Operating Handbook

For

Digiflight II 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, yaw disturbances in turbulence 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 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 all the electronic and sensing elements needed for the roll and pitch functions and interfaces to a rate-gyro-controlled yaw damper within a single panel-mounted programmer/computer package.

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 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.

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 BANK, which means the autopilot now uses an internal source of gyro information for bank angle. The lower left display shows the selected bank angle of flight. In the Digiflight II and IIVS, 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 or off.
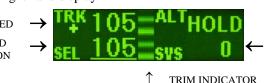
With the Digiflight IIVS, the vertical space between the left and right hand display area is used to show pitch trim. This display consists of four horizontal bars spaced vertically as the rungs on a ladder, and are made to move up or down when the aircraft is in need of being trimmed.

In the upper left where direction is shown, a flashing indicator is present beneath NO FIX. 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 and **GPS OK**. If GPS flight plan information is being received over the serial channel or if the programmer is a Digiflight IIVSG and GPS steering information is being received, a flashing plus sign will indicate the presence of a useable steering (GPSS 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 can be set by rotation of the encoder knob.

DG SLAVED → TRK +105 ALTHOLD

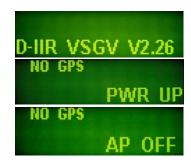SELECTED DIRECTION → SEL 105 SVS 0 ← SELECTED VERTICAL SPEED

↑ TRIM INDICATOR

Controls

The Digiflight II series autopilot uses the simplest controls available. All programming is done via a rotary encoder knob and two buttons labeled MODE and ALT. The MODE button toggles between the default (TRK) mode and the GPSS mode (or GPS NAV mode if GPS steering is not available), as well as moves the cursor back to the SEL numerals. The ALT button engages altitude hold or moves the cursor to the SVS numerals. If in the GPSS mode, the ALT button will engage the GPSV mode, if it is available. Both buttons are also used to enter the setup modes as well as maneuver through the setup screens. Engaging the autopilot can be done either by 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. The model and software version will be displayed for approximately ten seconds in the lower left. Then PWR UP in the lower right takes approximately another ten seconds.

When initializing is complete PWR UP will change to AP OFF

GPS Acquisition

Beneath the word NO FIX a flashing period • 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 **NO FIX** display cannot transition to the TRK mode.

When the GPS does obtain a fix, the period will be replaced by an asterisk *. This means that when a certain velocity is attained GPS OK 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.

If the GPS has a flight plan entered there will be a + after position fix is established.

Digiflight II

Lateral Modes

Upon being engaged, the autopilot will be in the basic lateral track 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°.

If a GPS flight plan has been entered into the GPS, pushing MODE 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. However, the autopilot must over-fly each way point prior to turning and intercepting the next course line.

If the GPSS option has been added, pushing the MODE button will engage GPS steering. In the GPSS mode the autopilot follows lateral steering or bank commands generated by a navigation system (EFIS or GPS).

Altitude Hold Mode

When the autopilot is engaged it will be in the basic lateral track 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 ALT button. The display will show:

If an altitude change is desired, it is necessary to turn off the altitude hold. To do this, press and release the ALT button. The display will show:
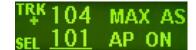
Minimum and Maximum Airspeed

The Digiflight II series autopilots have a minimum and maximum airspeed feature. These are added only for safety. If the autopilot is in altitude hold and the pilot reduces power to a point at which the airspeed falls below the

minimum airspeed set in the autopilot, the autopilot will allow the aircraft to begin a descent and flash MIN AS on the display.

Likewise if the autopilot is in altitude hold and the pilot adds power to a point at which the airspeed reaches the maximum airspeed, the autopilot will allow the aircraft to climb and will flash MAX AS on the display.

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 3 seconds during which time the words GYRO SET will be displayed.

Continue depressing the knob for 15 seconds to set the gyro center.

Power Loss

If there is a momentary loss of electrical power, the autopilot will disengage. The autopilot gyros may need to 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.
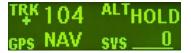
Digiflight IIVS

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°.

If a GPS flight plan has been entered into the GPS, pushing the MODE button 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. However, the autopilot must over-fly each waypoint prior to turning and intercepting the next course line.

If the GPSS option has been added, pushing the MODE button will engage the GPS Steering. In the GPSS mode the autopilot follows lateral steering or bank commands generated by a navigation system (EFIS or GPS). Once in the GPSS mode, pushing the ALT button will enter the GPSV mode as well. This feature will only be available when coupled to certain EFIS

systems or a GPS with vertical GPS steering outputs.

TRK +104 ALT HOLD
GPSS SVS ___ 0

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). To enter altitude hold at any time, push and release the ALT button two times.

TRK +104 ALT HOLD
SEL 104 SVS 0

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

TRK +104 ALT HOLD
SEL 104 SVS ___ 0

Rotation of the encoder knob will now change the selected vertical speed.

TRK +104
SEL 104 SVS 400↑

If the cursor is under the SVS number a single click of the ALT button will select zero vertical speed. If the selected vertical speed is set to zero, the display will show:
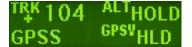
TRK +104 ALT HOLD
SEL 104 SVS ___ 0

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

If the autopilot is coupled to a GPS or EFIS system which can provide vertical GPS steering, once in the GPSS mode, pushing the ALT button will enter the GPSV mode as well. To use the GPSV mode with the GNS 430/530/480, the aircraft must be below the virtual glide slope and the autopilot must be in **altitude hold**. When approach is initiated and the CDI becomes active, the GPSV button can then be pushed and the unit will enter the GPSV mode. The first screen will show as below:

TRK +104 ALT HOLD
GPSS GPSV FLG

The screen will oscillate between GPSV FLG and GPSS HLD. When the VDI is no longer flagged, the unit will

enter GPSV hold, and the display will show as below:

```
TRK 104    ALTHOLD
 +
GPSS       GPSVHLD
```

Once the VDI has been above the center by one dot for at least 5 seconds the GPSV mode will ARM, and the display will show:

```
TRK 104    ALTHOLD
 +
GPSS       GPSVARM
```

As the VDI passes through center, the autopilot will couple to the virtual glide slope, and the display will show that the autopilot is now coupled to the virtual glide slope as below:

```
TRK 104
 +
GPSS          GPSV↓
```

Missed approach

Once the Glide Slope is coupled press any button to activate the Go Around mode. The autopilot will pitch up to +500 fpm and will engage TRK mode on the current track.

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.

Minimum and Maximum Airspeed

The Digiflight II series autopilots have a minimum and maximum airspeed feature. These are added only for safety. This feature is easier described using the Digiflight IIVS model as an example. If the pilot

commands a vertical speed climb in which the aircraft slows to the minimum airspeed, the aircraft will maintain that airspeed and will flash MIN AS on the display.

Likewise if the pilot commands a vertical speed descent in which the aircraft accelerates to the maximum airspeed, the autopilot will not fly the selected vertical speed, but will maintain the maximum airspeed and flash MAX AS.

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 15 seconds during which time the words GYRO SET will be displayed.

Power Loss

If there is a momentary loss of electrical power, the autopilot will disengage and

repower up. The autopilot gyros may need to 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. Continue to hold for approximately ten seconds, 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, bank angle setting, micro activity, minimum airspeed, maximum airspeed and static lag. To enter the lateral setup mode, press and hold the **MODE** button for approximately 3 seconds, until the first setup screen appears. The first setup screen shows the current value for the activity of the aileron servo, with an underline under the present setting of activity. A typical screen might show:

```
LAT ACTIVITY   _3
           EXIT   NEXT
```

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 36 may be chosen. In this example, the value of 3 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 ALT button to advance to the next setup screen.

```
LAT TORQUE    12
PREV    EXIT    NEXT
```

In a manner similar to activity, use the encoder knob to select the desired value of roll servo torque. This value should be between 7 and 12. 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 ALT button to advance to the next setup screen. The unit will now show the next screen:

```
BAUD         9600
PREV    EXIT    NEXT
```

The value shown represents the speed of the primary RS-232 interface to the external GPS unit. By default at the factory it is set to 9600 baud. 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 Garmin protocol (moving map output).

Once the desired baud rate or Garmin protocol has been selected, again press and release the ALT button to advance to the next setup screen. The unit will now show the next screen:

BANK ANGLE MED
PREV   EXIT   NEXT

The bank angle setting can be adjusted to suit the pilot. This setting controls how much bank the autopilot will command when in a turn. This will not change the flight dynamics of the system and any of the three settings will fly the aircraft equally well. Once the desired bank angle setting is selected, press and release the ALT button to advance to the next setup screen. The unit will now show the next screen:

MICROACTIVITY_0
PREV   EXIT   NEXT

The micro activity setting in most aircraft will be left at zero (0). Micro activity is used only in aircraft in which a slow wing rock has been observed in very still air. Sometimes there will be a small amount of lost motion in an aircrafts control system, and the micro activity setting is a way to compensate for the lost motion. Press and release the ALT button to advance to the next setup

screen. The unit will now show the next screen:

GPSS GAIN   16
PREV   EXIT   NEXT

This setup screen is used to increase the bank angle that the autopilot will fly in GPS Steering mode. Increase the value to increase the allowable bank angle. Press and release the ALT button to advance to the next setup screen, which is shown below:

YAW DAMPER? N
PREV   EXIT   NEXT

Set the Yaw Damper? to Y if there is a yaw damper installed and N if there is not a yaw damper installed. Press and release the ALT button to advance to the final setup screen.

This concludes the lateral setup procedure.

To configure the pitch portion of the autopilot push and hold the ALT button for 3 seconds. The first setup screen allows the pitch axis to be turned on or off. (NOT USED IN DII) The default of on will always be selected after a power cycle.

PITCH AXIS   ON
**   EXIT NEXT**

To turn the pitch axis off, select off, and click the knob to exit. To advance to the next setup screen, press and release the ALT button, the next setup screen is shown below:

VRT ACTIVITY   3
PREV   EXIT   NEXT

Turn the encoder knob to set the activity level to the desired value for the particular aircraft. Any value between 0 and 24 may be chosen. In this example, the value of 3 will be selected.

Once activity is set to the desired value, press and release the ALT button to advance to the next setup screen:

VRT TORQUE   12
PREV   EXIT   NEXT

In a manner similar to activity, use the encoder knob to select the desired value of pitch servo torque. This value should be between 7 and 12. 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 ALT button to advance to the next setup screen. The next screen will show:

MIN AIRSPD   70
PREV   EXIT   NEXT

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 ALT button to advance to the next setup screen. The next screen will show:

MAX AIRSPD 160
PREV   EXIT   NEXT

The maximum airspeed value is the fastest indicated airspeed the autopilot will fly, independent of what it is commanded to do. Rotate the knob to adjust this airspeed to a value safely below the red line airspeed, but above the normal cruise speed. Select the desired value, and then press the ALT button to advance to the next setup screen.

The next 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
PREV   EXIT   NEXT
```

Rotating the encoder knob will change the number as in previous setup screens. Having selected the desired value, press the ALT button to advance to the next setup screen. The next screen will show:

```
MICROACTIVITY_0
PREV   EXIT   NEXT
```

As before in the lateral setup mode, the micro activity setting in most aircraft will be left at zero (0). Micro activity is used only in aircraft in which a slow oscillation has been observed while in altitude hold, in very still air. Sometimes there will be a small amount of lost motion in an aircrafts control system, and the micro activity setting is a way to compensate for the lost motion. Press and release the ALT button to advance to the final setup screen.

```
HALF-STEP?      N
PREV   EXIT
```

This setting in most cases will not need to be changed. If the half step setting is set to Y (yes), then the pitch servo will now have higher resolution, and take smaller steps. While this setting will make the servo take smaller steps, it will decrease the amount of available torque. This setting should be left at N (No), unless it is observed that the nose moves up and down very slightly while in altitude hold in very still air. Press and release the knob and the display will return to normal flight screen.

Contrast Adjustment

The Digiflight II contrast should only be adjusted while on the ground. To enter the contrast adjust mode, with the autopilot powered off, push and hold the encoder knob in. Turn on the power to the autopilot, and after 1 second release the knob. The display will show the current contrast setting.

```
CONTRAST   7
```

Rotate the knob to select the desired contrast ratio. Repeat for MIN light setting. Too low a number and the words will fade out on the display, and too high a number the background will become dark, and the text unreadable. To exit, press and release the encoder knob.

TruTrak Flight Systems, Inc.