

A. EMERGENCY PROCEDURES

A.1. Introduction

The contents of this chapter pertain to the operations during abnormal and emergency situations. It is impossible to develop guidelines and procedures to deal with all situations. The judgment, skill, and training of all persons involved are necessary to bring an abnormal or emergency situation to a safe conclusion. Accordingly, it may be appropriate to refer to other publications such as FAR and AIM manuals. The guidance in this chapter is in the form of descriptions and detailed procedures. Unless safety is jeopardized they shall be applied in the handling of Abnormal and Emergency situations.

These procedures are written specifically for the Uglo 7 UA, using the Piccolo autopilot and Ground Control Station (GCS) system from Cloud Cap Technologies.

In general, the response to an in-flight emergency or severe change in weather is to bring the UA back to the main landing site and to begin landing procedures, using either manual or automatic landing. All incidents and accidents will follow reporting and notification processes and requirements as laid out in FAA Orders 8020.11, 7210.56, and in NTSB 830.

Finally, these procedures are written for a 3-pilot team consisting of the pilot-in-command (PIC) acting as a mission commander, and two pilots-at-control; one with manual flight control using pilot console (the PAC-M) and the other monitoring the PCC and controlling the UA when in semi-autonomous mode (the PAC-O). Only one of these co-pilots will be the acting PAC at a given time. In the minimum two-man team consisting of a ground based observer and a pilot-in-command (PIC), the PIC will be the PAC.

A.2. Distress Message

A hand-held VHF radio will be used to broadcast a distress message in some emergency situations to aid in maintaining a safe airspace when traffic is present in the COA airspace. Since the COA airspace is located near both Allentown Queen City Airport (XLL) and Lehigh Valley International Airport (ABE), messages will be broadcast on CTAF/UNICOM frequency 122.7 MHz and telephone contact will be established with the ABE Tower.

The distress message will contain the following information, and will be given in the order listed below. Once broadcast, the message will be repeated every five (5) minutes, upon changes in condition or known location, or upon any update requests received. Once the urgent condition is over, a final message will be broadcast to notify any traffic that the emergency condition is over.

1. PAN-PAN, PAN-PAN, PAN-PAN
2. "local traffic"
3. "this is unmanned aircraft Uglo 7 operating at from Goodman Campus"
4. The nature and type of the distress
5. Pilot's intention request
6. Last known position and heading
7. Altitude
8. Hours and minutes of fuel remaining
9. Weather

10. Other useful information such as visible landmarks, aircraft color, and that no people are on board

A.3. Operational Emergency Procedures

O-1. Pilot / Operator / Observer is unable to perform duties: If a crew member becomes incapacitated during a UA flight, then the duties of that person will be transferred to another certified crew member depending upon the status of the current flight and availability of crew members.

O-1.1. If the PAC-M becomes incapacitated, and there is no backup PAC-M available the PAC-O will command the UA to immediately land using the autoland waypoint plan. Any further contingency that requires manually piloting will result in the PAC-O issuing the aerodynamic termination command.

O-1.2. If the PAC-O becomes incapacitated, and there is no backup PAC-O available, and the PAC-M has VLOS then the PAC-M will take over control of the UA using the pilot interface and will pilot the UA to the primary landing site and initiate manual landing procedures.

O-1.3. If the PAC-M and PAC-O are both unable to perform their duties, the PIC (or certified crew member) will issue aerodynamic termination through the PCC.

O-1.4. If the observer becomes incapacitated and no backup observer is available, then if another crew member:

O-1.4.1. can determine the COA airspace is clear using LOS, then the PAC-O or PAC-M will initiate landing procedures. Under this emergency scenario a PAC that has LOS of the UA is allowed to control the aircraft without an observer only for performing landing procedures. For the PAC-M to initiate landing procedures the PAC-M must have VLOS to the UA.

O-1.4.2. cannot safely determine the COA airspace using LOS is clear, or there is manned aircraft within the COA airspace, then the PIC will command the PAC-O to command aerodynamic termination.

O-2. Loss of LOS by Observer: Loss of LOS by the observer can happen when the UA is farther than one (1) lateral mile or higher than 3000' vertical feet from the observer as set in AFS 400 Policy 05-01. Loss of LOS can also be caused by equipment failure when using aids to vision (e.g. binoculars), reduction of LOS range due to abrupt changes in weather or lighting conditions, or by losing acquisition of the UA.

O-2.1. If the UA is approaching the maximum LOS range from the observer, then the observer will inform the PIC to adjust the current flight plan accordingly to decrease the distance between the UA and the observer.

O-2.2. Upon a loss of LOS by the observer at their current location for more than five (5) seconds, the observer will immediately notify the PIC and all other observers.

O-2.2.1. If another crew member has LOS, then that crew member will notify the PIC and will act as the observer until the UA is within LOS range of the primary observer or the UA has landed.

O-2.2.2. If direct LOS cannot be acquired by another crew member within five (5) seconds:

O-2.2.2.1. and the COA airspace can be declared safe and unoccupied by a crew member, and the UA is still within the COA boundary and operating otherwise normally, as determined by the PAC-O, then the PAC-O will initiate landing procedures.

O-2.2.2.2. and the COA airspace is occupied by another aircraft, or cannot be declared safe by the observer, or the UA is not operating as expected by the PAC-M, then the PIC will command aerodynamic termination.

O-3. Loss of Communication Between PIC and Observer(s): Typically the PIC and observers will be co-located. In the event that they are not co-located communications will occur via handheld radio (primary) and cell phone as backup. Loss of communication between the PIC and the observers, or any other crew member, using handheld radios can occur due to discharged (dead) batteries, interference on current channel, or electronic or structural failure of the radio due to use. If there is a loss of communication using crew member hand-held radios, then cell phones will act as a backup communication system. Cell phones will have been programmed before hand to allow for one button contact with the PIC to minimize contact time.

O-3.1. If communication between the PIC and the observer is lost, the observer will initiate a cell phone call to the PIC.

O-3.1.1. If cell phone contact is made with twenty (20) seconds, and the observer still has LOS then the PIC will initiate landing procedures to terminate the current flight.

O-3.1.2. If the cell phone backup link fails, then the observer is no longer able to perform their duties then LOS has been lost. See Sections O-2 Loss of LOS by the Observer and Section O-1 Observer is Unable to Perform Duties for corrective actions.

O-4. Loss of Communication with ATC: This is only appropriate if during the COA application it is deemed necessary to maintain communication with ATC. The nearest controlled airport to Goodman is Lehigh Valley International Airport (LVI), which is 6.1 statute miles away (note that there is a natural barrier in the form of an 870 foot mountain between Goodman and LVI). Since the operation of the UA is to remain below 400' AGL at Goodman (well below the height of the mountain), the flight of the UA should remain in G airspace under VFR conditions. Therefore, it is not expected that there will be a requirement to maintain contact with ATC. If it is deemed necessary to have and maintain communication with ATC at LVI, this will be via cellular telephone. In this case, upon failure of the VHF radio or on loss of contact with ATC:

O-4.1. if the observer still has LOS to the UA and determines the airspace is safe, then the PAC will command the UA to return to the primary landing site and will initiate landing procedures.

O-4.2. if the observer does not have LOS or determines the airspace is unsafe, then the PAC will terminate the current flight with an aerodynamic termination.

O-5. UA Leaves COA Boundary Uncontrollable: This condition can occur only upon multiple system failures of the communication and navigation systems. For example, if a lost communication event occurs and the navigation solution (e.g. GPS) is thought to be accurate by the UA, though it is incorrect in its solution, then there is a chance for the UA to leave the COA boundary. In addition, if the lost communication waypoint is not loaded correctly or is the wrong geographic location, this could lead to the condition of the UA departing the COA boundary uncontrollable. In this situation, the first priority of the PIC is to maintain as safe an airspace surrounding the UA as possible. This is done by broadcasting a PAN-PAN message as described in Section A-1.2. Once it is determined that the UA is or will be leaving the COA airspace:

O-5.1. the observer will be immediately notified by the PIC to track the UA using all reasonable effort to not lose LOS.

O-5.2. the PIC will broadcast the distress message as outlined in Section A-1.2, and will repeat the message every five (5) minutes or upon changes in condition or known location/heading of the UA.

O-5.3. the PIC will initiate crash recovery procedures, getting required personal ready.

O-5.4. if the observer is not able to maintain LOS with the UA, the PIC will initiate lost plane procedures to locate the aircraft.

O-6. *Near Midair Collision:* A near midair collision is defined as an incident associated with the operation of the UA in which a possibility of collision occurs as a result of proximity of less than 500' to another aircraft, or a report is received from a pilot or a crew member stating that a collision hazard existed between two or more aircraft. It is the responsibility of the pilot and/or flight crew to determine whether a near midair collision did actually occur and, if so, to initiate a NMAC report as outlined in FAA Order 8020.11 and/or in AIM.

Traffic and collision avoidance is governed by FAR Part 91.113. However, since the Uglo 7 UA is significantly more maneuverable than any manned aircraft, the Uglo 7 UA will always give way to all other manned aircraft. In the event of a head-on approach, the Uglo 7 UA shall alter course to the right as per FAR 91.113e. If an uncooperative manned aircraft remains in the COA area the PIC will initiate immediate landing procedures.

If a NMAC hazard is detected by the observer (or any crewmember):

O-6.1. then the crew member should notify the PIC of the traffic collision risk and should advise the PIC on the best course of action to take with the UA given the current trajectories of the UA and the other aircraft.

O-6.2. the PIC will evaluate the situation to make sure the course of action given by the crew member is safe, and will instruct the PAC to take the safest appropriate action.

O-6.3. to provide the fastest response time possible, the PAC-M will be used to perform collision avoidance maneuvers as given by the PIC.

O-6.3.1. if the UA is in VLOS of the PAC-M, then the PAC-M will immediately take over manual control of the UA and perform the avoidance maneuvers as dictated by the PIC and the observer.

O-6.3.2. if the UA is not in VLOS of the PAC-M, then the assisted pilot mode of the autopilot will be used. Upon notification of a NMAC by the PIC, the PAC-O will immediately command the autopilot to assisted pilot mode for the PAC-M to take over PAC duties and perform collision avoidance as prescribed by the PIC and observer.

O-7. *Accident and Crash Recovery:* The recovery response plan outlines the specific duties and responsibilities applicable to the personnel required to perform an accident investigation in the event of a catastrophic failure. A running log of all actions encompasses agencies notified, person's names, and times of contact will be maintained by the PIC. Notification and reporting of all aircraft accidents and incidents will follow guidance as outlined in FAA Order 8020.11, 7210.56 and NTSB 830. Because of the small size of the UA the likelihood of significant damage to surrounding structures is small. In addition, since the UA propulsion is electrically powered, there is no on-board fuel that may contaminate the environment or pose as an accelerant for a fire. However, the risk of fire is still present due to the Li-Ion batteries used for propulsion and system power. Due to risk of hazardous fumes from burning components within the aircraft, the normal procedure is to let the aircraft burn when not endangering life or property.

O-8. *Lost Aircraft Procedures:* A lost plane emergency occurs when there is a communication failure leading to a lost communication event, and during the lost communication event the observer and all other crew members have lost LOS of the UA. With these two combined events the safe operation of the UA can no longer be maintained. In this situation, the first priority of the PIC is to maintain as safe an airspace surrounding the UA as possible. This is done by broadcasting a PAN-PAN message as described in Section A-1.2. Following this, recovery

operations will commence starting at the last known location of the Uglo 7 UA to find the aircraft and/or wreckage.

A.4. Ground Control Station

Because of the control multiplexer on board the aircraft the PAC-M can take over manual control using an RC transmitter, bypassing the Piccolo GCS completely. This will give the rest of the crew time to reset the ground control station with the aircraft under manual control. The typical procedure will be to land the aircraft under manual control.

G-1. *PCC Failure*: Failure of the PCC means that the PAC-O no longer has situational awareness of the UA and can no longer command or control the UA, and therefore act as PAC. In this condition the only PAC can be the PAC-M, and only if the PAC-M has VLOS.

If the PAC-O detects that the PCC has failed, either by locking up (remains open but inactive and unusable) or by crashing (actually closes the PCC program but Windows OS is still running), then:

G-1.1. if the PAC-M has VLOS, the PAC-M will take over manual piloting of the UA and will initiate landing procedures. During the landing procedures, the PAC-O will try the restart procedures of PCC to regain the telemetry download of the UA to regain situational awareness.

G-1.2. if the PAC-M does not have VLOS, but the observer still has LOS and determines the airspace is clear, then the PGS will be turned off for five (5) seconds longer than the communication timeout of ten (10) seconds. This will cause the UA to switch to the lost communication waypoint of the emergency plan, which should bring the UA into VLOS for the PAC-M. After fifteen (15) seconds of the PGS being powered off, it will be turned back on and the PAC-O will begin restart procedures of the PCC.

G-1.2.1. If the PCC becomes operational before the PAC-M has VLOS, then the PAC-O will terminate the current flight by initiating landing procedures.

G-1.2.2. If the PAC-M obtains VLOS before the PCC is operational again the PAC-M will take over manual control of the UA and terminate the current flight by initiating landing procedures.

G-1.3. if the PAC-M does not have VLOS, and the observer determines that the airspace is not clear of traffic or is not safe at any time, then the PAC-M will perform a manual aerodynamic termination by taking over manual control of the aircraft (the PGS must be turned on), closing the throttle and commanding maximum right aileron and rudder, up elevator, and maximum flaps.

G-2. *GCS-Laptop Failure (lock-up)*: A software failure of the GCS-Laptop will follow the same procedures as outline in Section G-1 PCC Failure. The only difference is that the time to restart the PCC program is significantly increased because now the laptop must be shutdown and be rebooted into the Windows OS. Once the laptop has successfully rebooted, the PCC can be restarted.

G-3. *Loss of GCS-Laptop power*: A power or hardware failure of the GCS-Laptop will follow the same procedures as outline in Section G-1 PCC Failure. The difference is that the time to restart the PCC program is significantly increased because now the laptop must be shutdown and be rebooted into the Windows OS. In addition, depending upon the type of power or hardware failure, it may not be possible to re-power or reboot the laptop to regain situational awareness. If the laptop has successfully re-powered and rebooted, the PCC can be restarted.

G-4. *Loss of PGS power*: The PGS has two available power sources: an external 16V system, and an internal 12V backup battery. If the external power to the PGS fails, then the internal backup battery system will maintain power to the PGS while it has enough charge. While running on the 16V system, the PGS is charging is the backup battery. With a failure of external power, the PGS

will report the lower voltage of the battery and the power status light on the PGS will turn off, indicating to the PAC-O that external power has failed. Upon failure of the external power supply then a crew member not acting as PAC will attempt to diagnose and fix the problem. In general this will consist of plugging in a disconnected power cable or restarting/refueling a generator. Upon failure of the external power source:

G-4.1. If the backup battery has sufficient charge then the PAC-O will terminate the current flight by initiating landing procedures.

G-4.2. If the backup battery also fails to power the PGS, then manual control can only be obtained through the RC transmitter.

G-4.2.1. If power is never restored to the PGS, then the autopilot will continue to execute the emergency flight plan as laid out in Section A-1.

G-4.2.2. If power is restored to the PGS, the PAC-O will watch for communication to be re-established between the PGS and the autopilot.

G-4.2.2.1. If communication is restored, then the PAC-O or PAC-M will take over control of the UA from the emergency flight plan and will terminate the current flight by initiating landing procedures.

G-4.2.2.2. If communication is never restored, then the autopilot will continue to execute the emergency flight plan as laid out in Section A-1.

G-5. *Malfunction of Pilot Console:* The PAC-M has two input devices: a standard 72MHz R/C transmitter and a pilot console (which is itself an R/C transmitter connected to the Piccolo GCS using a trainer cable). The 72MHz transmitter serves as the emergency back-up and will be used if control of the aircraft cannot be maintained through the GCS.

G-5.1. If the pilot console becomes disconnected from the PGS, then the PGS will stop sending pilot commands to the autopilot. After not receiving any pilot command packets from the PGS for the pilot timeout, the autopilot will switch to automatic mode and will enter into the closest waypoint plan at the time of the Pilot timeout.

G-5.1.1. Upon failure or disconnect of the console cable, the PAC-O cannot become the PAC until the autopilot has not received a pilot command for the duration of a pilot timeout. Once the pilot timeout has occurred, the PAC-O will act as PAC and maintain safe operations of the UA and will terminate the current flight by initiating landing procedures.

G-5.1.2. Before the cable is re-connected, the PAC-M must make sure that the pilot console has been switched into autopilot mode so that upon connection the PAC-M does not take over unexpected control of the UA.

G-5.1.3. If the cable and connections are undamaged, then the pilot console should be reconnected to the PGS. Operation of the pilot console should only be tested if the PAC-M has VLOS and the PIC determines it is safe given the current status of the UA.

G-5.2. *Other console failure:* If the pilot console fails for any reason besides a failure of the cable, then the console cannot be relied upon and the PAC-M may no longer be able to perform the duties of a PAC. Since there may be numerous failures of the console that are almost impossible to cover in this document, it will be up to the skill and knowledge of the PAC-M to detect that the UA is not responding as expected through the console. It must be noted that a failure of the autopilot or of an aerodynamic control surface can make the PAC-M believe a failure of the console is occurring.

Once the PAC-M determines that there is a failure of manual control through the console the PAC-M will take manual control using the 72MHz transmitter. Then:

G-5.2.1. the PAC-M will inform the PIC and the PAC-O of the failure and current reasons for the determination. This is to inform the PAC-O of specific information to look for from the telemetry of the UA to make sure it is not a failure of the autopilot or a control surface on the UA.

G-5.2.2. If the UA is in safe flight condition to enter autopilot mode, then the PAC-M will switch the console into autopilot mode and return control to the PAC-O. To make sure inadvertent control of the UA does not happen, the console should be disconnected from the PGS.

G-5.2.3. If the UA is not deemed by the PIC to be in a safe condition or location to switch to autopilot mode, or another condition exists that does not allow control to be switched to autopilot mode, then the PIC must decide whether to issue an aerodynamic termination or to have the PAC-M continue manually piloted flight to the best of the ability of the PAC-M given their controllability of the UA.

G-5.2.3.1. If at any time the PAC-M does not have sufficient control of the UA through the console and the PIC deems it unsafe to enter autopilot mode, then the PIC will command aerodynamic termination of the UA.

G-5.2.3.2. If the PAC-M has sufficient but degraded control to land, then they will initiate landing procedures.

G-6. *GPS Failure:* of the GCS GPS system only affects the operation of the UA if the GCS GPS solution is used to generate differential GPS correction messages for the UA. However, if the failure of the system is due to loss of satellite links then there is a chance that the UA will also lose satellites and possibly a valid solution. Upon failure of the GCS GPS:

G-6.1. A crew member will attempt to find and correct any problems with the GPS antenna or cable connection to the PGS.

G-6.2. the PAC-O should turn off DGPS mode of the PGS if enabled.

G-6.3. the PAC-O will pay special attention to the GPS location as reported by the UA and compare that with reported location and heading as reported by the observer and other systems such as the pressure altitude and airspeed.

G-6.3.1. If no errors or discrepancies are determined, the PAC-O will terminate the current flight by following standard landing procedures.

G-6.3.2. If there is a discrepancy of the GPS then the autopilot can no longer be used for navigation and the PAC-M must take over control of the UA following the procedures in Section A-8.1. GPS Failure.

A.5. Uglo 7 UA

A-1. *Lost Communication Emergency:* Since there is only a single communication link between the Uglo 7 UA and the GCS, a lost link constitutes a lost communication event. The Piccolo autopilot detects two types of lost links; one is when the aircraft is under manually piloted mode and the other is when the Piccolo is operating under fully automatic control. In this situation, the first priority of the PIC is to maintain as safe an airspace surrounding the UA as possible. This is done broadcasting a PAN-PAN message as described in Section described in Section A-1.2.

A-1.1. Upon detection of any lost-communication event, a crew member will inspect the communication antenna and cabling in the GCS for any failures or problems and will attempt to correct them to restore communications.

A-1.2. When the autopilot is under manual pilot (or manual assisted) control, a lost link is determined by the UA as not receiving any decodable manual pilot control packets for two (2) seconds, referred to as the Pilot timeout.

A-1.2.1. Once this condition is met, the autopilot will automatically switch to autopilot mode and enter into the closest waypoint plan at the time of the Pilot timeout.

A-1.2.2. If communication is re-established before the comm timeout occurs, the PAC will immediately begin landing procedures.

A-1.3. If communications fail entirely for ten (10) seconds (defined as the communication timeout) the autopilot will take automatic action depending upon the status of the GPS timeout.

A-1.3.1. After the communication timeout has occurred, if there is traffic in the COA airspace the PIC will begin broadcasting the appropriate PAN-PAN message, every 5 minutes for the duration of the lost-communication event.

A-1.3.2. If the GPS timeout has been asserted prior to the communication timeout, then when the communication timeout occurs the autopilot will issue an aerodynamic termination.

A-1.3.3. If the GPS timeout has not occurred, then the autopilot will switch from the current flight plan to the emergency waypoint plan, defined by the lost communication entry point. A-1.3.4. If communication is re-acquired during the emergency flight plan then the PAC will take over control and initiate landing procedures.

A-1.3.5. If communication is not re-acquired after two minutes of orbiting at the lost communication waypoint, then the autopilot will automatically switch to the autoland segment of the emergency flight plan.

A-2. *Engine Out:* The Uglo 7 UA can glide safely with the engine out. Thus engine out is not normally an emergency. It is an emergency if engine failure occurs during take-off or during a powered return to base. If a power failure occurs during takeoff the aircraft will be commanded to glide to a straight ahead landing.

Best glide ratio for Uglo 7 is approximately 8:1. Thus the aircraft can glide about 0.6 miles from an engine shut down at 400' AGL. This is enough that the aircraft can return to base from anywhere in the operational area. Hence standard procedure in the event of an engine failure is a gliding return to base. If the airspace is not clear then immediate landing will be initiated.

A-3. *Autopilot Power Loss:* The on-board R/C receiver is powered independently of the autopilot. Thus in the event of an autopilot power loss the PAC-M will take manual control of the aircraft using the backup transmitter. Immediate landing will be initiated.

A-4. *Loss of Servo Power:* Loss of power to the servos results in the UA being uncontrollable and unpredictable in its flight path. In this situation, the first priority of the PIC is to maintain as safe of an airspace surrounding the UA as possible. This is done broadcasting a PAN-PAN message as described in Section A-1.2. Upon loss of servo power:

A-4.1. the observer will be immediately notified by the PIC to track the UA using all reasonable effort to not lose LOS, however the PAC-O should still have situational awareness of the UA.

A-4.2. if the observer determines the UA has left the COA boundary or detects the presence of traffic in the COA airspace, the PIC will broadcast the distress message as outlined in Section A-1.2, and will repeat the message every five (5) minutes or upon changes in condition or known location/heading of the UA.

A-4.3. The PIC will initiate crash recovery procedures, getting required personal and equipment ready.

A-5. *Stuck (uncontrollable) Aerodynamic Surface:* An uncontrollable aerodynamic surface may be caused by physical or electrical failure of the servo actuators, or by physical failure of the surface. The response to an uncontrollable or failed aerodynamic surface is primarily determined

by the surface that failed and in what condition the surface is in, e.g. freely moving or frozen in place. In addition, there are some failures that the autopilot will be able to respond to and others that will require a manual pilot to make cognitive control decisions. In either case, it is up to the observer and the PAC-O to notice any changes in flight characteristics or performance. Upon the determination that there is failure of an aerodynamic control surface, it is up to the PIC, using their skill and knowledge, to determine what the safest course of action is.

A-5.1. If the autopilot is otherwise operating normally,

A-5.1.1. and the UA is not within VLOS of the PAC-M, then the PAC-O will command the UA to return to base and fly the emergency flight plan.

A-5.1.2. and the UA is within VLOS, then it will be up to the PIC to determine whether to manually land the UA or to let the autopilot perform and automatic landing.

A-5.2. If the autopilot is determined to not be flying within acceptable performance limits:

A-5.2.1. and the UA is not within VLOS of the PAC-M, the PIC will command aerodynamic termination.

A-5.2.2. and the UA is within VLOS of the PAC-M, and the PIC determines it is safe to take over manual control, the PAC-M will take over manual control and attempt to land the UA following standard landing procedures if possible. If at any moment the UA becomes unsafe or uncontrollable, the PIC will command the PAC-M to perform an aerodynamic termination.

A-6. *Structural Failures:* The response to a structural failure is determined by the type of failure and in what condition the failure put the UA in. In addition, there are some failures that the autopilot will be able to respond to and others that will require a manual pilot to make cognitive control decisions. In either case, it is up to the observer to notice any major structural failures and the PAC-O to notice any changes in flight characteristics or performance. Upon the determination that there is a structural failure, it is up to the PIC, using their skill and knowledge, to determine what the safest course of action is.

A-6.1. If the autopilot seems to be flying the UA within satisfaction

A-6.1.1. and the UA is not within VLOS of the PAC-M, then the PAC-O will command the UA to return to base and fly the emergency flight plan.

A-6.1.2. and the UA is within VLOS, then it will be up to the PIC to determine whether to manually land the UA or to let the autopilot perform and automatic landing.

A-6.2. If the autopilot is determined to not be flying the UA satisfactorily

A-6.2.1. and the UA is not within VLOS of the PAC-M, the PIC will command aerodynamic termination.

A-6.2.2. and the UA is within VLOS of the PAC-M, and the PIC determines it is safe to take over manual control, the PAC-M will take over manual control and attempt to land the UA following standard landing procedures if possible. If at any moment the UA becomes unsafe or uncontrollable, the PIC will command the PAC-M to perform an aerodynamic termination.

A-7. *Degrading Performance of the Autopilot:* Degrading or poor performance of the autopilot can be caused by bad or failed sensors, actuators, or by improperly set or adjusted feedback gains. It is expected that most failures showing as degraded autopilot performance is primarily due to the failure of on-board sensors such as the

- rate gyros
- accelerometers

- poor or bad GPS solution
- board temperature failure
- air-data system
- total (dynamic) pressure
- static pressure

Specifically, it is when these systems begin to degrade or are failing but are still somewhat functional and are effectively hiding their failure to the health and safety checks of the autopilot system. It is up to the observer and the PAC-O to notice any changes in flight characteristics or performance.

If it is determined that the autopilot is not performing as expected, or begins to deviate from expected operations, then

A-7.1. If the PAC-M has VLOS of the UA, then the PAC-M will terminate the flight by initiating landing procedures.

A-7.2. If the PAC-M does not have VLOS of the UA

A-7.2.1. and if the PAC-O can determine that it is not a rate gyro failure, then the assisted pilot mode will be used, and the PAC-M will navigate the UA back to base to initiate landing procedures. The observer will be used to aid in the navigation of the UA back to base.

A-7.2.2. if the PIC deems it is not safe for the PAC-M to use assisted pilot mode due to the failure, the PIC will command aerodynamic termination.

A-8. *Sensor Failures*

A-8.1. Failure of GPS

A-8.1.1. GPS Solution Discrepancy A discrepancy in the GPS can be caused by, for example, the PGS generating incorrect corrections while using differential GPS. A discrepancy in the GPS solution must be determined by the PAC-O or by the observer. The PAC-O can determine if there is a discrepancy in the solution by comparing the GPS data with that of other systems such as pressure altitude and airspeed. The observer can aid in this determination by watching for any unexpected departures of the UA from the current flight plan.

A-8.1.1.1. If the PAC-M has VLOS of the UA, then the PAC-M will terminate the flight by initiating landing procedures.

A-8.1.1.2. If the PAC-M does not have VLOS, then the assisted-pilot mode of the autopilot may be used to allow the PAC-M to navigate the UA back to the landing area. The observer will be used to direct the flight path of the UA to the PAC-M.

A-8.1.1.2.1. Once the UA is within the PAC-M VLOS, the PAC-M will initiate manual landing procedures.

A-8.1.1.2.2. If for some reason the PAC-M can not successfully navigate the UA back to VLOS, or the PIC deems the situation unsafe then the PIC will command aerodynamic termination.

A-8.1.2. GPS Timeout The GPS timeout defines the amount of time for the aircraft to continue to perform normally without a new GPS solution. When the GPS receiver has not generated a new solution within a ten (10) second period, the GPS timeout will be asserted by the autopilot. There are two different set of procedures that occur depending upon the status of the communication link when the GPS times out.

A-8.1.2.1. If the communication timeout has been asserted prior to the GPS timeout, the autopilot will automatically command an aerodynamic termination.

A-8.1.2.2. If the GPS timeout occurs while the UA has not lost communications, then the PIC will determine whether to issue an aerodynamic termination by the PAC-O or to have the PAC-M take over direct control.

A-8.1.2.2.1. If the PIC determines it is safe, and the PAC-M has VLOS, the PIC will command the PAC-M to take over control of the UA using the pilot console. Once the PAC-M has manual control, the PAC-M will fly the UA to the primary landing site and initiate landing procedures.

A-8.1.2.2.2. If the PAC-M does not or cannot acquire VLOS, or there are other circumstances that make manually piloting unsafe, the PIC will issue the aerodynamic termination command to the PAC-O.