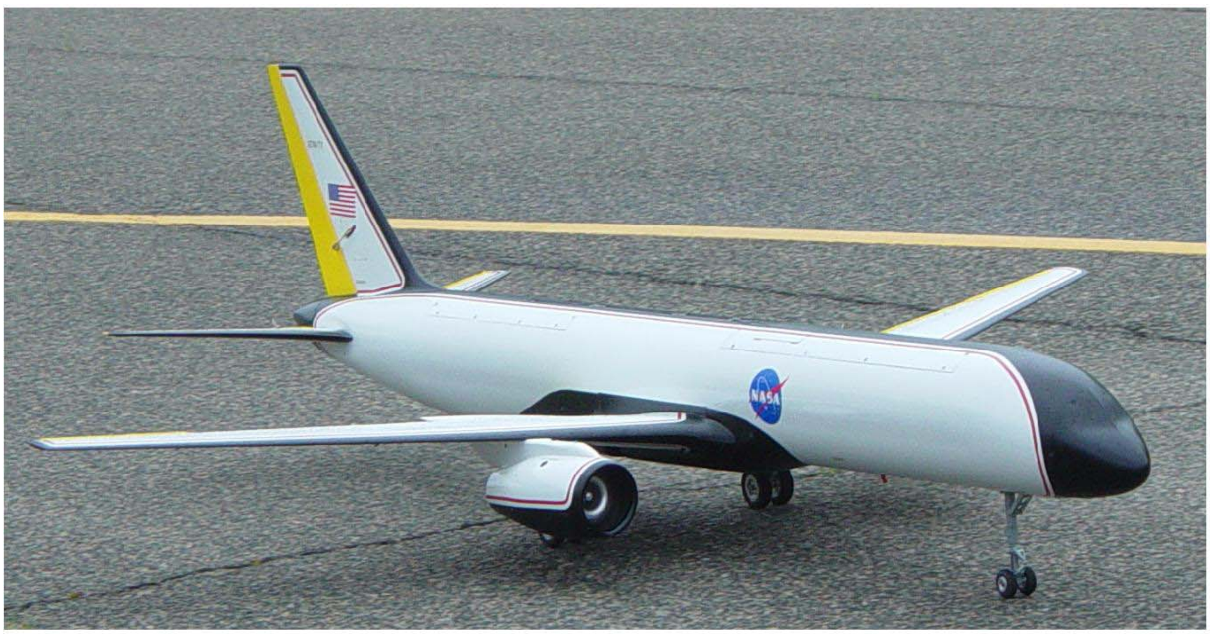
# Generic Transport Sub-Scale Model Project

GTMP-2001

# Safety Procedures



(b) (6) [redacted] — Date

Safety Officer

REVIEWED:

(b) (6) [redacted] — Date

Chief Engineer

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Program Office — Date

APPROVED:

(b) (6) [redacted] — Date

Project Manager

OSEMA — Date

Chairman ASRB — Date

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# Generic Transport Model Project

# INDEX

## APPLICABILITY

**All personnel working on or involved with this project shall read these safety procedures. Those that continue with the project shall periodically review these procedures to assure continued compliance in safe ground and flight operations.**

### Updating of Procedures

These procedures shall be updated as the fabrication, flying and knowledge of unmanned, remotely controlled, turbine powered, science gathering sub-scale aircraft develops.

The procedures and check-off lists compiled here strive to maintain a safe working environment so that the associated risk is eliminated or mitigated to the lowest possible level. Understanding that this is the objective, please contact the Safety Officer, the Chief Engineer or the Project Manager listed on the coversheet with improvements or recommendations associated with the safety of this project.

## Purpose

The objective of this procedure is to set forth general guidelines and instructions for the safe design, fabrication and flying of turbine powered sub-scaled aircraft. In this process, potential problems or situations were identified that could create a hazard to the public, project personnel, the sub-scaled aircraft, the environment, the facility or the surrounding area.

Each possible flight site will have its own regulations and controlled flight area. This procedure will set in place a process to insure that the Project is in compliance with these restrictions and regulations.

These procedures no matter how detailed or complete cannot replace the need for good sound judgment. Good sound judgment is not easy to define but extremely obvious when it is lacking. Using good judgment shall not be compromised for any reason. Personnel safety shall be the most important consideration when making decisions. Only through the efforts of everyone can the Project maintain a safe and injury free productive project.

The Academy of Model Aeronautics (AMA) is the official national organization for model aviation in the United States. All applicable guidelines from the AMA National Aircraft Safety Code are incorporated in this procedure. Safety information from the turbine engine manufacture and other equipment manufactures supplying items integrated into this project are also incorporated in this procedure. Applicable NASA and government safety standards dictate certain criteria and are referenced in this document.

While many similarities exist between this sub-scale aircraft and standard RC or UAV models, there are many differences. The number of actuated surfaces, dynamically scaling, the ability to transmit data and the science gathering equipment create a unique sub-scaled aircraft. These characteristics create an increased complexity and the need for combining the procedures from the groups listed above, but become useless if not properly implemented. The team members of this project are responsible for abiding by and carrying out all safety procedures.

## 1.0 Design Safety Features and Issues

### 1.1 Redundant Batteries and Wiring

The sub-scale aircraft is designed with dual batteries, each capable of providing sufficient power for the operation of all controls during normal flight.

Each main battery will provide the power required in normal operation for about one hour while the duration of each flight test is expected to be approximately 10 minutes. Each battery will power half of the controlled functions as explained in Section 1.2.

An integrated sensor will automatically monitor each battery. Should either battery reach a low voltage condition the landing gear will automatically deploy indicating to the pilot a low battery situation. The pilots shall immediately land the aircraft if the landing gear deploys. The sensor will also cause all controls to be powered by the healthy battery. The proper responses to mechanical or power failures are covered by document GTMP-2030 Emergency Procedures.

Wiring is sized to meet the maximum amperage load and to minimize the risk of onboard fires due to wire failure.

It is the Project's intent to produce a robust electrical system capable of overcoming the battery failure modes that are sometimes found in similar types of aircraft. Using the landing gear to indicate a low battery, dual batteries and implementing the battery charging and maintenance schedule explained in Section 3.4, the chance of losing the aircraft due to battery failure will be greatly reduced.

### 1.2 Control Surfaces Divided

The sub-scale aircraft control surfaces are divided so that half are run off one battery and half off the other. For example, inboard flaps (right and left) on one battery and outboard flaps (right and left) on the other. The engines will also be divided so the right side is operating off one battery and the left off the other battery. If all functions were pulling from both batteries at the same time, a single dead short could drain both batteries without the pilot realizing what was happening until it was to late. By dividing the functions into two groups a single short will not create a major failure.

### 1.3 Approved Radio Frequencies

(b) (6) [redacted] NASA Langley's Spectrum Manager has approved all radio frequencies used in conjunction with this aircraft as listed below:

Radio Frequency Authorization Serial Number NASA000304 for frequency 2240.5 MHz. This authorization must be updated by January 8, 2006. For continued use the request must be submitted to the Frequency Manager by October 10, 2005.

Radio Frequency Authorization Serial Number NASA900123 for frequency 1835.5 MHz. This authorization must be updated by December 18, 2006. For continued use the request must be submitted to the Frequency Manager by September 19, 2006.

Radio Frequency Authorization Serial Number NASA020008 for frequency 72.008-72.998 MHz, for Hampton, VA. This authorization must be updated by June 6, 2007. For continued use the request must be submitted to the Frequency Manager by March 8, 2007.

Radio Frequency Authorization Serial Number NASA020009 for frequency 72.008-72.998 MHz, for Wallops Island, VA. This authorization must be updated by June 6, 2007. For continued use the request must be submitted to the Frequency Manager by March 8, 2007.

Pilot training for turbine-powered aircraft will be conducted at Fentress Naval Auxiliary Landing Field and Wallops Flight Facility. All high risk testing and research will be conducted at Wallops Flight Facility. Each of these sites has approved the frequencies that are being used for up and down link controls and data gathering.

### 1.4 Flight Termination System (FTS)

This sub-scale aircraft is not limited to just one type of flight termination system but has several methodologies available. This was done by design because there are ***<u>at least 6</u>*** different categories that would dictate flight termination.

- Engine Failure or fuel fire
- Battery Failure or electrical fire
- Loss of Control Signal
- Aircraft spin or stall
- Danger to the crew, the public or the facility
- Failure of one or more critical control surfaces

The best course of flight termination is at least partially dictated by the reason for activating the FTS. A series of tests were performed analyzing the effect of loss of control signal and a loss of power for each component. These tests aided in developing the proper response to each type of failure. See Section 9.0 for a list of equipment tested.

### 1.4.1 Engine Emergency Shut Down

The sub-scale aircraft will be outfitted with an engine emergency shut down switch. This switch will be quickly and easily accessible by the pilot and the co-pilot on their respective transmitters. This will reduce the potential energy, reduce the engine temperature and limits the area of risk associated with flight termination should it be required.

Pilots will be trained in the location and actuation of the engine emergency shut down switch so it can be quickly engaged.

To prevent the sub-scale aircraft from flying away should the engine loose its control signal, the engines are programmed to go to the idle position upon loss of control signal. In the event the control signal is interrupted for a short period of time the pilot can regain control and land the aircraft safely. See Section 1.4.3 for additional information on loss of control signal.

### 1.4.2 Flip Recovery Tail

The “Flip Recovery Tail” when activated has been proven to cause the sub-scale aircraft to fall in an almost vertical direction. This function also returns the sub-scale aircraft to an orientation suitable for flight recovery. Once the desired orientation is achieved, the “Flip Recovery Tail” is returned to its normal flight position. The pilot will then be able to resume flight and subsequently land the sub-scale aircraft.
Should the sub-scale aircraft not be able to fly due to some other condition this will allow the Project to control the area in which the vehicle will be brought down. This also limits the risk to flight crew, observers, the facility and the public. For additional Emergency Procedures see document GTMP-2030.

### 1.4.3 Control Hard Over Default

The control surface actuation servos are pre-programmed to a “Hard Over” default position if control signal is lost. Should a condition occur where the sub-scale aircraft is not responding because the control signal is interrupted, the preprogrammed default positions will cause the sub-scale aircraft to come down in a tight spiral. Just as the Flip Recovery Tail limits the areas of risk so does the “Hard Over” default.

It was proven in bench testing, that if the control signal between the transmitter and receiver is restored prior to the sub-scale aircraft reaching the ground, the pilot can regain control of the aircraft. This is advantageous for at least two failure modes. First, a short loss of control signal (1-3 seconds) will not cause major damage to the aircraft. The second scenario, a backup transmitter shall be ready for use and if a total transmitter failure should occur, the first transmitter will be turned off and the backup turned on. This will allow the pilot to regain control of the aircraft and bring the aircraft down in a safe controlled manner. Precautions for the backup transmitters are covered in Section 3.6.

### 1.4.4 Combinations

Using combinations of these safety design features will provide the very best chance of recovering the aircraft in the case of an emergency. At the same time providing a reliable method of immediate flight termination regardless of the circumstances or component failures. The pilot must be trained to quickly recognize flight characteristics that indicate a problem. Accurately identifying emergency conditions and applying the proper response in a timely fashion provides the Project's best chance to minimize the associated risk. Emergency Procedures are detailed in document GTMP-2030.

## 1.5 Pilot and Co-Pilot

Each flight will require a pilot and a co-pilot to fly the sub-scaled aircraft. This will require the people designated for these positions to work in tandem during flight operations. The pilot will have all the main controls for flying the aircraft and the co-pilot will have the support functions with some control surfaces actuation. Controllers used by both pilot and co-pilot will be capable of actuating a flight termination system. There will be a backup or secondary controller for the pilot and the co-pilot.

Terminology used in communication shall be developed and implemented through practice prior to test-flights taking place. The pilot shall be in charge of the flight and shall always have authority to cancel a test flight for safety reasons.

## 1.6 Locking Landing Gear and Brakes

The landing gear is powered by a compressed air system and actuated by an electrically powered servo. When fully extended or retracted, the main landing gear has a mechanical lock that automatically holds it in place. When the nose landing gear is extended an over center design causes it to lock in place. When the nose gear is retracted a spring loaded clamp holds the gear in place. Once the main and nose gear are locked in position no air pressure is required to hold the gear in the extended or retracted position.

The brakes are also powered by the compressed air system and actuated by an electrically powered servo. The brakes are capable of holding the sub-scale aircraft in a stationary position with both engines in the idle position. The brakes will also be used after landing to reduce ground speed and bring the sub-scale aircraft to a complete stop.

There is an on board pressure gage that is easily visible by the ground crew for quick verification of air pressure.

Hose restraints shall be applied to all air connections to minimize the risk of an airline vibrating loose.

The air system has a sufficient reserve to actuate the landing gear and brakes five times without failure and shall be fully charged prior to each takeoff.

### 1.7 Aircraft Markings

The paint scheme that was developed had a two-fold purpose. The first was to allow the pilot to quickly recognize specific facts about the heading and attitude of the aircraft.

Second, a remote tracking station shall be incorporated to verify the position of the sub-scale aircraft.

## 2.0 Personnel Safety

A Pre-Flight Briefing shall be conducted prior to each flight test to inform all participating personnel of the planned testing for the sub-scaled aircraft and the potential hazards. All personnel involved in testing shall review this safety document prior to the day of flight. The briefing shall include a short review of safety and emergency procedures listed in this manual.

Each facility will have its own Standard Operating and Safety Procedures that must be reviewed. The Safety Officer will review facility safety requirements and brief personnel on additional safety requirements not covered in this document. These items shall be recorded and added as an addendum for each test facility.

Items provided for personnel safety shall be located in the general location of sub-scale aircraft maintenance and flight preparation area. A Material Safety Data Sheet (MSDS) for fuel and any other items required for maintenance and operation must be posted in this same area. The Safety Officer is responsible for assuring the test flight team meets and observes these criteria.

While the safety of the aircraft, the facility and the environment are extremely important, the safety of people associated with the project and those not associated with this project shall have precedence over all other issues.

### 2.1 Eye Protection

The turbine engines and the leaf blowers tend to make airborne all loose debris. All leaf blower operators must wear eye protection. Eye protection must be worn by all crewmembers that are within 25 feet of the aircraft when engines are running.

When dealing with liquids such as kerosene there is always a potential for splashing creating a hazard to eyes and skin. Those involved in fueling of the aircraft and the handling of kerosene or gasoline shall wear eye protection. Those involved in this activity shall be aware of the nearest eyewash facility and equipment.

Pilots and crewmembers associated with aircraft flight tracking shall be aware of sun conditions and position. Sunglasses shall be available and worn when appropriate.

### 2.2 Hearing protection

There is a great deal of noise associated with turbine engines. Ear protection shall be worn by all crewmembers when engines are running. Personnel performing required activities in the area when engines are running shall wear approved hearing protection with a Noise Reduction Rating (NRR) of 19dB or higher. This level of protection can easily be accomplished with either earplugs (29 dB) or earmuff-type protection (21 dB). Those involved directly with engine startup and operation on the ground are encouraged to use a combination of earplugs and earmuffs for greater protection.
If available, ground crew shall use ear protection with built-in microphones and speakers. By increasing the ability of the crewmembers to effectively communicate, hazards associated with miscommunication can be avoided. The difficulty in communication is one reason nonessential personnel shall be restricted from the designated engine startup, taxi and flight areas when starting and running engines.

### 2.3 Protective Gloves and Clothing

Gloves and aprons shall be available. It is strongly recommended personnel involved with the handling of kerosene and gasoline use these protective items.

Those crewmembers involved with engine starting or with the aircraft after engines are started shall follow these guidelines

- All loose objects that could fall out of pockets shall be removed prior to engine startup.

- Do not wear clothing that could be pulled into the turbine engine intake.

- Remove badges, jewelry, pens, pencils or other items that could come off and be sucked up be the turbine engine intake.

- Safety glasses will be restrained so they cannot fall off.

## 2.4 Fuel and Other Hazardous Chemicals

The turbine engines run on a ratio of 20 to 1 mixture of kerosene (K1) and turbine engine oil respectively. Fuel shall be kept in a metal container intended for kerosene use, which has blue markings. Each container shall be clearly marked as Kerosene/Oil Mixture. Stored kerosene fuel shall be kept at a safe distance from turbine engines during engine start up and operation. Kerosene containers shall be maintained in good condition at all times. Proper storage is required to insure kerosene will be safely transported to and from the test site.

Personnel involved with fuel mixing, handling and the aircraft fueling process shall wear personnel protective equipment (eye protection, gloves, apron or lab coat).

Propane is used in the start sequence for the turbine engines, however a minimum distance of two feet shall be maintained between turbine engines and propane containers. Do not place container behind the turbine engines or in the exhaust area. After starting the engines propane containers shall be relocated to a designated storage location at least twenty-five feet away prior to the aircraft moving. Propane containers shall be maintained in good condition at all times. Proper storage is required to insure propane will be safely transported to and from the test site.

High volume, high velocity forced air generators (leaf blowers) and/or compressed air shall be used in the turbine engine startup process. A 40 to 1 gasoline and two-cycle engine oil shall be used as fuel for the leaf blowers. Gasoline fuel shall be kept in a metal container intended for gasoline use, which is red in color. Each container shall be clearly marked as Gasoline/Oil Mixture. Stored gasoline fuel shall be kept at a safe distance of at least twenty-five feet away from turbine engines during engine start up and operation. Gasoline containers shall be maintained in good condition at all times. Proper storage is required to insure gasoline will be safely transported to and from the test site.

Material Safety Data Sheets shall be maintained for all the fuels and oils listed in this section. They will be kept in a bright yellow binder that is properly labeled and readily available at all times.

## 2.5 Batteries

There is always a potential for a fire when there is a combustible material in the same area as an ignition source. Fuel filling and battery charging shall be separated in space and time to avoid this potential hazard.

Battery acid from damaged or corroded batteries can create a hazardous condition for all personnel and equipment. Batteries shall be handled and stored properly to avoid damage. Should batteries become old, damaged or corroded they shall be properly disposed of in accordance with LAPG 8800.1 Chapter 5.

The battery health shall be monitored during charging. A ground station continually monitors the batteries until aircraft is ready to takeoff.

For additional battery information see Section 3.4.

**2.6 Fire Extinguishers**

There are several areas of consideration in choosing the proper fire extinguishers needed in the event of a fire. The sub-scale aircraft itself is obvious but just an important is the possibility of a grass or brush fire.

Two CO2 fire extinguishers shall be on hand and all personnel shall be trained in their use. One designated person shall stand by as a fire watch and man the fire extinguisher during fueling and engine startup. During all other operations fire extinguishers shall be made readily accessible to all personnel in the event there is a fire on the aircraft.

In case of a grass or brush fires a water fire extinguisher is required. It shall be kept readily available and all personnel shall be trained in its use. These portable type fire extinguishers shall have a 5-gallon capacity and pressurized by a hand pump. The 5-gallon containers require someone in reasonably good physical condition to get it to the fire site quickly. This type fire extinguisher is used by professional firefighters during controlled burns. To make this equipment more effective fighting fires an additive called “Drench” will be added to the water. Two ounces of “Drench” shall be added to the 5gallon tank, this will increase the penetration of the water by 400% and vaporization will takes place twice as fast.

“Drench in its diluted state creates very little hazard to personnel. Large quantities in its concentrated state can cause vomiting, abdominal pain, skin irritation or respiratory irritation. A Material Safety Data Sheet shall be maintained for “Drench”. It shall be kept in a bright yellow binder that is properly labeled and readily available at all times.

For additional information on fire extinguishers see Section 6.1.

**2.7 Safety Barrier**

Barriers shall be required protecting the length of the inhabited area of the flight line, maintenance area, engine startup area and observer area.

The safety barrier shall be a minimum of three feet high with supports spaced no more than twenty feet apart. (See Sect. 4.8)

## 3.0 Vehicle Safety

In addition to items listed in this section see section 10.0 for a listing of items that must be reviewed and signed off on before and after each flight. A qualified pilot shall be involved in the sub-scaled aircraft inspection and checkout.

All sub-scaled aircraft or models flown and/or tested in the Generic Transport Model (GTM) project that were designed and/or fabricated outside of NASA Langley shall meet current AMA safety regulations and guidelines for turbine and non-turbine vehicles. These vehicles shall be inspected to insure compliance with all applicable AMA requirements.

No work shall be performed on the model unless all aircraft logbooks are properly filled out. All work performed shall be approved and signed off by the Chief Engineer and person or persons performing maintenance, repairs or changes.

To comply with the dynamically scaling requirements of the sub-scaled aircraft a maximum weight of 55 pounds was calculated. The calculated weight includes airframe, batteries, receivers, transmitters, actuators, paint, fuel, ballasting material and all science gathering equipment ready for flight. The center of gravity (CG) must be checked and ballasting applied or equipment relocated to achieve proper CG location. The CG of the sub-scaled aircraft shall be verified with no more than 4 ounces of fuel. The CG location shall be 48.575 inches aft of the fuselage nose, which is engineering model station 57.3.

A tri-filar will be used to determine actual inertia values. These values shall be at a minimum for the initial flights to enhance responsiveness and easier control during initial flights. The inertias will be gradually changed to more accurately reflect the desired scaled inertias. This increase will cause the sub-scaled vehicle to react more sluggishly to pilot commands. Pilots shall always be made aware of any change that could affect the control and handling characteristics.

There shall be a pre-flight briefing of all crewmembers. This briefing shall review safety procedures, the testing plan, each crewmembers responsibilities and regulations of the test flight facility.

There shall be a post-flight safety briefing of all crewmembers within a week of the testing and prior to the next test. The test shall be reviewed for safety compliance, flight plan conformance, procedure improvements, vehicle handling, pilot control, problems incurred, required improvements and suggestions.

There shall be a post flight review held by those responsible for data or science gathering and research. Each flight will be evaluated and when needed recommendations shall be made for desired changes. These changes will be incorporated prior to the next test flight whenever possible.

## 3.1 Ground and Taxi Testing

Ground testing that includes low and high speed taxing of the sub-scale aircraft shall be performed, prior to airworthiness flight-testing. This test will verify the vehicle is capable of being controlled and maneuvered by the pilot and/or the co-pilot's transmitter in a confined area on the ground. Precautions shall be taken to ensure there is no potential for the sub-scale aircraft to become airborne.

The aircraft shall not become airborne at any time during this test, but all safety procedures detailed in this document shall be implemented to provide a minimum risk. Appropriate operational procedures shall be followed and checklist filled out simulating the planned sequence for the first flight.

Testing shall be limited to an approved list of maneuvers developed and documented with the objective of preparing the sub-scale aircraft and the pilots for the Airworthiness Test. This document shall be referred to, as Ground and Taxi Testing Plan document number GTMP-8001.

Proper documentation of this test shall be recorded in the aircraft flight log. All safety related incidents must be included in the test report.

A long-range test for the transmitter and receiver shall be required in this test.

The pilots and safety officer shall develop detailed Ground Operations and Taxi Test Procedures. The Chief Engineer shall certify that the sub-scaled vehicle has met all criteria established for Ground Operations and Taxi Test.
Ground Operations and Taxi Test must be complete and certified by the Chief Engineer prior to the start of Airworthiness Testing.

A safety barrier shall be installed to completely enclose the test area. The safety barrier shall meet specification as described in Section 2.7.

This process of testing shall be repeated prior to flight-testing if major structural or configuration changes are made to the sub-scale aircraft.

## 3.2 All Flight Testing

The initial flights for the sub-scale aircraft shall be conducted to determine airworthiness.

The safety procedures detailed in this document shall be implemented to provide a minimum risk. To enhance our risk mitigation effort, only essential personnel shall be involved until the sub-scale aircraft has been certified as airworthy.

Testing shall be limited to an approved list of maneuvers developed and documented to demonstrate the pilot's ability to control the sub-scale aircraft. This document shall be referred to as Airworthiness Test Plan document number GTMP-8003.

Proper documentation of this test shall be recorded in the aircraft flight log. All safety related incidents must be reported and included in the test report.

Airworthiness Testing Procedures shall include but are not limited to:
- Number of flights planned (minimum of four)
- Duration of each flight (one flight will demonstrate maximum planned flight-time
- Maximum altitude (400 feet recommended for first flight)
- Safe take-off and Landing
- Capable of staying within the designated fly zone

Detailed Airworthiness Test Procedures shall be developed in conjunction with Wallops Management and Safety personnel. The Chief Engineer shall certify that the sub-scaled vehicle has met all criteria established for airworthiness. Airworthiness Testing must be complete and certified by the Chief Engineer prior to any other flight-testing.

The testing process shall be repeated prior to other flight-testing if major structural or configuration changes are made to the sub-scale aircraft.

All testing shall follow a similar outline to that of the Airworthiness test, providing as much detail as needed to define the planned testing. When planning flight test be aware of the sun location and plan maneuvers above, below or to the side of a bright sun.
Testing shall be at an approved location where access is limited and there shall only be one aircraft in the Safe Fly Zone at any time. The Safe Fly Zone shall be determined prior to testing and the sub-scale aircraft shall not leave this area.

The flight logbooks must keep record of but not limited to:
- Vehicle preflight inspection
- Ground activity and time
- Engine start and shutdown time
- Takeoff
- Flight activity and time
- Landing
- Vehicle post flight inspection
- Weather conditions
- Accomplishments
- Problems
- Anything unusual or things that need to be investigated

- Aircraft handling characteristics
- Safety issues

### 3.3 Fuel Tanks and Fuel Filling

Prior to the start of the fueling process fire extinguishers and other safety equipment shall be in place as described in Sections 2.6 and 6.1.
A manual fuel shutoff valve is located on the aircraft and used to shut fuel off to the turbine engines during the fueling process. This valve must be in the off or closed position prior to the filling of fuel tanks and shall remain in the off position except during normal engine operation. Fuel tanks are provided with a fill port and vent or overflow port. The vent or overflow port shall be plugged at all times except when filling fuel tanks. When tanks are being filled the overflow port shall be connected to a fuel overflow tank. As tanks are filled the excess or overflow shall collect in the overflow tanks, at this point the fueling process will end and lines shall be plugged.

To prevent the possible collection of fuel in areas around the fuel tanks, fill port or overflow port, small holes are drilled in the fuselage to allow drainage. An inspection shall be made to verify no fuel has accumulated in these areas after fueling.

Fuel shall conform to specifications as described in Sect. 2.3.

There is a procedure used for shutting down the engines under normal situations. Should an emergency arise this procedure can be bypassed and the engines shutdown immediately. A three-position switch controls the engines; the positions are off, shutdown and run. To immediately shut-off fuel to the engine the switch shall be turned to the off position.

### 3.4 Batteries and Battery Charging

Each main battery is a rechargeable Ni-Cad type with 7.2 and or 6.0 Volt output and 2200 MAH. Batteries that are damaged or no longer useable shall be disposed of in accordance with LAPG 8800.1 chapter 5.

With the improvements that have been made in R/C equipment, a component failure that causes an aircraft model to crash has been almost eliminated. The most common problem that remains is battery failure, which is generally due to the lack of charging or improper charging. To insure the batteries are properly charged a Ground Support System shall be in place that will monitor the sub-scale aircraft batteries while the aircraft is on the ground. This system shall be capable of monitoring the batteries and testing for the following:
**Battery Maintenance Charging**
- Monitor Battery Voltage
- Monitor Charge Current
- Monitor Battery Temperature

**Battery Maintenance Discharging**
- Monitor Battery Voltage
- Monitor Discharge Current
- Monitor Battery Temperature
- Display Discharge Time History, battery capacity and status

**Model Electrical System Prior to Flight**
- Energize all Systems externally
- Checkout flight systems 1 & 2 independently
- Monitor all critical system voltage
- Verify redundancy of system
- Verify redundancy of Engine Control Units
- Perform Internal Power Testing

With monitoring and proper charging the Project can operate knowing that all precautions have been taken to insure ample battery life for each flight.

Batteries shall be cycled (fully discharged and fully charged) once every 60 days to prevent a condition called “memory”. If a battery is only partially discharged then recharged many times, it will begin to “remember” the level it was discharged and won’t fully recharge. Some types of batteries are more susceptible to this than others. The type batteries used on this project are unlikely to have this condition occur but this precaution shall be taken. Batteries can be fully discharged with a commercial cycling unit, or by leaving the system on and exercising the servos by moving the transmitter stick. During periods of prolonged storage or non-use, (more than 60 days) the batteries may need to be replaced. To determine if an old or stored battery needs to be replaced a battery power test analyzing its charging and power output capabilities shall be performed. Batteries shall automatically be replaced if there is a ten percent or greater reduction in charging capacity or output. Batteries shall be tested prior to use in a flight test after each six hours of operation or two months of nonuse. A record of all batteries shall be kept as part of the maintenance log to insure proper maintenance and replacement.

If sub-scaled aircraft is not going to be used for a period of two months or more batteries shall be removed. Batteries shall then be cycled and stored in a controlled environment not subject to extreme heat or cold. Before batteries are used again they shall be cycled and monitored for power and capacity.

Spare batteries shall be maintained to ensure testing is not delayed because of one bad battery.

### 3.5 Compressed Air Charging

Air pressure in the accumulator tank used for braking and landing gear deployment shall be 110-PSIG minimum to 115-PSIG maximum prior to takeoff.

A check to ensure the air system is maintaining air pressure and not leaking down for a minimum of at least 15 minutes shall be made prior to each flight.

For additional air system information see Section 1.6.

### 3.6 Receivers, Transmitters and Antennas

To protect against vibration shock and temperature extremes receivers and transmitters are mounted or wrapped in foam rubber or other vibration absorbing materials. They shall also be mounted as far as possible from devices that may emit high frequency noise, such as engines; pumps, batteries and wiring that carry a heavy current load.

Power switches for receivers and transmitters are mounted in a location that is easily accessible. This location also provides a clean environment free from engine exhaust, dirt, dust, fuel or other contaminates.

Electro-magnetic interference from other components could cause problems in communications with receivers and transmitters. Proper shielding is installed where testing has proven potential problem exists. As electric engines, motors or pumps start to wear from use they can cause additional interference. Should any problems arise in the future inspect aircraft for worn parts as well as shielding.

No antenna shall be used if it has been modified in any way other than with the approval of the manufacture.

No flight shall be initiated when the communications equipment for the aircraft or the base station are damaged or in need of repair.

Approval for transmitters and operating frequencies were obtained from the appropriate agencies (see Section 1.3).
Approval for transmitters and operating frequencies shall also be obtained from the authorities governing the flight site.

A range check between the transmitters and receivers shall be accomplished demonstrating proper actuation and control of all surfaces and flight equipment. Testing shall be in accordance with checks recommended by the radio transmitter manufacture. This checklist is part of the Aircraft Pre-Flight Checklist; the document numbers for each sub-scale aircraft checklist are listed in Section 10.0.

As a precaution against a transmitter failure, there will be backup transmitters for the pilot and co-pilot. One backup transmitter will be programmed identical to the pilot's transmitter and another programmed identical to the co-pilot's transmitter. The backup transmitters will be subject to the same preflight checks and requirements as the primary transmitters. The backup transmitter will be turned off after checkout and never turned on when the primary transmitter is on. The pilot and co-pilot are the only ones authorized to turn their respective transmitters on or off during a flight test. This is covered in the Preflight Checklist designated in Section 10.4.

### 3.7 Controls and Control Surfaces

All control surfaces must be visually inspected and tested prior to each flight. Control surface flutter can cause the sub-scale aircraft to go out of control and subsequently crash. The inspection of control surfaces shall include mounting of control horns, push rods, cables, servos, linkage, connections, hinges and overall play in surfaces. All surfaces shall demonstrate sufficient rigidity to withstand loading expected in flight. An inspection of all these items is included in the Aircraft Pre-Flight and Post Flight Checklist; the document numbers for each sub-scale aircraft checklist are listed in Section 10.0.

No flight shall be initiated when there is damage or repairs needed to any of the control surfaces.

If control surfaces demonstrate erratic behavior, a battery check shall be included in the trouble shooting investigation. The number one cause of failure in the communications between a remotely powered vehicle and the ground station is battery failure. Batteries shall be fully charged prior to takeoff (see Section 3.4).

### 3.8 Check-off List

Section 10.0 has a complete listing of Check-off sheets required for all sub-scale aircraft testing.

No flight shall take place before a complete Pre-Flight inspection of the sub-scale aircraft is conducted; the document numbers for each sub-scale aircraft pre-flight checklist are listed in Section 10.4.

All appropriate check-sheet shall be reviewed for compliance and approved for flight prior to each flight. These lists were compiled from years of experience in the RC field and shall not be neglected.

All Flight Termination System components shall be scrutinized to provide the best possible assurance that in the event of an emergency the sub-scale aircraft will be brought down in the designated area.

Post flight checks are just as important as the preflight. Damage caused during take-off, flight or landing can be detected and prevent future failures. These checks shall be made and documented on Post Flight Checklist. The document numbers for each sub-scale aircraft post flight checklist are listed in Section 10.5.

### 3.9 Incident Reporting

All issues or incident reporting shall be made in accordance with Section 7.0 of this manual.

### 3.10 Engine Safety

Two turbine engines that are capable of 18 to 20 pounds of thrust each power the sub-scale aircraft. Each has its own Engine Control Unit (ECU), fuel pump, thermocouple, throttle and RPM sensor. Each engine and Engine Control Unit (ECU) is a match set from the manufacture and cannot be interchanged. Operation of turbine engines must be in accordance with manufactures recommended specifications at all times.

When priming fuel pumps and fuel lines excessive fuel can collect in the engines. Compressed air or high velocity high volume forced air generators (leaf blowers) will be used to purge fuel from turbines prior to starting. Turbine engines create an increased hazard from lose debris; precautions shall be taken to minimize this hazard. (See Section 4.4)

When not in use covers shall be placed over the inlet and exhaust to prevent FOD (foreign object debris) from collecting in the engine compartment.

#### 3.10.1 Engine Starting

When starting turbine engines the aircraft shall be turned into the wind. This will help carry combustible products out the engine exhaust. Pointing the aircraft into the wind can make the engine start easier since the wind is not trying to blow fuel out the front of the engine.

Care must be taken when starting an engine to insure the exhaust is not pointed at personnel or combustible materials. Before starting engine, crewmembers and observers shall be assigned specific stations. No one shall be allowed behind the aircraft. Those involved in startup shall be instructed to keep all foreign objects away from rotating turbine blades. This will include fingers, badges, pens, pencils and loose clothing.

Before starting engines, remove loose objects or debris that could be blown around or create a hazard to personnel or equipment. Turbine engines at full throttle can ingest gravel and other debris. To minimize this potential a site inspection and clean up shall be made in accordance with Section 4.4 of this manual.

Observers and all personnel non-essential to the starting process shall be at least 40 feet from the turbines when starting and operating as recommended by the engine manufacture. If this is not available at a particular test site 25 feet shall be set as an absolute minimum safety boundary.

The turbine engines produce about 1 pound of thrust at idle and will cycle to full throttle during startup. This amount of thrust will cause the aircraft to move if no restraining devise is applied. Prior to starting the engines the sub-scale aircraft shall be restrained with wheel chocks or other device to ensure the vehicle remains stationary. Brakes shall be tested and operational to provide a positive lock when wheel chocks or other restraining devise is removed prior to takeoff.

There is a fuel shut off valve that must be turned to the on position just prior to starting the engines.

When starting engine use the engine startup checks, which are part of the Pre-Flight Checklist. The document numbers for each sub-scale aircraft checklist are listed in Section 10.0. Strict visual attention shall be given to the engines, with the intent of detecting any abnormality that could indicate a potential problem at the earliest possible time.

An excess of fuel at startup is called a wet start. To avoid wet starts two main precautions shall be taken. Pay strict attention to priming fuel lines and filling tanks to prevent pumping large amounts of fuel into the engines. As a last step prior to starting blow air through the engine and nacelle. If it is possible to see small amounts of fuel at the exhaust end of the nacelle, continue applying air until no fuel can be seen. If large amounts of fuel are seen stop the air, turn the sub-scale aircraft vertically with the nose up. Allow excessive fuel to be collected in a drip pan. Return the aircraft to its original position and repeat the process of applying air to the inlet. This process shall be repeated until no fuel can be seen blowing out of the exhaust end of the nacelles. Failure to do this can create a fire or explosion hazard.

### 3.10.2 Engine Shut down

When the engines are shut down the aircraft shall be pointed into the wind so high temperature air is not being blown back into the engine.
When engines are shutting down compressed air or high velocity high volume forced air generators shall be used to reduce engine temperature. This is done to increase the life of the turbine and reduce the potential of a fire due to high temperatures.
There is a fuel shut off valve that must be turned to the off position after engines are shut down.

### 3.10.3 Engine Restarts

Should an engine start and for any reason shut down shortly after, it is highly likely fuel will collect in the engine. The ECU will automatically shut off the fuel pump but the engine control switch must be turned to off. It is important to blow air through the engine as quickly as possible once the engine stops running. The air will cool the engine down helping protect the engine bearings from excessive heat. The air will also blow excess fuel out the exhaust and decrease the chance of an engine fire.

Once engine exhaust gas temperature has cooled down to below 100°C the ECU will allow the engine to be restarted. Follow procedures for starting in Section 3.10.1.

The restart shall include using the engine startup checklist from the beginning with appropriate signoff. If sufficient fuel was burned to warrant refueling the checklist covering fueling shall require new approval and signoff.

### 3.10.4 Take-Off

Residual thrust combined with throttle lag requires more pilot experience to prevent the model from trying to takeoff or other mishaps that could happen during high speed taxiing.

If a take off must be aborted, the delay in the reduction of power (throttle lag) must be taken into account, thus full power shall not be applied until the sub-scaled aircraft is tracking straight and in line with the runway. There is a large thrust to weight ratio. A computer simulator will help determine actual thrust required at point of liftoff (see Section 3.14).

The skill and experience required during takeoff of turbine power aircraft is very different from that required for standard RC or UAV type aircraft. No assumptions shall be made concerning the pilot skill level (no matter how much non-turbine experience) until the pilot proves the ability to handle turbine-powered aircraft.

### 3.10.5 In the event of a crash

Any engine involved in a crash where high G loads were probable must be examined and re-certified as safe. This re-certification must be issued by the manufacture or an approved service center before operating and flying.

An engine involved in any type of crash must be inspected. If there is any detectable damage to the engine it must be examined and re-certified as safe by the manufacture or an approved service center before operating and flying.

### 3.10.6 Speed limiter

The engines were selected to provide ample power for a relatively short takeoff. While this power is a benefit during takeoff it is a liability during flight because of the high speeds the aircraft could reach. In an effort to limit the top speed of the aircraft, a speed limiter has been added.

The speed limiter allows the pilot to set the maximum aircraft speed, the minimum speed (which will be set slightly above stall for pilot training) and can be used as a cruise control if desired. An onboard pitot tube shall be used to monitor the speed of the aircraft, feeding the speed limiter, which will control the engine throttle position.

## 3.11 Landing

As with takeoff more skill and experience is required for landing turbine powered RC or UAV type aircraft.

On landing if a go around is required it can take 1-3 seconds to go from low power to a point that will allow the aircraft to climb. If the decision to abort a landing is made too late, the aircraft could impact the ground while the engine is still spooling up. The model is equipped with spoilers that can be used as a speed brake. It can be advantageous to use spoilers at final approach, so that more power can be carried into landing. Then if more speed is needed the spoilers can be retracted which has the effect of adding a step increase in thrust and the aircraft will reach climbing speed more quickly.

Prior to landing the sub-scaled aircraft the landing gear will be deployed. Should the landing gear not deploy the proper course of action is covered in GTMP-2030 Emergency Procedures.

## 3.12 Post Flight Checkout

After each flight the scaled aircraft shall be examined for damage that may have occurred during takeoff, flight or landing. This inspection shall be in accordance with the Post Flight Checklist. The document numbers for each sub-scale aircraft checklist are listed in Section 10.0.

Use the check-off list for a methodical process of examining and recording all damage found on the sub-scaled aircraft. This is very important not only to find needed repairs but also to identify any recurring failures or problems. This could prevent major problems in the future.

### 3.13 Prior to Storage and Transporting

Prior to transporting of the aircraft from one facility to another or long term storage of the aircraft, the following steps shall be taken:

Remove all fuel from tanks and lines.

Turn all switches to the off position prior to disconnecting batteries.

Remove batteries and store in specified container or locker.

Reduce air pressure in landing gear system to 5 PSIG or less.

DONOT store aircraft so that it is supported by its landing gear for extended periods of time.

Restrain model properly to avoid possible damage in transporting aircraft.

All of these items shall be incorporated into a check-off list titled, Storage and Transporting Checklist of Sub-Scaled Aircraft. This checklist shall be implemented to avoid damage to the aircraft and potential hazards to personnel.

### 3.14 Computer Simulator

A computer simulator will be used to develop recommendations and criteria for test flights. This tool will better identify conditions such as wind velocity that could be detrimental to a successful test. The project also plans to use the simulator to calculate thrust requirements and planned maneuvers. The computer simulator shall be continually refined to create the best possible representation of the aircraft.

## 4.0 Site Safety

### 4.1 Contact Facility Manager or Facility Safety Manager

The facilities currently being considered for sub-scale aircraft testing shall have a person or persons designated as Flight Safety Manager or Flight Test Manager. Contact these individuals and establish in writing an authorized time, date, length and type of flight-testing desired. This person may be able to provide the Project with local weather conditions or regulations that may have an impact on flying and testing. Information provided by local resources will help insure the safety and success of the project only if it is properly implemented. A process to incorporate and disseminate all information that has relevance to the safety and success of this project shall be presented at the preflight crew meeting.

Depending on the facility a means of restricting access to the flight area shall be established. An inspection of the site may indicate the need to remove or relocate vehicles or equipment. These arrangements shall be made prior to the day of flight-testing.
In addition to abiding by the safety regulation in these procedures a review of the facility procedures and regulations shall be made to ensure Project compliance.

### 4.2 Local Fire Department Number and Contact

The Safety Officer has the responsibility of contacting the local Fire Department on the day of testing. The Fire Department shall be provided with an exact location of test, time of the testing and the type of testing to be done.

A phone shall be available with the Fire Departments number written down and readily available.

When the days testing is complete, a courtesy call shall be made to the Fire Department so they will be aware that all testing is complete for the day.

These items are incorporated in the Pre-Flight Checklist required for flight operation. The document numbers for each sub-scale aircraft checklist are listed in Section 10.0.

### 4.3 Safety Officer

All personnel involved in the operation of the sub-scale aircraft shall have the safety of the people and the aircraft in mind at all times. The Safety Officer shall fill the position as safety spotter or designate a person to this position. The primary function of the safety officer shall be to observe all aircraft crew and observer activity. The safety officer shall insure everyone is operating according to the safety procedures and document any changes or improvements needed.

The Safety Officer shall have the responsibility of identifying safety-training needs and requirements.

The Safety Officer shall ensure all aircraft crewmembers are trained in the use of fire extinguishers or assign this responsibility to another designated person.

### 4.4 Loose Debris

Everyone must be aware that the turbine engines might cause loose debris to become a potential hazard. Particularly with this aircraft the engines are very low to the ground and will tend to ingest anything in its path.

The leaf blowers can be used to remove excessive amounts of loose debris from the runway and engine start up area. Loose debris includes but not limited to sand, gravel, paper, plastic bags or any item that could easily be remove to create a safer test flight area.

An inspection of the area shall be made prior to engine startup focused on removing all loose debris. This shall include the area designated for engine startup, the taxiway, runway and any other area that could present a potential hazard because of loose debris.

After clean up efforts are complete a final inspection shall be made to ensure the area is free and clear of all loose objects and debris. A walk through of the entire area sufficient to ensure nothing was missed shall be made.

This inspection shall be included in the Test-Site Checklist; the document numbers for each sub-scale aircraft checklist are listed in Section 10.0.

### 4.5 Fire Hazards

Fire safety and prevention cannot be stressed enough. With engine temperatures that may reach 1250°F every precaution shall be taken.

Dried grass or shrubbery represents a potential for even a small fire to become unmanageable very quickly.

Wind conditions can change what seems to be a very small fire into a dangerous threat to personnel, wildlife and the facilities.

A review of the test site shall be made to determine potential fire hazards that may be unique to each test facility.

Fire fighting procedures are detailed in Section 6.1.

### 4.6 Observers

All observers or nonessential personnel shall be kept a minimum of 40 feet from designated engine start up area, taxiway, takeoff and landing areas. Researchers and other personnel that may benefit from a closer position shall maintain a minimum of 25 feet from sub-scale aircraft when turbine engines are running. Ear and eye protection must be worn by anyone closer than 40 feet to the aircraft when turbine engines are being started or in operation. Nonessential personnel shall not be permitted in the area for the initial Airworthiness Testing.

### 4.7 Fly Zone

Each flight site has a designated Flying Area or Safe Fly Zone and Flight Hazard Area or Containment Area. The flight coordinator shall contact the facility at which the testing will take place and obtain a detailed description of these areas. An on site review of these areas shall be made to identify visual aids and landmarks that will assist pilots in navigation of the sub-scale aircraft within these boundaries. The hazard zone has a direct correlation with speed and altitude of the vehicle. Pilots shall demonstrate the ability to control the aircraft within the Fly Zone and flight parameters specified. A means of determining that the aircraft is operating within the Fly Zone will be provided, such as but not limited to GPS or Ground Tracking Station. Should a violation of the Safe Fly Zone occur and the aircraft is not in a controlled turn returning to the Fly Zone, the pilot shall initiate the flight termination process.

### 4.8 Safety Barrier

A safety barrier presents an additional obstacle for the aircraft and pilot when taking off and landing and must not be installed at random. An inspection of the takeoff and landing area shall be made. With the knowledge of the testing planned and the number of people involved, a safety barrier location shall be determined and installed. The safety barrier shall provide for the protection of personnel, equipment and the aircraft.

## 5.0 Other Safety Considerations

### 5.1 The Public

The general public shall not be allowed in the area of vehicle testing. Only approved personnel shall be allowed in the proximity of vehicle testing.

The flight termination system will greatly reduce risk to the public.

### 5.2 Weather Conditions

Always use good judgment in deciding if weather conditions are suitable for flying. Prudence may dictate waiting for better weather.

Bad weather or poor visibility can adversely affect the operation and handling of the sub-scaled aircraft. Weather forecast must be reviewed prior to the scheduled flight day. An up to date weather report shall be required prior to testing, this report shall indicate current conditions and a forecast for the testing period.
No flight-testing shall be conducted during times when visibility is limited due to foggy or hazy conditions. The test flight plans shall indicate a maximum radius

or distance from the takeoff strip. Visibility shall be a minimum of one half mile greater than the scheduled test plan. This would mean a test flight with one-half mile radius would require a visibility range of one mile as a minimum. Similarly the test plans shall include a maximum altitude. The cloud ceiling shall be a minimum of 500 feet above the planned test. A test planned to fly at 1500 feet would require a minimum of 2000 feet visibility. Other weather conditions that shall be considered are: possible fronts moving in, possibility of thunderstorms and turbulences.

No flight-testing shall be conducted during periods of precipitation or electrical storm.

Initial flight-testing shall be conducted during times when grounds winds are blowing or gusting in excess of 6 Knots. This limit shall be maintained until pilots have experience with this aircraft.

No flight-testing shall be conducted during times when grounds winds are blowing or gusting in excess of 10 Knots. The ground wind resultant shall not exceed 10 Knots.

No flight-testing shall be conducted during times when winds aloft are blowing or gusting in excess of 16 Knots.

No flight-testing shall be conducted if winds conditions capable of adversely affecting takeoff or landing are monitored or visually obvious at the test site.

All flight-testing shall be conducted when flight site temperatures are above 50°F and below 100°F.

Winds aloft shall not be sufficient to cause the vehicle to exceed the boundaries of the designated hazard area.

There are no plans to perform any night flight-tests.

A bright sun can cause difficulties in visually tracking the aircraft. Proper planning and execution of the flight plan can reduce the risk of loosing visual contact. If the aircraft should cross in front of the sun the pilot or observers may try closing one eye until it passes through the blinding area. When it has passed through the bright area to the other side the pilot or observers will have at least one eye that is not momentarily impaired.

### 5.3 Climate Conditions (Particularly Dry)

Research weather patterns around the flight site for extremely dry or drought type conditions. If these conditions exist it may be appropriate to take additional precautions to avoid grass or brush fires. The local fire department can help by wetting down the area or recommending other safety precautions (this would involve further coordination with the fire department).

### 5.4 General Safety Issues

A general inspection shall be made to ensure all fasteners have been tightened.

When moving and transporting sub-scaled aircraft, install foam or other packing material to protect wing tips, horizontal tips and the tip of the vertical tail.

#### 5.4.1 Landing Gear

<u>Do not</u> hold landing gear retracts when air pressure is present at the cylinder and or during operation of the gear.

<u>Do not</u> place any part of the body in the retract mechanism or in the path of any moving parts.

<u>Do not</u> apply more than 125 PSIG to any part of the retract system.

<u>Do not</u> attempt to support the sub-scaled aircraft on these retracts without sufficient air pressure in the system to properly lock the gear.

<u>Do not</u> operate retracts or the sub-scaled aircraft if any retract or retract system part is missing, damaged or leaking.

Failure to follow these instructions can result in bodily harm and or damage to the aircraft.

## 6.0 Emergency Procedures

The following emergencies procedures shall be committed to memory by all of the Flight Team members.  In the event of unforeseen mechanical failure, electrical failure or personnel error the Project should be operating in one accord.  The safety of the Flight Team, observers and the general public shall take precedence over all other issues.

### 6.1 Fire Fighting Procedures

In the event of a fire immediately notify the local fire department.  Even if it appears that the fire can easily be contained make the call.  It is better for them to arrive at the site and not be needed than to have a situation get out of hand because the call was not made.  Often the Fire Department will wet the area down just as a precaution to insure the fire does not rekindle.  They will already be aware of your location based on your “Site Safety” precautions (Sect. 4.2).

For gas, kerosene or electrical fires, a CO2 fire extinguisher shall be used. If the fire is in the turbine engine area, apply extinguishing agent to the inlet end of the engine. If the fire is not in the engine, apply agent directly to the area burning. Always take into consideration wind conditions. It is important the wind does not blow the fire-fighting agent back into the operator's face. This could cause problems breathing if inhaled or blurred vision if it should get into the operator's eyes.

The amount of fuel on the sub-scaled aircraft when it is ready for takeoff is substantial. If the aircraft is burning to an extent that the fuel tanks could ignite it is better to keep a safe distance and let the professional firefighters handle the situation. While a CO2 fire extinguisher is extremely effective for gas, kerosene and electrical fires, they are almost useless against a grass or brush fire.

For grass or brush fires, a five-gallon water fire extinguisher is provided. Do not waste water on a gas or kerosene fire. Water only tends to move the fuel around and very little progress will be made towards extinguishing the fire. If a grass or brush fire is very small, water can be applied to the burning area. These fires tend to expand quickly in dry windy conditions. If this is the case, it is better to try to contain the fire by wetting down the area down wind of the fire before applying water to the fire itself.

There is a product called "Drench" that will increase the effectiveness of the water penetration by 400%. It is relatively inexpensive and only requires two ounces for five gallons of water. Using this product in conjunction with a five-gallon water fire extinguisher will provide a basic means of controlling grass and brush fires.

These fire extinguishers do not have adequate capacity for fighting large fires. That is why the first action when there is fire or smoke is to call the fire department.

### 6.2 Loss of Control

It cannot be stressed enough that should any trouble be encountered during flight, shutting down the engines will within seconds remove the ignition source and prevent a fire from starting. When an emergency situation occurs the pilot will have only a few seconds to recover control of the aircraft. This will depend on the altitude, attitude and speed of the aircraft. Should the pilot not regain control quickly, the aircraft shall be considered out of control. <u>Shutting down the engines is the number one response to an out of control aircraft</u>. If control is regained an experienced pilot can often land the aircraft without engine power.

## 6.3 Personnel Injury

A phone shall be available with the Fire Departments number written down and readily available (see Sect. 4.2).

As with any emergency you can dial 911, because the fire department knows your location and the testing being performed they will be able to respond quicker if dialed directly.

## 6.4 First-Aid Kit

As a precaution a first aid kit shall be maintained.

It shall provide for but not limited to:

- Treatment of burns
- Eyewash
- Materials for washing of skin splashed with kerosene

<u>It is mandatory</u> that anyone needing first aid report immediately to the nearest clinical facility for treatment.

# 7.0 Incidents and Accident Reporting

Reporting of an accident or incident involving the aircraft or flight crew shall be in accordance with NASA procedures. All incidents shall also be recorded in the aircraft flight log. The Chief Engineer is responsible for insuring the report is accurate and complete. The Chief Engineer can delegate part or all of the investigation to other personnel. Reports shall include all relevant information and corrective steps taken if any are needed. A copy of the report will be sent to the following:

MSB Organization Unit Manager (b) (6) [redacted]
Director of Office of Safety and Mission Assurance (b) (6) [redacted]

**In the event of a major incident the following will be contacted immediately:**

**NASA LaRC Emergency Dispatcher**
**(On site 42222 or off site (757-864-2222)**
MSB Organization Unit Manager (b) (6) [redacted]
Director of Office of Safety and Mission Assurance (b) (6) [redacted]

Based on the nature and severity of the incident the contacts listed above will determine all other branches or personnel to be notified.

## 8.0 Training

### 8.1 Pilots

Only qualified pilots that have demonstrated proficiency through pilot training will be flying the sub-scaled aircraft. A training program was established and implemented to improve the skills of individuals with some RC pilot experience to become qualified sub-scale turbine jet aircraft pilots.

All pilots have been trained and certified for Turbine Aircraft Operation per document number GTMP-8002. This document meets and exceeds all requirements established by the AMA for certification of turbine aircraft pilots.

The AMA requires a pilot wanting to fly turbine jet powered models to have a minimum of 50 flights with a qualified instructor prior to being certified as a jet model pilot. Exceptions are made for pilots that demonstrate to a qualified instructor the ability of safely handle turbine-powered aircraft.

All training flights shall be accomplished through the use of a “buddy box” that links the trainee with an experienced pilot. The experienced pilot shall have the ability to immediately take control of the aircraft should the need arise. The experienced pilot shall make the determination when a pilot is ready to fly solo.

Each individual pilot shall demonstrated the ability to control a series of training aircraft and meet all training requirements prior to being certified as a pilot for this project.

Pilots shall be able to demonstrate the ability to control the sub-scale aircraft so that line-of-sight is maintained at all times. The maximum distance shall be based on the ability of the pilot to visually distinguish, heading and attitude not to exceed designated fly zone parameters.

Pilots shall demonstrate the ability to recognize stall or loss of aerodynamic control and the ability to apply corrective measures as required.

The pilots shall ultimately be the ones to implement a Flight Termination System (FTS) and must be able to recognize when circumstances dictate this action. This shall be covered in the training process and the implementation of FTS shall be available to the pilot and co-pilot.

Pilots shall possess the ability needed to land a sub-scaled aircraft with engines off.

Pilots shall be experienced with turbine powered aircraft and particularly the lag between the throttle command and the engine response time.

Pilots shall have hands on experience with the lag time between controller and engine particularly associated with an aborted takeoff or landing.

There is no substitute for practice. When pilots have completed their training they shall schedule periodic flying times to maintain a high operational skill level. A system of checks to periodically renew certification is appropriate for all pilots.

Flight simulators shall be used to maintain pilot skills during the times it is impractical to practice with sub-scaled aircraft.

Each pilot shall be required to review regulations associated with each flight site prior to aircraft operation.

Future testing may require the pilot to fly the sub-scale aircraft by viewing the aircraft image through a computer monitor created by an onboard camera or flight tracking station. These skills would be needed when testing dictates altitudes or distances where visual recognition becomes difficult.

### 8.2 Fire Extinguishers

All members of the testing crew shall be trained in the use of $CO_2$ Fire Extinguishers.

A copy of the directions on how to properly use $CO_2$ Fire Extinguishers shall be maintained and available at the test site

A periodic inspection of the fire extinguishers shall be made by qualified personnel to insure they are in good working order.

All members of the testing crew shall be trained in the use of the Water Pump Fire Extinguisher. This type extinguisher is heavy and must be manned by someone physically capable of getting it to the fire quickly.

A copy of the directions on how to properly use Water Pump Fire Extinguishers shall be maintained and available at the test site

If there is smoke or fire a call must be made to the fire department. This process is explained in greater detail in Sect. 4.2 and 6.1of these procedures.

All members of the testing crew shall be checked out in calling the fire department and providing all essential information quickly and accurately. One individual shall have this as their primary responsibility in case of a fire.

## 9.0 Risk Assessment

The AAAC Safety Engineer performed a “Risk Analysis” for the GTM.

The best possible effort shall be made to avoid equipment failure however there is no way to be absolutely certain no components will fail during flight. To prepare for the unexpected each component shall be tested to evaluate the results of a loss of control signal, a loss of power or the loss of both at the same time. The results shall be documented and used to develop Risk Assessment procedures. If new components are added to the aircraft each shall be evaluated for loss of control signal and power as the components listed below. Test documents for this project are in the GTMP-6000 sub group. To locate specific testing documentation see the Project Document Number List GTMP-1003. The conditions to be tested are:

1. Loss of signal from Controller 1.
2. Loss of power to Controller 1.
3. Loss of signal from Controller 2.
4. Loss of power to Controller 2.
5. Loss of signal from Controllers 1 & 2.
6. Loss of power to Controllers 1 & 2.
7. Loss of signal to Receiver 1.
8. Loss of power to Receiver 1.
9. Loss of signal to Receiver 2.
10. Loss of power to Receiver 2.
11. Loss of power to ECU 1. (ECU 2 same)
12. Loss of Throttle Signal to ECU 1. (ECU 2 same)
13. Loss of RPM signal to ECU 1. (ECU 2 same)
14. Loss of Engine Exhaust Temperature signal to ECU 1. (ECU 2 same)
15. Loss of Signal to Fuel Pump for Engine 1. (Engine 2 same)
16. Loss of Power to Fuel Pump for Engine 1. (Engine 2 same)
17. Loss of power from Battery 1.
18. Loss of power from Battery 2.

19. Loss of power from Batteries 1 & 2.

20. Loss of Air Pressure due to the failure of any component of the air system.

21. Loss of Signal to Servo.

22. Loss of Power to Servo.

23. Loss of Signal and Power to Servo.

24. Loss of Signal to Speed Controller.

25. Loss of Power to Speed Controller.

26. Loss of Signal and Power to Speed Controller.

## 10.0 Check Lists

At least one person shall be designated as an official sub-scale aircraft inspector.

A copy of the appropriate inspection and sign off sheets shall be printed and filled out by a person designated as an official aircraft inspector and the Chief Engineer.

Each set of tests shall require check off lists, one from each categories.

### 10.1 Storage or Travel

GTMP-2002 Storage or Travel Checklist (prior to leaving NASA and prior to leaving flight site)

### 10.2 Test Site

GTMP-2003 Test Site Checklist

### 10.3 Engine

GTMP-2004 Engine AMT180SP Checklist

### 10.4 Pre-Flight

| | |
|---|---|
| GTMP-T33-2006 | T-33 Pre-Flight Checklist |
| GTMP-L1011-2008 | L1011 Pre-Flight Checklist |
| GTMP-mod2-2010 | L1011_mod2 Pre-Flight Checklist |
| GTMP-T1-2012 | T1 Pre-Flight Checklist |

### 10.5 Post Flight

| | |
|---|---|
| GTMP-T33-2005 | T-33 Post-Flight Checklist |
| GTMP-L1011-2007 | L1011 Post-Flight Checklist |
| GTMP-mod2-2009 | L1011_mod2 Post-Flight Checklist |
| GTMP-T1-2011 | T1 Post-Flight Checklist |

All document numbers are in the Project Document Number List GTMP-1003.