



# Application Note

Application Note Number	A-BE222-2020E-MR
Revision	0
Function	Main Rotor Track and Balance
Airframe	Bell 222
Engine	N/A
E-Setup Number	BE222_2020E_MR.asf
ACES Systems Analyzer	Model 2020 w/Main Rotor Enhanced Software
Firmware Version	2.00 or greater
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 Enhanced Main Rotor Performance Software option to perform main rotor track and balance on the Bell 222 helicopter. General instructions for the use of the Model 2020 can be found in user manual #2020OM-01. All procedures for track and balance and adjustments should be made in accordance with the Bell 222 Maintenance Manual.

## A. Required Equipment

The following ACES Systems' equipment is required.

Item	Quantity	Description	Part Number
1.	1	Model 2020 Analyzer	10-100-2020
2.	1	Optical Tracker Model 540	75-900-0217*
3.	1	Tracker Interface Model 541	10-100-0541**
4.	2	Sensor, Vibration, 991D-1	10-100-0075
5.	1	Cable, Sensor, 25'	10-320-0162
6.	1	Cable, Sensor, 50'	10-320-0163
7.	1	Magnetic Pickup	75-900-0187
8.	1	Cable, Magnetic Pickup, 25'	10-320-0052
9.	1	Mount, Sensor, .250, "L"	22-430-0035

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10.	1	Mount, Sensor, 5/16, "L"	22-430-0036
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### Optional Equipment

\*/\*\* Optical Tracker 540-2 or later have internal circuitry that eliminates the requirement for the 540 Tracker Interface cable.

### Miscellaneous Equipment

Adel clamps and wire ties.

## B. Equipment Installation

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1. Mount the 991D-1 sensor (P/N 10-100-0075) to sensor bracket (P/N 22-430-0035) and install on the left hand side of console. Sensor connector must face down as shown in Figure 1. Connect sensor cable (P/N 20-320-0162) to sensor and route to the analyzer. Connect sensor cable to channel A of the analyzer.
2. Gain access to the right hand side of the main transmission. Mount 991D-1 sensor (P/N 10-100-0075) to sensor bracket (P/N 22-430-0036) on the right hand input quill of the transmission. Sensor connector must face forward as shown in Figure 2. Connect sensor cable (P/N 20-320-0163) to sensor and route into cabin area and secure cowling. Connect sensor cable to channel B of the analyzer.

#### Note

**Route and secure all cables to prevent contact with hot and rotating components.**

3. Thread magnetic pickup (P/N 75-900-0187) into stationary swashplate. Adjust gap to .060-.070 in. and secure. Connect aircraft wiring to the magnetic pickup. Swashplate is fitted with a single and a double interrupter installed under the rotating swashplate. When the single interrupter is aligned with the magnetic pickup, the blank blade is forward.
4. Connect magnetic pickup cable (P/N 10-320-0052) to the azimuth receptacle on the left hand side of the console just forward of the vertical sensor. Route cable to analyzer. Connect cable to Tach channel 1 of the analyzer.
5. Connect tracker interface cable to the analyzer. Connect other end to the optical tracker.
6. Swashplate is fitted with a single screw that acts as the single interrupter and two screws that act as the double interrupter as shown in Figure 3. **The two double screws must be removed to prevent Tach errors.**

### Equipment Installation Diagram

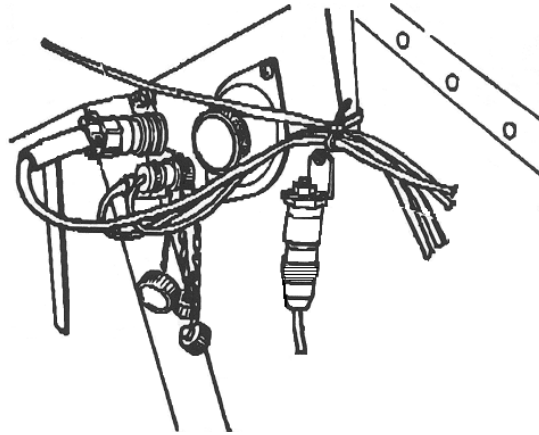


Figure 1

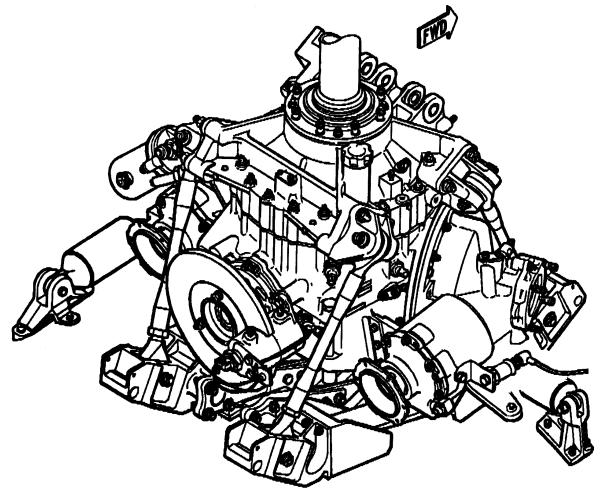


Figure 2

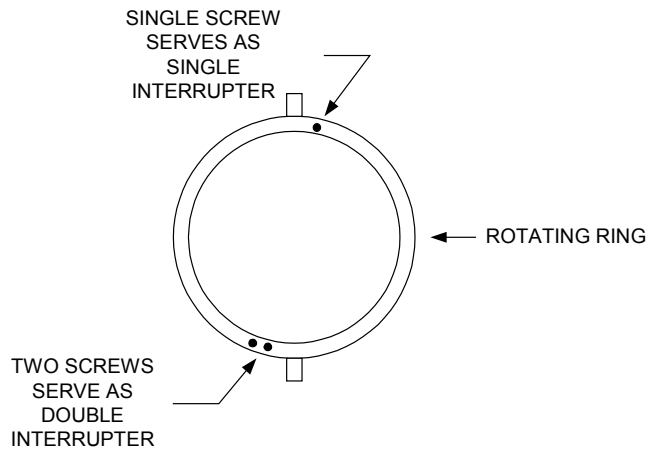
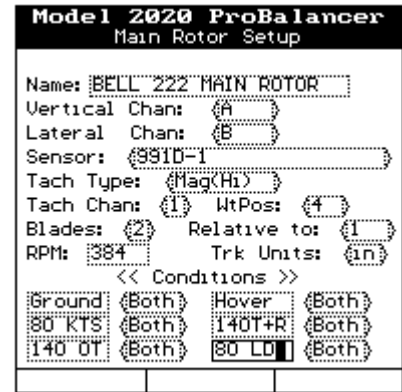


Figure 3

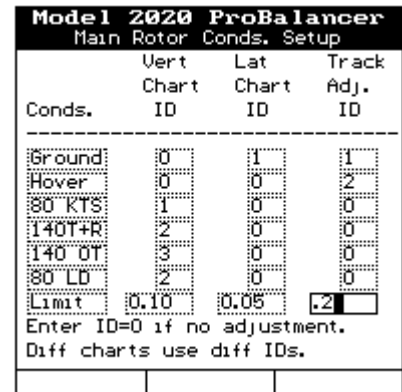
### C. Analyzer Set Up

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]**.

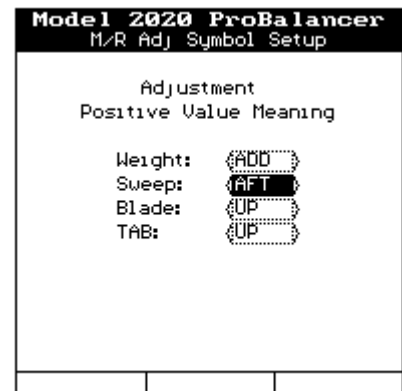
3. The “Main Rotor Setup” screen now appears. Enter the main rotor job setup as shown. The regimes are as follows; 100% Ground, Hover, 80KIAS, 140 KIAS, and 80 KIAS Letdown. The 140 KIAS regime has two charts, one for Outboard Tab/PCL and another for Inboard Tab/PCL. When completed press **[Enter]**.



4. The “Main Rotor Conditions” screen will be 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]**.



5. The “M/R Adjustment Symbol Setup” screen is displayed next. The function of this screen is to determine the direction of movement for a + adjustment. Enter the values as shown. When complete press **[Enter]**.



- Next the “Vertical: 80 KIAS Tab and Roll” chart. This chart will determine the trim tab and pitch link combination adjustments to perform for in-flight vertical vibration reduction. Enter the information exactly as it appears in the appropriate fields. When completed press **[Enter]**.

Model 2020 ProBalancer		
Main Rotor Chart Setup		
Name:	Vert: 80 KTS	
Chart Type:	Regular	
Sweep Only:	No	
Adj. Unit:	FLT	
Adj./IPS:	3.00	
Bld/Pos	Adj @	Bld/Pos
-----		
T UP	4	: 0
T DOWN	10	: 0
Bld/Pos: in CW or CCW order		
+Adj = WtAdd/SuAft/BldUp/TabUp		
Help		

- The next main rotor chart to define will be the “Vertical: 140 KIAS Tab and Roll” chart. This chart will determine the Inboard trim tab and pitch link combination adjustments to perform for in-flight vertical vibration reduction. Enter the information exactly as it appears in the appropriate fields. When completed press **[Enter]**.

Model 2020 ProBalancer		
Main Rotor Chart Setup		
Name:	Vert: 140T+R-80 LD	
Chart Type:	Regular	
Sweep Only:	No	
Adj. Unit:	FLT	
Adj./IPS:	3.00	
Bld/Pos	Adj @	Bld/Pos
-----		
T UP	4	: 0
T DOWN	10	: 0
Bld/Pos: in CW or CCW order		
+Adj = WtAdd/SuAft/BldUp/TabUp		
Help		

- Next the “Vertical: 140 KIAS Outboard Tab” chart will appear. This chart will determine the outboard tab adjustments required to minimize vertical vibrations once the tab and roll change adjustments are no longer required. Enter the information exactly as it appears in the appropriate fields. When completed, press **[Enter]**.

Model 2020 ProBalancer		
Main Rotor Chart Setup		
Name:	Vert: 140 OT	
Chart Type:	Regular	
Sweep Only:	No	
Adj. Unit:	DEG	
Adj./IPS:	2.00	
Bld/Pos	Adj @	Bld/Pos
-----		
T UP	1	: 0
T DOWN	7	: 0
Bld/Pos: in CW or CCW order		
+Adj = WtAdd/SuAft/BldUp/TabUp		
Help		

- Next the “Lateral: Ground” chart will appear. This chart will determine the amount of span and chord weight to add to minimize lateral vibration for ground. Enter the information exactly as it appears in the appropriate fields. When completed, press **[Enter]**.

Model 2020 ProBalancer					
Main Rotor Chart Setup					
Name:	Lat:	Ground			
Chart Type:	Irregular				
Sweep Only:	No				
Bld/Pos	Unit	Adj	IPS	Adj	@
TARGET	BLS	45.00	1.00	1	0
T CHD	GMS	750.00	0.50	10	0
BLANK	BLS	45.00	1.00	7	0
B CHD	GMS	750.00	0.50	4	00
+Adj = WtAdd/SuAft/BldUp/TabUp					
Help					

- Last, the “Tracking Influence Setup” screen will appear. This chart will determine the amount of pitch change adjustment required to improve track splits at ground. The hover adjustments are shown as blade tip weights (washers). The “Adj./in.” sensitivity tells the balancer the amount of adjustment required to equal one inch of movement at the blade tip. Enter the information exactly as it appears in the appropriate fields. When complete, press **[Enter]**.

Model 2020 ProBalancer				
Tracking Influence Setup				
Conds	AdjName	Unit	Adj./in	
Ground	PCL	F1t	10.00	
Hover	BTW	WSR	8.00	
+Adj = WtAdd/SuAft/BldUp/TabUp				

- Setup complete, press **[Backup]**, select “Start Job”, press **[Enter]** and then select the Bell 222 Main Rotor Setup that was just created.

Select Setup List	
1 >	BELL 222 MAIN ROTOR
2 >	R-22 MAIN ROTOR
3 >	EC 120 M/R
New	

## D. Data Acquisition

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

Model 2020 ProBalancer Customer Information		
Enter the following optional Customer Information.		
Name:	CUSTOMER NAME	
A/C Registrations:	N12345	
A/C Total Time:	1000	
Press ENTER to continue.		
Names		

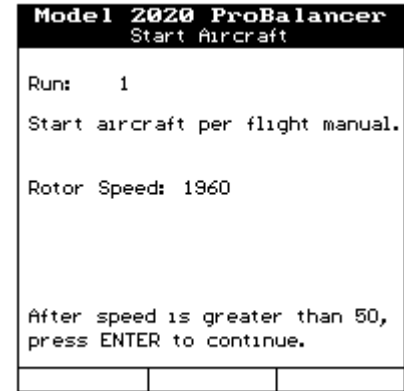
2. Tracking Selections screen. Allows the user to select tracking device for this particular job. Select Tracker or Strobe and press **[Enter]**.

Model 2020 ProBalancer Tracking Selections		
Track Device:	Tracker	
- For Optical Tracking Only		
Number of Rotations:	50	
Inches To Blade Tip:	135	

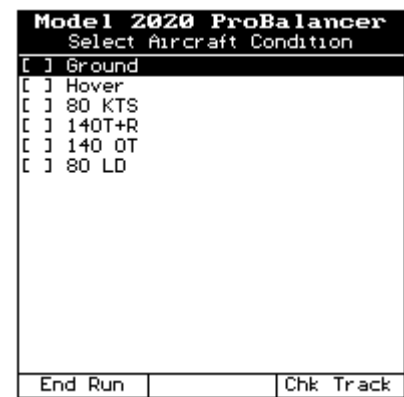
3. Main Rotor Equipment Setup screen. Information screen that prompts the user to verify equipment installation has been performed in accordance with channel selections that were specified when building the setup. Press **[Enter]**.

Model 2020 ProBalancer Main Rotor Equipment Setup		
Install the speed sensor and connect to TACH Channel 1		
Install vertical vibration sensor to vibration channel A		
Install lateral vibration sensor to vibration channel B		
Tach power is off		
Tach On		

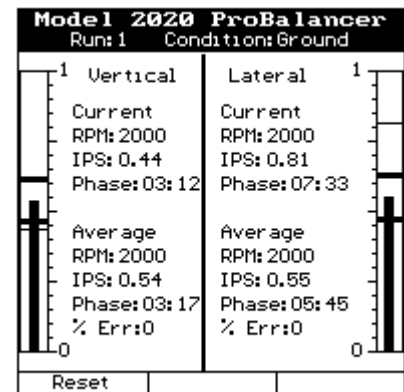
4. Start Aircraft screen. This screen allows the user to view the current main rotor rpm. When the aircraft has been started press **[Enter]**.



5. Select Aircraft Condition screen. Displays the ground and flight regimes that are specified in the setup. Select Ground and press **[Enter]**.



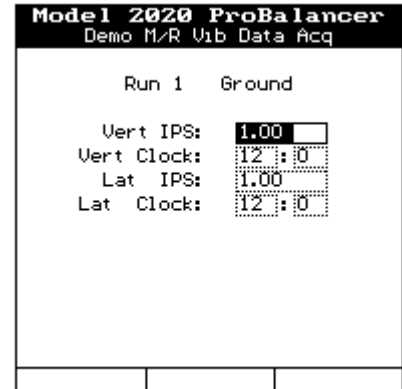
6. Acquiring Vibration Data. This screen is displayed during the vibration acquisition. When stable vibration readings are observed, press **[Enter]**.



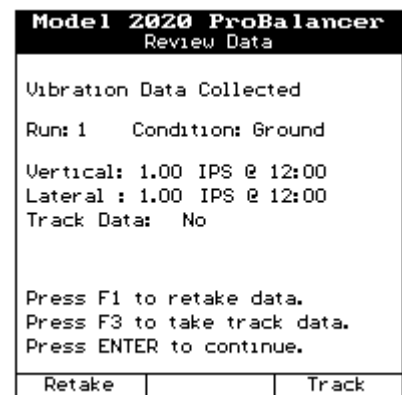
- Data Acquired. This screen allows the user to view the vibration readings that were acquired during the regime. Press **[Enter]** to continue.

**Note**

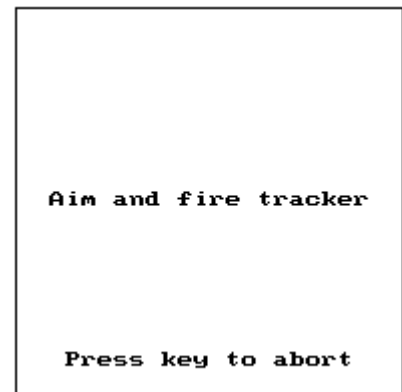
**At any time during a flight if the vibration levels are found to be too severe to continue, the user has the option to end run and solve for the vibration data acquired to that point.**



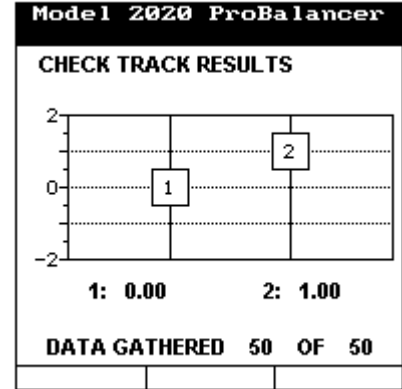
- Review Data. This screen allows the user to view the vibration readings that were acquired during the regime. Press **[Enter]** to continue or **[F3]** to take track data



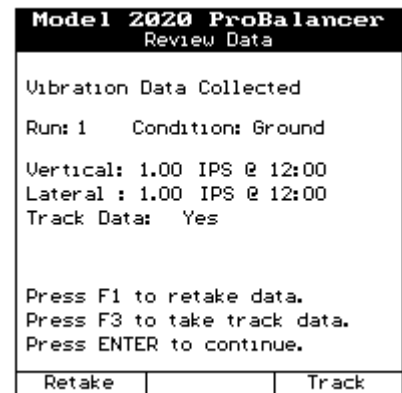
- The "Track Screen" will appear prompting you to aim and fire the tracker. Aim the tracker at the tip of the rotor disk at the 12:00 position. Move tracker up and down until green LED's are illuminated. Press trigger one time and release, continue to hold tracker with green LED's illuminated. The amber LED will pulsate during the acquisition. When tracker acquisition is complete the amber LED will extinguish.



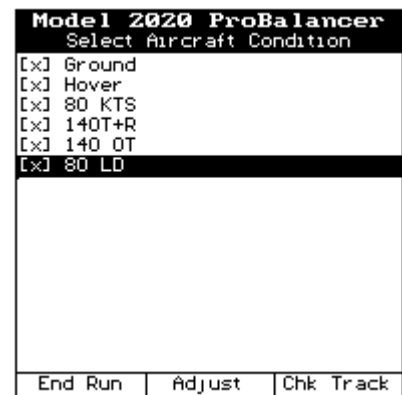
10. The track data will now appear on the screen. The track split will be shown. If the number of packets recorded is less than 75% of the total, press **[Enter]** and then **[F-1]** to retake the track reading. After review press **[Enter]** to continue.



11. The Review Data screen will reappear, press **[Enter]** to continue.



12. Repeat sequence through all flight regimes. After all data is acquired press the “Adjust” **[F-2]** button, shut down the aircraft and review solution options.



### Note

**It is important to remember that when installing or removing weights and recording their positions that 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 this screen 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. 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.

In order to help simplify the correct solution process on the Bell 222 Main Rotor, the following pages contain flow charts for Ground and In-flight and explanations of suggested solutions that should be followed.

14. Ground Lateral Chart. The ground lateral charts gives solutions in washers for chord weight. Washers are added to the trunnion as close to the amount as possible. The weight call out for span weight is incremented in balls. Approximately 45 lead balls added to a blade bolt equals 1.0 IPS.

Model 2020 ProBalancer		
M/R Sugg. and Inst. Adj		
Run 1		
Name: Lat:Ground,BLS,GMS		
Bld/Pos Suggested Installed		
-----		
TARGET	38.97	38.97 <input type="checkbox"/>
T CHD	750.00	750.00
BLANK	0.00	0.00
B CHD	0.00	0.00
+Adj = WtAdd/SuAft/BldUp/TabUp		
Inst=Sugg	Inst=None	Quit Job

15. The 80 KIAS Chart is identical to the 140 KIAS Tab and Roll chart with the exception of a 50% increase in influence. The solution given is to adjust the Target Blade Down by 4.5 flats. This chart is working Tab and Roll so the actual adjustment is to Lower the Target Blade by 4.5 flats, Tab the Target Blade Inboard Tab UP 4.5 degrees and adjust the Blank Blade Inboard Tab Down 4.5 degrees. The only time that the 80 KIAS solution should be used if the aircraft is not flown out to the 140 KIAS speed due to high vibration levels at 80 KIAS.

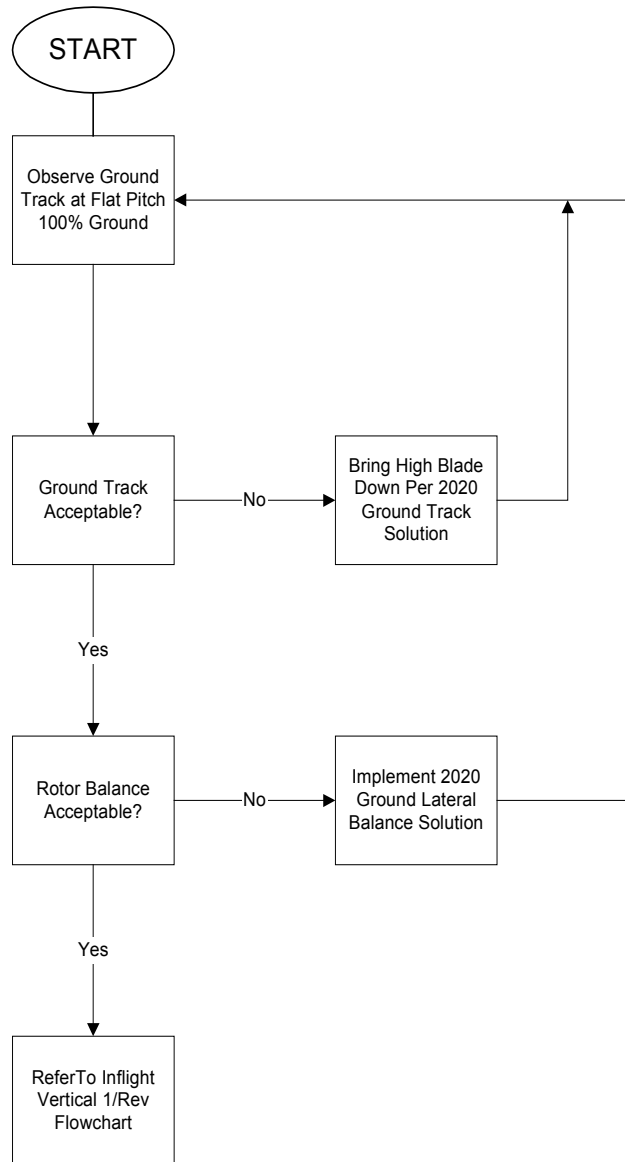
Model 2020 ProBalancer		
M/R Sugg. and Inst. Adj		
Run 1		
Name: Vert: 80 KTS,FLT		
Bld/Pos	Suggested	Installed
-----		
T UP	0.00	0.00
T DOWN	4.50	4.50
+Adj = WtAdd/SwAft/BldUp/TabUp		
Inst=Sugg	Inst=None	Quit Job

16. The 140 KIAS Tab and Roll chart. The solution given is to adjust the Target Blade Down by 3.9 flats. This chart is working Tab and Roll so the actual adjustment is to Lower the Target Blade by 3.9 flats, Tab the Target Blade inboard Tab UP 3 degrees and adjust the Blank Blade Tab Down 3 degrees. The inboard tabs are always adjusted equally and opposite.

Model 2020 ProBalancer		
M/R Sugg. and Inst. Adj		
Run 1		
Name: Vert: 140T+R-80 LD,FLT		
Bld/Pos	Suggested	Installed
-----		
T UP	0.00	0.00
T DOWN	3.00	3.00
+Adj = WtAdd/SwAft/BldUp/TabUp		
Inst=Sugg	Inst=None	Quit Job

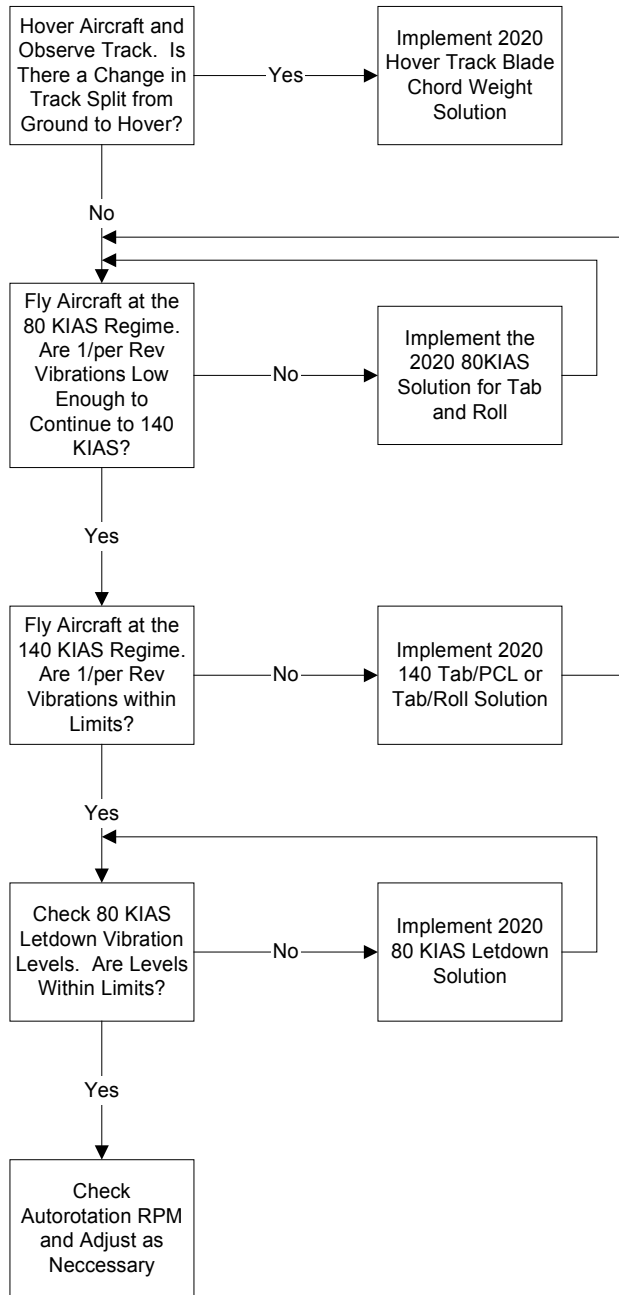
17. The 140 KIAS Outboard Tab/ PCL chart is used once the analyzer has lowered the /per rev vibrations and minimal solutions are being called for by the 140 KIAS Tab and Roll Chart. The solution called out for this chart can used Outboard Tab or PCL. It is advised to use the Tab rather than the PCL. PCL adjustments can affect the Lateral balance. The solution shown to the right can be implemented by adjusting the Target blade Outboard Tab up 1.73 degrees, and by bringing the Blank blade outboard Tab down 1.73 degrees or by adjusting the PCL's of the required blade the same amount. Solutions are implemented equal and opposite.

Model 2020 ProBalancer		
M/R Sugg. and Inst. Adj		
Run 1		
Name: Vert: 140 OT,DEG		
Bld/Pos	Suggested	Installed
-----		
T UP	1.73	1.73
T DOWN	0.00	0.00
+Adj = WtAdd/SuAft/BldUp/TabUp		
Inst=Sugg	Inst=None	Quit Job



Ground Balance Flowchart





**Inflight 1/Per Rev Flowchart**





# Application Note

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## Bell 222

## Main Rotor Balance

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