Operating Handbook

For

Digiflight SERIES AUTOPILOTS

TRUTRAK FLIGHT SYSTEMS

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General Introduction

The Trutrak autopilot can be defined as being an orthogonal rate system. This means that gyroscopic rate sensors are installed so as to sense motion about each of the major axes (roll, yaw, and pitch). These sensors generate the fast signal responses necessary to create an autopilot with the best possible dynamic performance.

To fly an aircraft well about the axis controlled by the ailerons, velocity of aileron movement must be directly proportional to the rate of roll for small movement. This means that aileron position corrections do not lag behind motion of the craft about the roll axis. Aileron control systems that use a turn coordinator, which senses twice as much azimuth as roll rate, cannot do this. Instead, in turbulence, yaw disturbances cause undesired aileron movement. In some aircraft this effect is so severe that the controls may even move momentarily in the wrong direction.

The challenge at Trutrak is to create, beyond question, systems with the very best dynamic performance available—systems that need not be disengaged in turbulence, but instead provide function when most needed.

The complete Trutrak flight control system combines within a single panel-mounted programmer/computer package which includes all the electronic and sensing elements needed for the roll and pitch functions and interfaces to a rate-gyro-controlled yaw damper.

Basic directional control is provided by digital selection of a GPS track to be flown. This replaces heading selection on the DG, and eliminates drift as well as crosswind correction. In the GPS steering mode of operation, the system responds to digital guidance information so as to fly a complex navigation program.

The vertical portion of the system contains a pressure signal source for altitude and vertical speed information, an airspeed signal source, and a high performance pitch rate gyro. These signals are combined to provide performance equal to that of the most expensive autopilots. Also by having airspeed information the system is stall proof. It is expected that other systems will soon be coming out with this same feature.

For any set of features all Trutrak computers are identical. Servos likewise are identical in velocity response. Servos do differ according to total torque required. By providing setup functions in the programmer for system activity and torque, one Trutrak programmer-servo combination can fly any aircraft.

As a starting point in understanding how to operate the TruTrak system, the following describes the presentation of data, the operating controls, and the procedures for selecting modes of operation.

POWER UP—AIRCRAFT STATIONARY

SEE INITIALIZING THE AUTOPILOT PAGE 4

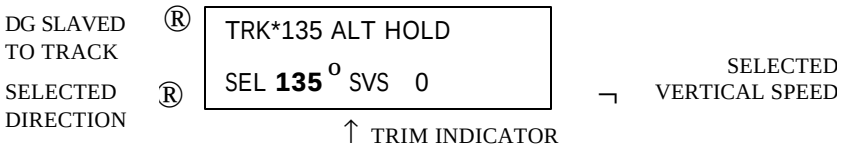
Mode and Data Display

This display normally shows operating modes and associated numerical data. It is also used to display setup mode screens and the setting of associated numerical data. When displaying operating modes, the left side shows lateral data and the right side shows vertical data. (See figure below.) The upper left display labeled TRK shows the electronic DG slaved to GPS track. When the GPS track is not available TRK will be replaced by MAG, which means the autopilot now uses an internal source of magnetic information for direction. The lower left display labeled SEL shows the selected direction of flight. In the Digiflight 200 and 200 VS, the upper right shows whether or not the unit is in the altitude hold mode. The lower right display shows selected vertical speed or whether the autopilot is on of off.

With the Digiflight 200VS, the vertical space between theleft and right hand display area is used to show pitch trim. This display consists of three horizontal bars spaced vertically as the rungs on a ladder, and are made to move up or down when the aircraft is in need of being trimmed.

In the upper left where direction is shown, a flashing indicator is present between TRK or MAG and the numerals that follow. When there is GPS serial data present but no position fix, this will be a flashing period. Once GPS position data becomes valid this will be a flashing asterisk. If GPS flight plan information is being received over the serial channel or if the GPS-S- option has been added and GPS steering information is being received, a flashing plus sign will indicate the presence of a useable steering (GPS-S- mode) or waypoint to waypoint (GPS NAV mode) signal.

A cursor in the form of an underline is shown beneath the SEL numerals. This is used to indicate that an underlined number will be set by rotation of the encoder knob.

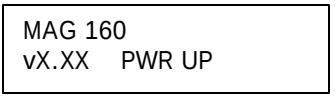


Controls

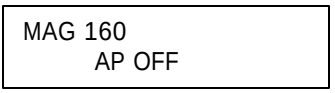
The Digiflight series autopilot uses the simplest controls available. All programming is done via a rotary encoder knob and entered by depressing and then releasing the knob. This will be referred to hereafter as enter. There is a small button located to the left of the display. This button toggles between the default (TRK) mode and the GPS-S- mode (or GPS NAV mode if GPS steering is not available). Engaging the autopilot can be done by either momentarily pushing and releasing the encoder knob on the programmer or by pushing and holding the switch located on the control wheel or stick for more than two seconds and then releasing. Disengaging can be done either of two ways: by pushing and holding the encoder knob on the programmer for approximately three seconds and then releasing the knob, OR by momentarily pushing and releasing the switch located on the control wheel or stick. This means that in addition to disengaging the autopilot, this switch also provides the function referred to as Control Wheel Steering in that the autopilot synchronizes to both direction and vertical speed upon being engaged.

Initializing the Autopilot

The autopilot master switch should be in the off position when the engine is started. Aircraft electrical systems can generate voltage transients during an engine start, and like other avionics systems, the autopilot should not be subjected unnecessarily to these conditions. After start up, turn on the autopilot master switch and hold the aircraft stationary as the internal gyros are initialized. This takes approximately ten seconds during which time the display will show the words PWR UP in the lower right. The software version will be momentarily displayed in the lower left.



When initializing is complete PWR UP will change to AP OFF.



GPS Acquisition

Between the word MAG and the three digit numeric display, a flashing period MAG•155 will appear each time the GPS sends a message to the autopilot (once per second). This indicates the GPS is working but has not yet obtained a position fix. As long as the period is shown, the heading display cannot transition to the TRK mode.

When the GPS does obtain a fix, the period will be replaced by an asterisk MAG*155. This means that when a certain velocity is attained MAG will be replaced by TRK. This happens at approximately 10 Knots ground speed as detected by GPS and will even occur at rapid taxi speeds.

Digiflight 100

Lateral Modes

Upon being engaged, the autopilot will be in the basic lateral mode, and it will be synchronized to the direction being flown at the time. The number following SEL (Selected direction) is underlined, meaning that rotation of the encoder will select heading. Rotation of the knob when it is not depressed will cause 5° steps of SEL and when it is depressed the steps will be 1°.

```
TRK*135
SEL 135   AP ON
```

If a GPS flight plan has been entered into the GPS, pushing the small button to the left of the display will engage the GPS NAV mode and a flashing plus sign will show. In the GPS NAV mode the autopilot will follow a flight plan programmed into the GPS. The autopilot must, however, over-fly each way point prior to turning and intercepting the next course line.

```
TRK+135
GPS NAV   AP ON
```

If the GPS-S- option has been added, pushing the small button to the left of the display will engage the GPS steering. In the GPS-S- mode the autopilot follows lateral steering or bank commands generated by a navigation system (EFIS or GPS).

```
TRK+135
GPS -S-   AP ON
```

Magnetic Back-Up Mode

The lateral modes previously described are based on GPS track being present. When GPS is lost, the DG

display is slaved to a magnetic heading source contained within the programmer and TRK is replaced with MAG. This magnetic mode is only a backup and would seldom be needed; however, it does provide a means of selecting and maintaining a drift-free direction of flight. If the GPS-S- signal source is functional, the GPS-S- mode will remain functional.

Gyro Set

When the initializing has been done correctly, the gyros should already be centered at the time of take off. If confirmation of this is desired, with the aircraft stationary on the runway and the autopilot disengaged, pressing and holding the encoder knob will put the gyros in the fast centering mode. The knob should be depressed for approximately 7 seconds during which time the words GYRO SET will be displayed.

```
MAG*180
      GYRO SET
```

Power Loss

If there is a momentary loss of electrical power, the autopilot will disengage. The autopilot gyros must now be manually re-initialized using the GYRO SET operation. Manually fly the aircraft in a straight line as steadily as possible, while holding in the knob for at least ten seconds after the words GYRO SET appear in the display. After approximately ten seconds have elapsed, release the knob. The autopilot may now be re-engaged, and any residual gyro offset will be slaved away automatically.

Digiflight 200

Lateral Modes

Upon being engaged, the autopilot will be in the basic lateral mode, and it will be synchronized to the direction being flown at the time. The number following SEL (Selected direction) is underlined, meaning that rotation of the encoder will select heading. Rotation of the knob when it is not depressed will cause 5° steps of SEL and when it is depressed the steps will be 1°.

```
TRK*135
SEL 135  AP ON
```

If a GPS flight plan has been entered into the GPS, pushing the small button to the left of the display will engage the GPS NAV mode and a flashing plus sign will show. In the GPS NAV mode, the autopilot will follow a flight plan

programmed into the GPS. The autopilot must, however, over-fly each way point prior to turning and intercepting the next course line.

```
TRK+135
GPS NAV    AP ON
```

If the GPS-S- option has been added, pushing the small button to the left of the display will engage the GPS steering. In the GPS-S- mode the autopilot follows lateral steering or bank commands generated by a navigation system (EFIS or GPS).

```
TRK+135
GPS -S-    AP ON
```

Magnetic Back-Up Mode

The lateral modes previously described are based on GPS track being present. When GPS is lost, the DG display is slaved to a magnetic heading source contained within the programmer and TRK is replaced with MAG. This magnetic mode is only a backup and would seldom be needed; however, it does provide a means of selecting and maintaining a drift-free direction of flight. If the GPS-S- signal source is functional, the GPS-S- mode will remain functional.

Altitude Hold Mode

When the autopilot is engaged it will be in the basic lateral mode, and will synchronize to the direction being flown at the time. The pitch servo will not be engaged at this time. To engage the altitude hold the aircraft must be at the desired altitude and be trimmed for level flight. After trimming the aircraft, to enter the altitude hold mode, simply press and release the encoder knob. The display will show:

```
TRK*135 ALT HOLD
SEL 135    AP ON
```

If an altitude change is desired, it is necessary to turn off the altitude hold. To do this, press and release the encoder knob. The display will show:

```
TRK*135
SEL 135    AP ON
```

Gyro Set

When the initializing has been done correctly, the gyros should already be centered at the time of take off. If confirmation of this is desired, with the aircraft stationary on the runway and the autopilot disengaged, pressing and holding the encoder knob will put the gyros in the fast centering mode. The knob should be depressed for approximately 7 seconds during

which time the words GYRO SET will be displayed.

```
MAG*180
      GYRO SET
```

Power Loss

If there is a momentary loss of electrical power, the autopilot will disengage. The autopilot gyros must now be manually re-initialized using the GYRO SET operation. Manually fly the aircraft in a straight line as steadily as possible, while holding in the knob for at least ten seconds after the words GYRO SET appear in the display. After approximately ten seconds have elapsed, release the knob. The autopilot may now be re-engaged, and any residual gyro offset will be slaved away automatically.

Digiflight 200VS

Lateral Modes

Upon being engaged, the autopilot will be in the basic lateral mode, and it will synchronize to both the direction and vertical speed being flown at the time. The number following SEL (Selected direction) is underlined, meaning that rotation of the encoder will select heading. Rotation of the knob when it is not depressed will cause 5° steps of SEL and when it is depressed the steps will be 1°.

```
TRK*135
SEL 135 SVS 100+
```

If a GPS flight plan has been entered into the GPS, pushing the small button to the left of the display will engage the GPS NAV mode and a flashing plus sign will show. In the GPS NAV mode the autopilot will follow a flight plan programmed into the GPs. The autopilot must, however, over-fly each way point prior to turning and intercepting the next course line.

```
TRK+135
GPS NAV SVS 100+
```

If the GPS-S- option has been added, pushing the small button to the left of the display will engage the GPS steering. In the GPS-S- mode the autopilot follows lateral steering or bank commands generated by a navigation system (EFIS or GPS).

```
TRK+135
GPS -S- SVS 100+
```

Magnetic Back-Up Mode

The lateral modes previously described are based on GPS track being present. When GPS is lost, the DG display is slaved to a magnetic heading source contained within the programmer, and TRK is replaced with MAG. This magnetic mode is only a backup and would seldom be needed; however, it does provide a means of selecting and maintaining a drift-free direction of flight. If the GPS-S- signal source is functional, the GPS-S- mode will remain functional.

Vertical Modes

When the autopilot is engaged it will synchronize to the direction and vertical speed being flown at the time, the lower right section of the display shows SVS (selected vertical speed). This is shown below:

```
TRK*135
SEL 135 SVS 100+
```

If an altitude change is desired, momentarily push and release the encoder knob and the cursor will move over to the selected vertical speed.

```
TRK*135
SEL 135 SVS 100+
```

Rotation of the encoder knob will now change the selected vertical speed. If the selected vertical speed is set to zero, the display will show:

```
TRK*135 ALT HOLD
SEL 135 SVS 0
```

Once the desired vertical speed has been selected, momentarily pushing and releasing the encoder knob will move the cursor back to SEL, or after approximately seven seconds without moving the encoder, the cursor will move back to SEL.

Setting Pitch Trim

The pitch servo contains a torque sensor that sends a signal to the computer when the up or down force greater than a threshold value is required to fly a selected flight condition. When this signal indicates an out of trim condition that persists in one direction for more than a pre-set length of time, the three moving horizontal bars will come into view and move according to the direction in which trim is required. The pilot is then required to operate the trim control (electric or manual) so as to bring the system to neutral trim. With mechanical trim this is easily done, but with electric systems it may be necessary to develop a technique. If the trim is slow enough, the pilot has plenty of time to react when the bars disappear before the trim condition is reversed. With a

fast trim it will be necessary to tap or pulse the trim button so that it will be slow enough to turn it off before going too far. When a reversal takes place, a slight tap in the opposite direction may be required to get the bars to stay off. Finally when the bars have been made to disappear and there has been no speed change, the bars can be ignored if they reappear in that it is known the aircraft is close to being in trim.

Gyro Set

When the initializing has been done correctly, the gyros should already be centered at the time of take off. If confirmation of this is desired, with the aircraft stationary on the runway and the autopilot disengaged, pressing and holding the encoder knob will put the gyros in the fast centering mode. The knob should be depressed for approximately 7 seconds during which time the words GYRO SET will be displayed.

```
MAG*180
     GYRO SET
```

Power Loss

If there is a momentary loss of electrical power, the autopilot will disengage. The autopilot gyros must now be manually re-initialized using the GYRO SET operation. Manually fly the aircraft in a straight line as steadily as possible, while holding in the knob for at least ten seconds after the words GYRO SET appear in the display. After approximately ten seconds have elapsed, release the knob. The autopilot may now be re-engaged, and any residual gyro offset will be slaved away automatically.

Digiflight Setup Procedure

The setup consists of setting activity, torque, serial baud rate, and magnetometer calibration. To enter the setup mode, the autopilot must first be engaged, then press and hold the encoder knob for approximately 8 seconds, until the first setup screen appears. The first setup screen shows current values for the activity and torque of the aileron servo, with an underline under the present setting of activity. A typical screen might show

```
LAT ACTIVITY 8
LAT TORQUE 200
```

The underlined number is set by rotating the encoder knob. Turn this knob to set the activity level to the desired value for the particular aircraft.

Any value between 0 and 12 may be chosen. In this example, the value of 1 will be selected. Activity should be set so as to not be excessive in turbulence and yet sufficient to fly without hunting in still air. (Any lost motion or play between the servo and the control surface can cause hunting in still air).

Once activity is set to the desired value, press and release the knob to confirm and enter the selected value into storage. The underline (cursor) will now move to the torque setting:

```
LAT ACTIVITY 1
LAT TORQUE 200
```

In a manner similar to activity, use the encoder knob to select the desired value of roll servo torque. This value should be between 75 and 250. A default value is set at the factory but may need to be modified to suit a particular aircraft. The value chosen should be sufficient to fly the aircraft, but not so much that it is difficult to override the autopilot if necessary.

Having selected the desired torque level, again press and release the encoder knob to confirm and enter the selected torque value into storage. The unit will now show the next screen:

```
BAUD RATE 4800
```

the speed of the primary RS

232 interface to the external GPS unit. By default at the factory it is set to 4800 baud, as that is the NMEA-0183 default. However, it may be set to any of 600, 1200, 2400, 4800, or 9600 baud. Consult the manual for the GPS unit and follow its setup instructions to determine its setting and set the baud rate of the autopilot to the same value. The autopilot will recognize NMEA-0183 protocol or Apollo GX50/GX60 protocol (moving map output).

Once the desired baud rate or Garmin protocol has been selected, again press and release the encoder knob to confirm and enter the selected baud rate into storage. The unit will now show the next screen:

```
MICROACTIVITY 0
```

This setting is to be left at zero unless advised by the factory. Press the encoder knob and the unit will now show the next screen:

```
MAG CALIBRATE? N
```

This setup allows the internal magnetometer in the unit to be compensated for any internal magnetic disturbances within the aircraft, and should be performed once the autopilot is installed in the panel of the aircraft. It may need to be repeated if the autopilot is

moved within the panel, or if new equipment is installed nearby. In order to skip this step, press and quickly release the encoder knob while **N** is selected.

If calibration is desired, it must be done in the air on a day in which there is little wind or turbulence. The autopilot will turn the aircraft through a full circle, using the GPS signal as a reference to calibrate the internal magnetometers.

The aircraft is turned, first to North, then East, then South, and finally West. At each step, the heading is maintained for approximately 20 seconds while the autopilot gathers and averages the data from the magnetometer.

The magnetometer is initially calibrated at the factory for operation in an environment free of magnetic disturbances, and should be functional, though not accurate, when mounted in the aircraft. To calibrate the magnetometer, the aircraft must first be trimmed for level flight.

(1) Rotate the encoder knob to select **Y** in the setup screen.

(2) Press and release the encoder knob to begin the setup sequence. The screen will now show:

```
CALIBRATING
  TURNING NORTH
```

The aircraft will now turn to North using GPS as a reference. Once this is done, the screen will now show:

```
CALIBRATING
    HOLDING NORTH
```

After a period of approximately 20 seconds, the screen will show:

```
CALIBRATING
  TURNING EAST
```

Again, the aircraft will turn to a heading of 090. In the same manner as before, the screen will say HOLDING for twenty seconds. This process is continued through South and West. Once the westerly data has been averaged for twenty seconds, the process is complete and the screen will show:

```
CALIBRATION DONE
  PRESS ENTER
```

At this time, press and release the encoder knob to confirm the calibration and enter the resulting data into permanent memory. This concludes the setup procedure for the Digiflight 100. The Digiflight 200 and 200VS continue to the next setup screen.

If magnetic calibration was not done, the next screen will begin the pitch setup. If magnetic calibration was done, the autopilot will be engaged. To configure the pitch portion of the autopilot it will be necessary to get into the setup

mode once again. Once in the setup mode, scroll though the various setup screens until the display shows:

```
VRT ACTIVITY 8
VRT TORQUE 200
```

The first screen shows current values for the activity and torque of the aileron servo with an underline under the present setting of activity. A typical screen might show:

```
VRT ACTIVITY 8
VRT TORQUE 200
```

Turn the encoder knob to set the activity level to the desired value for the particular aircraft. Any value between 0 and 12 may be chosen. In this example, the value of 4 will be selected.

Once activity is set to the desired value, press and release the knob to confirm and enter the selected value into storage. The underline (cursor) will now move to the torque setting:

```
VRT ACTIVITY 4
VRT TORQUE 200
```

In a manner similar to activity, use the encoder knob to select the desired value of pitch servo torque. This value should be between 75 and 250. A default value is set at the factory but may need to be modified to suit a particular aircraft. The value chosen should be sufficient to fly the aircraft, but not so much that it is difficult to override the autopilot if necessary.

Having selected the desired torque level, again press and release the encoder knob to confirm and enter the selected torque value into storage. The next screen will show:

```
MIN AIRSPD 95KT
```

Use the encoder knob to select the minimum airspeed at which the autopilot will fly the aircraft. This speed should be a safe margin above a stall. Press the knob to enter the minimum airspeed into storage.

The final screen in the setup procedure is the STATIC LAG setup screen. This setting should only be changed if autopilot tends to oscillate in pitch during altitude hold, due to lag in the static system. The display will show:

```
STATIC LAG 0
```

Rotating the encoder knob will change the number as in previous setup screens. Having selected the desired value, press and release the encoder knob to enter the value into memory.

This concludes the Digiflight 200 and 200VS setup.

TruTrak Flight Systems, Inc.

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