Safety Risk Analyses for AirSTAR Operations at Smithfield Airport (31VA)
Version 1.0
GTMP-7008

(b) (6)

[redacted]

6/8/09

Safety Risk Analyses for AirSTAR Operations at Smithfield Airport (31VA)
Version 1.0
GTMP-7008

SUBMITTED BY:

(b) (6) _____
D205/AirSTAR Chief Pilot

(b) (6) _____
D201/AirSTAR Pilot

REVIEWED BY:

(b) (6) _____
AirSTAR Airborne Facilities and Operations Lead

(b) (6) _____
AirSTAR Principal Investigator

(b) (6) _____
Project Manager

APPROVED:

(b) (6) _____
D1/LaRC Aviation Manager

(b) (6) _____
C2/LaRC Director Safety and Mission Assurance

(b) (6) _____
8030/WFF Range Safety Officer

CHANGE HISTORY LOG		
REVISION	**EFFECTIVE DATE**	**DESCRIPTION OF CHANGES**
1.0	6/12/09	Baseline, including comments from the (b) (6) [redacted] on 6/5/2009.

CONTENTS

1.0 INTRODUCTION

The NASA Langley Research Center (LaRC) is planning to provide range support for a category of Unmanned Aerial Vehicles (UAV's) based upon Radio Control (RC) Model Aircraft and their operations at Smithfield Food's private airstrip (31VA). The primary purpose of the RC Model Aircraft operations at 31VA is to conduct pilot proficiency flights (primarily landing practice) in support of the Airborne Subscale Transport Aircraft Research (AirSTAR) testbed project. These operations are required to support the research objectives of the NASA Aeronautics Research Mission Directorate. Other related operations include pilot training, airworthiness flights, functional check flights, system check flights and flight research.

31VA is a remote airstrip located in Smithfield, VA. See Figure 10.1.1 for an aerial view of the area. This airstrip is used infrequently for business jet activity. It is also used for other activities authorized by the property owner, but in general few people are on the property during AirSTAR operations.

Operations at 31VA require a Certificate of Authorization from the FAA. Currently, AirSTAR is operating under 2008-ESA-21. The COA is renewed every year and requires, among other things, that pilots and spotters have FAA Class-II medical certificates, NOTAMS are filed 24 hours prior to operations, flight altitudes are limited to 1,200 ft, and a monthly activity log and mishaps are communicated to the FAA.

The development and implementation of a Standard Operating Procedure (SOP) for RC Model Aircraft operations at 31VA will minimize the preparation, documentation and oversight required for each RC model. The SOP will provide safety limitations, requirements and procedures to the LaRC Aviation Manager and RC Model Aircraft users for the purpose of providing safety standards to ensure safe operations.

This risk analysis is a process used by management to make decisions regarding potentially hazardous operations. It addresses the Safety Risk Assessment associated with the proposed RC Model Aircraft operations. The objective of the process is to ensure (1) that the RC model aircraft hazards during ground and flight operations are identified and eliminated or, if not eliminated, to ensure that the associated risks are mitigated to the lowest practical level, and (2) that the operation of the RC Model Aircraft is contained within defined boundaries with an acceptable risk. This process ensures that management has the best possible information and analysis on which to base risk acceptance.

2.0 SCOPE

This document applies AirSTAR operations at this time. The AirSTAR project is endeavoring to develop a research capability employing high-end RC Model Aircraft to develop and evaluate adaptive controls, aerodynamic parameter identification methods, and avionics systems evaluation techniques at this time. The primary objective for operations at 31VA is to support pilot proficiency flights to directly

mitigate risk for research aircraft operations. The AirSTAR project operates a series of RC Model Aircraft that include basic propeller-driven trainer aircraft, sailplanes, and turbine-powered vehicles.

2.1 INTRODUCTION

The RC Model Aircraft is an unmanned aircraft that is remotely controlled. The Academy of Model Aeronautics (AMA) is the official national organization for model aviation in the United States. The AMA National Model Aircraft Safety Code will be used as a guide in establishing the limits, requirements, and procedures for operations at 31VA.

Permission to conduct RC Model Aircraft missions at 31VA must be obtained from the LaRC Aviation Manager per NASA NPR 7900.3B. Scheduling, coordination and communications with the LaRC Aviation Manager for RC Model Aircraft operations will be performed.

2.2 VEHICLES

The AMA defines the maximum gross takeoff weight with fuel of an RC Model Aircraft as 55 pounds. This should also include the weight of any payload. Except for batteries, recording and data transmissions, the scope does not include hazardous or active payloads. Models are normally constructed using commercially available RC model hardware and avionics.

The RC model engines are electric, air/fuel combustion, or gas turbine. For gas turbine operations the AMA states that individual engine thrust shall not exceed 35 pounds. Single or multiple installations are allowed. This scope does not include Jet Assisted Take-Off (JATO), rocket takeoff, or afterburners.

AirSTAR vehicles will conform to the AMA definition. Subsequent risk assessments will be performed for vehicles that exceed this specification.

2.3 MISSION

The primary mission to be conducted at 31VA is to provide pilot proficiency flights (primarily landing practice). Other missions include pilot training, airworthiness flights, functional check flights, system check flights and limited flight research activity. The proximity of 31VA to LaRC is of critical importance to accomplish this mission with acceptable resources.

All RC Model Aircraft operations will be line-of-sight from the pilot to the model and at a distance such that the pilot can distinguish visually the aircraft heading and position. This distance may vary depending on the size of the aircraft, weather conditions and other related factors. It is the responsibility of the pilot not to operate the model beyond his visual limitations. Models are to be manually flown using frequencies that are approved, controlled and coordinated for operations at 31VA. This scope does not include autonomous flights or interfaces to autopilots.

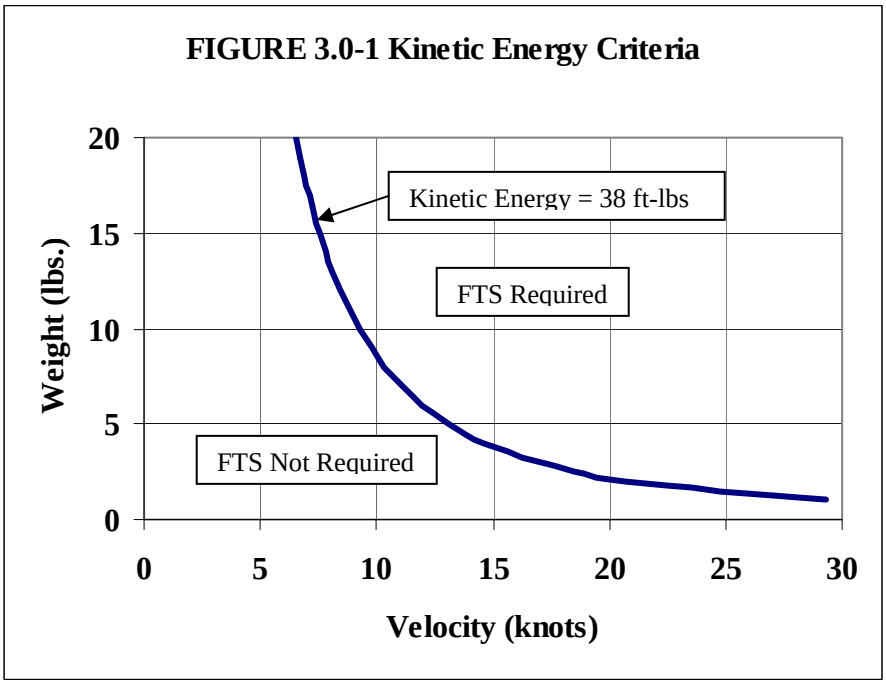
3.0 FLIGHT TERMINATION SYSTEM

A Flight Termination System (FTS) is required unless it is shown that the maximum range of the RC Model Aircraft is less than the range of all protected areas or it can be shown that the kinetic energy does not exceed 38 ft-lbs. See FIGURE 3.0-1 Kinetic Energy Criteria.

Most RC Model Aircraft do not contain a standard FTS, but are installed with a loss-of-signal fail-safe system. FTS is provided by the pilot RC model controller and transmitter, which, when turned "off", triggers the fail-safe mode in the onboard receiver activating preset functions that force descent. Verifying that the fail-safe performs to specification, prior to daily operations, completes the certification process.

The fail-safe system will be designed to contain the model in an approved hazard area due to a loss of the uplink signal. The fail-safe system will shut down or idle the engine(s) and provide surface deflection to contain the model in the hazard area.

FIGURE 3.0-1 Kinetic Energy Criteria



4.0 RADIO CONTROL SYSTEM

The airborne radio control system should employ commercial-off-the-shelf components to the greatest extent possible and follow GTMP-2033 regarding installation, inspection, and maintenance. Retaining strong linkage to stock components provides the ability to infer a reliability basis for AirSTAR operations.

Onboard EMI sources should be investigated and documented as to their effect upon the control system of the airplane. A ground based range check procedure shall be utilized before flight to ensure proper RF control.

Airborne and transmitter batteries shall be managed per GTMP-4060.

5.0 AIRWORTHINESS

All RC models flown under the AirSTAR Project shall follow the process defined in the GTMP-2023 to be certified as airworthy.

The first flight of any RC Model Aircraft at 31VA without airworthiness documentation shall be used to conduct a flight test to confirm that the model is airworthy. For each RC Model Aircraft, a configuration document should be maintained describing the flight test, airworthiness, and configuration. For AirSTAR operations the aircraft flight logbook is sufficient documentation (per GTMP-2033). Only experienced essential personnel, no program observers or payload personnel, will be in the area during the flight of an RC Model Aircraft until it has been certified airworthy. The Project Safety Officer or Systems Engineer shall complete the documentation process (per GTMP-2033).

The airworthiness test shall as a minimum include two successful shake down flights for certification. The first flight(s), limited to a maximum altitude of approximately 400 feet, should demonstrate satisfactory take-off, controlled flight and landing and be limited to approximately 3 to 6 minutes. The second flight(s) should demonstrate satisfactory take-off, controlled flight, operations in the flight envelope, landing and a flight time of at least ½ the maximum endurance. Remaining fuel shall be measured and used to gradually expand the flight endurance. Nominal operation of the aircraft during these tests shall be required as exit criteria for the airworthiness testing.

6.0 TRAINING AND PROFICIENCY FLIGHTS

Only qualified and experienced RC Model Aircraft pilots should be flying except during pilot training and proficiency flights as defined in GTMP-8002 (draft). The following should be considered for pilots flying RC Model Aircraft at 31VA.

1. Experience in piloting of RC Model Aircraft.
2. Demonstrated ability to fly successful flights of RC Model Aircraft
3. Ability to recognize stall and loss of aerodynamic control.
4. Familiarity with the particular airframe being flown.
5. Familiarity with the 31VA RC Model Aircraft SOP.

The AirSTAR Chief Pilot will assess pilots' capability of flying RC Model Aircraft and designate which aircraft are to be flown by each pilot. All pilots in training must be flying under the supervision of the AirSTAR Chief Pilot or his alternate. During pilot training, only experienced essential personnel, no program observers or payload personnel will be in the area.

7.0 SYSTEM HAZARDS

All system hazards described in this section shall be mitigated following procedures defined in GTMP-2001-A.

7.1 HAZARDOUS MECHANICAL SYSTEMS

RC Model Aircraft that utilize a propeller presents a sharp-object hazard while the engine is running. To minimize risk to personnel, a Pre-Flight Hazard Area of 25 feet radius will be established for non-essential personnel during this time. Active, essential personnel performing necessary tasks while the engine is running shall remain aft of the moving propeller. No metal propellers are to be used.

7.2 VEHICLE/PAYLOAD AND GROUND BASED TRANSMITTERS

The types of transmitters associated with RC Model Aircraft vary from mission to mission. Standard COTS RC Model aircraft transmitters are to be used for pilot to airplane control. These transmitters may be altered (by increasing power, changing antennas, etc.) with approval of the LaRC Spectrum Manager. All transmitting equipment, both ground and air based, must be approved for use by the LaRC Spectrum Manager.

7.3 HAZARDOUS CHEMICALS AND CHEMICAL SYSTEMS

RC Model Aircraft utilize 0.5 to 3 gallons of unleaded gasoline (or a gas-oil mix), kerosene, methanol, nitromethane* or propane for propulsion. The primary hazard associated with this system is the fuel's flammability. Personnel involved with fuel transfer and handling operations shall wear personnel safety glasses. A Material Safety Data Sheet (MSDS) for the fuel will be posted at the assembly area and operational site. A fire extinguisher will be available.

*Dry-chemical extinguishers shall not be used for extinguishing nitromethane fires. Only carbon-dioxide, alcohol-foam, and water-spray extinguishers are approved for nitromethane fires. AirSTAR flight operations personnel are trained in the use of the various types of fire extinguishers for specific situations. The AirSTAR flight operations trailer carries fire extinguishers with CO2, H20, and Dry-chemical.

Depending on mission requirements and availability, RC Model Aircraft may utilize Ni-Cad, Nickel-Metal Hydride (NiMH) or Lithium Batteries as power sources for the avionics and servo control subsystems. These batteries present excessive heat and/or fire hazards when their cells are electrically or mechanically abused or incinerated. These systems do not present any hazards during normal operating conditions. MSDS for each battery system will be posted at the assembly area and operational site per GTMP-4060.

7.4 NOISE HAZARD

The engines of some RC Model Aircraft generate a noise hazard while running. For models utilizing such engines, the Pre-Flight Hazard Area described above will be clear of non-active, non-essential personnel, while the engine is running. Active,

essential personnel performing specific tasks within this area for extended periods of time shall wear approved hearing protection with a Noise Reduction Rating (NRR) of 19 dB or higher. In practice, this includes all personnel who are working directly upon the vehicle while the engine is running. This level of protection can be accomplished with either earplugs (29 dB) or earmuff-type protection (21 dB).

7.5 GAS TURBINE HAZARDS

1. Intake Suction Hazard: During engine operations at maximum speed, the engine intake is enough to ingest loose gravel and other foreign objects within the immediate vicinity. Ensure the area is clear of foreign objects prior to engine startup and that personnel are free of loose or dangling objects.

2. Exhaust Flow Hazard: The exhaust gases exit at very high velocity and are extremely hot, which poses a hazard to personnel in the RC Model Aircraft exhaust path. Ensure the area immediately aft of the engine's exhaust path is clear of personnel and combustible material. Wheel brakes are mandatory unless the aircraft can be demonstrated to remain motionless when released with engine at idle.

3. Noise Hazard: Gas turbines present a noise hazard greater than the typical RC model engine. A 25-foot Danger Area for noise will be imposed upon non-participating personnel. Due to the short-term exposure to the high-level of noise for turbine starting procedures, ear muffs are an effective and acceptable hearing protection method (29 db).

4. Fire Hazard due to Starting a Wet/Flooded Engine: This could possibly result in a hot-start, with flames exiting the rear of the engine. If engine becomes flooded with fuel, tilt the engine forward slowly allowing the fuel to drain from the front of the engine. Be extra careful not to allow fuel to drip on starter motor assembly. If fuel drips into the starter motor assembly, the starter must be removed and cleaned prior to start. Failure to follow this step will result in starter failure, and starter motor may need replacing. A fire extinguisher will be available and AirSTAR personnel are trained in the use of them, and per GTMP-2001, personnel are assigned for fire-watch duty for all turbine operations.

7.6 OTHER HAZARDOUS SYSTEMS/MATERIALS/REQUIREMENTS

RC Model Aircraft and payloads typically do not utilize any other hazardous systems/materials/requirements than those identified in this Safety Risk Analysis. The scope does not include pyrotechnic systems, explosive systems, radioactive materials, lasers, or hazardous circuits.

8.0 SYSTEM RISK ASSESSMENT

A Preliminary Hazard Analysis (PHA) was developed to formally identify the hazards associated with fueling, starting, and shut-down of the RC Model Aircraft. The Risk Assessment Code (RAC) Matrix provides an aid in conducting qualitative and quantitative risk assessments of each hazard. See Table 8.0-1 Risk Assessment Code.

Table 8.0-1 Risk Assessment Code

Severity	Probability of Mishap				
	A-High .3	B-Fair .03	C-Slight .003	D-Remote .0003	E-Extremely Improbable
I-Catastrophic	1	1	1	2	3
II-Critical	1	1	2	3	3
III-Marginal	2	2	3	3	3
IV-Negligible	2	3	3	3	3

RAC 1 Operation prohibited. Risk must be suppressed to lower level.
RAC 2 Waiver required for operation
RAC 3 Operation permissible

The following potential hazards associated with the RC Model Aircraft have been identified.

1. Inadvertent Ignition of the Engine Fuel.

2. Personnel Contact with Moving Propeller.

3. Personnel Exposure to Excessive Noise.

4. Inert Debris Ingested by Turbojet.

5. Excessive Heat flow produced by exhaust from Turbojet.

The PHA results determined that each identified hazard has a Final RAC of 3: Operation Permissible. Detailed Hazard Reports associated with the above hazards are included as Enclosure 2. The following Table 8.0-2 is a summary of the risk assessment.

TABLE 8.0-2 Risk Assessment

HAZARD	SEVERITY	PROBABILITY	RAC
Inadvertent Ignition of Engine Fuel	II	E	3
Contact with Moving Propeller	III	C	3
Exposure to Excessive Noise	III	C	3
Inert Debris (Turbojet)	II	E	3
Excessive Heat (Turbojet)	II	E	3

9.0 FLIGHT HAZARD

In general, the reliability of RC Model Aircraft can be low with relatively high failure rates as operated by the general public. However, even with these high failure rates, approximately 150,000 RC Model Aircraft enthusiasts operating at more than 2,500 model aircraft club fields across the United States employ the AMA safety standards to result in an extremely improbable risk to damage of property or injury. This is essential in order to be a publicly-accepted form of recreation. The AirSTAR project builds upon the AMA safety standards but employs a well-supported risk management approach to significantly increase reliability and reduce the rate of accidents. AirSTAR procedures along with strong organizational support result in aircraft operations that have a high level of reliability due to the level of inspection, work quality, equipment quality, preventative maintenance performed. The resulting primary impact hazard, which could result in death, injury or property damage, is due to pilot error. Risk mitigation with respect to pilot error is accomplished by an adequate level of pilot currency and proficiency in accordance wit GTMP-8002.

10.0 FLIGHT RISK ASSESSMENT

10.1 FLIGHT HAZARD AREA OR CONTAINMENT AREA

The RC Model Aircraft will be flown within a defined Flight Operational Area and must be contained within the defined Flight Hazard Area. The Flight Hazard and Operation Areas are defined in Figure 10.1.1 below.

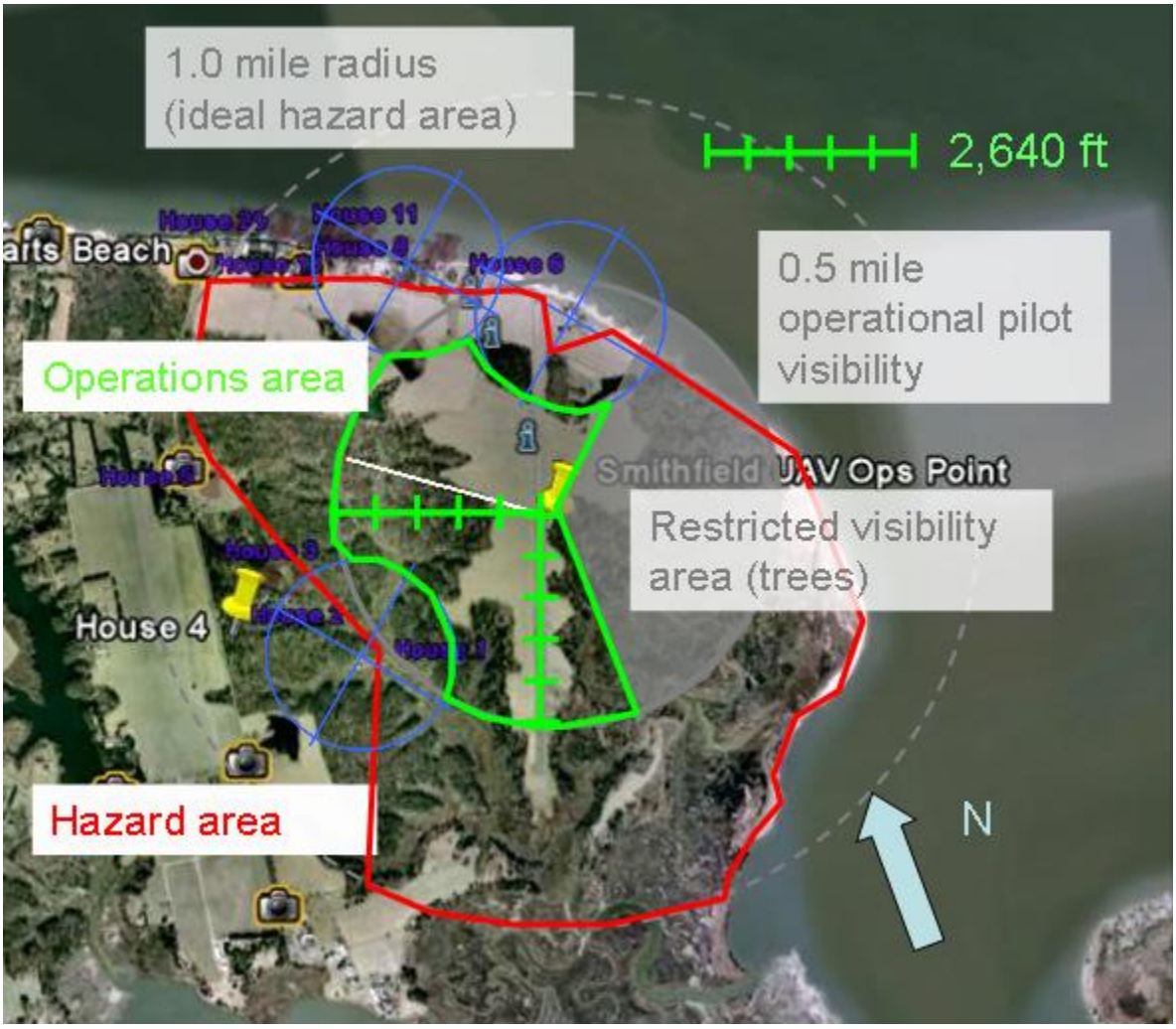


Figure 10.1.1. Graphical definition of flight operation and flight hazard areas at 31VA.

The flight area configurations are as follows. The maximum flight altitude is 1,000 for the flight operation area. Wind limits of 20 kts from the east and from the south are defined for flights above 600 ft AGL. The aircraft must be turning back into the operations area at the boundary of the operations area.

10.2 MITIGATIONS

CLEAR THE FLIGHT OPERATIONS AREA: The public, private property, national airspace, non-essential personnel, boats, aircraft, and high asset value property that are subject to damage by an RC Model Aircraft are to be clear of the Flight Operations Area. Management of the risk to full-scale aircraft in the flight area is per Certificate of Authorization (COA) with the FAA and includes filing NOTAMS and announcing when flights are going to be conducted on the 31VA Unicom freq (per GTMP-8020). In addition, coordination with the Smithfield Food aviation department is performed before each flight day. While NASA LaRC's permission to operate at 31VA does not include the ability to restrict or control other activities on this property, only personnel involved with the flight operations are within the

operations area when flight operations are conducted, and those personnel are behind barriers (cars, trucks, Jersey barriers) and are directly observing flight activities.

MINIMIZE PERSONNEL IN THE HAZARD AREA: NASA LaRC's permission to operate at 31VA does not include the ability to strictly control other activities on this range. However, the AirSTAR Operations Safety Supervisor (OSS) coordinates activities with the manager of the Smithfield property and is aware of the location and plans for others using the facility. Periodically, a very small number of people may be in the hazard area (5 to 10). Given the small number of people and large expanse of land within the hazard area, combined with the AirSTAR safety procedures and low-rate of operations at this facility (less than 20/month), this is not considered a significant risk. If the OSS determines these activities pose a significant risk from flight operations, due to the number or location of those personnel, AirSTAR flights will be suspended.

INTRUDER IN THE FLIGHT HAZARD AREA: If the pilot identifies or is informed by the spotter of another aircraft in the hazard area during flight operations, he will take appropriate collision avoidance action.

VIOLATION OF THE FLIGHT OPERATIONAL AREA: RC Model Aircraft contain a control system and have the potential of exceeding not only the Flight Operational Area but also the Flight Hazard Area. This probability of occurrence is deemed low since the aircraft must fail in such a way as to continue stable flight while negating the pilot control inputs or the fail-safe control inputs from the fail-safe system.

ACCURATE POSITIONAL INFORMATION: Periodically, GPS equipped aircraft will be flown to verify that operations are being conducted according to the defined operations area as well as posting spotters along the operations area perimeter.

FAA_REQUIRED SPOTTER: The FAA requires one spotter to observe the operations area during flight operations. This spotter is required to have a Class-2 Physical. The spotter will assist the pilot and communicate key events.

ESSENTIAL PERSONNEL: Only essential personnel are allowed in the Flight Operations Area.

BARRIER PROTECTION FOR ESSENTIAL PERSONNEL: A barrier protection system will be used to provide protection to the pilot and spotter. Additional flight personnel in the Flight Operations Area shall position themselves so that they are able to quickly take cover in or behind a vehicle (car/truck) or trailer.

BRIEFINGS FOR PARTICIPATING PERSONNEL: Pre-flight briefings will be conducted to inform all participating personnel of the operation of the RC Model Aircraft and related hazards. Personnel not associated with the flight operation who are in the Flight Hazard Area will also be provided a briefing regarding flight activities, time, duration.

WEATHER AND VISUAL CONDITIONS: Flights will be conducted according to GTMP-2072. Key weather parameters adhered to are: visibility greater than 1 mile, ceiling of 500 ft higher than planned operations, no flight in precipitation.

WIND LIMITATIONS: Wind limitations are established based on two considerations. One consideration is the operations of the aircraft near the runway during takeoff and landing operations. The other consideration is for fail-safe considerations and keeping the aircraft within the Flight Hazard Area. GTMP-2072 defines surface wind limits appropriate for takeoff and landing operations. For fail-safe Flight Hazard Area containment, the wind limits are 20 kts from the East and 20 kts from the South at 1,000 ft for operations above 600 ft. The wind vector will be resolved in those two directions and compared with the limit for flight above 600 ft. Winds at 1,000 ft will be obtained from Felker Airfield and/or Newport News Airport.

CHECKS TO CONFIRM FUNCTIONAL OPERATIONS: Functional checks of the RC model systems will be conducted prior to beginning taxi or flight operations such as radio equipment ground range test, control-aircraft response and fail-safe response, per GTMP-2001.

NO FLIGHTS DIRECTLY OVER OPERATIONS PERSONNEL: Flight paths will be adjusted to the keep aircraft from directly overflying the flight operations essential personnel.

10.3 PILOT INITIATED FLIGHT TERMINATION

1. The pilot will terminate the RC Model Aircraft flight using the fail-safe system if the model flies outside the Flight Operational Area and is not in a controlled turn back toward the Flight Operational Area.

2. The pilot will terminate the RC Model Aircraft flight using the fail-safe system if all visual contact and positional information is lost and the model can violate the Flight Operational Area.

3. The pilot will terminate the RC Model Aircraft flight using the fail-safe system at any time he determines that continued flight of the model would constitute a hazard to any property, aircraft, or person.

10.4 RISK ASSESSMENT

The NASA Range Safety Program (NPR 8715.5) states that acceptable Casualty Expectation (Ec) for the public is 30×10^{-6} and mission essential personnel is 300×10^{-6}. The NPR also states an acceptable Probability of Casualty (Pc) of 1×10^{-6}. The risk of impact with essential personnel in the Operations Area caused by an in-flight failure or error is reduced because of the mitigations addressed in this Safety Risk Analysis. The risk to essential personnel in the Operations Area is estimated to be on the order of 4×10^{-8} Ec and for those in the Hazard Area it is 5×10^{-9}. Since the Ec

value is less than 1 x 10^{-6}, the Pc criteria is also met. See ENCLOSURE 3, Casualty Expectation Calculation.

11.0 CONCLUSION

The Safety Risk Analysis showed that with mitigations each identified hazard has a final RAC of 3.

The NPR 8715.5 personnel risk are acceptable.

The Safety Risk Analysis conducted for the defined RC Model Aircraft activity at 31VA concludes that operations are permissible.

Enclosure 1: Safety Engineering Note

1) Noise Danger Area Calculation for RC Model Gas Turbine Engines

The noise hazard exists for only a short duration during aircraft start and engine checks when the engine is operated at its maximum power. This is only done for approximately 4 seconds for each flight.

P_1 = Sound Pressure Level of turbojet at @ 1 ft. = 160 dB.

Given: Hearing Protection used by Personnel consists of:

i) NASA-Issued Standard Earmuffs; NR = 29 dB,

NR_{MIN} = 160 dB - 29 dB = 131 dB. Therefore, personnel wearing earmuffs are protected from noise during these activities, assuming exposure is of short duration (app 4 seconds/flight). It is also assumes that the standard earmuffs provides more attenuation at the higher-frequency levels, where the turbojets emit most of their noise energy.

Enclosure 2: Detailed Hazard Reports

AUTHOR	HAZARD REPORT NUMBER	LAST MODIFIED
(b) (6)	RC-Model HR-1	6/3/09

HAZARDOUS SUBSYSTEM/OPERATION
Engine

HAZARD DESCRIPTOR
Inadvertent Fuel ignition.

HAZARD DESCRIPTION
Inadvertent Fuel ignition.

HAZARD CAUSE
1. Fuel Leak somewhere in system 2. Ignition Source (Electrical Short, frayed wires, etc) present. 3. Attempted restarts of a flooded engine (turbojets only).

HAZARD EFFECTS
Critical Burns/injury to nearby personnel

HAZARD CONTROLS
1.1 Fuel System is checked for leaks, cracks, etc. prior to fueling. 1.2 Fuel fill cap is tightly secured after fueling. 2.1 Ensure proper connections during assembly/pre-flight. 3.1 If engine becomes flooded with fuel, tilt the engine forward slowly allowing the fuel to drain from the front of the engine.

CONTROLS VERIFICATION
1.1.1 Test Conductor/OSS Verification prior to mission. 1.2.1Same as 1.1.1. 2.1.1 Test Conductor/OSS verification prior to mission. 3.1.1 Test Conductor/OSS verification.

VERIFICATION STATUS
1.1.1 Closed. 1.2.1 Closed. 2.1.1 Closed 3.1.1 Closed.

INITIAL RISK SEVERITY	**INITIAL MISHAP PROBABILITY**	**INITIAL RISK ASSESSMENT CODE**
II	**E**	**3**
INTERIM RISK SEVERITY	**INTERIM MISHAP PROBABILITY**	**INTERIM RISK ASSESSMENT CODE**
II	**E**	**3**
FINAL RISK SEVERITY	**FINAL MISHAP PROBABILITY**	**FINAL RISK ASSESSMENT CODE**
II	**E**	**3**

AUTHOR HAZARD REPORT NUMBER LAST MODIFIED
(b) (6) RC-Model HR-2 9/18/02

HAZARDOUS SUBSYSTEM/OPERATION
Engine Propeller

HAZARD DESCRIPTOR
Sharp-Object

HAZARD DESCRIPTION
Personnel Contact with Propeller while engine is running.

HAZARD CAUSE
1. Improper Engine start-up while another task is being performed. 2. Improper personnel access to UAV while engine is running.

HAZARD EFFECTS
Severe lacerations or other critical injury to personnel.

HAZARD CONTROLS
1.1 Notify Operations Safety Supervisor (OSS) before any engine start operation. 1.2 Verify non-essential personnel are clear of the propeller while engine is running. 2.1 Operational area will be restricted to active-essential, cognizant personnel

CONTROLS VERIFICATION
1.1.1 OSS Verification prior to Engine Start. 1.2.1 OSS Verification during operation. 2.1.1 Same as 1.1.1

VERIFICATION STATUS
1.1.1 Closed. 1.2.1 Closed: Same as 1.2.1 Closed. 2.1.1 Closed

INITIAL RISK SEVERITY	**INITIAL MISHAP PROBABILITY**	**INITIAL RISK ASSESSMENT CODE**
II	**C**	**2**
INTERIM RISK SEVERITY	**INTERIM MISHAP PROBABILITY**	**INTERIM RISK ASSESSMENT CODE**
II	**D**	**3**
FINAL RISK SEVERITY	**FINAL MISHAP PROBABILITY**	**FINAL RISK ASSESSMENT CODE**
II	**D**	**3**

AUTHOR HAZARD REPORT NUMBER LAST MODIFIED
(b) (6) RC-Model HR-3 9/18/02

HAZARDOUS SUBSYSTEM/OPERATION
Engine

HAZARD DESCRIPTOR
Noise

HAZARD DESCRIPTION
Engine-generated noise.

HAZARD CAUSE
Continuous Noise Greater than OSHA Permissible Exposure Level, while engine is running.

HAZARD EFFECTS
Critical hearing damage.

HAZARD CONTROLS
1.1 Personnel performing Engine checks must wear approved hearing protection while the engine is running. 1.2 Non-active, non-essential personnel shall clear Pre-Flight Danger Area while engine is running.

CONTROLS VERIFICATION
1.1.1 OSS Verification during operation. 1.2.1 Same as 1.1.1

VERIFICATION STATUS
1.1.1 Closed. 1.2.1 Closed.

INITIAL RISK SEVERITY	**INITIAL MISHAP PROBABILITY**	**INITIAL RISK ASSESSMENT CODE**
II	**C**	**2**
INTERIM RISK SEVERITY	**INTERIM MISHAP PROBABILITY**	**INTERIM RISK ASSESSMENT CODE**
II	**D**	**3**
FINAL RISK SEVERITY	**FINAL MISHAP PROBABILITY**	**FINAL RISK ASSESSMENT CODE**
II	**D**	**3**

AUTHOR	HAZARD REPORT NUMBER	LAST MODIFIED
(b) (6)	RC-Model HR-3	6/3/09

HAZARDOUS SUBSYSTEM/OPERATION
Engine (turbojets only)

HAZARD DESCRIPTOR
Inert Debris.

HAZARD DESCRIPTION
Inert Debris ingested by the Engine Intake

HAZARD CAUSE
1. Loose gravel, foreign objects, or other debris present in immediate vicinity.

HAZARD EFFECTS
Injury to nearby personnel

HAZARD CONTROLS
1.1 Ensure the area is clear of foreign objects prior to engine startup.

CONTROLS VERIFICATION
1.1.1 Test Conductor/OSS Verification of clean/clear area prior to startup.

VERIFICATION STATUS
1.1.1 Closed.

INITIAL RISK SEVERITY	**INITIAL MISHAP PROBABILITY**	**INITIAL RISK ASSESSMENT CODE**
II	**E**	**3**
INTERIM RISK SEVERITY	**INTERIM MISHAP PROBABILITY**	**INTERIM RISK ASSESSMENT CODE**
II	**E**	**3**
FINAL RISK SEVERITY	**FINAL MISHAP PROBABILITY**	**FINAL RISK ASSESSMENT CODE**
II	**E**	**3**

AUTHOR	HAZARD REPORT NUMBER	LAST MODIFIED
(b) (6)	RC-Model HR-4	6/3/09

HAZARDOUS SUBSYSTEM/OPERATION
Engine (turbojets only)

HAZARD DESCRIPTOR
Excessive Heat.

HAZARD DESCRIPTION
Excessive heat flow produced by exhaust.

HAZARD CAUSE
1. High-RPM engine running.

HAZARD EFFECTS
Injury to nearby personnel

HAZARD CONTROLS
1.2 Ensure the area immediately aft of the engine's exhaust path is clear of personnel.

CONTROLS VERIFICATION
1.1.1 Test Conductor/OSS Verification prior to startup.

VERIFICATION STATUS
1.1.1 Closed.

INITIAL RISK SEVERITY **II**	**INITIAL MISHAP PROBABILITY** **D**	**INITIAL RISK ASSESSMENT CODE** **3**
INTERIM RISK SEVERITY **II**	**INTERIM MISHAP PROBABILITY** **E**	**INTERIM RISK ASSESSMENT CODE** **3**
FINAL RISK SEVERITY **II**	**FINAL MISHAP PROBABILITY** **E**	**FINAL RISK ASSESSMENT CODE** **3**

Enclosure 3: Casualty Expectation Calculation

The Casualty Expectation (Ec) calculation was determined for two regions: the Flight Operations and the Hazard areas. Flight data acquired over 6 years of prior operations at 31VA was used to determine the rates of mishaps. A mishap was defined as a non-low energy uncontrolled impact (ie >30 kts) not on the runway which resulted in significant aircraft damage or potential to injure personnel and/or damage property. Cases where the vehicle rolled off the runway at low-speed at the end of the landing roll out were excluded. The mishaps were grouped by area (Operations or Hazard). A barrier protection factor of 0.1 was used for the ground operations crew that are part of the AirSTAR operations. No barrier protection factor was used for those in the Hazard area. Table E3.1 provides a summary of the mishaps used for the analysis. Mishaps resulting in significant aircraft damage were documented in official AirSTAR documents others were recorded in the aircraft logbooks (Category 3 or Category 4 events as defined in GTMP-8002).

Table E3.1 Summary of Mishaps Used for Ec Analysis

#	Event	Reference	Root Cause	Date of Event
1	Stars and Bars	GTMP-2090	Pilot Error	4/9/2009
2	King Cat JFLIC	GTMP-2084	Pilot Error	8/23/2008
3	R&W King Cat	Log Book Entry	Pilot Error	8/14/2008
4	#24 L1011	GTMP-2070	Pilot Error or EMI	11/9/2007
5	DV8R	GTMP-2069	Pilot error	8/23/2007
6	S1	GTMP-2068	Pilot error	9/20/2006
7	T-33	GTMP-2059	Radio failure	3/8/2006
8	US-120	Log Book Entry	Battery failure	6/30/2005
9	Mod-2 touchdown on gravel	050411-MOD2	Pilot Error	4/11/2005
10	Navy touchdown on gravel	Log Book Entry	Pilot Error	6/9/2004

The Ec equation is

Operation area: $Ec = Bf \times L_A \times P_{Fo} \times N_{eo} / A_o$ (4 X10 E-8)
Hazard area: $Ec = L_A \times P_{Fh} \times N_{nh} / A_h$ (5 X10 E-9)

Table E3.2 Parameters Used for CE Aanalysis.

Parameter	Value	Justification of the value of the parameter
Barrier protection factor B_f	0.1	Personnel in ops area will be behind cars/trucks and other barriers
Lethal Area, L_A	70 sq ft	The Lethal Area allows for a plan form area equivalent to the T-1 aircraft whose wingspan is 6.8 feet and overall length is 8 feet. Using a one-foot buffer the Lethal Area is 70 sq. ft.
Hazard Area A_h	43,791,288 sq ft	App eq 2*0.5 mi radius circles
Operations Ares A_o	10,947,822 sq ft	App eq to ½ of a 0.5 mi radius circle
Probability Failure, P_{Fo}	.57%	10 mishaps in 1750 flights in ops area, based on GTMP-8200 data.
Probability Failure, P_{Fh}	.06%	1 mishap in 1750 flights in hazard area
Number of Essential Personnel, N_{eo}	10	personnel in ops area
Number of non-essential personnel in Hazard area, N_{nh}	5	those not associated with AirSTAR ops

The Lethal Area allows for a platform area equivalent to the T-1 aircraft whose wingspan is 6.8 feet and overall length is 8 feet. Using a one-foot buffer the Lethal Area is 70 sq. ft.

References

1. Federal Aviation Administration Certificate of Authorization for 31VA. 2008-ESA-21.
2. 2002 Official AMA National Model Aircraft Safety Code dated January 1. 2002.
3. Risk Assessment Code Matrix GSFC/WFF Directive No. 803-PG-8715.1.3D dated August 10, 2005.
4. NASA NPR 8715.5 Range Safety Program..
5. Common Risk Criteria for National Test Ranges RCC 321 dated June 2002.
6. Safety Risk Analysis For Radio Control Model Aircraft Revision B, GSFC/WFF, 2004.
7. GTMP 2033 Rev C, Airworthiness Certification for AirSTAR Unmanned Remotely Piloted Aircraft, 12/1/2006.
8. GTMP 4060, AirSTAR Battery Management Process, 10/2007.
9. GTMP 2023, Safety Brief for Visitors-Smithfield, 7/11/2006.
10. GTMP-8002, Subscale Pilot Training Plan, Draft 5/2009.
11. GTMP-2001-A, Generic Transport Sub-Scale Model Project Safety Procedures, 2/28/2008.
12. GTMP-8020, GTM Pilot Training Operations Plan for Aberdeen Field, Smithfield, Virginia, 6/5/2009.
13. GTMP-2072, Weather Condition Guidelines for Safe AirSTAR Flight Operations, 5/8/2008.
14. GTMP-2090, Report of Findings For the KingCat Stars and Bars UAS Type D Mishap of April 17, 2009.
15. GTMP-2084, Report of Findings for the KingCat J-FLIC UAS Type D Mishap of September 30, 2008.
16. GTMP-2070, Report of Findings for the L1011 #24 UAS Type D Mishap of November 9, 2007.
17. GTMP-2069, Report of Findings for the VCU DV8R UAS Type D Mishap of August 23, 2007.
18. GTMP-2068, Report of Findings for the L1011-S1 UAS Type D Mishap of September 20, 2006.
19. GTMP-2059, T33 Unmanned Aircraft System (UAS) MISHAP, 3/8/2006.