B.T.A AS-07 Automatic Pilot

User Manual 2005.2

for Flight Stabilization of Fixed Wing Model Aircraft
B.T.A AS-07-B (Basic), B.T.A AS-07-G (GPS)

B.T.A AUTOMATIC PILOTING SYSTEMS LTD.

CONTENTS:

1. AS-07 PANEL DESCRIPTION - QUICK REFERENCE

1 Radio system Input/Output connector

2 Roll Gain Adjustment Potentiometer

3 TEST. when pushed, simulates autopilot feedback to a climb and right turn of the aircraft. If led on, you should see the right aileron going down and elevator going down (as written on the panel). This is a correct negative feedback reaction.

4 Determine feedback polarity of the autopilot. Should be in the polarity causing the appropriate test reaction as written on the panel.

5 GPS Aircraft Retreiver interface connector

6 Pitch Gain Adjustment Potentiometer

7 Mode Indicator LED shows Automatic (LED ON) or Normal mode (LED OFF), selected from the radio (through the mode input connector). Calibration (LED FLASHING) during power up only.


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7
ROLL GAIN
TEST
NORM
REV
ROLL PITCH
THIS SIDE UP
PUSH FOR DOWN & LEFT
ELE OUT
ELE IN
AIL OUT
AIL IN
MODE IN
B.T.A AS-07 AUTOPILOT
U.S Pat.4964598
GPS
PITCH GAIN
MODE
OFF-TRANSPARENT
ON - AUTOMATIC
BLINK-CALIBRATING

2. INTRODUCTION

2.1 APPLICATIONS

The B.T.A. Automatic Pilot presents a new approach in flying and controlling radio controlled airplanes. It was designed to enable beginners and unconfident flyers to fly safely. It will also help the more experienced scale flyers by giving them absolute safety and immunity to radio interference, and enable pleasant smooth flight. In the field of special flying for target purposes, filming, advertisement and night flying, B.T.A. offers the tool that turns a normal model into a real drone. The BTA Automatic Pilot combines the top in electronics, and know how in model flying, to give the best available performance from each model.

2.2 CONNECTIONS AND OPERATION

The automatic pilot is connected in the model to the aileron and elevator channels and stabilizes pitch and roll angles (or vertical speed and rate of turn). The angles of the airplane relative to the horizon are dictated by stick position whenever engaged (automatic pilot mode) in air. Centering the sticks will always return the plane to straight and level flight.

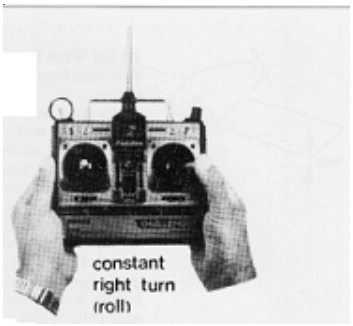
2.3 SO WHAT?

This represents a new mode of flying and is known as position flying. It gives performance and possibilities that are impossible with any other radio controlled system. Not to be confused with regular rate gyros, this autopilot really “feels” the airplane’s position. Rate gyros only detect dynamic changes and are therefore unsuitable for position stabilization. The B.T.A. autopilot will save the model from almost any bad position such as spin and dive. A rate gyro could never do that because it can’t sense a dive or return to level flight. (For applications see chapter 13).

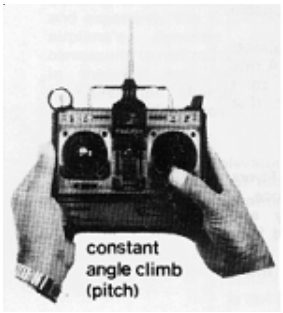
2.4 GETTING STARTED

The autopilot is intended for everyone. Flyers can use it to gain confidence and experience. In order to operate the unit safely and correctly the manual must be read and fully understood. Initial calibration could be done by a more skilled flyer until proper operation is achieved.

The AS-07 maintains level flight without any control input.

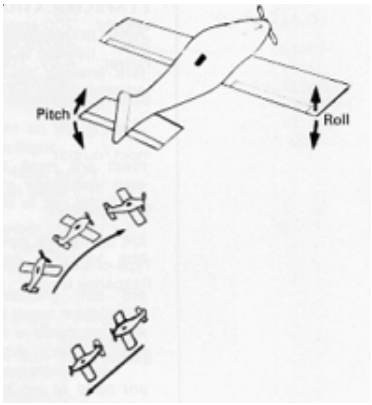


Turning is accomplished by constantly holding the stick in the required angle.



Climbing or descending is accomplished by constantly pressing the stick up or down.

3. PRINCIPLE OF OPERATION (U.S. PAT 4964598)



The B.T.A. autopilot stabilizes the airplane in roll (ailerons) and pitch (elevator). Stabilizing a moving airplane is done by sensing the airplane's position (or attitude) relative to the horizon.

Sensing of roll and pitch directly is difficult and expensive; the B.T.A. autopilot measures airplane's dynamic movements, which correspond to real roll and pitch. In the roll axis (ailerons), the autopilot measures the change of heading of the airplane to indicate roll. In the pitch axis (elevator), the autopilot measures the change of altitude (height) by means of a sensitive barometric sensor. This signal represents pitch. Since sensing is dynamic, the autopilot will work only in flight. Simulation on the ground is not possible.

3.1 SPECIFICATIONS AS-07

Weight: ..... 74 grams (2.5 oz.) with harness

Size: ..... 126x48x21mm (5.0"x1.9"x.8") 5.0” length includes mating connectors

Power: ..... 4.8-6.0V, 20mA (no additional battery required)

Input/output: ..... Pulse width modulation, 1.5 msec neutral position

Compatibility: ..... All radio systems (with 1.5 msec neutral)

Type of Stabilization: ..... 2 axis (roll, pitch)

Response time: ..... Roll: 0.5 sec.
..... Pitch: 0.3 sec. (depending on gain settings)

Sensors: ..... 1. Roll - rate of turn solid state gyro
..... 2. Pitch - rate of climb solid state absolute pressure sensor with
..... hardware differentiation over time.

Connectors: ..... 20 Pin with Radio System Adapter
..... 10 Pin GPS Plane Retriever Interface

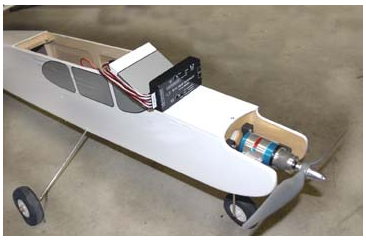
4. CAUTIONS

- Never take off without knowing which mode it is set to (automatic or normal). Always take off with the autopilot disengaged.
- Don't fly an autopilot in an airplane that has never flown before. Test flight must be done prior to automatic flight.
- Don't try to simulate flight on the ground. The autopilot only works in flight.
- Don't change the wires in the main connector, incorrect polarity will cause damage.
- Prevent dirt and oil from getting into the autopilot through the front panel holes.
- Don't leave the autopilot in direct sunlight for long time, as this will cause miscalibration due to temperature rise.
- It is highly recommended not to open the autopilot's box. In any case, do not move the internal potentiometers because they are precisely factory calibrated.

5. INSTALLATION AND SETUP

5.1 INSTALLATION

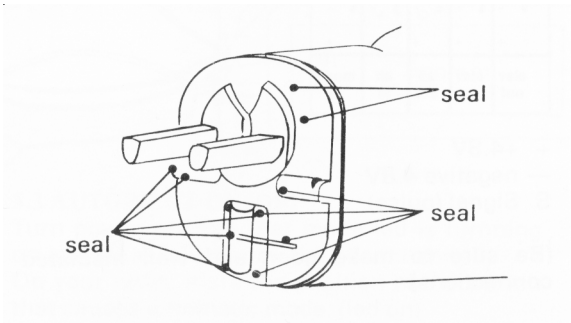
Install the autopilot wrapped with vibration isolating foam like a receiver. Leave the front panel accessible. The only requirement is that the autopilot should be level in the airplane and the arrows on the panel pointing toward the sky. Verify orientation after any adjustments.



The usual place for the autopilot in high wing airplanes is under the wing or somewhere in the fuselage (arrows pointing up during flight). It is sometimes necessary to move the servo tray towards the tail, in order to clear space for the autopilot. In some models, the autopilot can be placed parallel to the wing if it is more convenient. The images on this page show the mounting orientations.

5.2 SEALING

The autopilot is measuring changes in barometric pressure and is therefore sensitive to wind coming into the fuselage during flight. It is essential to seal all holes and openings on the firewall that face the airflow of the propeller. In scales, the front of the aircraft must be inspected for unwanted holes facing the airstream in flight. Sealing is best done with R.T.V. sealant. Operative check of the sealing is described in chapter 6.2.

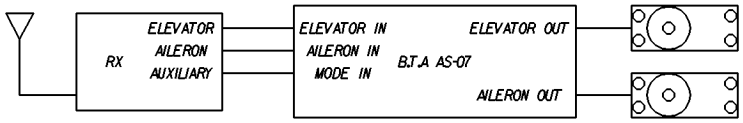


5.3 CONNECTORS

The AS-07 includes a wiring harness to interface with the receiver and servos. The radio connectors are universal and are compatible with all modern radio systems. If in doubt, verify polarity before making any connections. Incorrect polarity will result in damage to the autopilot and or the radio system.

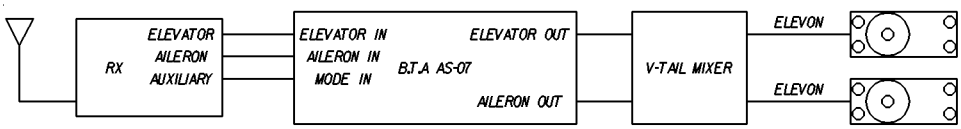
5.4 CONNECTION TO RECEIVER AND SERVOS

The AS-07 can be used with several types of control configurations including, standard, elevon, and flaperon installations. The following diagrams show how the autopilot integrates into the system.



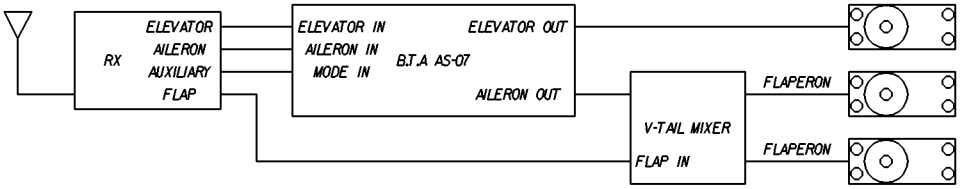
Standard Installation

For elevon installations the mixing of the control surfaces is done between the autopilot and the servos. Transmitter elevon or delta mixing must be disabled.



Elevon (Flying Wing) Installation

Flaperon systems are also an option. Again transmitter mixing must be disabled. Mixing of flaperon is done on the aircraft with a v-tail mixer. Follow the diagram and mixer instructions to get proper surface throws.



Flaperon Installation

5.5 AUTOPILOT ON/OFF

Turn power on. Verify that mode LED is turning on and off with the auxiliary channel switch. On the transmitter, mark the position of the switch that causes automatic mode. (LED on).

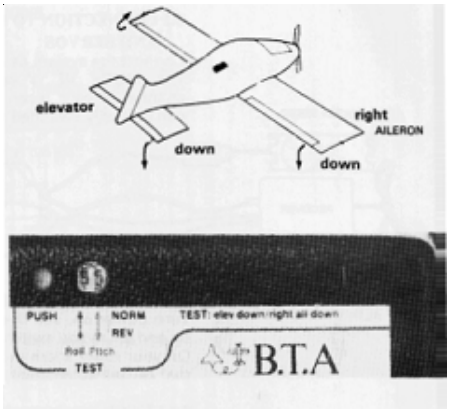
5.6 CHECK

Check that aileron stick moves ailerons and elevator stick moves elevator. In automatic mode the swing of the ailerons and elevators will appear smaller (like dual rate).

5.7 TEST

The test procedure is the most important part of the calibration. Be sure it is done correctly. Incorrect position of the autopilot norm/rev switches will result in dangerous and unstable flight (in automatic mode only, of course). It must be understood that there is no connection or influence of the autopilot's norm/rev switch on the servo's norm/rev switches in your radio.

While the system is fully connected (including wing servo) and operative, switch the autopilot on (LED on). Then press the test switch (with a screwdriver). The elevator should go down and the right aileron should also go down, as written on the front panel. If not, the elevator and aileron reversing switches should be adjusted.



6. OPERATION

6.1 PRE-FLIGHT CHECKS

Do not fly an autopilot on an airplane that has never flown before. Test flight will be done without an autopilot. If the airplane is flight proven and the autopilot was installed and tested, proceed.

6.2 CALIBRATION

The AS-07 calibrates automatically during the first 30 seconds after the radio system is switched on. During this period the model must not be moved and the transmitter should be 4-6 feet away with the antenna collapsed. During calibration the aileron and elevator servos will not respond unless the mode switch is ON. After calibration, if the mode switch is on, the unit will give the test reaction of down elevator and left roll for two seconds or indefinitely if the transmitter is off. Verify calibration by switching between off and on modes while paying attention to the control surfaces. Switch the AS-07 on with the mode switch on the transmitter. Watch the aileron, there should be no change in position when the switch is thrown. The elevator engagement is delayed for three seconds after the switch is thrown. If the center position of either surface changes, the calibration should be repeated with the transmitter further away or switched off. Significant trim or subtrim in the transmitter can cause a problem with calibration. This can be remedied by removing the trim and/or subtrim and adjusting the control linkages.

6.3 SEALING TEST

Switch the autopilot on (engine running). Restrain the airplane. Open and close the throttle in five second intervals. Watch that elevator is not influenced by propeller speed. If considerable deflections are noted, check and improve the sealing described previously in chapter 5.2.

6.4 TAKE OFF

Taking off must be done with the AS-07 off. Failure to do so can cause unwanted roll corrections as the model is steered down the runway with the rudder. Take of as usual and climb to comfortable altitude. Trim the airplane for straight and level flight.

6.5 AUTOPILOT ON

In level flight, switch the autopilot on. If anything strange happens, quickly switch the autopilot off. Review chapter 5 for installation or setup errors. If installed correctly the modell will continue to fly straight and level. Begin giving left, right, up and down commands. Remember to hold the stick constantly to maintain a bank or climb. Notice the model rights itself as soon as the stick is centered.

If there is a change in aileron trim when the autopilot is engaged, but passes the calibration procedure, the model could be out of trim in yaw(rudder trim). This will cause the model to fly in a slightly curved path which the AS-07 attempts to compensate for with opposite roll input. The roll can be trimmed out temporarily while AS-07 is in automatic mode or the trim can be corrected by adjusting the rudder trim to the same side as the roll. If the rudder trim is adjusted the aileron trim will also need to be adjusted with the AS-07 off. Once this is done, it should eliminate the trim change when AS-07 is engaged.

6.6 RESPONSE AND GAIN

If the model oscillates in flight the gain of the corresponding axis must be reduced. Decrease gain by turning the trimmers counter-clockwise as illustrated. Reduced gain results in less control surface travel when the autopilot is switched on. If the model is slow to right itself when the sticks are released the gain can be increased to improve stability. The ideal gain is slightly lower than the critical gain causing oscillations.

6.7 LANDING

Do not attempt landing in automatic mode until you understand how the unit works and have properly set up the model. The model must be properly calibrated, flying stable and smoothly in automatic mode, without swinging from left to right. When such calibration has been achieved, automatic mode landings may be attempted. Remember that when flying in the automatic mode the ailerons and elevator have smaller throw, so landing should be planned carefully with moderate approach angles, usually requiring a larger approach radius. When done correctly, landing in the automatic mode is smooth and easy. Approach the runway as usual but faster with moderate descent rate. The faster approach has to compensate for the limited full up elevator command in automatic mode, and to prevent stalling before touchdown.

The AS-07 will not compensate for a drift due to crosswind. It does stabilize the model, but will not steer it to the landing strip. Use a slip method to compensate for cross winds. Experiment at higher altitudes prior to the landing attempt. Sudden changes in yaw with rudder control input will result in the opposite roll compensantion in automatic mode. This is mainly a concern when landing in crosswinds, when yaw corrections are needed to touchdown in the proper location.

7. APPLICATIONS APPENDIX AND BACKGROUND

7.1 APPLICATIONS

- As an initial training aid: the model may be flown with the autopilot engaged throughout the flight, after takeoff.
- Advanced training: the model is flown with the autopilot disengaged, but can be engaged if the student experiences difficulties.
- Scale flying: the autopilot is engaged to give better scale flight characteristics by reducing sudden responses, which spoil the look of scale flight.
- Special applications: the autopilot will control the model at the extremes of height and range in events such as cross-country gliding, where visual control can become difficult.
- Enhanced failsafe protection: the autopilot will bring the model to a controlled touch down.

7.2 WHAT IT DOES

This is a true autopilot, and its function should not be confused with that of a gyro or failsafe.

7.3 THE GYRO

As used in model aircraft, this is essentially a damping device for correcting unwanted changes in attitude or heading caused by external forces acting on the model. A gyro will oppose a turbulence-induced roll when fitted on the ailerons of a glider, but it will not bring it back to level flight. If the glider is banked using ailerons, and the control stick is centered, a gyro will not roll the wings level, but will try to keep the model in a bank.

7.4 THE FAILSAFE

The purpose of a failsafe is to prevent the model from continuing to fly away following radio failure, not to land the model safely. What the failsafe does, is to move the servos to pre-programmed positions when the transmitter signal is lost. What the model does next depends on the attitude of the model when the failsafe activated and the flying characteristics of the model, as well as the failsafe control positions.

7.5 THE B.T.A. AUTOPILOT

The main function of the autopilot is to return the model to a pre-programmed flight attitude (normally straight-and-level flight) when the control sticks are centered. It does this regardless of the attitude of the model at that time. The autopilot will even recover the model from an inverted dive or spin.

The autopilot operates via the aileron and elevator channels to control the model (throttle and rudder are unaffected) and is simply plugged in between the receiver and the servos. A spare channel (the gear channel is ideal) is used for engaging and disengaging the autopilot from the transmitter.

The autopilot is powered by the receiver battery and is switched on by the receiver switch — there is no separate power switch. It is engaged and disengaged from the transmitter at any time.

Autopilot Disengaged

The model is flown normally and full control response is available. The autopilot is transparent. If the autopilot is now required, perhaps because the pilot has become disorientated, or has lost control of the model, the control sticks are released and the autopilot switched on. The autopilot will now return the model to straight and level flight. This will give the pilot time to regain orientation and control of the model.

Autopilot Engaged

The model is still controlled by the pilot. The autopilot will level the model whenever the sticks are centered. Depending on gain settings it will limit the amount of response similar to a dual rate. The sticks now however dictate the roll and pitch angles. When the stick is held it will cause the model to bank. The model will not roll inverted when the autopilot is engaged. The autopilot restricts the attitude of the model and the control inputs, within adjustable limits.

Attitude

The maximum bank and pitch angles may be limited by reducing gains. Reducing gains will increase the time for recovery from unusual attitudes after engaging automatic mode. While flying with the autopilot engaged, it will prevent the model from becoming inverted and will also reduce the risk of inadvertent stalling.

Control Input

The control movements are reduced depending on gain, thus making the model less responsive and easier for the student to control.

Height Control

The autopilot does not have a height lock. It will not hold the model at any particular height. It will return the model towards the height at which the maneuver commenced. If the model is diving steeply and the autopilot is engaged and the sticks are released, the autopilot will recover some of the height lost. The amount of height recovered depends on the steepness of the dive, the steeper the dive, the more height recovered. The autopilot will not stall the model if the throttle is closed. With the controls centered the autopilot will allow a gradual descent. Similarly, if the throttle is fully opened the autopilot will allow a gradual climb. This allows the model to be used in gliders without a power source.

7.6 USE OF THE AUTOPILOT WITH FAILSAFE

The autopilot will operate in conjunction with a failsafe to provide much better protection from loss of transmitter signal. When both are correctly set, the combination will ensure that the model is actually controlled back onto the ground, instead of merely being prevented from continuing to fly away. The failsafe should be programmed to switch the autopilot on. Modern transmitters allow all the channels to be programmed, as well as setting the controls to the required position.

When used for this type of application the failsafe may be set to engage the autopilot, give a small aileron deflection, small up elevator deflection, straight rudder, and engine off. When set in this manner if the radio signal is lost, the failsafe will close the throttle and engage the autopilot, which will then control the model in a shallow descending turn. This will minimize the damage to the model on landing and the turn will reduce the distance the model will travel, particularly if the model was pointing away from the pilot when the failsafe activated.

8. PLANE RETRIEVER PANEL DESCRIPTION - QUICK REFERENCE

1 NMEA Output connector

2 Power LED (red)

3 Data Indicator LED (red)

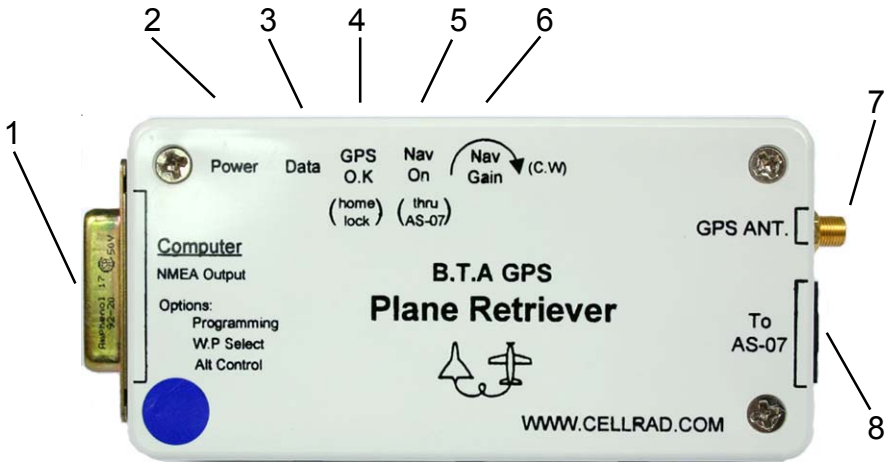
4 GPS Home Lock LED (green)

5 Navigation LED (amber)

6 Navigation Gain Potentiometer

7 GPS Antenna connector

8 AS-07 Interface connector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Options:
Programming
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B.T.A GPS
Plane Retriever
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AS-07
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9 Introduction AS-07 with GPS Plane Retreiver

The AS-07 with the optional GPS homing function provides the ultimate protection from flyaways and loss of visual contact. The system includes a small antenna for GPS signal reception and navigation software which will guide the model back to the take off site when activated. The unit has three modes of operation, transparent(off), stabilization, and homing navigation.

10 Principle of Operation

The Retriever samples the home coordinate after power up and stores it as the target. When activated, it compares bearing to target and current heading to determine how much the model must turn to head home. The turn duration is based on a 10 degree per scond turn rate. After the turn is complete it will resample target and heading, initiating another turn if needed. Once the model passes the home location it will begin to circle or fly a figure eight pattern.

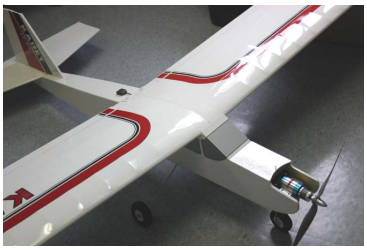
11 Retriever Specifications

Weight: ..... 85 grams (3.0 oz.)
Size: ..... 105x48x21mm (4.1"x1.9"x.8")
Power: ..... 4.8-6.0V, 50mA (no additional connections required)
Connectors: ..... 10 Pin AS-07 Interface
..... MCX for GPS antenna
..... Connector for NMEA output
GPS Type ..... Trimble Lassen SQ
Backup Battery CR2032
Navigation Processor ..... Motorola 68HC908GR8

12 Retriever Installation and Setup

12.1 Installation

Mount the Retriever module in vibration isolating foam. Install it so the LED's and gain potentiometer are visible. Connect the interface lead to the AS-07. The antenna must be installed externally for best reception. Use double-sided foam tape to install the antenna with the plastic dome facing the sky. Connect the antenna to the retriever.



12.2 Setup

Follow the previous instructions for setup of the AS-07. The main difference is that the input mode switch should be a three position switch. This allows easy selection of the three operating modes. It could also be assigned to a slider or potentiometer. One extreme will be off, center will be stabilization (AS-07) on, and the other extreme will be navigation (Retriever) on. Mark the transmitter accordingly.

Take the system outside and turn the receiver on. After the AS-07 initializes the Plane Retriever will begin acquiring the home location. The Power LED should be lit and the Data LED flashes indicating it is receiving data. Initial cold start home point recognition may take up to five minutes while the GPS searches for available satellites. Home location acquisition is indicated by the GPS Home Lock LED flashing.

The green LED will flash very briefly, and after one minute the flash duration will increase. This will be readily apparent when observed. The change in flash duration indicates the Home Location is locked and the model is ready to take off. After initial power up locating home should occur approximately 10 seconds after AS-07 initializes. The GPS satellites are recorded in memory after initial power up. The information is valid for about one week. After one week, or if the model is transproted a great distance, it may take up to five minutes to acquire home. If the unit continually takes a long period of time to acquire home the memory backup battery has failed and must be replaced.

Switch the mode switch to navigation and verify the Nav On LED lights. The model must be moving for navigation to function, there will be no control deflection while stationary. Calibrate the AS-07 without switching on the navigation. Do not attempt to adjust the navigation until the stabilization is adjusted and flies the model smoothly. Ideal gains for the AS-07 will allow the model to complete a complete 360 degree turn in 36 seconds, by pushing the aileron trim all the way to one side. The Retriever is designed to turn at a rate of 10 degrees per second. When the AS-07 is adjusted to turn at this rate the navigation gain should be set at the center for proper operation. The model should be trimmed to fly a straight path and have the same response right and left. With the model several hundred feet away from the home location, switch the navigation on. The model should turn straight toward the home location and level. If it over controls the nav gain must be reduced. If it levels and corrects again, gain must be increased. Navigation gain that is set too low is desirable over excessive gain. It will again sample the heading and correct toward home after the initial turn is completed. Excessive gain can cause erratic behavior. Once home location is reached it will begin to circle around home or fly a figure eight pattern through home. There is no navigation within a 200 foot radius of the home location. Changing autopilot gain settings will require adjustment of the Retriever gain.

13 Retriever Operation

NEVER take off with the Navigation on!! The unit can't determine where the flight line is and may fly well behind it for several reasons. If it is critical this doesn't happen, power up the aircraft on the runway or flying field rather than in the pit area. The pilot can control the model while navigation is on but it will continue to correct toward home. It is best to avoid inputting aileron or rudder commands, but altitude may be adjusted with throttle and elevator. It is important to understand that the rate of turn response of the AS-07 and airplane is proportional to airspeed. The gain can be adjsuted by 20-30% simply by changing speed through thottle setting.

Thank you for purchasing the B.T.A. autopilot, the world's first automatic pilot commercially available for model airplanes. This instrument is elaborate enough to fit the most demanding applications and at the same time is ideal for beginners as a training aid. Like all radio controlled equipment the AS-07 autopilot must be appropriately maintained and operated. Responsibility of proper usage lies on the user and it is therefore essential to read and follow this manual step by step. Good luck and joyful flights.

OTHER UAV SUBSYSTEMS AVAILABLE FROM WIRELESS AVIONICS (B.T.A)

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