Application Note

Sikorsky S-76A/B/C

Main Rotor Track and Balance (Pushrod/Tab Method)

Part Number: 11-200-0142

AppNote Number: A-SIS76-2020-MR(PRT) (Rev. 1, Sept. 2004)

Application Note

Application Note Number	A-SIS76-2020-MR(PRT)
Revision	1 (From Airframe data dated Jul 1996)
Function	Main Rotor Track and Balance
Airframe	Sikorsky S-76 A/B/C
Engine	N/A
E-Setup Number	a-sis76-2020-mr(prt).asf
ACES Systems Analyzer	Model 2020 or Model 2020 with EPS
Firmware Version	2.0 or greater
Procedure	Pushrod / Tab Method

Introduction

This procedure should be accomplished if an acceptable 1/rev vibration level cannot be attained after an initial track and balance is performed using the Sikorsky S-76 Main Rotor Pushrod Method AppNote. It is important the user have a thorough knowledge of the S-76 tracking procedure. The Model 2020 is limited to one adjustment per run.

This Application Note covers the required equipment, equipment installation, analyzer setup, data acquisition and solution process for using the ACES Systems Model 2020 with the Main Rotor Enhanced Performance Software (EPS) option to perform main rotor track and balance on the airframe listed above. General instructions for the use of the Model 2020 can be found in the Model 2020 User Manual #2020-OM-01 (P/N 75-900-2020), Enhanced Performance Software Operational Supplement #2020-OM-01 Supplement 1 (P/N 75-900-2022), and Optical Tracker Operational Supplement #540-OS-1 (P/N 75-900-2021). All procedures for track and balance and all adjustments should be made in accordance with the Airframe Maintenance Manual.

A. Required Equipment

The following ACES Systems equipment is required.

Item	Quantity	Description	Part Number
1.	1	Analyzer, Model 2020	10-100-2020
2.	2	Sensor, Vibe, Accel, 991D-1	69-100-0075
3.	1	Cable, Sensor 991D-1, 25’	10-320-0162
4.	1	Cable, Sensor 991D-1, 50’	10-320-0163
5.	1	Cable, Magnetic Pickup, 25’	10-320-0052
6.	1	Sensor, Magnetic Passive Speed	75-900-0187

7.	2	Mount, Vibe Sensor “Z”	22-430-0037
8.	1	Mount, Magnetic Pickup (Sikorsky)	76076-55021-041
9.	1	Sweep (Sikorsky)	76076-55021-106
10.	1	Tracker, Optical, Model 540-2	75-900-0542*

*This listing shows the latest design parts. It is acceptable to perform this task using previous designs with the appropriate accessories. For compatibility issues, contact ACES Systems.

Optional Equipment

Item	Quantity	Description	Part Number
1.	1	Option, 2020 Enhanced Main Rotor	11-900-0003
2.	1	Target Assy., Tip,	As Required
3.	1	Cable, Interf. Assy. Strobe-ACES 2020	10-320-0161
4.	1	Strobelight Model 135M-12	75-900-0194

Miscellaneous Equipment

Tape or tie wraps to secure cables to airframe.

B. Equipment Installation

1. Turn the Main Rotor and position the Red Blade over the nose of the aircraft. This will become Blade number 1 for tracking references. The remaining blades will be numbered in passing order, Black will be Blade 2, Yellow will be Blade 3, and Blue will be Blade 4. (See Figure 1)
2. If the aircraft does not have the Magnetic Pickup Mount (P/N 76076-55021-041) installed, remove two bolts and washers from the bearing retainer on the bottom of the stationary swashplate at a position near the scissors.
3. Position the Magnetic Pickup Mount on the retainer with the leg projecting up to large hole in the swashplate and secure with two bolts and washers. Torque bolts in accordance with the appropriate Sikorsky Maintenance Manual and safety wire. (See figure 2)
4. Remove the upper jam nut from the Magnetic Passive Speed Sensor (P/N 75-900-0187). Install the Speed Sensor into the mount. Loosely install the upper jam nut. (See figure 2)
5. Remove two bolts and washers from the bearing retainer on top of the rotating swashplate at the position of the Magnetic Passive Speed Sensor. Position Sweep (Sikorsky P/N 76076-55021-106) on rotating swashplate and secure with nuts and bolts. Torque bolts in accordance with the appropriate Sikorsky Maintenance Manual and safety wire. (See figure 2)
6. With the Red Blade over the nose, check that the Sweep and Speed Sensor align. Adjust the clearance between Sweep and Speed Sensor to 0.020 – 0.040”. Tighten upper jam nut and safety wire. (See figure 2)

7. Connect Speed Sensor end of Magnetic Pickup Cable (P/N 10-320-0052) to Speed Sensor. In some airframes, you may be able to connect the Speed Sensor end of the cable inside the cabin to a pre-wired connector. Route the cable to the cabin. Secure cable with tape or tie wraps. Connect analyzer end of Cable to Tach 1 on the analyzer.
8. Mount a 991D-1 Vibration Sensor (P/N 69-100-0075) and Vibration Sensor "Z" Mount (P/N 22-430-0037) to the co-pilot's outboard seat track. (See Figure 3) The sensor connector must face UP. Connect the 25' Vibration Sensor Cable (P/N 10-320-0162) to the Sensor and route to the analyzer. Secure cable with tape or tie wraps. Connect the cable to Channel A on the analyzer.
9. Mount a 991D-1 Vibration Sensor (P/N 69-100-0075) and Vibration Sensor "Z" Mount (P/N 22-430-0037) to the pilot's outboard seat track. (See Figure 3) The sensor connector must face UP. Connect the 50' Vibration Sensor Cable (P/N 10-320-0163) to the Sensor and route to the analyzer. Secure cable with tape or tie wraps. Connect the cable to Channel B on the analyzer.
10. Connect the Optical Tracker (P/N 75-900-0542) to the Aux./Comm port on the Model 2020 analyzer.

NOTE

Secure and route cables as not to interfere with hot or rotating components. Allow enough slack in the cable to allow for full collective and cyclic inputs.

Equipment Installation Diagram

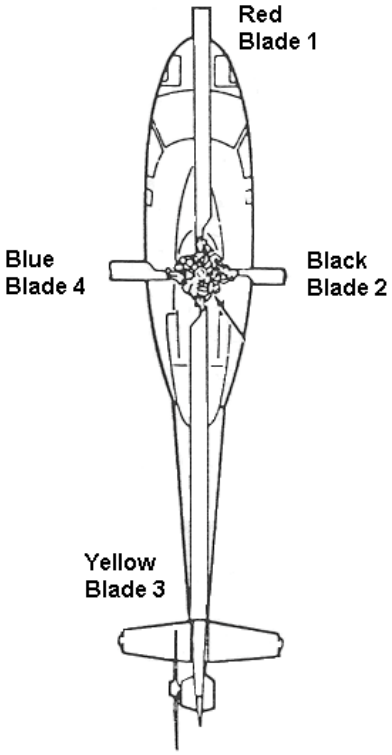


Figure 1

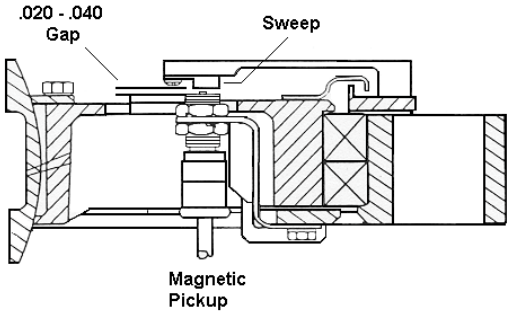


Figure 2

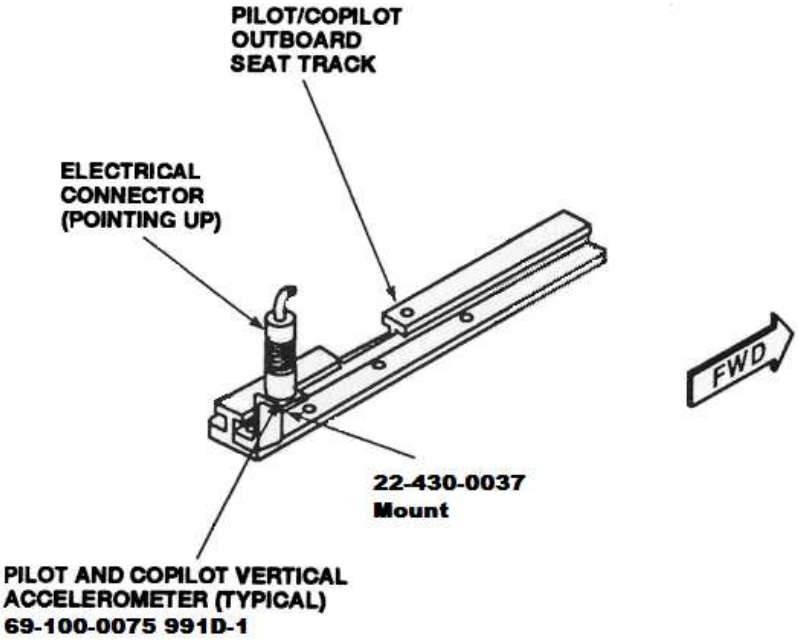
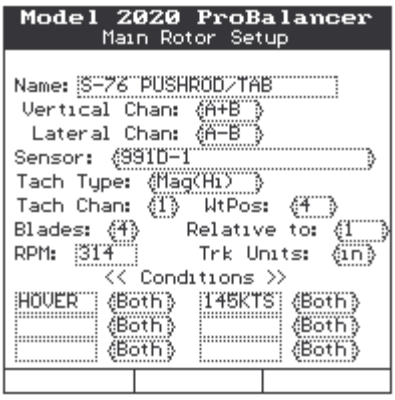


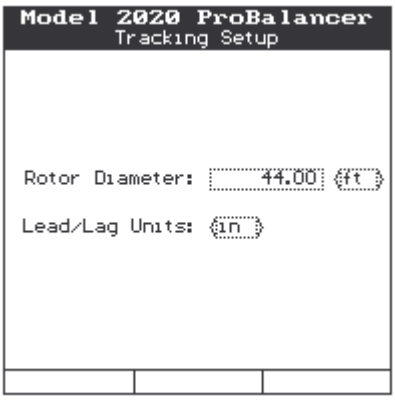
Figure 3

C. Analyzer Set Up

1. Turn the analyzer **[ON].**
2. Enter a new setup as follows; from the “Main Menu” select “Main Rotor Track and Balance” and press **[ENTER].** From the “Main Rotor Tack and Balance” menu, select “Manage Setups” and press **[ENTER].** From the “Manage Setups” menu, select “New” and press **[ENTER].**
3. The “Main Rotor Setup” screen now appears. Enter the main rotor setup as shown. Enter the Rotor RPM for the S-76 A as 293. Enter the Rotor RPM for the S-76 B/C as 314. When completed, press **[ENTER].** (The screens presented below have had the cursor removed for clarity.)

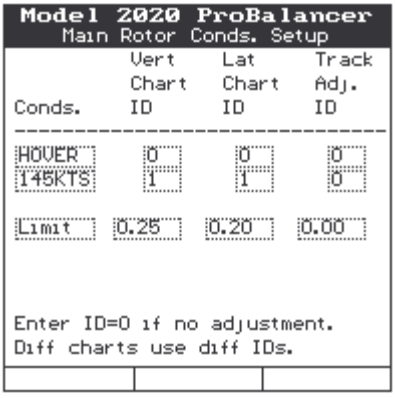


4. The “Tracking Setup” screen will appear next. This screen is used to define the rotor diameter and the units used to describe the lead/lag readings. Enter the information as shown and press **[ENTER].**

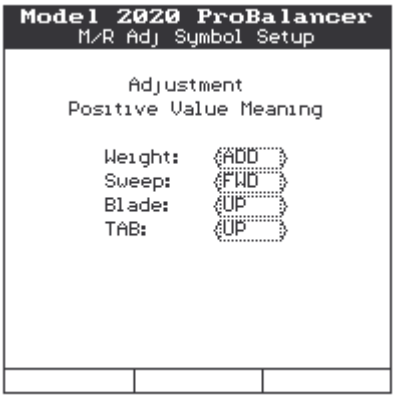


5. The “Main Rotor Conds. Setup” screen will determine the charts to be used when calculating corrections for a given measurement. Chart “ID’s” of similar measurements with the same number will average the readings together for use in solutions. The “limit” field under each measurement type will set the point at which the analyzer will determine whether corrections

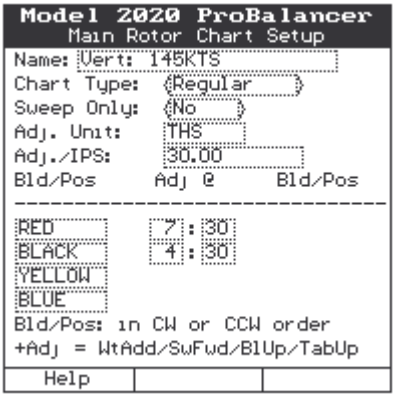
are needed. Enter the information exactly as it appears in the appropriate fields. When completed, press **[ENTER].**



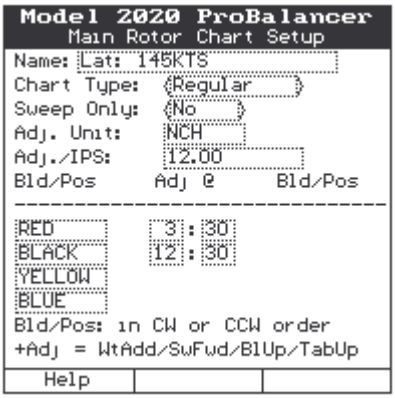
6. The "M/R Adj Symbol Setup" screen is displayed next. The function of this screen is to determine the direction of movement for a positive (+) adjustment. In this application, a positive move indication means to ADD weight, sweep a blade FWD, and move the blade UP with both Pitch Change Link (BLADE) or Trim Tab (TAB). Enter the values as shown. When completed, press **[ENTER].**



7. The first main rotor chart to define will be the "Vert: 145KTS" chart. This chart will determine the Trim Tab adjustments to perform for in-flight vertical vibration reduction. Solutions from this chart will be used if the separation between A+B (Vertical) and A-B (Roll) readings is greater than 3 notches of adjustment. Enter the information exactly as it appears in the appropriate fields. As entered, it will take 30 THOUSANDTHS (THS) of adjustment to the trim tab to reduce approximately 1.0 IPS of vertical vibration. When completed, press **[ENTER].**



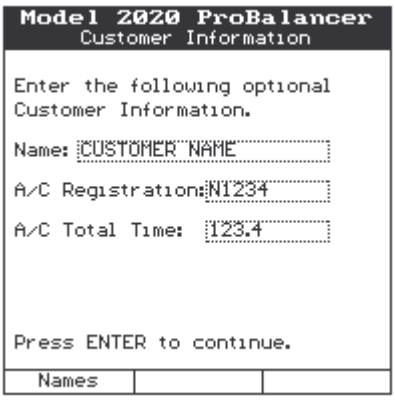
8. The second main rotor chart to define will be the “Lat: 145KTS” chart. This chart will actually define the vertical Pitch Change Link (PCL) Notch (NCH) adjustments to perform for in-flight vertical vibrations. Due to the limitations of the 2020, these adjustments will be labeled Lateral even though they are based upon the A-B (Roll) polar chart moves. You will use solutions from this chart after the A+B (Vertical) and A-B (Roll) vibration points are separated by less than 3 notches of adjustment. As entered, it will take 12 NCH of PCL adjustment to correct approximately 1.0 IPS of vertical vibration. When completed, press **[ENTER].**



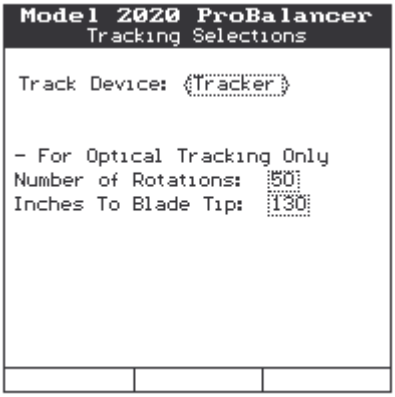
9. Setup complete, press **[BACKUP],** select “Start Job”, press **[ENTER]** and then select the “Main Rotor Setup” that was just created.

D. Data Acquisition

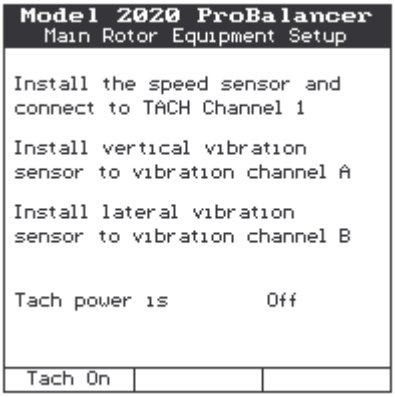
1. “Customer Information” screen. It is recommended to complete this screen so that customer information will appear on the printout assisting in identification of the job when it is stored in the analyzer memory. When finished press **[ENTER].**



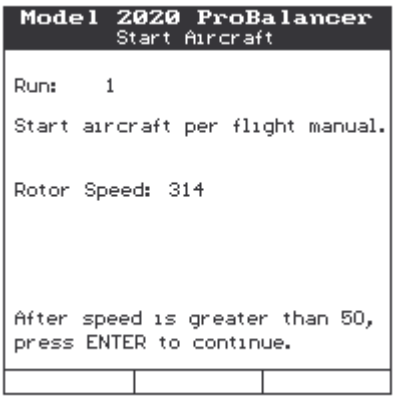
2. "Tracking Selections" screen. Allows the user to select a tracking device for this particular job. Select <Tracker> and enter the additional data as displayed or select <Strobe>. Then press **[ENTER].**



3. "Main Rotor Equipment Setup". Information screen that prompts the user to verify equipment installation has been performed in accordance with channel selections that were specified when building the setup. The pilot's vertical vibration sensor will be connected to Channel B of the analyzer. The "Lateral" label is a limitation of the Model 2020. Both sensors will actually be used for Vertical/Roll measurements.



4. "Start Aircraft" screen. This screen allows the user to view the current main rotor rpm. When the rotor speed is stable and above 50 RPM, press **[ENTER].**

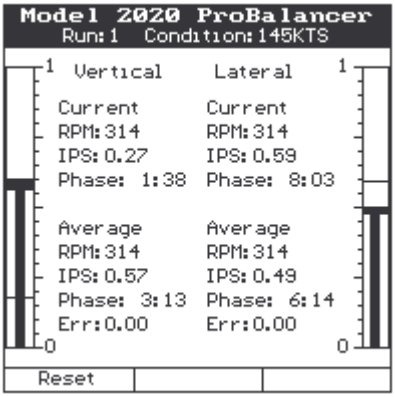


5. "Select Aircraft Condition" screen. Displays the flight regimes that are specified in the setup. Select "HOVER" and press **[ENTER].**

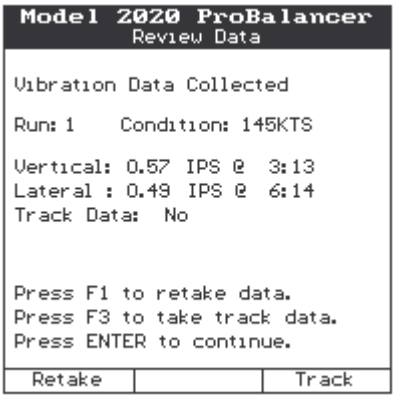
NOTE

The following examples will show data collection for the 145KTS Condition. This is for simplicity as the 145KTS Condition will be the only condition used to generate a solution. Use the same procedure to gather HOVER data. The HOVER data will be used to base implementation of the correct 145KTS solution upon.

6. "Run: 1 Condition: 145KTS" screen. This screen is displayed during the vibration acquisition. The title will change to reflect the current run and condition. When the RPM, IPS and Clock readings under "Average" show minimum change, press **[ENTER].**



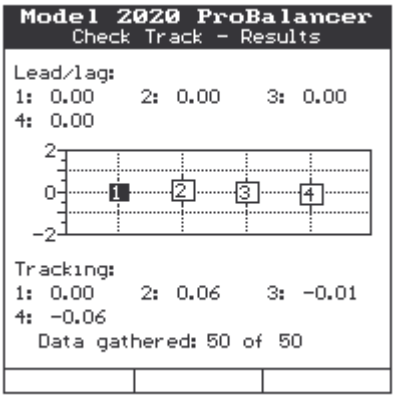
7. "Review Data". This screen allows the user to view the vibration readings that were acquired during the regime. Press **[ENTER]** to continue or **[F3]** to take track readings.



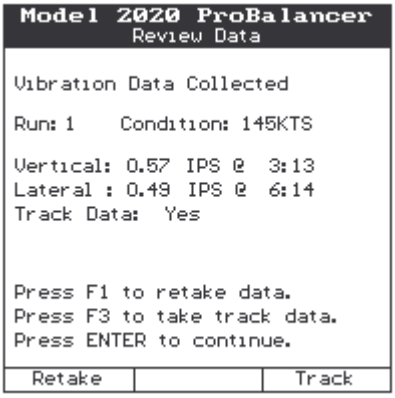
8. If **[F3]** was pressed, the "Track Screen" will appear prompting the user to aim and fire the tracker.

9. To aim the tracker, raise the tracker smoothly towards the rotating rotor disk while observing the LEDs on the back of the tracker.
   a. Raise the tracker until the three green LED lights are illuminated.
   b. Raise the tracker further to verify the upper set of three red LEDs illuminate. Illumination of the three upper LEDs verifies there is enough contrast to operate the tracker. If the upper set of red LEDs does not illuminate, there is not enough contrast for the tracker to operate properly.
   c. If sufficient contrast is verified, slowly lower the tracker to a point where the center green LED is illuminated. Hold the tracker steady in this position.
   d. To activate the tracker, press and release the trigger one time. It is not necessary to hold the trigger down. Continue to hold the tracker steady (green lights illuminated) while acquiring data.
   e. When the amber light extinguishes, data acquisition is complete and you may lower the tracker.

10. The track data will now appear on the screen. The track split will be shown. If the "Data Gathered" is less than 75% of the total "Number of Rotations" defined in paragraph D.2 above, press **[ENTER]** and then "Track" **[F3]** to retake the track reading. After successfully gathering enough data, press **[ENTER]** to continue.



11. The "Review Data" screen will reappear, if the readings are acceptable, press **[ENTER]** to continue. If the readings are unsatisfactory, use "Retake" **[F1]** to return to paragraph D.6 above. Use "Track" **[F3]** to return to paragraph D.8 above to retake track readings only.



12. Repeat sequence through all flight regimes. After all data is acquired press the "Adjust" **[F2]** button, shut down the aircraft and review the solution options.

NOTE

At any time during the flight, if the vibration levels are found to be too severe to continue, the user has the option to "End Run" [F1] and solve for vibration data acquired to that point.

13. The analyzer will present all of the solutions possible from the data gathered. It is possible for the analyzer to give two adjustments that would adversely affect the other. The user is ultimately responsible for determining which adjustments to implement and which to discard. If a suggested correction is determined unnecessary, use "Inst=None" **[F2]** to eliminate data in the "Installed" column. Make the desired adjustments to the rotor system as called for by analyzer and press **[ENTER].** The user will now be prompted to start the engine and continue with run #2.

NOTE

It is important to remember that when installing or removing weights and recording their positions the influence used for the next run will be updated by the result from the previous run's solution. Therefore, be as accurate as possible when recording adjustments made regardless whether the recommended solution is implemented. The only entries on these screens should reflect the actual solution implemented.

E. Sample Solutions

This section contains samples of the solution screens presented by the analyzer. The corrections are examples only and do not reflect actual aircraft data. At no point should a correction be made that contradicts information in the maintenance manual. All solutions may not appear after every run. Solutions will only be presented for readings that exceed the limits set in Paragraph C.5 above. It is necessary to add the closest measurable amount of correction and record the actual correction in the "Installed" column.

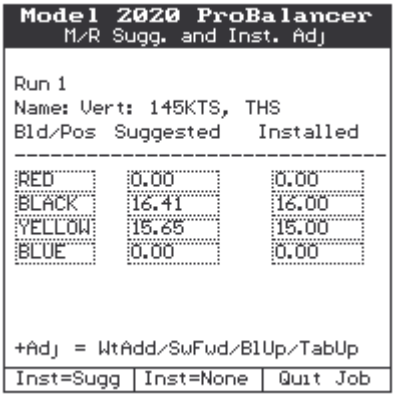
NOTE

The Model 2020 analyzer is designed to implement one solution per run. Even though multiple solution screens are presented, the user must choose the single solution to implement between runs. Entering solutions from multiple screens on the same run will corrupt the Influence Coefficient Update during the job.

1. The first possible solution screen is the "Vert: 145KTS" solution. This screen will suggest Trim Tab adjustments based on the measured vertical vibration readings. Choose this solution when the A+B and A-B readings are separated by greater than a 3 notch move on the polar chart.

   In the example below, it is suggested to adjust the "Black" trim tab up 16.41 Thousandths (THS) and the "Yellow" trim tab up 15.65 THS. The closest measurable adjustment was determined to be and adjustment of the "Black" up 16.00 THS and "Yellow" up 15.00 THS. This adjustment was made and entered into the analyzer.

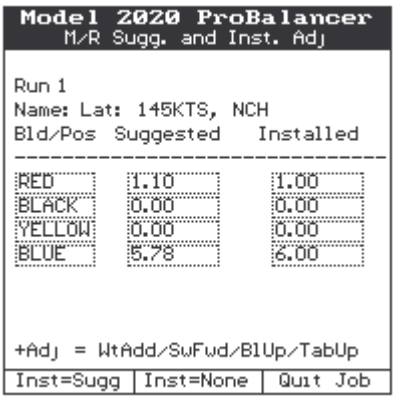
   It is acceptable to adjust the opposite blade in the opposite direction. This decision will be based on the track trend of the 145KTS flight condition.



2. The second possible solution screen is the “Lat: Vert 145KTS” solution. This solution is based upon the A-B (Roll) Pitch Change Link (PCL) Notch (NCH) solution from the polar chart. This move will be made after both A+B and A-B readings are located within a 3 notch move from each other as viewed on the polar chart.

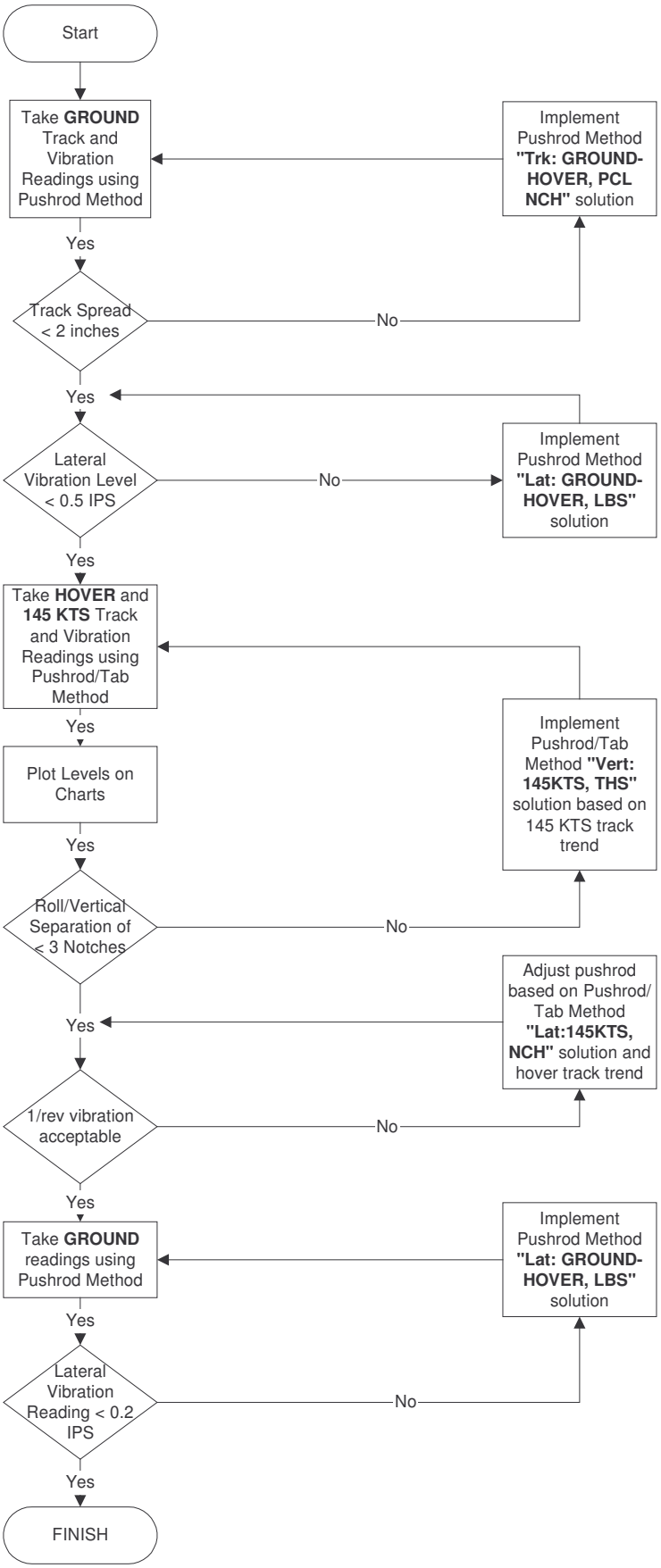
   In the example below, it is suggested to adjust the Red blade 1.10 Notch (NCH) up and the Blue blade 5.78 NCH up to reduce the A-B vibration levels. The closest measurable adjustment was determined to be an adjustment of the Red blade up 1.00 NCH and the Blue blade up 6.00 NCH. This adjustment was made and entered into the analyzer.

   It is acceptable to adjust the opposite blade in the opposite direction. This decision will be based on the track trend of the HOVER flight condition.



   Use the flow chart below along with the additional AppNote (11-200-0082) for the Pushrod Method of track and balance for the Sikorsky S-76 Main Rotor to complete the balance process.

   The two methods are required in conjunction, in some cases, to achieve the smoothest possible ride comfort. Due to the two sensor limitation of the Model 2020 analyzer, in some cases, both setups and two jobs may need to be accomplished to perform a complete Main Rotor Balance on the Sikorsky S-76.


Start
Take **GROUND** Track and Vibration Readings using Pushrod Method
Implement Pushrod Method **"Trk: GROUND-HOVER, PCL NCH"** solution
Yes
Track Spread < 2 inches
No
Yes
Lateral Vibration Level < 0.5 IPS
No
Implement Pushrod Method **"Lat: GROUND-HOVER, LBS"** solution
Yes
Take **HOVER** and **145 KTS** Track and Vibration Readings using Pushrod/Tab Method
Yes
Plot Levels on Charts
Implement Pushrod/Tab Method **"Vert: 145KTS, THS"** solution based on 145 KTS track trend
Yes
Roll/Vertical Separation of < 3 Notches
No
Adjust pushrod based on Pushrod/ Tab Method **"Lat:145KTS, NCH"** solution and hover track trend
Yes
1/rev vibration acceptable
No
Yes
Take **GROUND** readings using Pushrod Method
Implement Pushrod Method **"Lat: GROUND-HOVER, LBS"** solution
Yes
Lateral Vibration Reading < 0.2 IPS
No
Yes
FINISH