with active precipitation.

3.2 User supply requirements

Prior to testing, the user shall ensure the suitcase is charged by plugging the suitcase into any standard 120V power source for several hours prior to testing. The suitcase may also be plugged in for the duration of the test if power is available at the testing location.

3.3 Storage Configuration

3.3.1 Transportation Recommendations

3.4 Set up Configuration

3.4.1 Assembly process

3.4.1.1 *Assembly of the Test Stand*

3.4.1.2 *Cable connection*

3.4.2 Pre-Test Check

Follow the assembly process, complete the installation of each component and the connection of the cables. After assembly, it should be confirmed that all systems, equipment, and safety devices are correctly installed and configured. Before testing, ensure that there are sufficient and qualified testing and safety personnel, including operator in command, supervisor, observers, and safety officers, and that all are in place and fulfilling their respective responsibilities. Then fill out and verify the Pre-Test Checklist (Appendix 3). All items on this checklist must be verified to be correct. Subsequent testing can only proceed after confirmation by the relevant responsible personnel and obtaining the necessary authorization. Any testing operations are strictly

prohibited if personnel are not in place, safety checks have not been passed, or confirmation has not been completed.

Set up Checklist(will replace by the Pre-Test Checklist)		

3.4.2 Operations

After assembly is complete and the Pre-Test Checklist is finished, the operation process is as follows:

System powers on, click to enter the test program. With the motor disconnected, confirm the test pop-up and select "Test". At this point, the system will automatically enter the calibration procedure; after calibration,a notification will appear indicating that calibration is complete.Then connect to the motor, input relevant test information, and set the sampling time. Then insert the key into the key switch and turn it to the ARMED position. The system will start a 5-second countdown and simultaneously activate the warning lights and siren. The key switch must remain in the same position throughout the countdown and ignition phases until the ignition button indicator light illuminates. Press the ignition button while keeping the key switch in the same position, and the system will ignite and begin data acquisition; after the test, the system will automatically display and save the test data.

3.4.3 Post-Fire

Post-Test Safety Checklist		

Once the launch station has finished the testing procedures, the terminal will display “Test Complete. Recorded data is in [file name]”. The file name given contains thrust

measurements from the test. The suitcase has an external USB port to connect to in order to offload the file.

If there is an issue during communications, launch, or other, then the data is also stored on the test stand Arduino's SD card. This version does not include information about the motor tested, or calibration data.

4 Maintenance and Inspection

4.1 Overview

This chapter aims to ensure reliability, safety, and accuracy during long-term usage. The goal of maintenance and inspection is:

Trying to keep electrical and mechanical components in operating condition; ensure the accuracy of the load sensing system and ignition system; reduce system failure rate and prevent major accidents.

4.2 Electrical System

The electrical system includes: Power supply system, Cable Bundle, Ignition control system, and Microcontroller and Amplifier.

4.2.1 Power supply system

The RMTS power subsystem provides regulated DC power to all control and test modules, ensuring stable operation during ignition, data acquisition, and safety functions. It includes the battery charger, 12 V battery, and two Power Supply Units (PSUs) that deliver 5 V DC and 24 V DC outputs.

To maintain reliable system performance, the power system should be inspected regularly. Detailed inspection requirements and standards are listed in the table below.).

Module	Frequency	Content	Standard
Battery Charger	Every Month	Disconnect from AC and check wiring integrity. Measure output voltage.	Output voltage: 12 V DC. No overheating, abnormal noise, or damage to housing. Ventilation unobstructed.
Battery (12 V)	Every Test	Measure battery terminal voltage and inspect terminals.	Voltage ≥ 12.0 V indicates normal condition. If < 12.0 V, recharge immediately. Terminals are clean, firmly connected, and free of corrosion.

5 V PSU	Every Test	Verify input wiring, measure output voltage to Arduino.	Output $\approx 5.0 \text{ V DC} \pm 10\%$. No burnt odor or noise.
24 V PSU	Every Test	Verify input wiring, measure output voltage to relay and alarm module.	Output $\approx 24 \text{ V DC} \pm 10\%$. Relay operation normal.

Table X. Power Supply System Inspection and Standards

4.2.2 Cable Bundle

The RMTS system electrical system includes two main parts: the Controller Suitcase and the Test Stand Data Box. The two main components are connected using a Cable Bundle. To ensure the RMTS's proper operation, the condition of all interfaces and cables should be checked regularly. Specific inspection details are shown on the table below.

Module	Frequency	Content	Standard
TTL to RS485	Every Test	Reliably transmit signals.	The signal is clear, and the waveform is not distorted.
MIL-STD Conn.	Every Test	Connector contact	The connector housing is undamaged, and the connector metal is free of rust and debris.
Cable Bundle	Every Test	Cable	The cable is intact, and the insulation is undamaged.
HDMI & USB Hub	Every Test	Connector contact	External devices can be used normally.

Table X. Inspection of cables and connectors

4.2.3 Ignition control system

The ignition control system consists of a relay module, a key switch, and push buttons, used to implement safe ignition logic control for rocket engine testing.

This system ensures that the ignition circuit is closed only after authorized and safety conditions are met. Regular inspections should be carried out to ensure equipment safety. Specific details are shown on the table below.

Module	Frequency	Content	Standard
Relay & Control Logic	Every Test	Verify that the Relay Module logic corresponds to Raspberry Pi trigger mode.	Control logic consistent; no false triggering or signal delay.
Coil Drive Voltage	Every Test	Measure relay coil voltage during activation.	Voltage = 12 V or 24 V \pm 5%.
Contact Response	Every Test	Trigger ignition command in test mode and observe relay switching waveform.	No mechanical sticking or chatter.
Key Switch & Push Button Action	Every Test	Rotate key switch and press button to verify smooth operation and return.	Smooth mechanical action; normal rebound; no jamming.
Emergency Cutoff	Every 3 Months	Simulate emergency shutdown scenario by releasing the key switch.	The system can cut off the power in an emergency.
Ignitor	Every Test	Confirmed there is no oxidation or dirt.	Able to ignite normally when the rated current is reached.

Table X. Inspection ignition control system

4.2.4 Microcontroller and Amplifier

The microcontroller and amplifier subsystem will control the electrical system and take the data from the load cell. The test data will also save from there. To keep the RMTS work properly, it is necessary to do the institution regularly. The details are shown in the table below.

Module	Frequency	Content	Standard
Raspberry Pi	Every Test	Check power-up sequence, software startup, and connections between each component. Verify SSH / console access is working.	The system would boot up and have access. Could access the testing software.
Arduino	Every Test	Verify the Arduino has connections with Raspberry Pi and other components.	No data loss
Load Cell Amplifier	Every Test	Check the connection status	Have normal signal output; waveform clean without distortion.

		and the output is normal.	
Connectos	Every Month	Verify amplifier supply voltage and connector integrity.	Supply stable connections; contacts clean no oxidation.
Connectos	Every Test	Inspect RS485/LVDS cable shielding and connector seating.	Shield continuity verified; connector firm.

Table X. Inspection ignition control system

4.2.5 Data storage

Under normal circumstances the data is stored in the Raspberry Pi's terminal. However, the Arduino has an SD card that stores the raw data. To ensure the normal operation of the equipment, it is necessary to maintain the data storage device.

Module	Frequency	Content	Standard
Raspberry Pi	Every Test	Check if the data can be read and whether the data content is readable.	Have clear data
Arduino	Every Test	Verify the Arduino has connections with the sensors and the sd card reader	No data loss
Arduino	Every Test	Check the connection status and the data could save to the SD card	The file can be saved without data corruption.
SD cards	Every 3 Month	Verify the SD card and the card reader was not damaged.	Supply stable connections; contacts clean no oxidation.

Table X. Data storage system

4.3 Structural and mechanical system

The unit consists of two main parts: the Motor Mount Frame & Test Jig, and the Sampling Electronics Box.

The mount frame is a monolithic steel structure used to secure all components. The test jig is a detachable assembly containing a lathe chuck for holding the rocket engine,

three load cells, and a blast deflector plate. The sampling electronics box is an ammo can that houses the electronic modules required for loading cell measurements and transmits data to the control suitcase. To maintain the equipment operation, see the table below for maintenance details.

Module	Frequency	Content	Standard
Structure	Every Test	Check for bends, cracks, or peeling coating.	Have complete appearance. No deformation; no cracks; no exposed base metal.
Fasteners	Every Test	Inspect all fasteners	No obvious rust, no looseness, and matches the torque setting.
Lathe Chuck	Every Test	Check the chuck clamping action and whether the motor direction is aligned with the axis.	The clamping action is smooth, no shaking, the engine axis offset does not exceed 2.5 degrees.
Lathe Chuck	Every Test	Check the jaw for obvious deformation, wear, corrosion and cracks.	No obvious deformation, wear, corrosion and cracks.
Lathe Chuck	Every Test	Check threads and guide rails for lubricating grease	The grease is evenly distributed, with no obvious friction.

Corrosion	Every 3 Month	Inspect the structure, welds, baffles, and bolt surfaces for rust.	The protective coating is intact and there is no serious corrosion.
Welds	Every 3 Month	Inspect all welds	No cracks or corrosion in the weld

Table X. Motor Mount Frame & Test Jig

Module	Frequency	Content	Standard
Inspection after water ingress incident	After every suspected water ingress/high humidity	Check the Humidity Indicator Card	Refer to the card face instructions
Shipping container	After every transport	Check the exterior of the shipping container	The exterior is intact, with no obvious deformation or damage.
Structural component inspection	After every transport	Inspect all structural components	The exterior is intact, with no obvious deformation or damage.
Fastener Inspection	After every transport	Inspect all fastener	No looseness, torque meets standards

Table x. Water and Crate inspection

4.4 Troubleshooting

Here are troubleshooting for some common failure methods. For more potential issues, please refer to the FMEA table (Appendix X).

References

Internal Documentation References	
1	Test Procedures
2	Requirements
3	EAP
4	FMEA

External References	
5	https://www.thrustcurve.org/info/raspformat.html
6	https://www.tripoli.org/safetycode
7	
8	
9	

Appendix

(include any supporting calculations, test data, drawings, etc.)

Bill of materials

MINIMUM DISTANCE TABLE

Installed Total Impulse (Newton-Seconds)	Equivalent High Power Motor Type	Minimum Diameter of Cleared Area (ft.)	Minimum Personnel Distance (ft.)	Minimum Personnel Distance (Complex Rocket) (ft.)
0 -- 320.00	H or smaller	50	100	200
320.01 -- 640.00	I	50	100	200
640.01 -- 1,280.00	J	50	100	200
1,280.01 -- 2,560.00	K	75	200	300
2,560.01 -- 5,120.00	L	100	300	500
5,120.01 -- 10,240.00	M	125	500	1000
10,240.01 -- 20,480.00	N	125	1000	1500
20,480.01 -- 40,960.00	O	125	1500	2000

Note: A Complex rocket is one that is multi-staged or that is propelled by two or more rocket motors

Revision of August 2012

A1.

Launch Site Dimensions

Installed Total Impulse (N-sec)	Equivalent Motor Type	Minimum Site Dimensions (ft)
0.00 - 1.25	1/4A, 1/2A	50
1.26 - 2.50	A	100
2.51 - 5.00	B	200
5.01 - 10.00	C	400
10.01 - 20.00	D	500
20.01 - 40.00	E	1,000
40.01 - 80.00	F	1,000
80.01 - 160.00	G	1,000
160.01 - 320.00	Two Gs	1,500

A2.

Minimum Required On-Site Personnel		
Staff	Minimum number of people	Responsibility
Operator in Command	1	Responsible for performing operations and testing
Supervisor	1	Monitor the test, decide whether to conduct the test, and monitor the safety officer.
Safety Officer	1	Test area safety, site clearing, emergency response and personnel safety
Observer	1(Safety Officer can do both)	Monitoring the test area, recording the test process.
Other Crew Member	0	Assist the above personnel in their work

Minimum Required On-Site Personnel

Pre-Test Checklist

Test No.:	Motor No.:	Motor Class:
Operator in Command:	Supervisor:	Date:
Observer :	Testing Site Location:	
Safety officer:		
Other Crew Member:		

Authorization for test in restricted testsite : _____
 Authorized by: _____ Date: _____

A3. Somehow this table is not working in google doc, I will upload the PDF later.