FLIGHT RESEARCH HAZARD ANALYSIS	PROGRAM: T1 Remotely Piloted Vehicle	HAZARD ANALYSIS # T1 001 Revision No. 2

HAZARD (One hazard per page)
Engine failure or loss of thrust

PHASE OF OPERATION
T,I,L

ANALYSIS IS:
● Initial ○ Addendum
○ Revision

UNDESIRED EVENT
Loss of fuel flow resulting in engine failure or loss of thrust

SYSTEM/FUNCTION/ACTIVITY
Engine

CAUSE OF UNDESIRED EVENT
1a) Exhaustion (Pilot error,leak)
1b) Contamination (Air or particles)

EFFECT OF UNDESIRED EVENT
Potential for CFIT or potential loss of control, loss of T1 and/or damage to property in excess of $500K
(Hazard does not include injury to persons)

CONTROLS/CORRECTIVE ACTION
Generic: Utilize trainer A/C and simulator to train pilots how to handle engine failure. Utilize simulator to determine max single engine throttle setting allowable with A/C still controllable (Vmc) Utilize simulator to determine rudder gyro gains needed to counteract single engine scenario.
1a) Fuel system integrity (leak) checked in post flight procedure, and operationally verified in preflight procedure 1a) Determine what (if any) software limit for maximum throttle RPM should be (based on VMC). Use new maximum throttle setting to dictate max flight time with 20% reserve.
1b) Engine testing (Phase 4) performed introduced large amounts of air into fuel lines. Engine is very resilient and loss of thrust only about 10-15%
1b) Established and trained personnel on fueling/de-fueling procedures

REMARKS/ADDITIONAL INFORMATION
Note:
- First flights will be limited to 10 minutes (or shorter if dictated by adjusted maximum throttle RPM determined in simulator)
- Engine testing found spool up time of 3 seconds is sufficient with reduced maximum throttle RPM setting (reducing maximum throttle RPM does not result in insufficient engine spool up/go around capability)

RISK ASSESSMENT *	
SEVERITY	I - Catastrophic
LOCAL HAZARD PROBABILITY/RAC	C - Possible
PRECEDING HAZARDS PROBABILITY	
NET PROBABILITY	
NET RAC	2

PREPARED BY:	DATE:	DATE CHECKED BY ACMO/ASO:	DATE CLOSED OUT BY ASRB:
(b) (6)	8-2-2004		

FLIGHT RESEARCH HAZARD ANALYSIS	PROGRAM: T1 Remotely Piloted Vehicle	HAZARD ANALYSIS # T1 002 Revision No. 2

HAZARD (One hazard per page)	PHASE OF OPERATION	ANALYSIS IS:
Engine failure or loss of thrust (Continued)	T,I,L	● Initial ○ Addendum ○ Revision

UNDESIRED EVENT
Loss of fuel flow due to fuel starvation resulting in engine failure or loss of thrust

SYSTEM/FUNCTION/ACTIVITY
Engine

CAUSE OF UNDESIRED EVENT
2a) Excessive time inverted or zero-G flight
2b) Fuel line connectors fail (no/low fuel flow)

EFFECT OF UNDESIRED EVENT
Potential for CFIT or potential loss of control, loss of T1 and/or damage to property in excess of $500K
(Hazard does not include injury to persons)

CONTROLS/CORRECTIVE ACTION
Generic: Engine testing (Phase 4) demonstrated engines and fuel systems are robust and can accommodate widely varying fuel flows (flameout resistant if starvation is temporary). Using off the shelf reliable, proven R/C engine components. Sealed (non-vented) fuel tanks provide fuel at all attitudes and g loads provided seal remains intact (non-vented)
2a) Create prohibited aircraft maneuvers list (In flight briefing guide): Prohibit intentional inverted or neg-G flight during training flights 2b) Engine start procedure utilizes “external tank” that verifies full fuel system operation. Add note to preflight procedure stating that successful external tank feeding will be performed prior to flight 2b) Modify preflight procedure to have warning that feeding from fuel fill valve (as opposed to fuel tank vent) does not verify fuel tank operation and could result in some fuel being “trapped” 2b) Utilize “safety wire” or collar to secure all fuel connections

REMARKS/ADDITIONAL INFORMATION
Generic:
-Incorporate ARCATS data telemetry system that displays to pilot indicated airspeed, GPS altitude, GPS coordinates, ground speed, battery voltages and pneumatic pressure
2) Incorporate “plug” in fuel vent lines to provide two methods of sealing fuel bladder vent lines (ball valve and plug)

RISK ASSESSMENT *	
SEVERITY	I - Catastrophic
LOCAL HAZARD PROBABILITY/RAC	C - Possible
PRECEDING HAZARDS PROBABILITY	
NET PROBABILITY	
NET RAC	2

PREPARED BY:	DATE:	DATE CHECKED BY ACMO/ASO:	DATE CLOSED OUT BY ASRB:
-(b) (6) [redacted]	8-2-2004		

FLIGHT RESEARCH HAZARD ANALYSIS	PROGRAM: T1 Remotely Piloted Vehicle	HAZARD ANALYSIS # T1 003 Revision No. 2

HAZARD (One hazard per page)	PHASE OF OPERATION	ANALYSIS IS:
Engine failure or loss of thrust (Continued)	T,I,L	● Initial ○ Addendum ○ Revision

UNDESIRED EVENT

Loss of fuel flow due to fuel starvation resulting in engine failure or loss of thrust

SYSTEM/FUNCTION/ACTIVITY

Engine

CAUSE OF UNDESIRED EVENT

2c) Fuel fill ball valve left open or fails/leaks

2d) Main fuel tank vent line leaks 2e) Engine feed fuel shutoff valve left off (or secured in flight)

EFFECT OF UNDESIRED EVENT

Potential for CFIT and potential loss of control, loss of T1 and/or damage to property in excess of $500K
(Hazard does not include injury to persons)

CONTROLS/CORRECTIVE ACTION

2c) Preflight procedure verifies valve is off, valve location makes leak detection likely 2d) If one tank vent leaks, normal fuel operation will continue from remaining sealed tank. Gravity feed only operation will continue from tank with vent leak. 2d) Utilizing two methods (ball valve and plug) in fuel tank vent lines 2e) Good fuel system design ensures fuel in lines insufficient to run engines after starting when fuel shutoff valve in off position 2e) Shutoff valve placement ensures no chance to inadvertently secure in flight

REMARKS/ADDITIONAL INFORMATION

Generic (cont.):

- Utilize pilot simulator training syllabus of 3 one hour sessions that exposes pilots to normal operation and emergencies scenarios
- Incorporate pilot performance written summary after each simulator training event

RISK ASSESSMENT *	
SEVERITY	I - Catastrophic
LOCAL HAZARD PROBABILITY/RAC	C - Possible
PRECEDING HAZARDS PROBABILITY	
NET PROBABILITY	
NET RAC	2

PREPARED BY:	DATE:	DATE CHECKED BY ACMO/ASO:	DATE CLOSED OUT BY ASRB:
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FLIGHT RESEARCH HAZARD ANALYSIS	PROGRAM: T1 Remotely Piloted Vehicle	HAZARD ANALYSIS # T1 004 Revision No. 2

HAZARD (One hazard per page)
Engine failure or loss of thrust (Continued)

PHASE OF OPERATION
T,I,L

ANALYSIS IS:
● Initial ○ Addendum
○ Revision

UNDESIRED EVENT
Airflow disruption and/or engine flameout resulting in engine failure or loss of thrust

SYSTEM/FUNCTION/ACTIVITY
Engine

CAUSE OF UNDESIRED EVENT
3) Airflow loss /disruption
4) Engine flameout (combustion chamber out)

EFFECT OF UNDESIRED EVENT
Potential for CFIT and potential loss of control, loss of T1 and/or damage to property in excess of $500K
(Hazard does not include injury to persons)

CONTROLS/CORRECTIVE ACTION
3) Proven nacelle design and fabrication (manufacturer). High quality assembly at LaRC model shop 3) Utilized Phase 4 engine testing to ingest air directly into engines at all angles of attack/sideslip. (Engines not alpha/beta sensitive) 3) Engines located at underside of wings (not subject to airflow disruption at high alpha) however higher potential for FOD (see next hazard sheet) 3) Procedures requires a daily FOD walk on runway to ensure no FOD/materials to block engine airflow 4) Engine remains lit with robust combustion chamber flame holder. Engine does not have continuous ignitor, or re-light capability (see engine testing summary documentation) 4) SOP states that operations shall not be conducted in inclement weather (precluding engine failure due to environment) 4) Team fully investigated in-flight re-light capability, and determined that this technology is in its first stages for R/C aircraft, and additionally is weight prohibited for this aircraft (See documentation)

REMARKS/ADDITIONAL INFORMATION
Generic:
-Develop flight briefing guide (covers admin., emergencies, flight specifics)
-Develop aircraft “test” plan (first few flights) of aircraft systems

RISK ASSESSMENT *

SEVERITY	I - Catastrophic
LOCAL HAZARD PROBABILITY/RAC	C - Possible
PRECEDING HAZARDS PROBABILITY	
NET PROBABILITY	
NET RAC	2

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FLIGHT RESEARCH HAZARD ANALYSIS	PROGRAM: T1 Remotely Piloted Vehicle	HAZARD ANALYSIS # T1 005 Revision No. 2

HAZARD (One hazard per page)	PHASE OF OPERATION	ANALYSIS IS:
Engine failure or loss of thrust (Continued)	T,I,L	● Initial ○ Addendum ○ Revision

UNDESIRED EVENT
Mechanical failure resulting in engine failure or loss of thrust

SYSTEM/FUNCTION/ACTIVITY
Engine

CAUSE OF UNDESIRED EVENT
5) Mechanical Failure (FOD/poor design / poor fab. or installation)

EFFECT OF UNDESIRED EVENT
Potential for CFIT and potential loss of control, loss of T1 and/or damage to property in excess of $500K
(Hazard does not include injury to persons)

CONTROLS/CORRECTIVE ACTION
5) See manufacturer's product information, engine history data, and installation documentation. Using well tested, reliable, off-the-shelf engines 5) Personnel trained in ground procedures for aircraft preflight inspection, FOD walk down, turnaround and post flight inspection (locate engine damage) 5) Motor inspection dictated in procedures in accordance with engine manufacture's recommendations 5) Service or replace motors in accordance with engine manufacturer's recommendations
Generic: Document Vmc speed and train pilot's ground crewman to callout airspeed (from ARCAT system) during critical portions of flight

REMARKS/ADDITIONAL INFORMATION

RISK ASSESSMENT *	
SEVERITY	I - Catastrophic
LOCAL HAZARD PROBABILITY/RAC	C - Possible
PRECEDING HAZARDS PROBABILITY	
NET PROBABILITY	
NET RAC	2

PREPARED BY:	DATE:	DATE CHECKED BY ACMO/ASO:	DATE CLOSED OUT BY ASRB:
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FLIGHT RESEARCH HAZARD ANALYSIS	PROGRAM: T1 Remotely Piloted Vehicle	HAZARD ANALYSIS # T1 006 Revision No. 2

HAZARD (One hazard per page)	PHASE OF OPERATION	ANALYSIS IS:
Engine failure or loss of thrust (Continued)	T,I,L	● Initial ○ Addendum ○ Revision

UNDESIRED EVENT

Undesired shutdown of engine(s) resulting in loss of thrust

SYSTEM/FUNCTION/ACTIVITY

Engine

CAUSE OF UNDESIRED EVENT

6) Loss of throttle control signal from receiver
7) Pilot error
8) Loss of engine thermocouple or engine RPM signal (or thermocouple “moves”)

EFFECT OF UNDESIRED EVENT

Potential for CFIT and potential loss of control, loss of T1 and/or damage to property in excess of $500K
(Hazard does not include injury to persons)

CONTROLS/CORRECTIVE ACTION

Generic: Determine engine out (dual and single eng) flight profiles (practice after first few flights). Develop To/Ldg engine failure procedures (versus just engine failure in flight) Loss of any engine connection and/or signal from receiver back, secures motor. (Not preferred but this is how the system responds) See engine failure in-flight procedure. Utilize pilot simulator training syllabus of 3 one hour sessions that exposes pilots to normal operation and emergencies scenarios.
6) Pre-flt procedure ensures that fail-safe (throttles idle and rudder over) prior to every flight 8) Ensure engine thermocouple securely (mechanically) held in position (or engine temps out of tolerance and engine will auto secure)

REMARKS/ADDITIONAL INFORMATION

Note:
- Include note in pilot briefing guide that if both xmtrs are on simultaneously (pilot and backup transmitters), receivers initiate fail-safe mode
6) Both engines to be wired to one of dual “split” receivers. Single receiver failure will result in both engines operating normal, or both secured in flight (depending on which receiver fails). Remaining flight control authority (half of surfaces) enable pilot to maintain aircraft control.

RISK ASSESSMENT *	
SEVERITY	I - Catastrophic
LOCAL HAZARD PROBABILITY/RAC	C - Possible
PRECEDING HAZARDS PROBABILITY	
NET PROBABILITY	
NET RAC	2

PREPARED BY:	DATE:	DATE CHECKED BY ACMO/ASO:	DATE CLOSED OUT BY ASRB:
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FLIGHT RESEARCH HAZARD ANALYSIS	PROGRAM: T1 Remotely Piloted Vehicle	HAZARD ANALYSIS # T1 007 Revision No. 2

HAZARD (One hazard per page)	PHASE OF OPERATION	ANALYSIS IS:
Engine failure/loss of thrust or un-commanded throttle	T,I,L	● Initial ○ Addendum ○ Revision

UNDESIRED EVENT

Fuel pump or fuel control failure results in engine failure/loss of thrust or un-commanded throttle

SYSTEM/FUNCTION/ACTIVITY

Engine

CAUSE OF UNDESIRED EVENT

9) ECU failure (electrical / battery/ regs. low/high)
10) Fuel Pump failure (elec./ mech./ or supplies high/low)

EFFECT OF UNDESIRED EVENT

Potential for CFIT and potential loss of control, loss of T1 and/or damage to property in excess of $500K
(Hazard does not include injury to persons)

CONTROLS/CORRECTIVE ACTION

Generic: Utilize pilot simulator training syllabus of 3 one hour sessions that exposes pilots to normal operation and emergencies scenarios.
9) Loss of any engine connection and/or signal from receiver back, secures motor. See engine failure in-flight procedure. 9) Develop an un-commanded throttle procedure (fly till fuel exhausted, secure engine(s) in-flight or perform CFIT) 9) Utilizing off the shelf, "proven" engine system components 9) Using battery "tracking system" and procedures for historical battery monitoring. Battery charge checked just prior to flight in preflight procedure. 9) Utilizing battery bus system that ensures battery power supplied to both ECUs from either battery 10) Utilizing off the shelf, "proven" engine system components. 10) See un-commanded throttle procedure or engine failure procedures

REMARKS/ADDITIONAL INFORMATION

Note:
- Incorporate ARCATS data telemetry system that displays to pilot indicated airspeed, GPS altitude, GPS coordinates, ground speed, battery voltages and pneumatic pressure
- Similar aircraft (L-1011 OEM) is safely operated in hobby community without indicated airspeed, GPS coordinates and battery status, so loss of any of these will not constitute an emergency situation.

RISK ASSESSMENT *	
SEVERITY	I - Catastrophic
LOCAL HAZARD PROBABILITY/RAC	C - Possible
PRECEDING HAZARDS PROBABILITY	
NET PROBABILITY	
NET RAC	2

PREPARED BY:	DATE:	DATE CHECKED BY ACMO/ASO:	DATE CLOSED OUT BY ASRB:
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FLIGHT RESEARCH HAZARD ANALYSIS	PROGRAM: T1 Remotely Piloted Vehicle	HAZARD ANALYSIS # T1 008 Revision No. 2

HAZARD (One hazard per page)
Engine failure or loss of thrust (Continued)

PHASE OF OPERATION
A

ANALYSIS IS:
● Initial ○ Addendum
○ Revision

UNDESIRED EVENT
Fire or environmental conditions result in aircraft damage engine failure/loss of thrust

SYSTEM/FUNCTION/ACTIVITY
Engine

CAUSE OF UNDESIRED EVENT
11) Fire
12) Environmental

EFFECT OF UNDESIRED EVENT
Potential for CFIT and potential loss of control, loss of T1 and/or damage to property
(Hazard does not include injury to persons)

CONTROLS/CORRECTIVE ACTION
11) Established on deck and in-flight fire procedures 11) Fire fighting equipment available during all operations (ground, flight, servicing etc.) 11) Use of post flight, and preflight procedures prevent inadvertent fuel leaks minimizing fire potential. 12) Procedures dictates min wx requirements (safety document/flight briefing guide) 12) Determine environmental limits (performance calculations for high/hot/humid) and ensure safety document dictates these limits (Temp of 40-100 deg F) General component environmental limits already published in manufacturer literature
12) If transmitter software limiting maximum engine thrust available, determine that remaining thrust (subject to high/hot/humid) is sufficient for refusal speeds, runway lengths, single engine climb out etc.

REMARKS/ADDITIONAL INFORMATION
Note:
-Engine operations have been conducted during wet, hot, and cold environmental conditions with no performance degradation experienced.

RISK ASSESSMENT *

SEVERITY	I - Catastrophic
LOCAL HAZARD PROBABILITY/RAC	C - Possible
PRECEDING HAZARDS PROBABILITY	
NET PROBABILITY	
NET RAC	2

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FLIGHT RESEARCH HAZARD ANALYSIS	PROGRAM: T1 Remotely Piloted Vehicle	HAZARD ANALYSIS # T1 009 Revision No. 2

HAZARD (One hazard per page)	PHASE OF OPERATION	ANALYSIS IS:
Loss of control of aircraft	T,I,L	● Initial ○ Addendum ○ Revision

UNDESIRED EVENT
Human error resulting in loss of control of aircraft

SYSTEM/FUNCTION/ACTIVITY
Aircraft

CAUSE OF UNDESIRED EVENT
1) Pilot Error (PIO, loss of SA etc.)
2) Improper WT & Balance

EFFECT OF UNDESIRED EVENT
Potential loss of T1, damage to property in excess of $500K
(Hazard does not include injury to persons)

CONTROLS/CORRECTIVE ACTION
1) Robust pilot training program using progressively advanced models 1) Utilize pilot simulator training syllabus of 3 one hour sessions that exposes pilots to normal operation and emergencies scenarios. 1) Aircraft color scheme reduces likelihood of pilot loss of aircraft attitude 1) Utilize trainer aircraft and simulator to standardize crew challenge/reply (T/O, landing checks etc.) 2) Established baseline weight and balance limits, and ensure within limits on preflight checklist (Ensure cg limits from aircraft owners manual make it into Post flight checklist) 2) Conducted review of aircraft interior to examine possible weight and balance shifts/failures (under G-loading) in-flight. Internal systems integrity check performed at each post flight inspection.

REMARKS/ADDITIONAL INFORMATION

RISK ASSESSMENT *	
SEVERITY	I - Catastrophic
LOCAL HAZARD PROBABILITY/RAC	C - Possible
PRECEDING HAZARDS PROBABILITY	
NET PROBABILITY	
NET RAC	2

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FLIGHT RESEARCH HAZARD ANALYSIS	PROGRAM: T1 Remotely Piloted Vehicle	HAZARD ANALYSIS # T1 010 Revision No. 2

HAZARD (One hazard per page)	PHASE OF OPERATION	ANALYSIS IS:
Loss of control of aircraft (Continued)	T,I,L	● Initial ○ Addendum ○ Revision

UNDESIRED EVENT
Aerodynamic or environmental conditions result in loss of control of aircraft

SYSTEM/FUNCTION/ACTIVITY
Aircraft

CAUSE OF UNDESIRED EVENT
3) Aerodynamics: flight control rigging, inadequate design, operating outside flight envelope
4) Environmental Factors

EFFECT OF UNDESIRED EVENT
Potential loss of T1, damage to property in excess of $500K
(Hazard does not include injury to persons)

CONTROLS/CORRECTIVE ACTION
3) Robust and sustained pilot training program, from trainer aircraft to advanced jets 3) Utilize pilot simulator training syllabus of 3 one hour sessions conducted that exposes pilots to normal operation and emergencies scenarios 3) Utilize ARCAT system to provide altitude/airspeed 3) Unique model designed and assembled to high quality standards by LaRC model shop, and supervised by chief engineer 3) Model design reviewed by Centers' Model Systems Engineers 4) Implemented color scheme that enhances visibility/orientation 4) Established SOP limits for wind/gusts, X-wind, visibility, WX, day/night, other RC aircraft (See safety document and briefing guide)

REMARKS/ADDITIONAL INFORMATION

RISK ASSESSMENT *	
SEVERITY	I - Catastrophic
LOCAL HAZARD PROBABILITY/RAC	C - Possible
PRECEDING HAZARDS PROBABILITY	
NET PROBABILITY	
NET RAC	2

PREPARED BY:	DATE:	DATE CHECKED BY ACMO/ASO:	DATE CLOSED OUT BY ASRB:
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FLIGHT RESEARCH HAZARD ANALYSIS	PROGRAM: T1 Remotely Piloted Vehicle	HAZARD ANALYSIS # T1 011 Revision No. 2

HAZARD (One hazard per page)	PHASE OF OPERATION	ANALYSIS IS:
Loss of control of aircraft (Continued)	T,I,L	● Initial ○ Addendum ○ Revision

UNDESIRED EVENT
Flight control failure results in loss of control of aircraft

SYSTEM/FUNCTION/ACTIVITY
Aircraft

CAUSE OF UNDESIRED EVENT
5a) Poor design, fabrication, or installation (includes gyro failure, gyro mounting failure, hard over nose wheel etc.)
5b) Flip tail inadvertent mechanical release

EFFECT OF UNDESIRED EVENT
Potential loss of T1, damage to property in excess of $500K
(Hazard does not include injury to persons)

CONTROLS/CORRECTIVE ACTION
Generic: Established flight control emergency procedures / Perform high/low speed taxi testing prior to first flight. Using off the shelf reliable R/C components. Model systems report reviewed by model systems engineer. 5a) Conducted servo torque load testing (see documentation) 5a) Utilize preflight procedure to ensure gyro mounting secure prior to flight 5a) Utilize high speed taxi and simulator to adjust gyro sensitivity to lowest effective setting 5b) Mechanical flip tail will be mechanically locked out

REMARKS/ADDITIONAL INFORMATION
Note:
- If flip-tail mechanically releases (not commanded to release) flight will terminate with no way to reset tail

RISK ASSESSMENT *	
SEVERITY	I - Catastrophic
LOCAL HAZARD PROBABILITY/RAC	C - Possible
PRECEDING HAZARDS PROBABILITY	
NET PROBABILITY	
NET RAC	2

PREPARED BY:	DATE:	DATE CHECKED BY ACMO/ASO:	DATE CLOSED OUT BY ASRB:
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FLIGHT RESEARCH HAZARD ANALYSIS	PROGRAM: T1 Remotely Piloted Vehicle	HAZARD ANALYSIS # T1 012 Revision No. 2

HAZARD (One hazard per page)	PHASE OF OPERATION	ANALYSIS IS:
Loss of control of aircraft (Continued)	T,I,L	● Initial ○ Addendum ○ Revision

UNDESIRED EVENT
Mechanical overload of aircraft structure results in loss of control of aircraft

SYSTEM/FUNCTION/ACTIVITY
Aircraft

CAUSE OF UNDESIRED EVENT
6) Structural overload/failure of aircraft (design/ fabrication/installation etc.)
7) Midair / bird strike

EFFECT OF UNDESIRED EVENT
Potential loss of T1, damage to property in excess of $500K
(Hazard does not include injury to persons)

CONTROLS/CORRECTIVE ACTION
6) Conducted aircraft proof load testing (wings, horizontal stab, spin recovery tail, and landing gear tested). 6) Model systems report reviewed by model systems engineer 6) Installing ARCAT system G load monitoring, and using post flight tracking to trend/analyze G loads 7) Midair will likely lead to loss of aircraft, therefore, SOP dictates that no other models will be flown while T-1 is in flight.

REMARKS/ADDITIONAL INFORMATION
Note:
-Safety engineer on site will have responsibility to cancel flight operations on “high” bird activity days.

RISK ASSESSMENT *	
SEVERITY	I - Catastrophic
LOCAL HAZARD PROBABILITY/RAC	C - Possible
PRECEDING HAZARDS PROBABILITY	
NET PROBABILITY	
NET RAC	2

PREPARED BY:	DATE:	DATE CHECKED BY ACMO/ASO:	DATE CLOSED OUT BY ASRB:
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FLIGHT RESEARCH HAZARD ANALYSIS	PROGRAM: T1 Remotely Piloted Vehicle	HAZARD ANALYSIS # T1 013 Revision No. 2

HAZARD (One hazard per page)
Loss of control of aircraft (command and control system failures)

PHASE OF OPERATION
T,I,L

ANALYSIS IS:
● Initial ○ Addendum
○ Revision

UNDESIRED EVENT
RF signal related failures result in loss of control of aircraft

SYSTEM/FUNCTION/ACTIVITY
Aircraft

CAUSE OF UNDESIRED EVENT
1) Loss or interruption of RF signal(s) XMTR or Receiver
2) EMI
3) Vehicle flown out of reception area (poor navigation)

EFFECT OF UNDESIRED EVENT
Potential loss of T1, damage to property in excess of $500K
(Hazard does not include injury to persons)

CONTROLS/CORRECTIVE ACTION
Generic: Fail safe mode entry (upon loss of xmtr signal) will result in termination of flight (engine(s) to idle, rudder deflected over)
1) Ensure backup transmitter programmed and nearby to assume command for non-time critical transmitter failures 1) R/F distance testing performed on preflight inspection 1) Xmtr program version control and loading procedures utilized to ensure correct/current software 1) Battery bus system provides power to both ECUS and receivers in event of one battery failure 1) Split receivers provide dual or no engines and half flight controls if one receiver fails 2) SOP dictates Xmtr flags (prevent same frequency operation) and no other Xmtrs on while flight in progress 2) Conducted RF susceptibility testing with engines operating and found no anomalies 2) Coordinate with Wallops realtime to ensure no external EMI, other fields have no EMI capability 3) Xmtr power ensures reliable communication throughout operating area. 3) Receiver(s) initiate fail safe mode

REMARKS/ADDITIONAL INFORMATION
Note:
- Incorporate fail-safe check into takeoff checklist
- Clearly label pilot, and backup transmitters to distinguish between them

RISK ASSESSMENT *

SEVERITY	I - Catastrophic
LOCAL HAZARD PROBABILITY/RAC	C - Possible
PRECEDING HAZARDS PROBABILITY	
NET PROBABILITY	
NET RAC	2

PREPARED BY:	DATE:	DATE CHECKED BY ACMO/ASO:	DATE CLOSED OUT BY ASRB:
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FLIGHT RESEARCH HAZARD ANALYSIS	PROGRAM: T1 Remotely Piloted Vehicle	HAZARD ANALYSIS # T1 014 Revision No. 2

HAZARD (One hazard per page)	PHASE OF OPERATION	ANALYSIS IS:
Loss of control of aircraft (command and control system failures) (Continued)	T,I,L	● Initial ○ Addendum ○ Revision

UNDESIRED EVENT
See hazard above.

SYSTEM/FUNCTION/ACTIVITY
Aircraft

CAUSE OF UNDESIRED EVENT
4) Poor RF system design
5) Poor RF fabrication or installation

EFFECT OF UNDESIRED EVENT
Potential loss of T1, damage to property in excess of $500K
(Hazard does not include injury to persons)

CONTROLS/CORRECTIVE ACTION
Generic: Using off the shelf reliable R/C components. RF range checks conducted in accordance with preflight procedures. High quality assembly/installation performed by highly experienced LaRC model shop and team personnel.
5) Aircraft maintenance logbook tracks work conducted/modifications to ensure high quality during/after initial assembly

REMARKS/ADDITIONAL INFORMATION

RISK ASSESSMENT *	
SEVERITY	I - Catastrophic
LOCAL HAZARD PROBABILITY/RAC	C - Possible
PRECEDING HAZARDS PROBABILITY	
NET PROBABILITY	
NET RAC	2

PREPARED BY:	DATE:	DATE CHECKED BY ACMO/ASO:	DATE CLOSED OUT BY ASRB:
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FLIGHT RESEARCH HAZARD ANALYSIS	PROGRAM: T1 Remotely Piloted Vehicle	HAZARD ANALYSIS # T1 015 Revision No. 2

HAZARD (One hazard per page)
Loss of control of aircraft (command and control system failures)
(Continued)

PHASE OF OPERATION
T,I,L

ANALYSIS IS:
● Initial ○ Addendum
○ Revision

UNDESIRED EVENT
Unstable control system/aircraft results in inability to control aircraft

SYSTEM/FUNCTION/ACTIVITY
Aircraft

CAUSE OF UNDESIRED EVENT
6) Control Laws / aircraft stability

EFFECT OF UNDESIRED EVENT
Potential loss of T1, damage to property in excess of $500K
(Hazard does not include injury to persons)

CONTROLS/CORRECTIVE ACTION
6) Utilizing commercially available or off the shelf control system 6) Utilizing simulator to verify that aircraft will have a stable dynamic/static margins. 6) Xmtr program version control and loading procedures utilized to ensure correct flight control software in Xmtrs.

REMARKS/ADDITIONAL INFORMATION

RISK ASSESSMENT *	
SEVERITY	I - Catastrophic
LOCAL HAZARD PROBABILITY/RAC	C - Possible
PRECEDING HAZARDS PROBABILITY	
NET PROBABILITY	
NET RAC	2

PREPARED BY:	DATE:	DATE CHECKED BY ACMO/ASO:	DATE CLOSED OUT BY ASRB:
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FLIGHT RESEARCH HAZARD ANALYSIS	PROGRAM: T1 Remotely Piloted Vehicle	HAZARD ANALYSIS # T1 016 Revision No. 2

HAZARD (One hazard per page)
Landing Gear fails to retract or fails to extend with aircraft in flight (all extend, nose wheel, one main, both mains, stub gear, cocked nose wheel)

PHASE OF OPERATION
I

ANALYSIS IS:
● Initial ○ Addendum
○ Revision

UNDESIRED EVENT
One or more landing gear fails to extend or retract

SYSTEM/FUNCTION/ACTIVITY
Landing Gear

CAUSE OF UNDESIRED EVENT
1) Loss of air pressure (leak in bottle, lines/T's/air charge or pressure √ valves, brakes etc.)
2) Failure of RF system prior to servo (Xmtr, receiver, etc.)
3) Electrical / Mechanical failure of landing gear servo

EFFECT OF UNDESIRED EVENT
Potential loss of T1, damage to property in excess of $500K
(Hazard does not include injury to persons)

CONTROLS/CORRECTIVE ACTION
1) Placement of brakes moved to right slider switch. Brakes can unintentionally be left on, but air supply pressure is only lost on cycling of brakes 1) Devised appropriate gear emergency procedures 1) Air lines will be replaced yearly. 1) Utilize "collars" or wire to prevent pressurized air lines from detaching. 1) Determined thru testing that 6 cycles of gear actuation deplete bottle, pilots trained to use 2-4 gear actuation max (Brakes will be done during high speed taxi testing) (Need this if have to cycle gear in flight for some emergency scenarios) 1) Perform "leak down" test of air system according to time interval specified in procedures (done every 25 flights) 1) ARCAT system allows pilot to monitor bottle pressure realtime 2) Will lead to gear all up or all down with inability to change configuration. See appropriate gear emergency procedure.
3) Will lead to gear all up or all down scenario with inability to change configuration. See appropriate gear emergency procedure

REMARKS/ADDITIONAL INFORMATION
Note:
-Single air bottle provides air supply for both landing gear and braking systems
-Investigated intentional use of fail-safe mode entry to attempt to bypass Xmtr failure to activate gear. Determined that preferable to conduct gear unsafe landing rather than risk losing aircraft by entering fail safe mode and subsequently trying to recover aircraft

RISK ASSESSMENT *

SEVERITY	I - Catastrophic
LOCAL HAZARD PROBABILITY/RAC	C - Possible
PRECEDING HAZARDS PROBABILITY	
NET PROBABILITY	
NET RAC	2

PREPARED BY:	DATE:	DATE CHECKED BY ACMO/ASO:	DATE CLOSED OUT BY ASRB:
-(b) (6) [redacted]	8-2-2004		

FLIGHT RESEARCH HAZARD ANALYSIS	PROGRAM: T1 Remotely Piloted Vehicle	HAZARD ANALYSIS # T1 017 Revision No. 2

HAZARD (One hazard per page)
Landing Gear fails to retract or fails to extend with aircraft in flight (all extend, nose wheel, one main, both mains, stub gear, cocked nose wheel) (Continued)

PHASE OF OPERATION
I

ANALYSIS IS:
● Initial ○ Addendum
○ Revision

UNDESIRED EVENT
One or more landing gear fails to extend or retract

SYSTEM/FUNCTION/ACTIVITY
Landing Gear

CAUSE OF UNDESIRED EVENT
4) Failure of landing gear air switching valve
5) Gear, gear door, nose wheel steering mechanical binding

EFFECT OF UNDESIRED EVENT
Potential loss of T1, damage to property in excess of $500K
(Hazard does not include injury to persons)

CONTROLS/CORRECTIVE ACTION
Generic: Move brake system supply line to be part of gear deployment supply line (to prevent brake pressure bleed down in flight with gear up). Devise Ldg gear failure emergency procedures (fails extend, retract, or partial gear, cocked nose wheel). Paint interior of gear doors (struts) visible paint scheme so may be able to visually confirm gear door position in-flight. Make aircraft "arrestment netting system available (prior to flight) to minimize damage in event of abnormal gear landing 4) Should lead to all gear up or all gear down scenario with inability to change. See appropriate gear emergency procedure. 5) Perform actual nose wheel hardware testing to confirm proper system design (Use full throw of nose wheel steering each way and simultaneously raise gear to check for mechanical binding)

REMARKS/ADDITIONAL INFORMATION
Note:
- Examined gear system operation, and determined cannot free fall gear due to nose over center pivot and main mechanical pin lock

RISK ASSESSMENT *

SEVERITY	I - Catastrophic
LOCAL HAZARD PROBABILITY/RAC	C - Possible
PRECEDING HAZARDS PROBABILITY	
NET PROBABILITY	
NET RAC	2

PREPARED BY:	DATE:	DATE CHECKED BY ACMO/ASO:	DATE CLOSED OUT BY ASRB:
-(b) (6) [redacted]	8-2-2004		

FLIGHT RESEARCH HAZARD ANALYSIS	PROGRAM: T1 Remotely Piloted Vehicle	HAZARD ANALYSIS # T1 018 Revision No. 2

HAZARD (One hazard per page)
Landing Gear fails to retract or fails to extend with aircraft in flight (all extend, nose wheel, one main, both mains, stub gear, cocked nose wheel) (Continued)

PHASE OF OPERATION
I

ANALYSIS IS:
● Initial ○ Addendum
○ Revision

UNDESIRED EVENT
One or more landing gear fails to extend or retract

SYSTEM/FUNCTION/ACTIVITY
Landing Gear

CAUSE OF UNDESIRED EVENT
6) Blockage in air system (Lines pinched/Contamination)
7) Air bottle fails (see Haz # 31,32)
8) Human error (air bottle insufficiently serviced)

EFFECT OF UNDESIRED EVENT
Potential loss of T1, damage to property in excess of $500K
(Hazard does not include injury to persons)

CONTROLS/CORRECTIVE ACTION
6) Utilizing filtered compressed air for bottle servicing (in accordance with servicing procedure) 7) Air bottle rated for 150 psi (only charging to 110 psi)
7) See documentation (GTMP 2027) of factors of safety for air bottle 8) Trained operators utilizing checklists

REMARKS/ADDITIONAL INFORMATION

RISK ASSESSMENT *

SEVERITY	I - Catastrophic
LOCAL HAZARD PROBABILITY/RAC	C - Possible
PRECEDING HAZARDS PROBABILITY	
NET PROBABILITY	
NET RAC	2

PREPARED BY:	DATE:	DATE CHECKED BY ACMO/ASO:	DATE CLOSED OUT BY ASRB:
(b) (6)	8-2-2004		

FLIGHT RESEARCH HAZARD ANALYSIS	PROGRAM: T1 Remotely Piloted Vehicle	HAZARD ANALYSIS # T1 019 Revision No. 2

HAZARD (One hazard per page)
Inadvertent raising of landing gear while aircraft is on deck

PHASE OF OPERATION
G

ANALYSIS IS:
● Initial ○ Addendum
○ Revision

UNDESIRED EVENT
Human error results in inadvertent raising of landing gear while aircraft is on deck

SYSTEM/FUNCTION/ACTIVITY
Landing Gear

CAUSE OF UNDESIRED EVENT
1) Servicing personnel / pilot error

EFFECT OF UNDESIRED EVENT
Possible personnel injury (pinched digits), with only minimal damage to model

CONTROLS/CORRECTIVE ACTION
1) Established procedures (preflight, post flight and servicing) and trained personnel 1)Robust pilot/crew training, and use of standardized checklists
1) Ensure takeoff checklist ensures gear commanded down, not just visually confirmed down prior to T/O. This will prevent inadvertent gear retraction when aircraft experiences reduced weight on wheels during takeoff roll.

REMARKS/ADDITIONAL INFORMATION
Note: Examined possibility of interlocking gear with other systems via Xmtr (i.e. flaps down can't raise gear). Decided not to do as hazard severity is low and interlock will introduce other unintended hazards (Example inability to raise gear during single engine climb out without raising flaps)

RISK ASSESSMENT *

SEVERITY	III - Marginal
LOCAL HAZARD PROBABILITY/RAC	C - Possible
PRECEDING HAZARDS PROBABILITY	
NET PROBABILITY	
NET RAC	3

PREPARED BY:	DATE:	DATE CHECKED BY ACMO/ASO:	DATE CLOSED OUT BY ASRB:
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FLIGHT RESEARCH HAZARD ANALYSIS	PROGRAM: T1 Remotely Piloted Vehicle	HAZARD ANALYSIS # T1 020 Revision No. 2

HAZARD (One hazard per page)
Inadvertent raising of landing gear while aircraft is on deck (Continued)

PHASE OF OPERATION
Ground Operations

ANALYSIS IS:
● Initial ○ Addendum
○ Revision

UNDESIRED EVENT
Mechanical or control system malfunction results in inadvertent raising of landing gear while aircraft is on deck

SYSTEM/FUNCTION/ACTIVITY
Landing Gear

CAUSE OF UNDESIRED EVENT
2) Error in control system (EMI, receiver failure modes etc.)
3) Landing gear switching valve failure
4) Leak in air system between switching valve and gear air actuators (positive air pressure required to lock main gear)

EFFECT OF UNDESIRED EVENT
Possible personnel injury (pinched digits), with only minimal damage to model

CONTROLS/CORRECTIVE ACTION
2) Xmtr program version control and loading procedures utilized to ensure correct/current software in Xmtrs. 2) SOP dictates Xmtr flags (prevent same frequency operation) and no other Xmtrs on while flight in progress 2) Coordinate with Wallops realtime to ensure no external EMI. 2) Other fields have no EMI monitored capability 2) Xmtr power ensures reliable communication throughout operating area. 3) Using off the shelf R/C components (fabricated at factory) 4) Actual hardware testing determines that a loss of air pressure will not lead to inadvertent gear collapse once gear in place (due to nose over center pivot, and main gear locking "pins")

REMARKS/ADDITIONAL INFORMATION

RISK ASSESSMENT *	
SEVERITY	III - Marginal
LOCAL HAZARD PROBABILITY/RAC	C - Possible
PRECEDING HAZARDS PROBABILITY	
NET PROBABILITY	
NET RAC	3

PREPARED BY:	DATE:	DATE CHECKED BY ACMO/ASO:	DATE CLOSED OUT BY ASRB:
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FLIGHT RESEARCH HAZARD ANALYSIS	PROGRAM: T1 Remotely Piloted Vehicle	HAZARD ANALYSIS # T1 021 Revision No. 2

HAZARD (One hazard per page)	PHASE OF OPERATION	ANALYSIS IS:
Brakes fail to engage (or some brakes fail)	T,I,L,G	● Initial ○ Addendum ○ Revision

UNDESIRED EVENT
Human error results in failure of one or more brakes to engage

SYSTEM/FUNCTION/ACTIVITY
Landing Gear

CAUSE OF UNDESIRED EVENT
1) Pilot or ground personnel error

EFFECT OF UNDESIRED EVENT
Aircraft departs runway, or paved taxi way. Possible damage to T1, damage to property in excess of $50K
(Hazard does not include injury to persons)

CONTROLS/CORRECTIVE ACTION
1) Pilot training includes ground handling, normal taxi procedures. 1) Normal and emergency (brake failure) operating procedures 1) System design allows pilot to only apply brakes in unison. 1) Pilot training will incorporate securing aircraft engines when aircraft is about to depart paved surface (minimize damage to aircraft due to FOD) 1) Pilots trained on acceptable number of gear actuations and/or brake applications available prior to exhausting air supply See flight briefing guide 1) Brake system fully charged prior to takeoff via established preflight procedure. 1) Placement of brakes moved to right slider switch, to match other trainer aircraft which standardizes pilot training between aircraft types

REMARKS/ADDITIONAL INFORMATION
Note:
- Procedures ensure that personnel are clear of area during all T/Os, Ldgs

RISK ASSESSMENT *	
SEVERITY	II - Critical
LOCAL HAZARD PROBABILITY/RAC	C - Possible
PRECEDING HAZARDS PROBABILITY	
NET PROBABILITY	
NET RAC	3

PREPARED BY:	DATE:	DATE CHECKED BY ACMO/ASO:	DATE CLOSED OUT BY ASRB:
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FLIGHT RESEARCH HAZARD ANALYSIS	PROGRAM: T1 Remotely Piloted Vehicle	HAZARD ANALYSIS # T1 022 Revision No. 2

HAZARD (One hazard per page)	PHASE OF OPERATION	ANALYSIS IS:
Brakes fail to engage (or some brakes fail) (Continued)	T,I,L,G	● Initial ○ Addendum ○ Revision

UNDESIRED EVENT

Mechanical or control system failure results in failure of one or more brakes to engage

SYSTEM/FUNCTION/ACTIVITY

Landing Gear

CAUSE OF UNDESIRED EVENT

2) Failure of RF system prior to servo (Xmtr, receiver, etc.)
3) Electrical / Mechanical failure of brake servo or failure of smooth stop braking valve
4) Failure of tire/rim brake components

EFFECT OF UNDESIRED EVENT

Aircraft departs runway, or paved taxi way. Possible damage to T1, damage to property in excess of $50K
(Hazard does not include injury to persons)

CONTROLS/CORRECTIVE ACTION

Generic: Established and maintaining configuration management of all Xmtr software programming. Conduct high speed abort brake testing. Ensure brakes have received adequate break-in according to manufacturers instructions. Brake emergency procedures established. Pilot training emphasizes no/minimal brake use during T/O and Ldg. 2) Can result in failure of all brakes, see appropriate emergency procedure 3) Results in failure of all brakes (either on or off), see emergency procedures 3) Results in failure of all brakes (either on or off), see emergency procedure 4) Results in individual brake failures. If some brakes fail to engage, since multiple brakes per wheel truck, will have smaller directional effect. 4) Individual wheel brake binding checked in accordance with preflight procedure just prior to aircraft T/O.

REMARKS/ADDITIONAL INFORMATION

RISK ASSESSMENT *	
SEVERITY	II - Critical
LOCAL HAZARD PROBABILITY/RAC	C - Possible
PRECEDING HAZARDS PROBABILITY	
NET PROBABILITY	
NET RAC	3

PREPARED BY:	DATE:	DATE CHECKED BY ACMO/ASO:	DATE CLOSED OUT BY ASRB:
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FLIGHT RESEARCH HAZARD ANALYSIS	PROGRAM: T1 Remotely Piloted Vehicle	HAZARD ANALYSIS # T1 023 Revision No. 2

HAZARD (One hazard per page)	PHASE OF OPERATION	ANALYSIS IS:
Brakes fail to engage (or some brakes fail) (Continued)	T,I,L,G	● Initial ○ Addendum ○ Revision

UNDESIRED EVENT

Brake system air supply failure results in failure of one or more brakes to engage

SYSTEM/FUNCTION/ACTIVITY

Landing Gear

CAUSE OF UNDESIRED EVENT

5) Loss of air pressure (leak in system-bottle, lines/T's/air charge or pressure √ valves, brakes etc.)
6) Blockage in air system (Line pinched / Contaminated)
7) Air bottle fails

EFFECT OF UNDESIRED EVENT

Aircraft departs runway, or paved taxi way. Possible damage to T1, damage to property in excess of $50K
(Hazard does not include injury to persons)

CONTROLS/CORRECTIVE ACTION

5) Using off the shelf, reliable air system components. 5) Conducted inspection during landing gear actuation to ensure no brake line impingement that could result in air line/connection failures. 5) Air lines will utilize collars or similar device to secure connections. 5) Air supply loss prior to brake valve will lead to no brakes, failures aft of brake valve can lead to loss of individual brakes. See emergency procedures 6) Utilizing filtered compressed air for bottle servicing (in accordance with servicing procedure). 7) Air tanks are rated by manufacturer for 150 psi, but are only charged to 110 psi. 7) Air bottle material stress analysis performed (see GTMP-2027)

REMARKS/ADDITIONAL INFORMATION

Generic: Failure of both brakes not likely to lead to aircraft damage (using long runways, just be sure to secure engine before aircraft departs runway)

RISK ASSESSMENT *	
SEVERITY	II - Critical
LOCAL HAZARD PROBABILITY/RAC	C - Possible
PRECEDING HAZARDS PROBABILITY	
NET PROBABILITY	
NET RAC	3

PREPARED BY:	DATE:	DATE CHECKED BY ACMO/ASO:	DATE CLOSED OUT BY ASRB:
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FLIGHT RESEARCH HAZARD ANALYSIS	PROGRAM: T1 Remotely Piloted Vehicle	HAZARD ANALYSIS # T1 024 Revision No. 2

HAZARD (One hazard per page)	PHASE OF OPERATION	ANALYSIS IS:
Brakes fail (All or some brakes locked)	T,I,L,G	● Initial ○ Addendum ○ Revision

UNDESIRED EVENT
Human error results in one or more brakes unintentionally engaged during critical phase of flight

SYSTEM/FUNCTION/ACTIVITY
Landing Gear

CAUSE OF UNDESIRED EVENT
1) Pilot or ground personnel error

EFFECT OF UNDESIRED EVENT
Aircraft departs runway, or paved taxi way. Possible damage to T1, damage to property in excess of $50K
(Hazard does not include injury to persons)

CONTROLS/CORRECTIVE ACTION
1) Brakes moved to right slider switch to standardize pilot controller with other trainer aircraft 1) Brake system functionally checked during preflight procedure and during normal taxi to position for takeoff. Any ground personnel error that would result in brakes locked will be apparent during checks conducted prior to takeoff roll.

REMARKS/ADDITIONAL INFORMATION
Note:
-Brakes take approximately 1 second to release (for non-rotating tires) after command to release brakes is sent to the smooth stop valve

RISK ASSESSMENT *	
SEVERITY	II - Critical
LOCAL HAZARD PROBABILITY/RAC	C - Possible
PRECEDING HAZARDS PROBABILITY	
NET PROBABILITY	
NET RAC	3

PREPARED BY:	DATE:	DATE CHECKED BY ACMO/ASO:	DATE CLOSED OUT BY ASRB:
-(b) (6) [redacted]	8-2-2004		

FLIGHT RESEARCH HAZARD ANALYSIS	PROGRAM: T1 Remotely Piloted Vehicle	HAZARD ANALYSIS # T1 025 Revision No. 2

HAZARD (One hazard per page)
Brakes fail (All or some brakes locked) (Continued)

PHASE OF OPERATION
T,I,L,G

ANALYSIS IS:
● Initial ○ Addendum
○ Revision

UNDESIRED EVENT
Mechanical or control system failure results in one or more brakes being locked

SYSTEM/FUNCTION/ACTIVITY
Landing Gear

CAUSE OF UNDESIRED EVENT
2) Failure of RF system prior to servo (Xmtr, receiver, etc.)
3) Electrical / Mechanical failure of brake servo
4) Failure of brake smooth stop valve

EFFECT OF UNDESIRED EVENT
Aircraft departs runway, or paved taxi way. Possible damage to T1, damage to property in excess of $50K
(Hazard does not include injury to persons)

CONTROLS/CORRECTIVE ACTION
Generic: Established and maintaining configuration management of all Xmtr software programming. Brake emergency procedures established. Pilot training emphasizes no/minimal brake and nose-wheel steering use during T/O and Ldg. See also EMI on hazard # 13.
3) Can result in failure of all brakes locked, see emergency procedure.
4) Can result in failure of all brakes (all brakes engaged) See appropriate emergency procedure

REMARKS/ADDITIONAL INFORMATION
Note:
- Engaged brakes are not sufficient enough to remain locked on landing, however landing with brakes engaged will greatly increase tire wear
- Wheel trucks are four wheels per main mount, which will mitigate loss of directional control if only one tire is “locked”

RISK ASSESSMENT *	
SEVERITY	II - Critical
LOCAL HAZARD PROBABILITY/RAC	C - Possible
PRECEDING HAZARDS PROBABILITY	
NET PROBABILITY	
NET RAC	3

PREPARED BY:	DATE:	DATE CHECKED BY ACMO/ASO:	DATE CLOSED OUT BY ASRB:
(b) (6)	8-2-2004		

FLIGHT RESEARCH HAZARD ANALYSIS	PROGRAM: T1 Remotely Piloted Vehicle	HAZARD ANALYSIS # T1 026 Revision No. 2

HAZARD (One hazard per page)	PHASE OF OPERATION	ANALYSIS IS:
Brakes fail (All or some brakes locked) (Continued)	T,I,L,G	● Initial ○ Addendum ○ Revision

UNDESIRED EVENT

Air or mechanical binding in tire brake system results in one or more brakes being locked

SYSTEM/FUNCTION/ACTIVITY

Landing Gear

CAUSE OF UNDESIRED EVENT

5) Blockage in air system (Lines pinched/Contamination)
6) Stuck brake gasket (fails to release air pressure within tire RIM)
7) Binding of tire/Rim and/or tire braking system

EFFECT OF UNDESIRED EVENT

Aircraft departs runway, or paved taxi way. Possible damage to T1, damage to property in excess of $50K
(Hazard does not include injury to persons)

CONTROLS/CORRECTIVE ACTION

Generic: Preflight procedure checks brake application (each wheel) and ensures brakes release/spin free prior to every flight 5) Mechanical inspection of air line routing states that mechanical impingement will not occur. 5) Utilizing filtered compressed air for bottle servicing (in accordance with servicing procedure). See appropriate emergency procedure 6,7) Results in individual brake failures. If fails on will result in directional control problems, see emergency procedures. However, additional landing gear truck wheels will help mitigate directional control problems. 6,7) Utilizing off the shelf proven air braking system

REMARKS/ADDITIONAL INFORMATION

RISK ASSESSMENT *	
SEVERITY	II - Critical
LOCAL HAZARD PROBABILITY/RAC	C - Possible
PRECEDING HAZARDS PROBABILITY	
NET PROBABILITY	
NET RAC	3

PREPARED BY:	DATE:	DATE CHECKED BY ACMO/ASO:	DATE CLOSED OUT BY ASRB:
(b) (6)	8-2-2004		

FLIGHT RESEARCH HAZARD ANALYSIS	PROGRAM: T1 Remotely Piloted Vehicle	HAZARD ANALYSIS # T1 027 Revision No. 2

HAZARD (One hazard per page)	PHASE OF OPERATION	ANALYSIS IS:
Access hatch or panel(s) come off or partially off	T,I,L	● Initial ○ Addendum ○ Revision

UNDESIRED EVENT
Human error or mechanical over stress lead to complete or partial failure of hatch/panels

SYSTEM/FUNCTION/ACTIVITY
Structure of Aircraft

CAUSE OF UNDESIRED EVENT
1) Human error
2) Poor Design / Structural / mechanical failure
3) Internal over pressure

EFFECT OF UNDESIRED EVENT
Potential loss of T1, damage to property in excess of $500K
(Hazard does not include injury to persons)

CONTROLS/CORRECTIVE ACTION
1) Operate in accordance with pre, and post-flt √'s and procedures 1) Paint "witness" marks on latch assembly components that visually indicate when latches are secure 2) Fabricated by highly skilled LaRC model shop under supervision of chief engineer 2) Model systems report analysis 3) Fuselage is a well ventilated, therefore any internal pressurization that would lead to failure would have to be a very rapid pressurization. See hazards # 31-32.
3) Using off the shelf R/C components

REMARKS/ADDITIONAL INFORMATION

RISK ASSESSMENT *	
SEVERITY	I - Catastrophic
LOCAL HAZARD PROBABILITY/RAC	C - Possible
PRECEDING HAZARDS PROBABILITY	
NET PROBABILITY	
NET RAC	2

PREPARED BY:	DATE:	DATE CHECKED BY ACMO/ASO:	DATE CLOSED OUT BY ASRB:
(b) (6)	8-2-2004		

FLIGHT RESEARCH HAZARD ANALYSIS	PROGRAM: T1 Remotely Piloted Vehicle	HAZARD ANALYSIS # T1 028 Revision No. 2

HAZARD (One hazard per page)	PHASE OF OPERATION	ANALYSIS IS:
Floating, jammed, inoperative flight control surface(s)	T,I,L	● Initial ○ Addendum ○ Revision

UNDESIRED EVENT
Mechanical failure or aerodynamic overload results in floating, jammed or inoperative flight control surfaces

SYSTEM/FUNCTION/ACTIVITY
Structure of Aircraft

CAUSE OF UNDESIRED EVENT
1) Mechanical / structural binding
2) Flight surface air overload (insufficient control power)
3) Controls flutter

EFFECT OF UNDESIRED EVENT
Potential loss of T1, damage to property
(Hazard does not include injury to persons)

CONTROLS/CORRECTIVE ACTION
Generic: Model systems report analysis conducted. Utilize gradual systems checkouts during initial test flights (T1 Test Plan) Paint underside of gear doors and spoilers a visually significant color to assist aircrew in determining the nature of the flight control problem. Pilot simulator training to include flight control emergencies. See appropriate emergency procedure.
2) Servo performance study completed which analyzed performance (torque etc.) available from servos 3) Control surfaces light weight (no mass balancing required), control slop removed from linkages, and/or controls are sealed

REMARKS/ADDITIONAL INFORMATION

RISK ASSESSMENT *	
SEVERITY	I - Catastrophic
LOCAL HAZARD PROBABILITY/RAC	D - Remote
PRECEDING HAZARDS PROBABILITY	
NET PROBABILITY	
NET RAC	3

PREPARED BY:	DATE:	DATE CHECKED BY ACMO/ASO:	DATE CLOSED OUT BY ASRB:
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FLIGHT RESEARCH HAZARD ANALYSIS	PROGRAM: T1 Remotely Piloted Vehicle	HAZARD ANALYSIS # T1 029 Revision No. 2

HAZARD (One hazard per page)	PHASE OF OPERATION	ANALYSIS IS:
Floating, jammed, inoperative flight control surface(s) (Continued)	T,I,L	● Initial ○ Addendum ○ Revision

UNDESIRED EVENT
Control system failure results in floating, jammed or inoperative flight control surfaces

SYSTEM/FUNCTION/ACTIVITY
Structure of Aircraft

CAUSE OF UNDESIRED EVENT
4) Servo failure
5) Control system failure (receiver, pwr supply, gnd)

EFFECT OF UNDESIRED EVENT
Potential loss of T1, damage to property
(Hazard does not include injury to persons)

CONTROLS/CORRECTIVE ACTION
Generic: Pilot simulator training to include flight control emergencies. See appropriate emergency procedure. Using off the shelf reliable R/C control system and servo components.
5) Xmtr program version control and loading procedures utilized to ensure correct/current software in Xmtrs. 5) Battery management procedures utilized. 5) Battery bus system provides redundant power in event of battery failure (loss of battery will fail half of the servos) 5) Hardware testing shows that loss of power, ground, receiver signal to servos causes servos to take trail (aerodynamically loaded servos will unload or float). 5) Hardware testing shows that when servo/receiver battery voltage drops below 4 volts, receiver signal fails and servos float or unload. 5) ARCAT system allows pilot to monitor battery voltages realtime

REMARKS/ADDITIONAL INFORMATION
Note:
- Receivers and ECUs are powered by either battery via battery bus system
- A trimmed flight condition will **not** be maintained when servos float, which will result in rapid uncontrolled descent.

RISK ASSESSMENT *	
SEVERITY	I - Catastrophic
LOCAL HAZARD PROBABILITY/RAC	D - Remote
PRECEDING HAZARDS PROBABILITY	
NET PROBABILITY	
NET RAC	3

PREPARED BY:	DATE:	DATE CHECKED BY ACMO/ASO:	DATE CLOSED OUT BY ASRB:
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FLIGHT RESEARCH HAZARD ANALYSIS	PROGRAM: T1 Remotely Piloted Vehicle	HAZARD ANALYSIS # T1 030 Revision No. 2

HAZARD (One hazard per page)	PHASE OF OPERATION	ANALYSIS IS:
Ground based accident	G	● Initial ○ Addendum ○ Revision

UNDESIRED EVENT
Errors in ground operations and/or servicing result in ground based accident

SYSTEM/FUNCTION/ACTIVITY
Aircraft

CAUSE OF UNDESIRED EVENT
1) Ground crew handling (loading/unloading) / Servicing (Air, fuel, electrical)
2) Preflight / Starting (personnel, FOD, etc.) / Taxi/TO/Ldg (Hot brakes, depart runway etc.) / Post flight
3) Environmental (Heat, gases, noise etc.)

EFFECT OF UNDESIRED EVENT
Potential loss of T1, damage to property in excess of $500K or injury to persons

CONTROLS/CORRECTIVE ACTION
Generic: Normal and emergency procedures developed. Properly trained personnel. Portable first aid kit is available on site.

1) Utilize cradle/trailer etc. for transportation 1) Utilizing off the shelf fueling/de-fueling and engine components with long history of safe operation 1) Lithium-ion batteries charged in accordance with best practices 2) Personnel properly trained on FOD prevention and danger associated with spinning engines. 3) PPE worn during aircraft servicing and ground operations

REMARKS/ADDITIONAL INFORMATION

RISK ASSESSMENT *	
SEVERITY	I - Catastrophic
LOCAL HAZARD PROBABILITY/RAC	D - Remote
PRECEDING HAZARDS PROBABILITY	
NET PROBABILITY	
NET RAC	3

PREPARED BY:	DATE:	DATE CHECKED BY ACMO/ASO:	DATE CLOSED OUT BY ASRB:
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FLIGHT RESEARCH HAZARD ANALYSIS	PROGRAM: T1 Remotely Piloted Vehicle	HAZARD ANALYSIS # T1 031 Revision No. 2

HAZARD (One hazard per page)
Unconfined explosion and / or release of energy

PHASE OF OPERATION
G

ANALYSIS IS:
● Initial ○ Addendum
○ Revision

UNDESIRED EVENT
Ignition of aircraft fuel or mechanical overload of air cylinder causes an unconfined explosion or release of energy

SYSTEM/FUNCTION/ACTIVITY
Aircraft

CAUSE OF UNDESIRED EVENT
1) Ignition of fuel or fuel fumes
2) Over pressure / damage in air cylinder

EFFECT OF UNDESIRED EVENT
Potential loss of T1, damage to property in excess of $500K or injury/death to persons.

CONTROLS/CORRECTIVE ACTION
Generic: Preposition emergency equipment on site, and brief personnel on procedures. Fire/Crash Crew notified (via procedures) prior to commencing operations. Utilizing normal and emergency procedures for operations. Personal protective equipment (safety glasses and ear plugs) worn.
1) Fuel system design contains small volumes of fuel, prevents fume accumulation and additionally model fuel has a high flash point. 2) Utilizing off the shelf air system components with long history of safe operation, and minimal system energy (small bottles, low pressures) 2) Model systems report. 2) Air bottle material analysis and stress analysis performed. 2) Incorporate inline regulator/relief valve that does not allow portable air bottle servicing unit to provide greater than 120 psi

REMARKS/ADDITIONAL INFORMATION
Note:
Lithium-ion batteries will burn in the event that they are mechanically punctured.
1) Batteries will be strapped in containment "box" with cushioning provided to try and prevent mechanical puncture. Amend safety document to make personnel aware that post crash aircraft recovery should ascertain battery status in a safe manner (Procedures to call for fire equipment at the ready, and personnel wearing PPE)

RISK ASSESSMENT *

SEVERITY	I - Catastrophic
LOCAL HAZARD PROBABILITY/RAC	D - Remote
PRECEDING HAZARDS PROBABILITY	
NET PROBABILITY	
NET RAC	3

PREPARED BY:	DATE:	DATE CHECKED BY ACMO/ASO:	DATE CLOSED OUT BY ASRB:
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FLIGHT RESEARCH HAZARD ANALYSIS	PROGRAM: T1 Remotely Piloted Vehicle	HAZARD ANALYSIS # T1 032 Revision No. 2

HAZARD (One hazard per page)	PHASE OF OPERATION	ANALYSIS IS:
Unconfined explosion and / or release of energy (Continued)	T,I,L,G	● Initial ○ Addendum ○ Revision

UNDESIRED EVENT
Failure on engine turbine results in unconfined explosion or release of energy

SYSTEM/FUNCTION/ACTIVITY
Aircraft

CAUSE OF UNDESIRED EVENT
3) Unconfined failure of turbine motors

EFFECT OF UNDESIRED EVENT
Potential loss of T1, damage to property or injury/death to persons.

CONTROLS/CORRECTIVE ACTION
3) Utilizing off the shelf engine components with long history of safe operation 3) Preflight motor inspections and proper servicing (oil etc.) 3) Utilizing normal and emergency procedures for operations 3) Manufacturer states that catastrophic failure of bearing or shaft does not throw turbine blades through casing (No containment ring failures to date) 3) Prevent FOD!! Procedures ensure personnel avoid danger areas when motors are turning.

REMARKS/ADDITIONAL INFORMATION

RISK ASSESSMENT *	
SEVERITY	I - Catastrophic
LOCAL HAZARD PROBABILITY/RAC	D - Remote
PRECEDING HAZARDS PROBABILITY	
NET PROBABILITY	
NET RAC	3

PREPARED BY:	DATE:	DATE CHECKED BY ACMO/ASO:	DATE CLOSED OUT BY ASRB:
(b) (6)	8-2-2004		

FLIGHT RESEARCH HAZARD ANALYSIS	PROGRAM: T1 Remotely Piloted Vehicle	HAZARD ANALYSIS # T1 033 Revision No. 2

HAZARD (One hazard per page)
Undesired / uncontrolled aircraft trajectory (This hazard covers injury, and covers a system or human error and the possibility of aircraft hitting personnel)

PHASE OF OPERATION
A

ANALYSIS IS:
● Initial ○ Addendum
○ Revision

UNDESIRED EVENT
This hazard covers the higher severity (injury/death to personnel) not covered in previous hazards (1-18, 21-29, 34)

SYSTEM/FUNCTION/ACTIVITY
Aircraft

CAUSE OF UNDESIRED EVENT
1) See hazards (1-18, 21-29, 34)

EFFECT OF UNDESIRED EVENT
Possible loss of T1, damage to property in excess of $500K and/or injury/death of personnel

CONTROLS/CORRECTIVE ACTION
1) Procedures and training will ensure that personnel are located such that they cannot be hit by aircraft during critical phases of flight (T/o & Ldg) reference Aberdeen Field operations plan 1) Aircraft operating area (remote locations) minimizes personnel exposure to injury 1) Protective barriers provided to crew personnel 1) Automatic or aircrew initiated flight termination systems available (throttles to idle, rudder deflected over) 1) Fail-safe methods(throttles/rudder) will be verified prior to each flight 1) Pilot training emphasizes need for intentional grounding when appropriate

REMARKS/ADDITIONAL INFORMATION
Note: This hazard documents the risk to personnel. It is specifically written to document controls specifically implemented to protect personnel.

RISK ASSESSMENT *	
SEVERITY	I - Catastrophic
LOCAL HAZARD PROBABILITY/RAC	D - Remote
PRECEDING HAZARDS PROBABILITY	
NET PROBABILITY	
NET RAC	3

PREPARED BY:	DATE:	DATE CHECKED BY ACMO/ASO:	DATE CLOSED OUT BY ASRB:
(b) (6)	8-2-2004		

FLIGHT RESEARCH HAZARD ANALYSIS	PROGRAM: T1 Remotely Piloted Vehicle	HAZARD ANALYSIS # T1 034 Revision No. 2

HAZARD (One hazard per page)
RF receiver fails to initiate fail-safe mode entry

PHASE OF OPERATION
T,I,L

ANALYSIS IS:
● Initial ○ Addendum
○ Revision

UNDESIRED EVENT
Hardware or software failure causes receiver not to enter fail-safe mode

SYSTEM/FUNCTION/ACTIVITY
Aircraft

CAUSE OF UNDESIRED EVENT
1) Failure of receiver/servo battery
2) Failure of electrical conductors (any of 3) from receiver to fail-safe servo
3) Bad software load on receiver

EFFECT OF UNDESIRED EVENT
Potential loss of T1, damage to property
(Hazard does not include injury to persons)

CONTROLS/CORRECTIVE ACTION
1) Receiver and servo ground testing conducted from single power supply . Drop in supply voltage (less than 4 volts) causes receiver to cease sending signal to servo. The servo in turn floats (only forces are internal friction) Were this to occur in flight such that all servos float, (aircraft would not be trimmed up) which would result in rapid aircraft departure. Additionally, the failure of the receiver signal to be received by the engine control units causes the engines to secure automatically. 2) Hardware testing showed that loss of any of the three wire connections to the servo resulted in the servo "floating". 3) Preflight procedures verify that receiver software load initiates fail-safe upon loss of transmitter signal. Note: Simulation shows that aircraft is slightly stable in spiral mode, and tail gyro increase stability slightly. Dual (split) receivers provide for 1/2 flight control authority in event of one receiver failure (can either continue to control aircraft or terminate flight with remaining servos)

REMARKS/ADDITIONAL INFORMATION
Note:
Fail-safe mode is initiated by the receiver upon loss on Xmtr signal. The receiver performs fail safe by:
1) Signaling the engine control units to drive the engines to idle
2) Driving the rudder servo over to one side (if rudder on that servo)
- Split receivers maintain 1/2 servo operation in event one receiver fails (can either continue to control aircraft or terminate flight with remaining servos)

RISK ASSESSMENT *

SEVERITY	I - Catastrophic
LOCAL HAZARD PROBABILITY/RAC	C - Possible
PRECEDING HAZARDS PROBABILITY	
NET PROBABILITY	
NET RAC	2

PREPARED BY:	DATE:	DATE CHECKED BY ACMO/ASO:	DATE CLOSED OUT BY ASRB:
(b) (6)	8-2-2004		

FLIGHT RESEARCH HAZARD ANALYSIS	PROGRAM: T1 Remotely Piloted Vehicle	HAZARD ANALYSIS # T1 035 Revision No. 2

HAZARD (One hazard per page)	PHASE OF OPERATION	ANALYSIS IS:
Loss of model upon water entry	T,I,L	● Initial ○ Addendum ○ Revision

UNDESIRED EVENT
Any hazard scenario that results in aircraft water entry

SYSTEM/FUNCTION/ACTIVITY

CAUSE OF UNDESIRED EVENT
1) Any failure mode that results in aircraft water entry

EFFECT OF UNDESIRED EVENT
Potential loss of T1, damage to property
(Hazard does not include injury to persons)

CONTROLS/CORRECTIVE ACTION
- Incorporate air bladders (where possible) in fuselage to facilitate water recovery (at Wallops only) but ensure air bladders do not impinge rear flight control linkages

REMARKS/ADDITIONAL INFORMATION
If aircraft "ditching" has occurred, it is likely that significant damage has already occurred and this control is to prevent total loss of the aircraft (All system components will not be used in other aircraft)

RISK ASSESSMENT *	
SEVERITY	I - Catastrophic
LOCAL HAZARD PROBABILITY/RAC	C - Possible
PRECEDING HAZARDS PROBABILITY	
NET PROBABILITY	
NET RAC	2

PREPARED BY:	DATE:	DATE CHECKED BY ACMO/ASO:	DATE CLOSED OUT BY ASRB:
-(b) (6) [redacted]	8-2-2004		