



Application Note

Agusta 109E Power

Main Rotor Track and Balance

Part Number: 11-200-0003

AppNote Number: A-AG109E-2020-MR (Rev. 2, May 2005)

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Application Note

Application Note Number	A-AG109E-2020-MR
Revision	2 (From Airframe Rev 7)
Function	Main Rotor Track and Balance
Airframe	Agusta A109E Power
Engine	N/A
E-Setup Number	a-ag109e-2020-mr.asf
ACES Systems Analyzer	Model 2020 or Model 2020 with EPS
Boot/App Version	3.03/3.03 or later
Procedure	N/A

Introduction

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-OM-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. Equipment Setup

Required Equipment: The following equipment is required to perform a Main Rotor Track and Balance:

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	Sensor, Magnetic Passive Speed	75-900-0187
6.	2	Mount, 1/4X28 Sensor, Vibe 1/4" Hole, S/Stl	22-430-0035
7.	1	Tracker, Optical, Model 540-2	75-900-0542*



8.	1	Cable, Adapter, Magnetic Pickup	10-320-0220
9.	1	Option, 2020 Enhanced Main Rotor	11-900-0003**

*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.

**Using the Enhanced Main Rotor Option will require entries on screens not found in the standard 2020 software. If your 2020 does not display all of the following screens, contact ACES Systems to learn about the benefits and availability of EPS.

Miscellaneous Equipment

Tape or tie wraps to secure cables to airframe.

B. Equipment Installation

Note:

Interrupter and magnetic pickup should be permanently installed on swashplate. If not, install as described in Maintenance Manual.

1. Install Sensor Mount (Item 6) between the pilot's and copilot's seats and a second Sensor Mount (Item 6) to upper left nut of the pilot's inertia reel. Secure the first 991D-1 Vibration Sensor (Item 2) to the bracket so that it is perpendicular to the longitudinal axis of the aircraft with connector pointing to the right. Install second 991D-1 Vibration Sensor (Item 2) into bracket so that connector faces up. (Figure 1)
2. Install Sensor Cable (Item 3) to Vertical 991D-1 Sensor and connect to Channel A on the Model 2020 Analyzer.
3. Install Sensor Cable (Item 4) to Lateral 991D-1 Sensor and connect to Channel B on the Model 2020 Analyzer.
4. Connect Magnetic Pickup Adapter Cable (Item 8) to the signal socket located above and behind the pilot's head. Connect other end of cable to Tach 1 on the Model 2020 Analyzer.
5. Connect optical tracker (Item 8) to the Aux/Comm. port on the Model 2020 Analyzer. The blades will be numbered as in (Figure 2). This is the location of the main rotor head when the magnetic pickup and interrupter are aligned.

NOTE

Secure and route cables as not to interfere with any flight controls in the cockpit area.

Equipment Installation Diagram

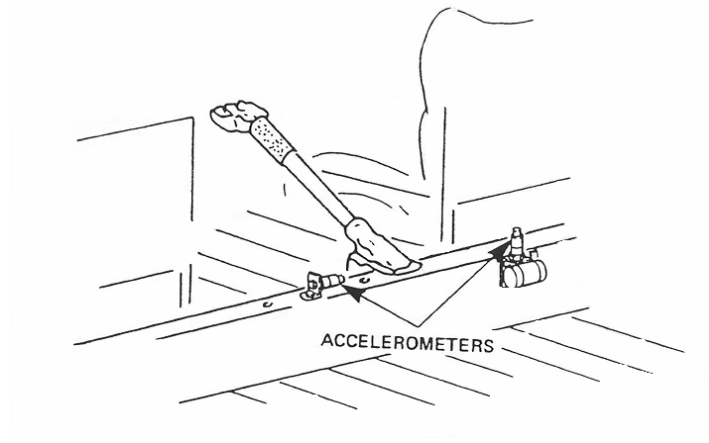


Figure 1

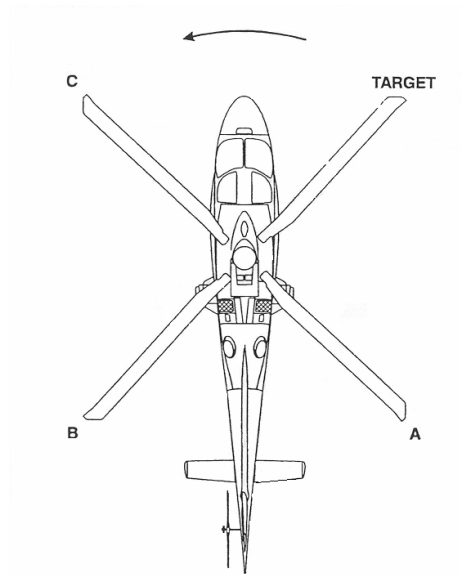


Figure 2



8. The “Main Rotor Conds. Setup” screen will appear next as displayed below. Enter the information as indicated in the illustration below. Press [ENTER] to continue.

Model 2020 ProBalancer Main Rotor Conds. Setup			
Conds.	Vert Chart ID	Lat Chart ID	Track Adj. ID
Ground	0	1	1
Hover	0	0	1
80 KTS	0	0	2
140KTS	1	0	2
Limit	0.20	0.20	0.25

Enter ID=0 if no adjustment.
Diff charts use diff IDs.

9. The next screen to appear will be the “M/R Adj Symbol Setup” screen. 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) and Trim Tab (TAB). Enter the values as shown below. When completed press [ENTER].Next, the balance charts will be entered into the analyzer.

Model 2020 ProBalancer M/R Adj Symbol Setup	
Adjustment Positive Value Meaning	
Weight:	ADD
Sweep:	FWD
Blade:	UP
TAB:	UP

10. The first balance chart to define will be the “Vert: 140KTS” chart. Enter the information as presented below. Press [ENTER] to continue.

```

Model 2020 ProBalancer
Main Rotor Chart Setup
Name: Vert:140KTS
Chart Type: Regular
Sweep Only: No
Adj. Unit: DEG
Adj./IPS: 8.00
Bld/Pos      Adj @      Bld/Pos
-----
TARGET       5 : 30
A            2 : 30
B
C
Bld/Pos: in CW or CCW order
+Adj = WtAdd/SwFwd/BIUp/TabUp
Help
    
```

11. The second chart to define will be the “Lat: Ground” chart. Enter the information as shown below and press [ENTER] to continue.

```

Model 2020 ProBalancer
Main Rotor Chart Setup
Name: Lat:Ground
Chart Type: Regular
Sweep Only: No
Adj. Unit: GMS
Adj./IPS: 1200.00
Bld/Pos      Adj @      Bld/Pos
-----
TARGET       2 : 50
A           11 : 50
B
C
Bld/Pos: in CW or CCW order
+Adj = WtAdd/SwFwd/BIUp/TabUp
Help
    
```

12. Finally, the “Tracking Influence Setup” screen data will be entered as shown below. When completed, press [ENTER] to continue.

```

Model 2020 ProBalancer
Tracking Influence Setup
Conds      AdjName  Unit  Adj/in
-----
Ground-Hover  PCL    Flt   4.00
80 KTS-140KTS  TAB    Deg   1.00
+Adj = WtAdd/SwFwd/BIUp/TabUp
    
```

D. Data Acquisition

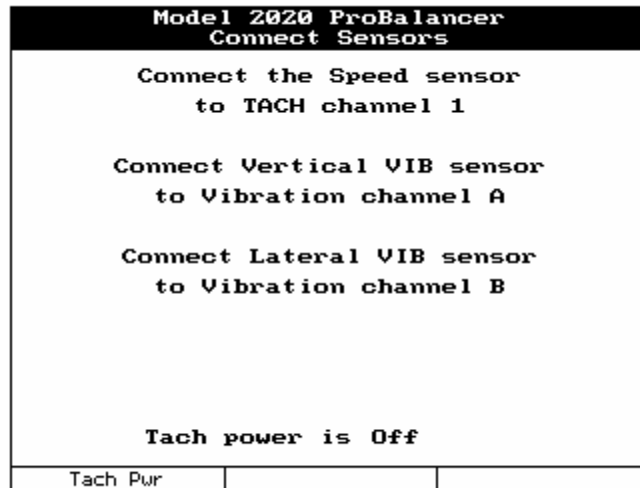
1. The Customer Information Screen will be displayed, as shown below. Use the analyzer keypad to enter a customer name in the “Name:” field. The analyzer will maintain a list of customer names as new names are entered. If names have been previously entered into this analyzer, you may press the [F1] “Names” key and select a customer's name from the provided list. Press the [↓] key to move to the next field and use the analyzer keypad to enter the optional aircraft registration and aircraft total time as required. When all fields are complete, press the [ENTER] key to accept and continue.

Model 2020 ProBalancer Customer Information		
Enter the following optional Customer Information.		
Name:	CUSTOMER NAME	
A/C Registration:	N1234	
A/C Total Time:	123.4	
Press ENTER to continue.		
Names		

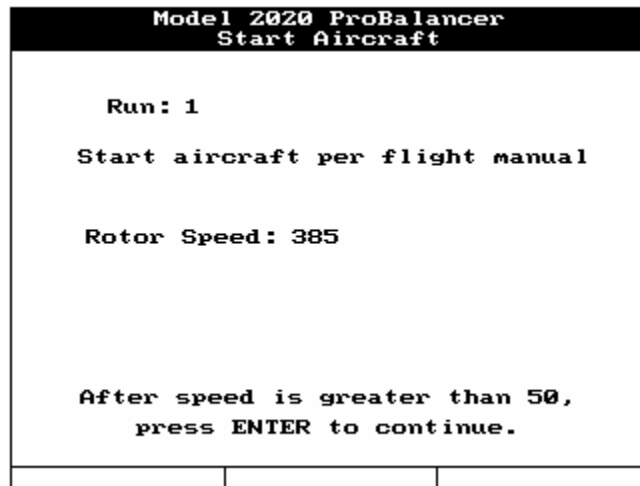
2. The next screen to be displayed is the “Tracking Selections”, as shown below. Enter the data as displayed. When all fields are complete, press the [ENTER] key to continue.

Model 2020 ProBalancer Tracking Selections		
Track Device:	Tracker	
- For Optical Tracking Only -		
Number of Rotations:	50	
Inches To Bld Tip:	144	

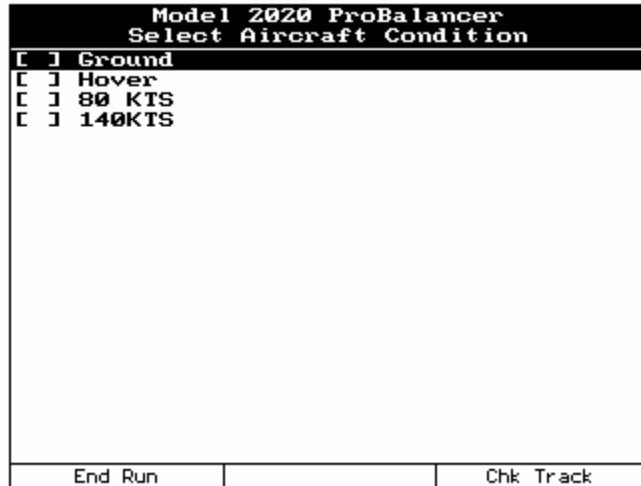
3. The next screen to be displayed will be the “Connect Sensors” screen as illustrated below. This screen gives instructions on installing sensors and cables. Press [ENTER] to continue to the next screen.



4. The “Start Aircraft” screen will be displayed with instructions to “Start Aircraft per Flight Manual”. When the aircraft is started and normal operating conditions have been established, press the [ENTER] key to continue.



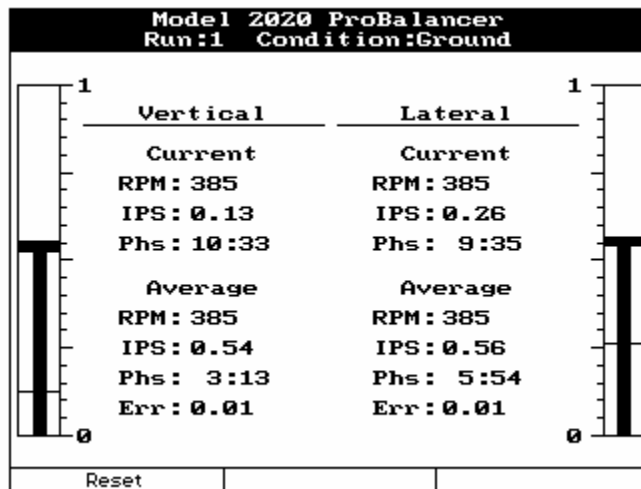
5. The analyzer will display the “Select Aircraft Condition” screen as displayed below. Select the condition that you want to gather data for using the [↑] [↓] arrows and press [ENTER]. Pressing [F3] “Chk Track” will allow you to view the track picture but will not save the reading as part of the highlighted condition. See paragraph 7 below to record the track picture with the condition’s vibration readings.



Note

At any time during a flight if the vibration levels are found to be too severe to continue, the user has the option to end run and solve for the vibration data acquired to that point.

- After pressing [ENTER] the “Run: 1 Condition: Ground” screen will be displayed as shown in the example below. Chapter 16 of the Model 2020 User’s Manual gives detailed instructions on how to read the converging scale if you are not familiar with it. Operate the aircraft in the configuration for the selected condition and allow the analyzer to collect data. The “Err:” indication at the bottom of the text portion of the screen should be as steady as possible with very little change before you press [ENTER] to stop acquisition. If the “Err” is not “0”, this is not an indication of failure or fault, only that the vibration averaging errors cannot be resolved below the displayed level. This “Err” value will typically be higher as the balancing process reduces the vibration amplitude.



- The “Review Vibe Data” screen will be displayed as shown in the example below. These are the amplitude and clock angle readings for the condition. You may retake the data by pressing the [F1] “Retake” function key as indicated at the bottom of the screen. When satisfied with the acquired data as displayed, press the [ENTER] key to accept the data with

“No” track information and continue. To record the track picture for the condition, press [F3] “Track” and proceed to paragraph 8.

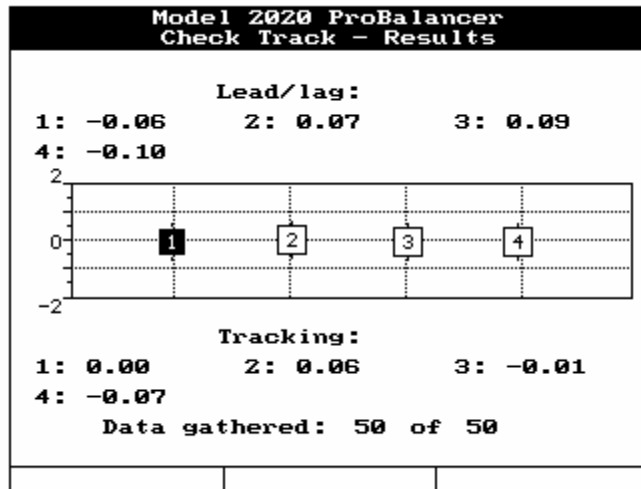
Model 2020 ProBalancer Review Vib Data		
Run: 1		
Condition: Ground		
Vertical: 0.54	IPS @ 3:13	
Lateral: 0.56	IPS @ 5:54	
Track Data: No		
Press F1 to retake data.		
Press F3 to take track data.		
Press ENTER to continue.		
Retake		Track

8. The “Aim and fire tracker” screen will be displayed as shown in the example below. To aim the tracker, raise the tracker smoothly towards the rotating rotor disk while observing the LEDs on the back of the tracker.

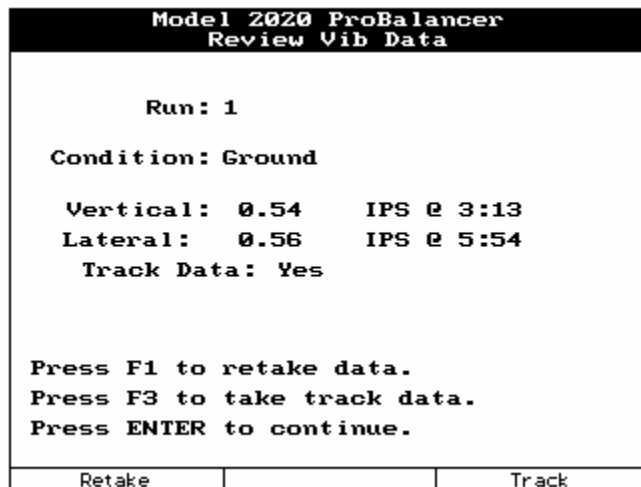
Aim and fire tracker		
Press key to abort		

- Raise the tracker until the three green LED lights are illuminated.
- 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.
- 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.
- 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.
9. The track picture will be displayed on the “Check Track – Results” screen. Lead/lag readings will be displayed at the top of the screen. A negative number (-) indicates a “Lead” condition as this blade is the indicated measurement less than the average interval. A positive number (no sign) indicates a “Lag” condition as this blade is the indicated measurement more than the average interval. Readings will be displayed graphically in the center of the screen. Lead readings will be indicated to the Left of the average interval marking vertical line. Lag readings will be displayed to the Right of the line. Track readings will be displayed above or below the line relative to the average of all blades or in relation to the blade specified in the setup, Paragraph C.6. The bottom of the screen will give a numeric reading of the blade track elevation. The bottom line will display the number of data samples gathered. If the total number of data samples gathered is less than 75% of the total number of samples requested (the last value on the line) the results are questionable and should be retaken. When you are happy with the quality of the data, press [ENTER] to continue.



10. The “Review Vibe Data” screen will reappear as shown in the example below. This time the “Track Data” line will read “Yes” indicating that track data has been taken and stored in this condition. You may retake vibration data by pressing the [F1] “Retake” function key as indicated at the bottom of the screen. You may retake the track data by pressing the [F3] “Track” key. If you are satisfied with the current measurements, press [ENTER] to continue.



11. The “Select Aircraft Condition” screen will reappear as shown in the example below. This time any condition that has stored vibration and/or track data will have an [x] preceding the condition name. Repeat sequence through all flight regimes. You can choose to “End Run” at any time by pressing the [F1] “End Run” key. This sequence will allow you to review all previous measurements before proceeding to the suggested solutions. If a condition has recorded a vibration or track reading that is in excess of the limits defined in paragraph C.8 above, the word “Adjust” will appear above the [F2] key. Pressing [F2] “Adjust” will bypass the review process and move directly to the suggested solution screens. In either case you will be taken to paragraph 12 below.

Model 2020 ProBalancer Select Aircraft Condition		
[x]	Ground	
[x]	Hover	
[x]	80 KTS	
[x]	140KTS	
End Run	Adjust	Chk Track

NOTE

The [F1] “End Run” and [F2] “Adjust” keys are the only ways to exit this screen. Pressing [ENTER] will restart the data collection process for the highlighted condition.

12. The analyzer will display the “Shut Down Aircraft” screen. When this process is complete, press the [F3] “Continue” key to review the data or view the suggested solutions.

Model 2020 ProBalancer Shut Down Aircraft		
Shut Down Aircraft per flight manual instructions		
		Continue

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.

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.

E. Solution Examples

This section contains samples of the solution screens presented by the analyzer. The corrections are examples only and do not reflect actual aircraft data.

CAUTION

At no point should a correction be made that contradicts information in the maintenance manual.

NOTE

Solutions will only be presented for readings that exceed the limits set in Paragraph C.8 above. All solutions may not appear after every run. It is necessary to add the closest measurable amount of correction and record the actual correction in the "Installed" column.

The Model 2020 analyzer is designed to implement one solution per run. Even though multiple solution screens are presented, the user must pick a 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: 140KTS" solution. This screen will suggest Trim Tab adjustments based on the measured vertical vibration readings.

In the example below, it is suggested to adjust the "TARGET" trim tab up 1.93 degrees (DEG) and the "C" trim tab up 2.85 DEG. The closest possible adjustment was 2.00 degrees on the TARGET Blade and 3.00 DEG on the C Blade. This adjustment was made and entered into the analyzer.

Model 2020 ProBalancer M/R Sugg. and Inst. Adj		
Run 1		
Name: Vert:140KTS, DEG		
Bld/Pos	Suggested	Installed
TARGET	1.93	2.00
A	0.00	0.00
B	0.00	0.00
C	2.85	3.00
+Adj = WtAdd/SwFwd/BlUp/TabUp		
Inst=Sugg	Inst=None	Quit Job

2. The second possible solution screen available is from the “Lat: Ground” chart. This screen suggests the corrections to make to improve Lateral vibration readings. In the example below, the suggestion is to add 321.00 GMS to the TARGET Blade and add 43.97 grams (GMS) to the C Blade. The closest measurable value was the addition of 221.00 GMS to the TARGET Blade, the removal of (-) 100.00 GMS from the B Blade and the addition of 44.00 GMS to the C Blade. To enter a negative (-) number press the [SPACE] key once. This move was made and entered into the analyzer.

Model 2020 ProBalancer M/R Sugg. and Inst. Adj		
Run 1		
Name: Lat:Ground, GMS		
Bld/Pos	Suggested	Installed
TARGET	321.00	221.00
A	0.00	0.00
B	0.00	-100.00
C	43.97	44.00
+Adj = WtAdd/SwFwd/BlUp/TabUp		
Inst=Sugg	Inst=None	Quit Job

3. The third possible solution comes from the “Trk: Ground – Hover, PCL, Flt” chart. The analyzer will present a suggested correction to the Pitch Change Links (PCL) in flats (Flt) to bring the track within limits. In this case, the analyzer will present solutions to work toward the TARGET Blade as defined in Paragraph C.6 the line reading “Relative to”. Adjusting the A Blade DOWN by (-) 0.40 Flt, bringing the B Blade down by (-) 1.20 Flt, and bringing the C Blade up by 0.40 Flt should correct the track split. The closest measurable adjustments were determined to be to adjust the A Blade down (-) 0.50 Flt, the B Blade down (-) 1.00 Flt, and the C Blade up 0.50 Flt. The adjustments are made and entered into the analyzer. To enter a negative (-) number press the [SPACE] key once.

Model 2020 ProBalancer M/R Sugg. and Inst. Adj		
Run 1		
Name: Trk:Ground-Hover, PCL,Flt		
Bld/Pos	Suggested	Installed
TARGET	0.00	0.00
A	-0.40	-0.50
B	-1.20	-1.00
C	0.40	0.50
+Adj = WtAdd/SwFwd/BlUp/TabUp		
Inst=Sugg	Inst=None	Quit Job

4. The final possible solution comes from the “Trk: 80 KTS – 140KTS, TAB, Deg” chart. The analyzer will present a suggested correction to the Trim Tabs in Degrees (DEG) to bring the track within limits. In this case, the analyzer will present solutions to work toward the TARGET Blade as defined in Paragraph C.6 the line reading “Relative to”. Adjusting the A Blade DOWN by (-) 0.27 Deg and the C Blade UP by 0.03 Deg should correct the track split. The closest measurable adjustments were determined to be to adjust the A Blade down (-) 0.25 Deg and the C Blade was left alone. The adjustments are made and entered into the analyzer. To enter a negative (-) number press the [SPACE] key once. Keep in mind adjustments from this screen may contradict adjustments to the trim tabs from the “Vert: 140KTS, DEG” chart. You will be responsible for choosing the solution path that meets your needs.

Model 2020 ProBalancer M/R Sugg. and Inst. Adj		
Run 1		
Name: Trk:80 KTS-140KTS, TAB,De		
Bld/Pos	Suggested	Installed
TARGET	0.00	0.00
A	-0.27	-0.25
B	0.00	0.00
C	0.03	0.00
+Adj = WtAdd/SwFwd/BlUp/TabUp		
Inst=Sugg	Inst=None	Quit Job

F. Quit Job

1. Repeat steps D.4 through D.13 applying the solutions as necessary. If all measurements in all conditions are below the limits set in Paragraph C.8 above, the message below will appear. Pressing the [BACKUP] key will allow you to return to review the measurements from all runs. Pressing the [ENTER] key will allow you to take additional readings if you choose. Pressing [F3] “Quit Job” will mark the job as complete and take you to paragraph 2 below.

Model 2020 ProBalancer M/R Track & Balance		
<p>No solutions are recommended.</p> <p>Press BACKUP to view data.</p> <p>Press ENTER for next Run.</p> <p>Press F3 to quit job.</p>		
		Quit Job

2. From this screen, decide if you would like to update the ICF used in the original setup. Pressing [F1] “Yes” will add the chart corrections from this job to the ICF from the original setup. This can be a powerful tool when using this setup in the future. The chart corrections learned as a result of the previous job will be applied from the beginning of the next job that uses the same setup. This can reduce the number of runs required to balance the helicopter. If you select [F3] “No” any chart corrections applied during the previous job will be discarded. The setup will revert to the chart settings in place before the job was started. This can be useful if the helicopter didn’t respond as others of the same model or if a mistake was made somewhere during the job that caused extra runs to balance the helicopter.

Model 2020 ProBalancer Update Setup ICFs?		
<p>Do you want to update the setup's influence coefficients based on the result of this job?</p>		
Yes		No