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X-57 Maxwell

Mod II Mission Operations Plan (MOP)

OPS-CEPT-002

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OPS-CEPT-002
Mod II Mission Operations Plan

Revision History

REV	DATE	DESCRIPTION	AUTHOR
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Table of Contents

Acronym List

AFRC	Armstrong Flight Research Center
Comm.	Communication
FTE	Flight Test Engineer
MC	Mission Critical (parameters)
MC	Mission Controller
MCC	Mission Control Center
MR	Mission Rule
NASA	National Aeronautics & Space Administration
RCO	Range Control Officer
RTB	Return To Base
SF	Safety of Flight
ST	Safety of Test
TD	Test Director
TIE	Test Information Engineer
TM	Telemetry
UHF	Ultra High Frequency
VHF	Very High Frequency

1 Purpose

The purpose of this document is to formally document the X-57 Mod II Mission Operations plan. This plan encompasses the Mission Rules, Mission Limits, Communication Plan, Control Room Operations Plan, and the Control Room Training Plan in effect for all X-57 mission operations, which require control room support conducted with the X-57 Maxwell aircraft (tail number NASA 857) in the Mod II configuration.

2 Scope

The Mission Rules, Mission Limits, Communication Plan, Control Room Operations Plan, and Control Room Training Plan apply to all missions, which require control room support conducted with NASA 857 in the Mod II configuration. X-57 aircraft ground operations, which do not require control room support are governed by procedures unique to each ground operation.

3 Mission Rules

Mission Rules state how the X-57 team shall operate in specific circumstances. Rationale is provided with each Mission Rule to provide justification or rationale for the prescribed action.

Mission Rules use specific terminology and definitions, which are presented below.

The Mission Rules are broken out into the following sections: Ground Mission Rules and Flight Mission Rules.

Appendix A contains a summary of the flight mission rules suitable for inclusion in the flight cards.

3.1 Mission Rule Terminology

The use of the word “Shall” indicates a mandatory action.

The use of the word “Is” indicates a mandatory requirement.

The use of the word “Should” denotes a recommendation on how to proceed and may be ignored based on a judgement call by the Mission Controller upon consultation with the Test Director and the X-57 pilot.

The following phrases shall be used by the test team to communicate the type of landing to be used at the end of a mission. The landing definitions are based on the status of the safety related Go/No-Gos and whether a hazardous condition has arisen.

  - Return to Base (RTB) – Landing as planned
    - Nominal end of mission.
  - Land as Soon as Practical – Landing as planned
    - Used in non-emergency situations where the mission is terminated.
    - Exceedance/Loss of a Safety of Flight (SF) or Safety of Test (ST) parameter with no indication of a safety issue.
      - e.g. motor winding temps exceeded limits, but returned when torque command reduced
  - Land as Soon as Possible – Pilot discretion on landing location
    - Exceedance/Loss of a Safety of Flight (SF) or Safety of Test (ST) parameter with indication of a safety issue.
      - e.g. single motor bearing temps increased significantly but motor safely shut down and bearing temps remained within limits
  - Battery Emergency – Pilot discretion on minimizing time to landing
    - Urgent life-threatening situation where the pilot needs to exit the aircraft immediately.

The use of the term “envelope expansion” is defined to be flight at a flight condition and configuration not previously flown and cleared. A flight condition is considered cleared once the planned dynamic maneuvers have been completed and the pilots and control room have determined the results to be safe to continue flight and to proceed to the next test point.

The term “pre-cleared” flight envelope is used to refer to an airspeed and aircraft configuration in which the pilot is to return when any issue arises. For the X-57 Mod II aircraft, the pre-cleared airspeed is flight at 90 KIAS for level flight, climbs, and descents.

Safety of Flight (SF), Safety of Test (ST), and Mission Critical (MC) Go/No-Go (GNG) Parameters are defined in OPS-CEPT-001 X-57 Mod II Go/No-Go Parameter List. The definitions are repeated here since the X-57 Mission Rules make reference to specific actions related to SF, ST, and MC GNG parameters. The actions specified in the GNG parameter definitions are consistent with the X-57 Mission Rules.

- Safety of Flight - Parameter monitored by the control room as a mitigation for a flight safety hazard throughout the entire flight. An RTB is called if any of the following occur: loss of parameter, discrepancies with the parameter, or exceedance of a Safety Critical Go/No-Go Criteria.
- Safety of Test - Parameter monitored by the control room as a mitigation for a flight safety hazard during a flight test maneuver. Flight test maneuvers requiring this parameter are discontinued and an RTB may be called if any of the following occur: loss of parameter, discrepancies with the parameter, or exceedance of a Safety Critical Go/No-Go Criteria.
- Mission Critical – Mission Critical Parameters are required to meet research objectives and requirements. Failure of a mission critical parameter may result in discontinuation of test points requiring the parameter.

- Technically Desired - Technically Desired Parameters are those that are not Safety of Flight, Safety of Test, or Mission Critical. Technically Desired Parameters are those that the project will make an effort to capture, but are not considered necessary for mission success. Failure of these parameters will not result in discontinuation of any test points and will not impact the planned flow of a mission.

3.2 Ground Mission Rules

1. No systems (including laptops) shall simultaneously connect to the aircraft and the Internet (including guest wireless, air cards, etc.)
    a. Rationale: IT security rules require that aircraft systems be isolated in order to avoid security risks.

2. The Safety of Flight (SF), Safety of Test (ST), and Mission Critical (MC) parameters shall be verified as operational or dispositioned appropriately prior to take-off.
    a. Rationale: SF and ST parameters are required to ensure safe operation of the aircraft. MC parameters are required in order to ensure mission success.
    b. Note: Dispositioning will be consistent with the definitions of SF, ST, MC found in GNG document and the Mission Controller and Test Director must concur with the disposition. The Mission Controller and Test Director will each document in their copy of the flight cards any GNG parameter dispositions, which are made after the time of crew brief.

3.3 Flight Mission Rules

Note: The following Flight Mission Rules also pertain to any operation involving taxiing of the aircraft unless otherwise noted.

1. Control Room Support is required.
    a. Rationale: Control room monitoring of SF and ST parameters is required in order to ensure safe conduct of the flight and mission. MC parameters are required in order to ensure mission success.

2. Safety Chase is required for all flights.
    a. Rationale: Safety chase is required in order to provide the Mod II pilot assistance in the event of an in-flight emergency and to assist with monitoring of the airspace.
    b. Note: Not required for operations involving taxiing.

3. Safety of Flight, Safety of Test, and Mission Critical parameters shall be continuously monitored and if the parameters become non-functional, discrepant, or exceed any of the GNG criteria, the Test Director shall be consulted, and a plan forward will be decided upon.
    a. Rationale: Control room monitoring by the responsible discipline of SF and ST parameters is required in order to ensure safe conduct of the flight and mission. Monitoring of the MC parameters is required to ensure mission objectives are met.
    b. Note: Dispositioning will be consistent with the definitions of SF, ST, MC found in GNG document and the Mission Controller and Test Director must concur with the disposition. The Mission Controller and Test Director will each document in their copy of the flight cards any GNG parameter dispositions, which are made after the time of crew brief.

4. If an Aircraft or Mission Limit is exceeded, a knock it off shall be called and the test team shall follow the prescribed action.
    a. Rationale: Aircraft and Mission Limits are in place to ensure safe operation of the aircraft and mission. Exceeding any of these operating limits may place the crew in a hazardous situation.

5. In the event of loss of communication between any elements of the test team (pilot, Mission Controller, chase, ground asset, etc…) and does not recover, testing shall be terminated and the aircraft shall RTB.
    a. Rationale: Communication is required between all elements of the test team.

6. In the event of loss of telemetry between the aircraft and the control room, the aircraft shall return to and remain in a pre-cleared portion of the flight envelope. If data TM does not recover, the aircraft shall RTB.
    a. Rationale: A control room is needed to monitor SF and ST parameters and in order to safely conduct envelope expansion flights.

7. If the on-board Data Recorder is non-functional, the mission may proceed/continue if telemetry is confirmed.
    a. Rationale: Recording of the telemetry stream data is sufficient for post-flight data processing needs.

8. After yawing maneuvers that produce a buildup of aircraft sideslip, except 2-1-1's and doublets, the rudder pedal input shall not be released abruptly. It should be released in a slow and controlled manner.
    a. Rationale: Maintain structural loads of the vertical tail within allowable limits. The vertical tail limits are documented in MEM-CEPT-009, Rudder Limitations for Mod II, III/IV Flight.

9. Maneuvers requiring rudder pedal input of alternating directions, including 2-1-1's and doublets, are allowed only with control room monitoring of the estimated force on the vertical tail.
    a. Rationale: The input of maneuvers requiring alternating rudder inputs may result in vertical tail loads, which exceed flight limits. A control room is required to ensure the safe build-up and conduct of these types of maneuvers. The vertical tail limits are documented in MEM-CEPT-009, Rudder Limitations for Mod II, III/IV Flight.

10. Changes to Control Room Displays are not permitted during a mission other than to change colors, and strip-chart speeds.
    a. Rationale: Changes to real-time displays need to be reviewed through the CCB process before being implemented. The CCB process ensures that all disciplines involved have a chance to view and comment on changes being made. It is not always obvious at first glance how changes in one discipline may affect another discipline's displays.

11. The prop pitch control levers shall not be set above 2,250 RPM at traction bus voltages below 425V while at idle power settings or below 350V while at full power settings.
    a. Rationale: There is a potential of a CMC overcurrent fault at RPMs above ~2,600 RPM at Traction bus voltages below 350 V. The CMC software Merlin logic should protect against this overcurrent fault, but it is not planned to be tested in-flight. The above operational limitations will preclude flight in this corner of the flight envelope, thereby avoiding any potential issue with CMC(s) faulting or the Merlin logic.

3.4 Management of Mission Rules

This document will be updated as necessary to properly reflect and capture project needs. Mission Rules briefed at flight crew briefs must reflect the status of this document. Non-applicable Mission Rules to a particular flight will be included in flight crew briefs but "grayed out". If a Mission Rule needs to be added to or deleted from the project, a new revision of this document with all approval signatures is required. When

Mission Rules are deleted, they are removed from Section 3 and moved to Section 7 “Deleted X-57 Mission Rules” along with rationale for deleting the Mission Rule(s).

4 Mission Limits

A Mission Limit states a limit on X-57 operations and states how the X-57 team shall respond when the limit is exceeded. Mission limits consist of Aircraft Operating Limits, Meteorological Limits, and Traction System Operating Limits. The Traction System is defined to include the cruise motors, the cruise motor controllers, and the battery system. All other parameter limits are covered in OPS-CEPT-001 X-57 Mod II Go/No-Go & Critical Parameter List.

Note that the aircraft operating limits are documented in the Flight Manual and are re-stated here for emphasis and to place all limits within one document.

Appendix B contains a summary of the mission limits suitable for inclusion in the flight cards.

4.1 Aircraft Operating Limits

Aircraft operating limits are listed below along with the rationale, reference, and flight test team action upon exceedance. For airspeed limits, refer to the Flight Manual or OPS-CEPT-006 Mod II Airspeeds.

Aircraft Operating Limits - (All numbers assume 3,000 lb. takeoff weight)					
Limit	**Value**	**Description**	**Rationale**	**Reference**	**Flight Test Team Action Upon Exceedance**
Altitude	14,000 ft.	Maximum allowable flight altitude.	Flight above 14,000 ft. requires supplemental oxygen, which is not available on the Mod II aircraft.	Tecnam Flight Manual Page 2-11.	Decrease altitude
Symetric Flight Nz (Flaps Retracted)	2.4 / -1.29g	Maximum and minimum allowable symmetric g limits with flaps retracted.	Structural analysis of the modified aircraft has set the G limits	ANLYS-CEPT-007.	Structures to assess validity of Exceedance. If true, land as soon as possible/practical.
Asymmetric Flight Nz (Flaps Retracted)	2.1 / -1.29g	Maximum and minimum allowable asymmetric g limits with flaps retracted.	Structural analysis of the modified aircraft has set the G limits	ANLYS-CEPT-007.	Structures to assess validity of Exceedance. If true, land as soon as possible/practical.
Flight Nz with Any Flaps Extended	1.7 / 0.0g	Maximum and minimum allowable g limits with any flap extension.	Structural analysis of the modified aircraft has set the G limits	ANLYS-CEPT-007.	Structures to assess validity of Exceedance. If true, land as soon as possible/practical.
Landing Load (G)	2 g	Maximum allowable landing load. Rounded 2.34 to 2.3 at 3,000 lb. weight.	Structural analysis of the landing gear has set the allowable landing load.	ANLYS-CEPT-007.	Discontinue flight testing until structural assessment complete.
Landing Sink Rate	7 ft/sec	Maximum allowable landing sink rate.	Structural analysis of the landing gear has set the allowable landing sink rate.	ANLYS-CEPT-007.	Discontinue flight testing until structural assessment complete.
TGW	3,000 lb	Maximum allowable takeoff gross weight.	Structural analysis of the modified aircraft has set the maximum allowable takeoff gross weight.	ANLYS-CEPT-007.	Takeoff not allowed.
CG Forward Limit	16.5% MAC	Forward CG Limit	CG limit restricted to remain within the Tecnam flight manual limits.	Tecnam Flight Manual Page 2-17.	Takeoff not allowed.
CG Aft Limit	31% MAC	Aft CG Limit	CG limit restricted to remain within the Tecnam flight manual limits.	Tecnam Flight Manual Page 2-17.	Takeoff not allowed.
Vertical Tail Load	623 lbf Design Limit (DL) 560.7 lbf Inspection Limit (IL) 498 lbf (KIOL) Knock-it-off Limit	Vertical tail load Design Limit	Vertical tail structural limits must be maintained.	MEM-CEPT-009	For DL & IL Exceedance Land as soon as Possible/Practical Structures to provide guidance on further airspeed and maneuver restrictions. For KIOL Exceedance Knock off current test point Structures to provide feedback on test technique.
Bank Angle	60^{o}	Bank Angle Limit	Allowable Bank Angle per the Tecnam flight manual.	Tecnam Flight Manual Page 2-19.	Return to wings-level flight and ensure limit not exceeded in the future.
Meteorological Limits					
Limit	**Value**	**Description**	**Rationale**	**Reference**	**Flight Test Team Action Upon Exceedance**
Allowable Crosswind	14.5 Kts.	Maximum allowable landing crosswind.	Structural analysis of the landing gear has set the allowable crosswind limit.	ANLYS-CEPT-007.	Takeoff or landing not allowed.
Maximum Takeoff Ground Temperature	34.5 C (94 F)	Maximum Takeoff Ground Temperature	36C is the value used for hot day subystem and system analysis.	GUIDE-CEPT-002 Release A 1/21/21 and CMC HW Review RFA 002 Response dated 6/6/22	Takeoff not allowed. Taxi testing allowed with monitoring of thermal limits.
Minimum Takeoff Ground Temperature	-16 C (3 F)	Minimum Takeoff Ground Temperature	-16C is the value used for cold day subystem and system analysis.	GUIDE-CEPT-002 Release A 1/21/21	Takeoff not allowed.
Flight in expected and/or known icing conditions, in proximity of storms or in turbulence is forbidden.			The aircraft is not equiped with a de-icing system.	Technam Flight Manual Page 2-20.	Aircrew shall exit the area and either return to clear air or land as soon as practical.
No flight through visible moisture.			Rain and other forms of moisture will affect the research instrumentation and systems on the aircraft.	Standard AFRC practice for research aircraft.	Test team to first assess health of the aircraft, research, and instrumentation systems. Land as soon as practical.
Day VFR Operations Only			Day VFR Operations allows the pilot to "see and avoid" other aircraft or obstacles. Research flights are high workload events, and adding instrument flying to the pilot's workload is not safe.	Standard AFRC practice for research aircraft.	Land as soon as practical if airborne. Takeoff not allowed.
No flight in conditions of greater than light turbulence			Structural analysis has limited flight to conditions of no greather than light turbulence.	ANLYS-CEPT-007.	Aircrew shall exit the area and either return to clear air or land as soon as practical.

4.2 Meteorological Limits

The Meteorological Limits for the X-57 Mod II aircraft are listed below along with the rationale, reference, and flight test team action upon exceedance.

Meteorological Limits					
Limit	**Value**	**Description**	**Rationale**	**Reference**	**Flight Test Team Action Upon Exceedance**
Allowable Crosswind	14.5 Kts.	Maximum allowable landing crosswind.	Structural analysis of the landing gear has set the allowable crosswind limit.	ANLYS-CEPT-007.	Takeoff or landing not allowed.
Maximum Takeoff Ground Temperature	34.5 C (94 F)	Maximum Takeoff Ground Temperature	36C is the value used for hot day subystem and system analysis.	GUIDE-CEPT-002 Release A 1/21/21 and CMC HW Review RFA 002 Response dated 6/6/22	Takeoff not allowed. Taxi testing allowed with monitoring of thermal limits.
Minimum Takeoff Ground Temperature	-16 C (3 F)	Minimum Takeoff Ground Temperature	-16C is the value used for cold day subystem and system analysis.	GUIDE-CEPT-002 Release A 1/21/21	Takeoff not allowed.
Flight in expected and/or known icing conditions, in proximity of storms or in turbulence is forbidden.			The aircraft is not equiped with a de-icing system.	Technam Flight Manual Page 2-20.	Aircrew shall exit the area and either return to clear air or land as soon as practical.
No flight through visible moisture.			Rain and other forms of moisture will affect the research instrumentation and systems on the aircraft.	Standard AFRC practice for research aircraft.	Test team to first assess health of the aircraft, research, and instrumentation systems. Land as soon as practical.
Day VFR Operations Only			Day VFR Operations allows the pilot to "see and avoid" other aircraft or obstacles. Research flights are high workload events, and adding instrument flying to the pilot's workload is not safe.	Standard AFRC practice for research aircraft.	Land as soon as practical if airborne. Takeoff not allowed.
No flight in conditions of greater than light turbulence			Structural analysis has limited flight to conditions of no greather than light turbulence.	ANLYS-CEPT-007.	Aircrew shall exit the area and either return to clear air or land as soon as practical.

4.3 Traction System Operation Limits

Mission specific traction system operating limits, such as Bingo and Joker State of Charge (SOC) and/or Traction Bus Voltage Limits will be briefed at Crew Brief prior to each flight.

Traction system operating limits are documented in the OPS-CEPT-001 Mod II Go/No-Go Parameters. The below table summarizes the traction system operating limits. Refer to OPS-CEPT-001 for the official traction system operating limits.

Limit	Minimum Value	Maximum Value	Rationale	Flight Test Team Action Upon Exceedance of Red Limit
Battery Pack Voltage	Yellow: 350 VDC Red: 320 VDC	537.6	Yellow source is Traction Battery Low Voltage Annunciator Alarm Setting. Red Source is battery system User's Manual and Safety Instructions for the System charge and discharge cut-off voltages.	Land as Soon as Possible
Battery Cell Temperature - Average	N/A	Yellow: 60 C Red: 65 C	Yellow is the cell maximum temperature for discharge per the Battery System User's Manual and Safety Instructions. Red is the limit at which the BMS Master Fault is set per the BMS Software Design Description SDD-CEPT-043	Remove traction system power for affected battery pack Declare Battery Emergency
Battery Cell Temperature - Maximum	N/A	Yellow: 60 C Red: 65 C	Yellow is the cell maximum temperature for discharge per the Battery System User's Manual and Safety Instructions. Red is the limit at which the BMS Master Fault is set per the BMS Software Design Description SDD-CEPT-043	Remove traction system power for affected battery pack Declare Battery Emergency
Battery Cell Voltage - Maximum	Yellow - 2.8 Red - 2.5	4.2	Yellow limit provide margin. The battery system user's manual states that 2.5V and 4.2V are the minimum and maximum allowable voltages.	Remove traction system power for affected battery pack Land as Soon as Possible
Battery Cell Voltage - Minimum	Yellow - 2.8 Red - 2.5	4.2	Yellow limit provide margin. The battery system user's manual states that 2.5V and 4.2V are the minimum and maximum allowable voltages.	Remove traction system power for affected battery pack Land as Soon as Possible
Battery System Isolation Status	Asserted		Loss or any intermittant signal that indicates isolation is compromised	Remove traction system power for affected battery pack Land as Soon as Possible
Battery System Master Fault	Asserted		Master Fault indicates an issue with the battery system operation.	Remove traction system power for affected battery pack Land as Soon as Possible
Cruise Motor Winding Temperatures	N/A	Yellow: 124 C Red: 135 C	thermal-go-no-go Spreadsheet	Reduce torque command for associated cruise motor. If temperatures do not drop below red limit, disarm affected CMCs and land as soon as possible. If temperatures do drop below red limit, land as soon as practical.
Cruise Motor Bearing Temperatures	N/A	Yellow: 89 C Red: 99 C	thermal-go-no-go Spreadsheet	Disarm associated CMCs. Land as Soon as Possible
Cruise Motor Controller Temperature - MOSFET	N/A	Yellow: 123 C Red: 134 C	thermal-go-no-go Spreadsheet	Reduce torque command for associated cruise motor. If temperatures do not drop below red limit, disarm affected CMCs and land as soon as possible. If temperatures do drop below red limit, land as soon as practical.
Cruise Motor Controller Temperature - FPGA	N/A	Yellow: 89 C Red 100 C	thermal-go-no-go Spreadsheet	Reduce torque command for associated cruise motor. If temperatures do not drop below red limit, disarm affected CMCs. In all instances, Land as Soon as Practical.
Cruise Motor Controller - Master Fault	Asserted		Master Fault indicates an issue with the cruise motor controller operation.	If CMC still powering motor, it is commanding last valid throttle setting; disarm CMC prior to landing. If CMC not powering motor, disarm CMC. Single CMC - Land as Soon as Practical. Multiple CMC - Land as Soon as Possible
Cruise Motor Controller Temperature - Driver Board	N/A	Yellow: 89 C Red 100 C	thermal-go-no-go Spreadsheet	Reduce torque command for associated cruise motor. If temperatures do not drop below red limit, disarm affected CMCs. In all instances, Land as Soon as Practical.
Cruise Motor Controller Temperature - Vicor Power Supply	N/A	Yellow: 74 C Red: 85 C	thermal-go-no-go Spreadsheet	Reduce torque command for associated cruise motor. If temperatures do not drop below red limit, disarm affected CMCs. In all instances, Land as Soon as Practical.
Cruise Motor Controller Temperature - CPU Board	N/A	Yellow: 74 C Red: 85 C	thermal-go-no-go Spreadsheet	Reduce torque command for associated cruise motor. If temperatures do not drop below red limit, disarm affected CMCs. In all instances, Land as Soon as Practical.
Avionics Bus Current	N/A	Yellow: 65 A Red: 70 A	Max expected current is 61 A. Hardware limit is 72.4 A when battery voltage is ≤400 V and 87.0 A when battery voltage is >400 V.	Land as Soon as Possible
Avionics Bus Voltage	11.5 V	14.6 V	Yellow is the Traction Battery Low Voltage Warning in the cockpit per ICD-CEPT-006. Red Limit is the Battery System Discharge cut-off voltage per the battery system User's Manual and Safety Instructions.	Land as Soon as Possible
Traction Bus Current	N/A	Yellow: 100 A Red: 150 A	Max expected current for dual-CMC (nominal) operation is 92 A. Single-CMC Overdrive could draw 143 A while the pilot is stabilizing the aircraft. SAE 50881 analysis and GRC Mod 3 duct COMSOL thermal model estimate hardware limit is 180 A.	Reduce torque commands for both motors. If current draw does not return to limits, remove traction system power for affected battery pack. In all instances, Land as Soon as Possible.
Traction Bus Voltage	Yellow: 350 Red: 320	537.6	Yellow is the Traction Battery Low Voltage Warning in the cockpit per ICD-CEPT-006. Red Limit is the Battery System Discharge cut-off voltage per the battery system User's Manual and Safety Instructions.	Land as Soon as Possible

5 Monitoring and Communication Plan

The X-57 Mod II flights require a team of engineers monitoring data during a mission. Section 5.1 defines the discipline monitoring and reporting plan. Section 5.2 details the communication loops and flow. Section 5.3 describes the control room etiquette. Section 5.4 defines the mission specific radio calls.

5.1 Monitoring and Reporting Plan

The discipline leads are responsible for monitoring the SF, ST, and MC parameters assigned to their discipline as documented in OPS-CEPT-001 X-57 Mod II Go/No-Go Parameter List. If a SF or ST parameter limit is exceeded or the parameter is non-functional, the discipline lead is responsible for immediately informing the Mission Controller and Test Director of an issue on Data 1, and they are to use the terminology in Section 5.4 as appropriate. The Mission Controller and Test Director also monitor a subset of the SF and ST parameters, and they will act as appropriate without waiting on input from the discipline leads.

If a MC parameter develops an issue, the discipline lead is responsible for informing the Test Director on Data 2 of the problem.

5.2 Communication Plan for Flight Operations

The communication plan for flight operations is shown in Figure 1.

The discipline specific subnets (Data 3, 4, and 5) are to be used for intra-discipline communication.

Data 2 is to be used for non-urgent communication between the discipline leads and the Test Director.

Data 1 is to be used for communication between the Test Director and the Mission Controller. Urgent calls are to be made by Discipline Leads and Engineers on Data 1. Data 1 is also where the Mission Controller will communicate with the test team.

The entire test team in the control room is expected to monitor the UHF/VHF channel, Data 1, Data 2, and the discipline specific subnets.

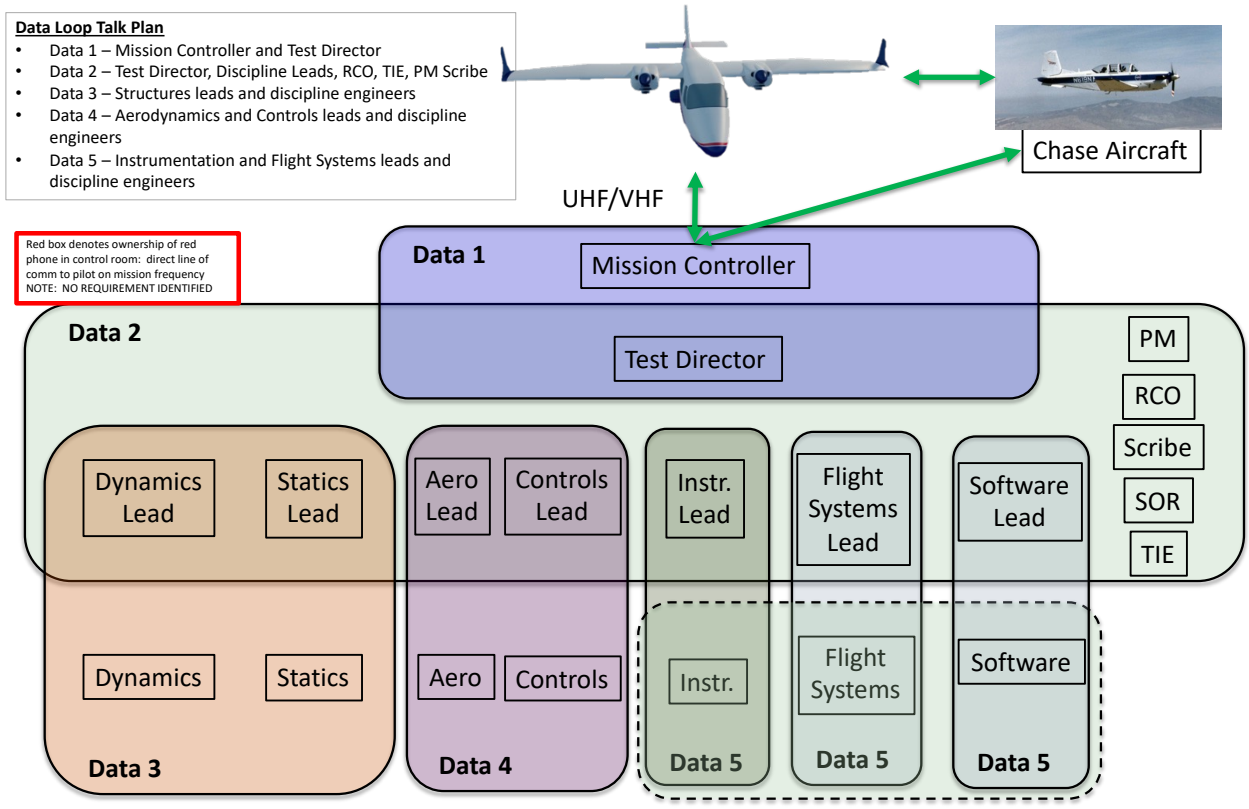

Figure 1: Communication Plan for X-57 Mod II Control Room Operations

5.3 Control Room Communication Etiquette

The control room test team will remain focused on the mission and only make mission specific calls on the data subnets. The test team will minimize all non-mission related discussions, especially during flight.

When making a call to another person on a Data subnet, the person making the call is to use the following format. "Person being called, Person calling, Subnet ID". For example, "Statics, this is TD on Data 2".

When the Test Director or Mission Controller make a general call on Data 1 or Data 2, they will use the following format, "This is TD on Data 2, information follows".

5.4 Radio Calls

The X-57 Mod II flight test team shall use the following radio calls for urgent and non-urgent communications with the aircraft. The research pilots, chase aircraft pilot, Mission Controller, or control room personnel with a red phone (as applicable) can make the following radio calls during a mission. Definitions of and corresponding actions for each type of call are specified below. Specific test point criteria for making the calls, determining which personnel have red phones, and other details shall be discussed during the crew briefings prior to flight. Discipline leads may also make these calls on Data 1 or Data 2 for the Mission Controller to relay to the aircrew.

- **"Knock-it-Off" (3 Times)**
  - Definition – An urgent call made to immediately discontinue test point and prohibits repeats until deemed safe to continue.
    - **Note:** Once the aircraft has returned to a cleared and safe operating condition, a Knock-it-Off call shall be followed by brief reason why the call was made along with additional actions if needed.
  - Pilot Action – Pilot shall discontinue test point, return to last cleared flight condition, acknowledge the call, accomplish any associated boldface, and wait until directed by the Mission Controller.
  - Chase Aircraft Action – Make the call as needed, monitor situation and remain clear of the research aircraft.
  - MCC Personnel Action – Make call to corresponding person up the chain of communication plan leading to the Mission Controller, and on to the pilot. If red phone is necessary and available, use red phone to make call directly to the pilot of the test aircraft.

Note: RTB's shall be identified on a case by case basis unless otherwise noted in the mission rules.

- **"Terminate" (3 Times)**
  - Definition – Non-urgent call made to terminate or discontinue test point.
  - Pilot Action – Pilot shall discontinue test point, acknowledge the call, and prepare for next event.
  - Chase Aircraft Action – Make the call as needed, monitor situation and continue chase normally.

- **"Hold-Hold-Hold"**
  - Definition – Non-urgent call made to hold the current condition.
  - Pilot Action – Pilot shall acknowledge the call and hold the current condition until directed otherwise by the Mission Controller.
  - Chase Aircraft Action – Make the call as needed, monitor situation and continue chase normally.

- **Advisory Calls**
  - Definition – Non-urgent call made to improve situational awareness to pilot
  - Pilot Action – Pilot should listen to the advisory, acknowledge the call, and act as they deem necessary.
  - Chase Aircraft Action – Make the call as needed, monitor situation and act as they deem necessary.

6 Control Room Operations Plan

X-57 control room operations will be conducted from Mission Control Center 1 (MCC1) at AFRC.

6.1 X-57 Mod II MCC1 Staffing Plan

The nominal X-57 Mod II MCC1 staffing plan is show in Figure 2. The staffing plan identifies where each discipline will sit, who is qualified to serve as discipline lead along with qualified backups, and required discipline support staffing. Up to 17 personnel are required in MCC1 to support an X-57 Mod II flight. The actual number of personnel in MCC1 may be much higher to aid in monitoring and for training purposes.

Any changes to the X-57 Mod II MCC1 Staffing plan are to be briefed at Crew Brief.

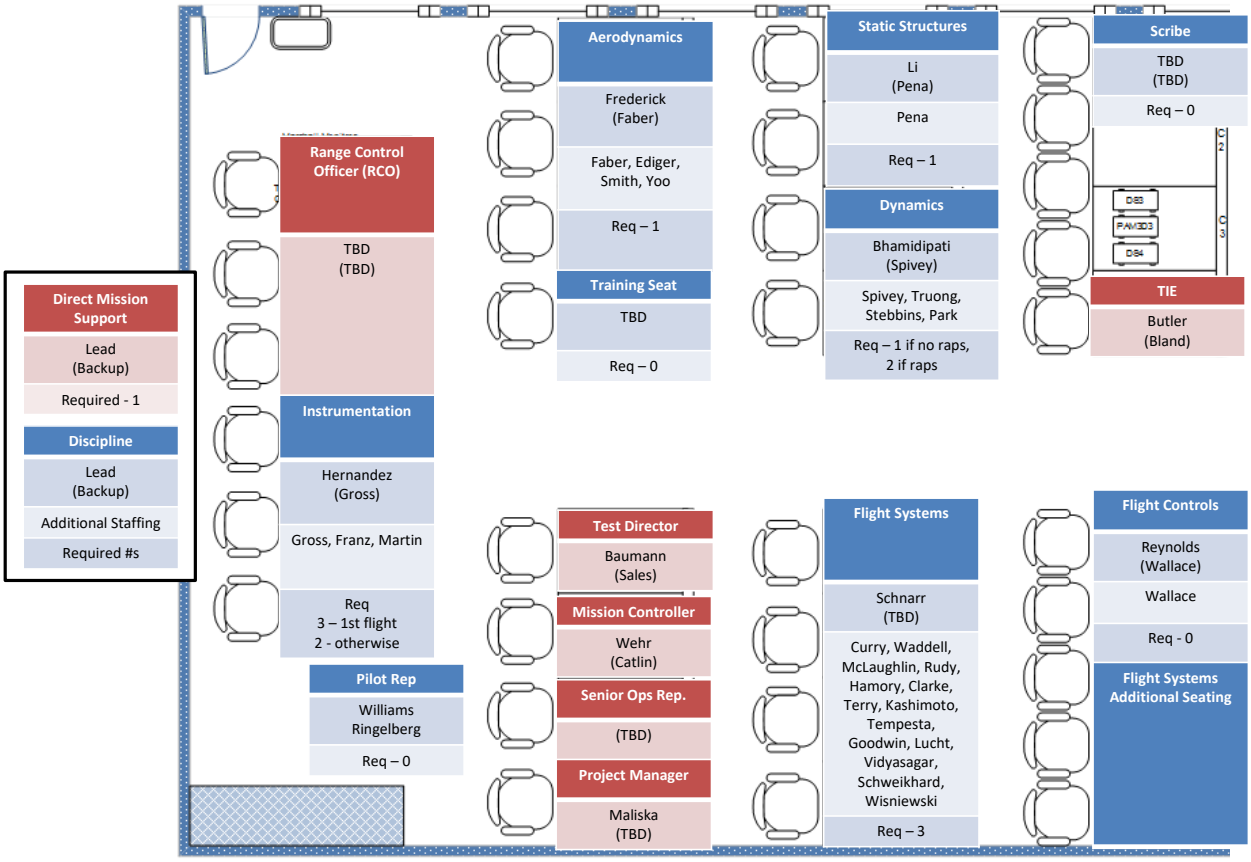

Figure 2: Nominal X-57 Mod II MCC1 Staffing Plan

6.2 Control Room Training Plan

In order to prepare the team for the Mod II flights, there will be a number of full-test team and discipline level training exercises.

6.2.1 Full-Test Team Control Room Training Exercises

Prior to the first Mod II flight, the team will conduct training for the test team. The training activities are listed and summarized below in the approximate order of execution.

1. Test Planning Working Group (TPWG) Discussions
    - Roundtable Discussion of Emergency Procedures (EPs)
    - Discussion of Mission Operations Plan (MOP)
        - Review of Mission Rules
        - Review of Comm Plan
        - Review of Aircraft, Meteorological, Traction System Operating Limits

    - Discussion of Go/No-Gos
2. System Safety Working Group (SSWG) Discussions
    - In-depth review of the Mod II Flight Test Hazards by the test team
3. Mission & EP Simulation in the control room
    - Test team will step through the day-of-flight and flight cards as they would in a nominal mission.
    - The mission walk-thru will be repeated several times with simulated Eps for the team to react to. The System Safety Lead will hand out EP scenario cards and the control room team will work through the various scenarios
    - The Mission & EP Simulations will be conducted at least twice and as needed until the Mission Controller, Test Director, Project Manager, and System Safety Lead agree that the test team is ready for flight.
4. Combined System Test (CST)
    - The CST will be an opportunity for the team to gain experience executing the day-of-flight and low-speed taxi test cards.
5. Taxi Tests
    - The Taxi Tests will be an opportunity for the team to gain experience conducting a test operation.

The X-57 Lead Operations Engineer will maintain a training log for control room personnel.

6.2.2 Discipline Specific Control Room Training Requirements

Discipline specific training plans are required and will be briefed at FRR. The discipline specific training plans will ensure all personnel who sit in the control room are familiar with the following:

- control room displays
- discipline specific Go/No-Gos (GNGs), understands the GNG rationale, understands how to monitor the GNG parameters, and when safety related calls are needed based on the SF/ST GNGs
- discipline data objectives and what needs to be monitored during each flight/maneuver
- comm. plan
- day-of-flight and flight cards

The discipline lead and their backup are expected to have a complete level of understanding of the above topics. This understanding will be demonstrated during the test team training exercises and will be assessed by the Mission Controller and Test Director. The discipline engineers are expected to be familiar enough with the above topics to support the discipline lead.

6.2.3 Minimum Training Requirements

Project members with defined control room roles are required to meet minimum training requirements outlined in Table 1. These training sessions are designed to familiarize personnel with displays, culture, communication protocols, and mishap plans used during flight tests. Personnel who miss training events will complete equivalent training as deemed appropriate by the Chief Engineer, Lead Operations Engineer, and applicable Lead Discipline Engineer.

	Control Room Position			
Training Event*	**Mission Controller**	**Test Director**	**Discipline Lead**	**Discipline Support**
Previous Control Room Experience	Certified Mission Controller or Trainee with a Certified Backup AFOP-7900.3-029	Previous Experience as a Test Director	Serves as Project discipline technical lead Previous experience desired, but not required.	Desired, but not required.
Review of Mission Operations Plan	Yes	Yes	Yes	Yes
Familiar with EPS to include at a minimum participation at EP roundtable discussions	Yes	Yes	Yes	No, but pre-briefed on specific emergency calls they are responsible for
Familiar with Go/No-Go Parameter List	Yes	Yes	Yes and familiar with specific locations of all Go-no-Go parameters on discipline real-time displays	No, but cognizant of the Go/No-Gos assigned for monitoring by the lead
Familiar with Project Hazards	Yes	Yes	Yes	No, but cognizant of discipline specific hazards.
Mission & EP Simulations in the Control Room	Yes	Yes	Yes	Participation in at least 1 event.
Combined System Test	Yes	Yes	Yes	Yes
Taxi Tests	Yes	Yes	Yes, if required for test support.**	Yes, if required for test support.**
Crew Brief for each flight	Yes	Yes	Yes, if required for test support.**	Yes, if required for test support.**
Familiar with X-57 Mishap Preparedness and Contingency Plan (MPCP) (MPCP-CEPT-001)	Yes	Yes	No	No
Familiar with Dryden Aeronautical Test Range (DATR) Incident Response (AFOP-8715.5-002)	Yes	Yes	No	No
Familiar with Center Mishap Preparedness and Contingency Plan (AFPL-8621.1-001)	Yes	No	No	No
Approval Authority	430 Branch Chief	430 Branch Chief 510 Branch Chief	Branch Chief OE Lead Chief Engineer	Branch Chief Discipline Lead Chief Engineer

*Deviation from training requirements must be approved by the Project OE Lead, Chief Engineer, and the Approval Authority
**Back briefing of discipline lead and team members may be allowed at the discretion of the Mission Controller and Test Director

Table 1: Project Personnel Control Room Training Requirements

7 Deleted X-57 Mission Rules

None

Appendix A: Mission Rule Summary Table

Flight Mission Rule Summary	
#	Mission Rule Summary
1	Control Room Support is required.
2	Safety Chase is required for all flights.
3	SF, ST, and MC shall be continuously monitored.
4	Aircraft, Meteorological, and Traction System Operating Limits shall be followed. If exceeded, a knock-it-off call shall be made.
5	Communication required between all elements of the test team.
6	Data TM required.
7	On-board Data Recorder failure allowed if TM is confirmed.
8	After yawing maneuvers that produce a buildup of aircraft sideslip, except 2-1-1's and doublets, the rudder pedal input shall not be released abruptly. It should be released in a slow and controlled manner.
9	Maneuvers requiring rudder pedal input of alternating directions, including 2-1-1's and doublets, are allowed only with control room monitoring of the estimated force on the vertical tail.
10	Changes to Control Room Displays are not permitted during a mission other than to change colors, and strip-chart speeds.
11	The prop pitch control levers shall not be set above 2,250 RPM at: traction bus voltages below 425V while at idle power settings or below 350V while at full power settings.

Appendix B: Mission Limit Summary Table

Aircraft Operating Limits - (All numbers assume 3,000 lb. takeoff weight)		
Limit	**Value**	**Description**
Altitude	14,000 ft.	Maximum allowable flight altitude.
Symetric Flight Nz (Flaps Retracted)	2.4 / -1.29g	Maximum and minimum allowable symmetric g limits with flaps retracted.
Asymmetric Flight Nz (Flaps Retracted)	2.1 / -1.29g	Maximum and minimum allowable asymmetric g limits with flaps retracted.
Flight Nz with Any Flaps Extended	1.7 / 0.0g	Maximum and minimum allowable g limits with any flap extension.
Landing Load (G)	2	Maximum allowable landing load.
Landing Sink Rate	7 ft/sec	Maximum allowable landing sink rate.
TGW	3,000 lb	Maximum allowable takeoff gross weight.
CG Forward Limit	0.221 m (16.5% MAC)	Forward CG Limit
CG Aft Limit	0.415 m (31% MAC)	Aft CG Limit
Vertical Tail Load	623 lbf Design Limit (DL) 560.7 lbf Inspection Limit (IL) 498 lbf (KIOL) Knock-it-off Limit	Vertical tail load Design Limit
Bank Angle	60°	Bank Angle Limit
Meteorological Limits		
Limit	**Value**	**Description**
Allowable Crosswind	14.5	Maximum allowable landing crosswind.
Maximum Takeoff Ground Temperature	34.5 C (94 F)	Maximum Takeoff Ground Temperature
Minimum Takeoff Ground Temperature	-16 C (3 F)	Minimum Takeoff Ground Temperature
Flight in expected and/or known icing conditions, in proximity of storms or in turbulence is forbidden.		
No flight through visible moisture.		
Day VFR Operations Only		
No flight in conditions of greater than light turbulence		
Traction System Limits		
Description	**Minimum Value**	**Maximum Value**
Battery Pack Voltage	Yellow: 350 VDC Red: 320 VDC	537.6
Battery Cell Temperature - Average	N/A	Yellow: 60 C Red: 65 C
Battery Cell Temperature - Maximum	N/A	Yellow: 60 C Red: 65 C
Battery Cell Voltage - Maximum	Yellow - 2.8 Red - 2.5	4.2
Battery Cell Voltage - Minimum	Yellow - 2.8 Red - 2.5	4.2
Battery System Isolation Status	Asserted	
Battery System Master Fault	Asserted	
Cruise Motor Winding Temperatures	N/A	Yellow: 124 C Red: 135 C
Cruise Motor Bearing Temperatures	N/A	Yellow: 89 C Red: 99 C
Cruise Motor Controller Temperature - MOSFET	N/A	Yellow: 123 C Red: 134 C
Cruise Motor Controller Temperature - FPGA	N/A	Yellow: 89 C Red 100 C
Cruise Motor Controller - Master Fault	Asserted	
Cruise Motor Controller Temperature - Driver Board	N/A	Yellow: 89 C Red 100 C
Cruise Motor Controller Temperature - Vicor Power Supply	N/A	Yellow: 74 C Red: 85 C
Cruise Motor Controller Temperature - CPU Board	N/A	Yellow: 74 C Red: 85 C
Avionics Bus Current	N/A	Yellow: 65 A Red: 70 A
Avionics Bus Voltage	11.5 V	14.6 V
Traction Bus Current	N/A	Yellow: 100 A Red: 150 A
Traction Bus Voltage	Yellow: 350 Red: 320	537.6