



**NATIONAL TRANSPORTATION SAFETY BOARD**  
Office of Aviation Safety

**AIRWORTHINESS GROUP CHAIRMAN'S FACTUAL REPORT**

October 15, 2021

**A. ACCIDENT**

**ERA21LA065**

Operator: Private  
Location: Leesburg, Virginia  
Date: December 6, 2020  
Time: 1420 Eastern Standard Time (EST)  
Aircraft: Piper PA-46-600TP (M600), SN 4698111  
Registration: N282ST

**B. AIRWORTHINESS GROUP**

Chairman: Clinton R. Crookshanks  
National Transportation Safety Board  
Denver, Colorado

Member: Damian Galbraith  
Piper Aircraft, Inc.  
Vero Beach, Florida

Member: Robert Martellotti  
Piper Aircraft, Inc.  
Vero Beach, Florida

**C. SUMMARY**

On December 6, 2020, about 1420 eastern standard time, a Piper PA-46-600TP, N282ST, sustained minor damage when it was involved in an incident near Leesburg, Virginia. The pilot was not injured. The airplane was operated as a Title 14 Code of Federal Regulations Part 91 personal flight.

## D. DETAILS OF THE INVESTIGATION

### 1.0 Aircraft

The Piper PA-46-600TP M600 is a single turbine engine, propeller driven, low wing airplane that was certified in June 2016, Figure 1. The airplane is equipped with a conventional tail, retractable tricycle landing gear, and can carry a single pilot and 5 passengers. The airplane is 29.7 feet long, 11.3 feet high at the tail and has a wingspan of 43.16 feet. The airplane is powered by a Pratt & Whitney Canada PT6A turbine engine that drives a Hartzell four or five-blade constant speed, full feathering, reversible propeller.

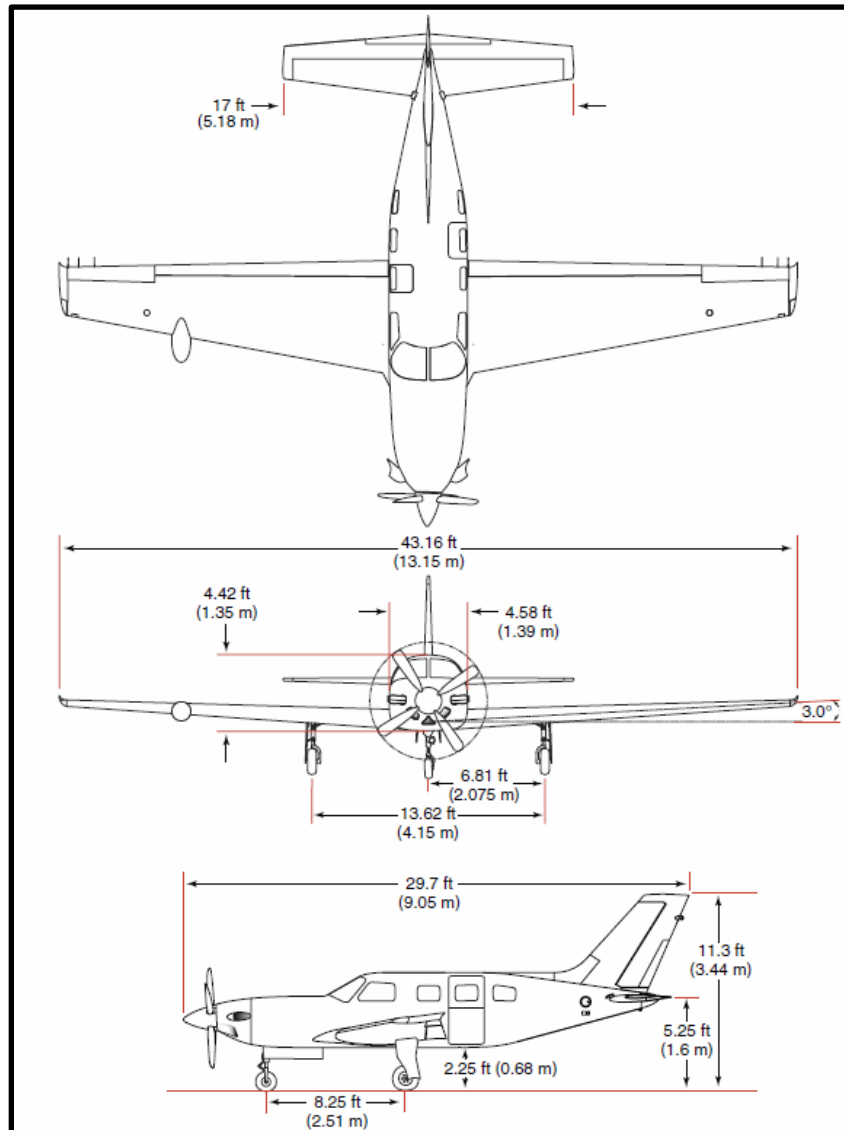


Figure 1-Piper PA-46-600TP M600 airplane 3-view drawing.

## 1.1 Nose Landing Gear Steering

The retractable nose landing gear (NLG) is attached to the engine mount at the upper end of the trunnion assembly by two trunnion bolts. The NLG strut assembly is installed inside the trunnion assembly where it can rotate for nose wheel steering. The retract actuator is attached to the NLG trunnion assembly and engine mount to allow the NLG to retract aft into the wheel well. A down spring is also attached to the trunnion assembly and engine mount to assist with NLG extension if there is a hydraulic failure. During retraction, the NLG strut and tire rotate 90° left through a mechanism that stows the NLG tire in a horizontal position. The NLG is steerable through a 50° arc by use of the rudder pedals, 20° left and 30° right, Figure 2. The pilot and right seat rudder pedals are hung from a torque tube assembly below the instrument panel that connects both right rudder pedals to each other and both left rudder pedals to each other. The rudder is connected by cables to sectors on the rudder pedal torque tubes. The rudder cables run aft through the fuselage to the rudder sector. The pilot right rudder pedal and the right seat left rudder pedal are connected to the steering bell-crank through pushrods that translate the linear motion of the pedals to a rotational motion of the bell-crank. The steering bell crank is attached to a fitting in the aft end of the NLG wheel well. Bellows assemblies are installed around the pushrods where they pass through the pressure bulkhead. The primary rudder mechanical stops are located adjacent to the rudder sector in the empennage to limit the deflection of the rudder and thus the motion of the rudder pedals. Secondary rudder pedal mechanical stops are installed in a machined aluminum fitting aft of the steering bell-crank. The secondary stops allow for a small amount of additional motion of the rudder pedals as the rudder cables stretch before the stops engage the steering bell-crank. The steering bungee is connected to the left side of the steering bell-crank at the aft end and to the left side of the steering arm at the forward end to translate the rotational motion of the bell-crank to a rotational motion of the steering arm. A spring is installed in the bungee to dampen any vibrations from the NLG. The steering arm is attached to a mount plate on the engine mount with a bolt and can be adjusted forward and aft for proper rigging through a locking assembly. The NLG steering horn is attached to the top of the NLG strut with 3 bolts. With the gear in the extended position the right and left forward faces of the steering arm engage the right and left pads and rollers on the steering horn to transmit the rotational motion of the steering arm to a rotational motion of the NLG strut. When the NLG retracts, the strut rotates about the trunnions and the steering horn disengages from the steering arm preventing rudder pedal motion from being translated to NLG steering.

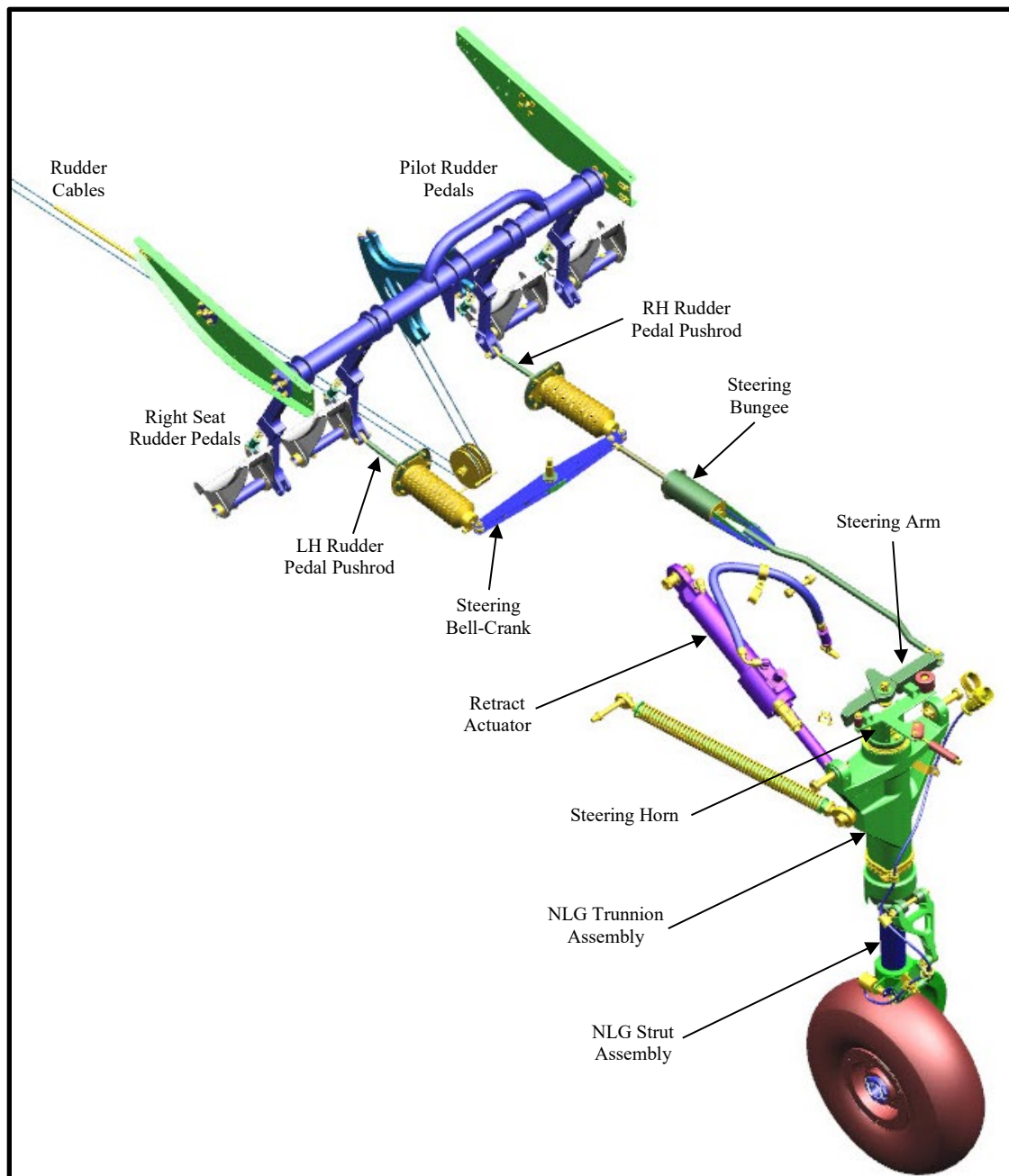


Figure 2-M600 Steering system illustration.

## 1.2 Aircraft Towing

The airplane can be maneuvered on the ground by power equipment using a tow bar attached to the NLG axle. Piper has established turn limits for towing and a placard is installed on the lower end of the NLG trunnion assembly. A corresponding red line on the NLG strut allows the operator to see the relationship between the turn angle of the NLG strut and wheel and the towing limits, Figure 3. The placard towing limits allow for turning about 20° right and left.



Figure 3-M600 NLG turn limits placard.

The Piper M600 Pilot's Operating Handbook (POH) contains a caution about towing in Section 8 – Handling, Servicing and Maintenance as shown in Figure 4. Similar cautions are contained in the M600 Aircraft Maintenance Manual (AMM), Section 9-10-00 and the M600 Training Manual, Chapter 12.

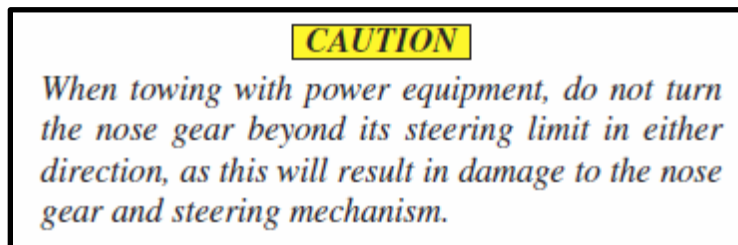


Figure 4-M600 POH Towing Caution.

If the NLG is externally turned beyond the left or right placard limits, mechanical stops will engage where portions of the NLG and steering mechanism come into contact. If turned beyond limits to the right, a machined stop on the lower portion of the rotating strut assembly will contact a machined stop on the lower end of the stationary trunnion assembly, Figure 5. The right stops will engage when the NLG tire is turned about 36° right. Further turning to the right may damage the machined stops and will load the strut-trunnion interface but will not affect the steering arm or steering horn. If turned beyond limits to the left, the steering arm left flange aft face will contact the steering arm mount plate on the engine mount, Figure 6. The left stops will engage when the NLG tire is turned about 30.5° left. Further turning to the left may damage the steering arm or mount plate or may apply a torsional load to the steering horn installed on top of the NLG strut. The rudder primary and secondary mechanical stops do not allow the mechanical turn limit stops to engage through pilot input at the rudder pedals. There are machined stops on the left side of the lower strut and trunnion assemblies similar to those on the right. These stops can only engage during NLG retraction as the strut rotates 90° to stow in the wheel well.



*Figure 5-M600 Right turn mechanical stop between trunnion and strut just prior to engagement.*



*Figure 6-M600 Left turn mechanical stop between engine mount and steering arm just prior to engagement.*

### **1.3 Aircraft Landing Procedures**

The POH contains the airplane normal procedures in Section 4 and the landing procedures are contained in section 4.5p, as shown in Figure 7. The procedures caution the pilot about centering the rudder prior to nose wheel touchdown.

#### 4.5p LANDING

##### CAUTION

*In crosswind conditions, the nosewheel may not be aligned with the runway as the wheel touches down because of opposite rudder input. To prevent swerving in the direction the nosewheel is offset, the rudder must be promptly centered just as the nosewheel touches down.*

##### CAUTION

*Abrupt or aggressive application of reverse thrust during landing rollout, especially during crosswind landings, may reduce directional control.*

##### NORMAL TECHNIQUE

POWER Lever.....IDLE  
Brakes.....MODERATE (or as required)  
POWER Lever..... BETA (or REVERSE as required)

Figure 7-POH Normal landing procedures.

## 2.0 Incident Aircraft Examination

An NTSB investigator examined the airplane at a maintenance facility at Leesburg Executive Airport (JYO) along with a Piper air safety investigator on December 11, 2020. The following information was developed from photos and notes obtained from the investigator, the pilot, and the Piper air safety investigator that examined the airplane.

The pilot reported that winds were 340° at 12 kts gusting to 17 kts – “straight down the runway” – when he landed on runway 35. He stated that it was a light touchdown and that about 2-4 seconds after traveling “straight,” the airplane “went careening to the left.” He stated that the right brake locked, and the right main landing gear (RMLG) tire “blew” from the skidding. The pilot applied “significant” rudder and brake inputs to correct the deviation and was able to straighten the airplane’s path; however, the airplane departed the left side of the runway, about 530 ft from the initial landing point. The left wing impacted a runway distance remaining sign during the excursion and the airplane came to rest on a measured heading about 359° about 12 ft from the runway edge.

The left wingtip exhibited impact damage just aft of the navigation light and slight buckling of the upper wing skin just inboard of the wingtip and forward of the main wing spar. The left main landing gear (LMLG) strut and tire were intact, but the tire exhibited two flat spots. Removal of the Schrader valve access plate from the hubcap revealed the assembly was not clocked correctly. The hubcap was removed to access the Schrader valve. The LMLG tire pressure measured 44 psi. The manufacturer specified a MLG tire pressure of 99-104 psi at the time of the incident. The right

main landing gear (RMLG) strut and tire were intact, but the tire exhibited two flat spots. The orientation of the hubcap was unknown. One of the flat spots penetrated through the entire thickness and the tire was deflated. There was dirt and grass embedded between the RMLG tire and wheel on the inboard side. The preload bearings and brakes on both MLG exhibited no anomalies. The upper trunnion bushings on both MLG exhibited some play.

The NLG strut and tire were intact, and the tire pressure measured 33 psi. The manufacturer specified a NLG tire pressure of 92-97 psi at the time of the incident. The NLG lower fork was deformed to the left such that the wheel was offset about 10° from vertical. The raised 'Goodyear' lettering on the right sidewall was partially abraded away and there was crosswise scuffing of the tread, Figure 8. The steering horn remained installed on the top of the NLG strut and had some areas of chipped and cracked paint. There was chipped paint, but no mechanical damage noted to the right turn and left mechanical stops on the trunnion and strut. There was a small impact mark noted on the aft face of the left side of the steering arm that serves as the left turn mechanical stop. The left and right rudder pedal pushrod forward rod ends had several threads exposed forward of the jam nut. There was white grease protruding out of the forward end of the steering bungee.



*Figure 8-NLG tire with abrasion and crosswise scuffing.*

The gaps between the steering arm and steering horn rollers were measured. A 0.020-inch feeler gage could be inserted between each roller and the steering arm simultaneously with the rudder pedals in the neutral position. The gap between the right steering horn roller and steering arm measured 0.015-inch with the right rudder pedal pushed to the stop. The gap between the left steering horn roller and the steering arm measured 0.010-inch with the left rudder pedal pushed to the stop. The rake angle of the nose landing gear was measured to be 90.0°. All values were within manufacturer specifications.

The NLG steering horn was retained and shipped to the NTSB Materials Laboratory for further examination. See the NTSB Materials Laboratory Factual Report 21-009 in the public docket for the details of the examination.

### 3.0 Runway Examination

The airplane came to rest in the grass about 12 feet from the left edge of the runway 35 paved surface and about 2,370 feet from the approach end of the runway, Figure 9. There were three distinct ground scars in the grass coincident with the locations of the RMLG, LMLG, and NLG between the edge of the runway and the airplane resting point. The LMLG departed the left side of the paved surface about 2,170 feet from the approach end, the NLG departed about 2,212 feet from the approach end, and the RMLG departed about 2,243 feet from the approach end. At the runway departure point the NLG ground scar was 4 feet from the RMLG ground scar and 8.8 feet from the LMLG ground scar measured perpendicular to the scars. There were distinct rubber transfer marks on the paved surface of Runway 35 that matched the locations of the ground scars. The rubber transfer marks were traced back to their beginning points on the runway surface. The LMLG rubber transfer mark showed four parallel lines with spaces between consistent with the tire tread pattern and the tires rolling with brakes applied. The LMLG mark began about 1,996 feet from the approach end of the runway and 9.5 feet left of the centerline, arced to the left, and continued to the LMLG departure point. The marks were lighter in appearance for the first 85 feet then became much darker consistent with heavier braking action. The RMLG rubber transfer mark began about 1,820 feet from the approach end of the runway and about 9 feet right of the centerline, arced to the left, and showed four parallel lines with spaces between for the first 7 feet then transitioned to a darker and wider line with no tread pattern consistent with a skidding tire. The dark, wide RMLG skid mark continued until about 60 feet from the departure point where it transitioned to a very light mark. The NLG rubber transfer mark began about 1,840 feet from the approach end of the runway and 1 foot right of the centerline and continued until about 2,068 feet from the approach end and 22 feet left of the centerline. The NLG rubber transfer mark was a wider line of varying intensity with no tread pattern consistent with a skidding tire.



Figure 9-Rubber transfer marks on Runway 35.

#### 4.0 Maintenance Records Examination<sup>1</sup>

The incident airplane, S/N 4698111, had accrued 91 hours total time as reported by the pilot at the time of the incident. The airplane received its airworthiness certificate on December 7, 2019. On January 17, 2020, the steering horn, P/N 85154-012, was removed from the NLG so that the steering pads could be resurfaced in accordance with the manufacturing drawing. The steering horn was reinstalled while the airplane was still at the Piper factory service center after it had accrued 5 hours total time.

The airplane manufacturer's Warrantable 1<sup>st</sup> 50-hour inspection was completed by Skytech, Inc., on May 20, 2020. During this maintenance visit the NLG and MLG oleo struts were serviced. The airplane had accrued 25.0 hours total time at the time of the maintenance. The most recent maintenance on the airplane was work on the avionics performed on August 7, 2020, at an airplane total time of 52.1 hours.

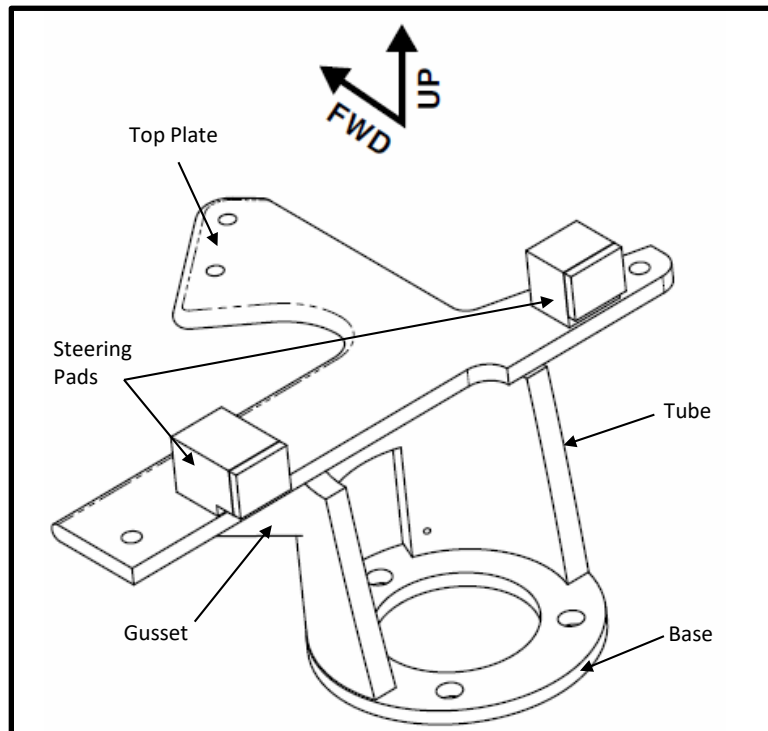
#### 5.0 Tests and Research

##### 5.1 Steering Horn Assembly

The incident airplane had a part number (PN) 85154-012 steering horn assembly installed at manufacture. The 85154-012 steering horn assembly consists of a steel base (PN 85154-004), tube (PN 85154-003), gusset (PN 85154-006), top plate (PN 85154-013), and two steering pads

<sup>1</sup> The pertinent maintenance records are contained in Appendix A.

(PN 85154-010 and -011) welded together in accordance with drawing 85154, Figure 10. The steering horn is attached to the NLG strut with 3 bolts through the base. A PN 83638-005 rub block is attached to the forward leg of the top plate, a PN 83638-002 roller (large) is attached to the left leg of the top plate, and a PN 83638-006 roller (small) is attached to the right leg of the top plate through the holes shown in accordance with revision C of the Nose Landing Gear Assy drawing 46N32A001. The two steering pads and two steering rollers interface with the steering arm to provide nose wheel steering with the NLG in the down position. The 85154-012 steering horn assembly was the same as used on the M500 airplane and was installed on M600 airplanes with serial number (SN) 4698001 to SN 4698135. Piper discovered alignment issues with certain steering horn assemblies installed on airplanes with SN 4698102 and above where the location of the steering pads and rollers was not consistent due to variances in the tolerance stack up. The alignment could be adjusted by machining the faces of the steering pads to achieve the necessary dimensional relationship between the pads and rollers. The incident airplane steering horn was reworked at the factory prior to delivery to align the pad faces with the rollers.



*Figure 10-Drawing of Steering Horn Assembly.*

Starting at SN 4698136 the nose wheel steering horn and roller assembly was changed with the issuance of PN 46N32A009-001. The new assembly utilized a horn assembly with PN 85154-014. The overall design of the steering horn assembly did not change, however, the tolerances on certain critical dimensions were tightened. The design and PN of the top plate, steering pads, gusset, and tube did not change with the new design. The overall location of the steering pads did not change with the new design, but the pad faces were deemed critical dimensions and an allowance was made for machining to meet the critical dimensions. The roller attach hole sizes and locations were also deemed critical and more tightly controlled. The overall size of the base did not change, but the PN changed to 85154-015 and the size and location of the mounting holes were more tightly controlled. The new steering horn utilized updated rollers with new PNs where

the size and hole locations were more tightly controlled.

## **5.2 Steering Horn Examination**

The steering horn assembly from the incident airplane was shipped to the NTSB Materials Laboratory for examination. See the NTSB Materials Laboratory Factual Report 21-009 in the public docket for the details of the examination. There was chipped and disbonded white paint noted in many areas with associated cracks in the paint film. There was some light corrosion noted on the exposed steel. No other anomalies were noted. The steering horn was shipped to Piper for a dimensional inspection. The following is a summary of the airplane manufacturer's inspection.

The accident steering horn assembly was PN 85154-012 that was manufactured in August 2019 and had the airplane SN 4698111 marked on it. The left and right steering pad faces measured 0.0015-inch aft of the left (large) roller and right (small) roller tangent lines, respectively. The left roller hole location measured 0.001-inch aft of its maximum tolerance. The right roller hole location measured 0.001-inch closer laterally to the center of the base than its maximum tolerance. The left steering pad (PN 85154-010) measured 0.030-inch closer laterally to the center of the base than its maximum tolerance and the right steering pad (PN 85154-011) measured 0.020-inch closer laterally to the center of the base than its maximum tolerance. All other dimensions were within the drawing tolerances. All of the steering horn hardware was intact and appeared undamaged.

## **5.3 Recorded Flight Data**

The Garmin G3000 Integrated Avionics System on the airplane records certain flight parameters at a rate of 1 Hertz for each flight. A maintenance-oriented data set (CMC data) is recorded and stored internally in the unit. The airplane manufacturer defines a flight-oriented data set (log data) to be recorded directly to an SD card, when installed, that can be easily removed and analyzed. New data files are created each time the airplane power and avionics system are turned on, and the file naming convention provides the date and starting point (airport identifier) if a valid GPS signal is obtained. The CMC data can be retroactively retrieved by copying it to an SD card. If the correct wheel speed sensors are installed and the software version is the correct version, MLG wheel speed data can be obtained from the CMC dataset. Both the CMC and available log data were downloaded from the accident airplane after the incident; however, the incident airplane did not have MLG wheel speed sensors installed.

Piper plotted the altitude, groundspeed, heading, track, pitch and lateral acceleration data for the incident landing from the SD card at the request of the NTSB, Figure 11. The touchdown point was estimated based on the altitude and pitch parameters. The runway departure timing was estimated based on the airplane position information. The NLG touchdown can be estimated based on the pitch parameter. Immediately after touchdown, there was a right lateral acceleration that was immediately followed by a lateral acceleration to the left that continued for the next three seconds. As the left lateral acceleration increased, the heading and track began to diverge indicating the airplane was in a skid with the track exceeding the heading. The touchdown ground speed was about 65 kts. About 3 seconds after touchdown the groundspeed showed an increase in the negative slope and the pitch decreased indicating application of brakes. Starting about 5

seconds after touchdown, the lateral acceleration transitioned to the right and the track decreased below the heading. The airplane departed the runway between 6 and 7 seconds after the touchdown at a ground speed about 38 kts. The airplane came to rest about 12 seconds after touchdown on a heading of 359°.

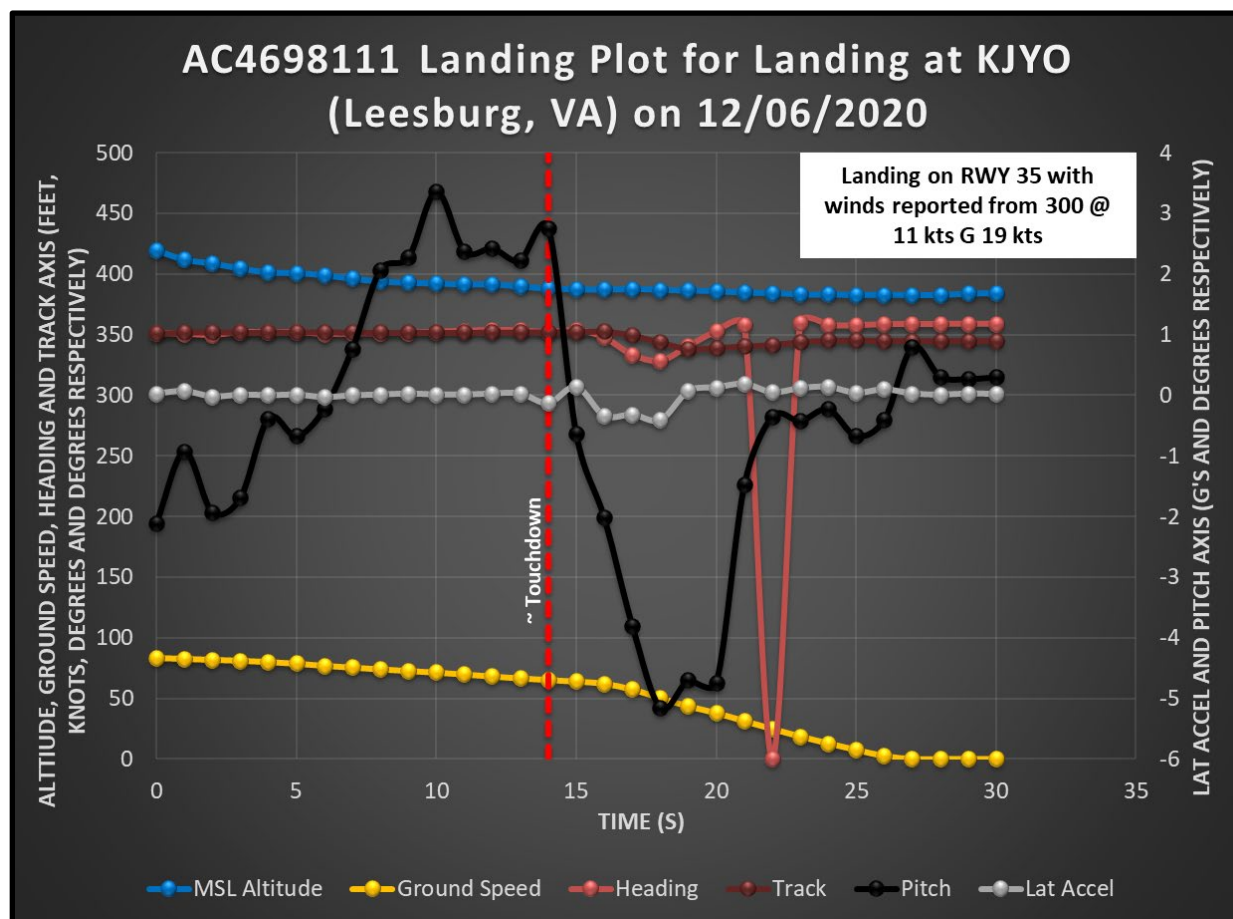


Figure 11-Plot of data from N282ST incident landing.

## 6.0 Piper Published Service Information

On July 24, 2020, Piper issued Service Letter (SL) 1285 Proper Tire Pressure Maintenance. The SL affected all models of the PA-46 airplane and for the PA-46-600TP increased the tire pressures. The NLG tire pressures increased from 88 psi to 88-92 psi unloaded and 92-97 loaded. The MLG tire pressures increased from 95 psi to 95-99 psi unloaded and 99-104 psi loaded. SL 1285A was issued on January 12, 2021, to supersede SL 1285 and added information on replacement placards and a revision to the Pilot's Operating Handbook (POH). The increased tire pressures remained the same in SL 1285A. SL 1285B was issued on June 15, 2021, to supersede SL 1285A. The tire pressures for the PA-46-600TP changed as follows. The NLG tire pressure should be 88 psi maximum unloaded and 88-92 psi loaded. The MLG tire pressure should be 95 psi maximum unloaded and 95-99 psi loaded. The SL also added information about temperature effects and changed the PN for the replacement placards.

Piper issued SL 1286 Nose Landing Gear Steering Components Inspection and Adjustment on August 18, 2020, applicable to all PA-46 airplanes. The SL highlighted existing Airplane Maintenance Manual (AMM) procedures for NLG alignment, NLG rake angle adjustment, and rudder cable tension and updated the procedures for measuring and adjusting the clearance between the NLG steering arm and steering horn rollers. It recommended compliance within 50 hours and recurring inspection every 100 hours. SL 1286A was issued on January 21, 2021, to supersede SL 1286 for all PA-46 airplanes and contained updated nose landing gear alignment procedures for the M600 airplanes. The recommended compliance remained the same as the original, but it recommended compliance at the next scheduled maintenance visit for M600 airplanes. SL 1286B was issued on January 28, 2021, for all PA-46 airplanes to supersede SL 1286A and added new information on rigging of the rudder-aileron interconnect for M600 airplanes. The recommended compliance remained the same as the original, but it recommended compliance at the next scheduled maintenance visit for M600 airplanes that were compliant with SL 1286 and prior to further flight for M600 airplanes that were compliant with SL 1286A. SL 1286C was issued on March 24, 2021, to supersede SL 1286B and contained clarification of the procedures to check and adjust the clearance between the NLG steering arm and steering horn rollers and the NLG alignment. The recommended compliance time remained the same as the original, but it recommended no further action until the next recurring action for M600 airplanes that already complied with SL 1286B, compliance before further flight for M600 airplanes that already complied with SL 1286A, and compliance at the next maintenance visit for M600 airplanes that already complied with SL 1286. SL 1286D was issued on October 15, 2021, to supersede SL 1286C and updated the clearance between the steering arm and rollers to 0.010-inch minimum when pushing the right and left rudder pedals to the stops. The recommended compliance remained the same as the original, but it recommended no further action until the next recurring action for M600 airplanes that already complied with SL 1286B or SL 1286C, compliance before further flight for M600 airplanes that already complied with SL 1286A, and compliance at the next maintenance visit for M600 airplanes that already complied with SL 1286.

Piper issued Service Bulletin (SB) 1350 Nose Landing Gear Steering Horn and Arm Assemblies Inspection on December 17, 2020, applicable to 3 specific M350 airplanes, 4 specific M500 airplanes, and M600 airplanes with SN 4698100 through SN 4698135. Piper considered compliance with the SB mandatory at the next maintenance visit but not to exceed 50 hours. The SB called for inspection of the steering horn and steering arm and replacement, if necessary. The aim of the SB was to make the affected airplanes compliant with the updated alignment requirements between the steering horn pads and rollers in accordance with the updated steering horn design discussed above. SB 1350A was issued on February 10, 2021, to supersede SB 1350 for the same affected airplanes and updated the torque of the bolts that attach the steering horn to the NLG strut from 25-30 in-lb to 60-75 in-lb.

#### **E. ADDITIONAL AIRCRAFT**

During the course of this investigation, the NTSB was notified of similar events involving Piper PA-46-600TP airplanes. Accident investigations were not initiated for these events due to the lack of substantial damage sustained by the airplanes, but the NTSB did gather information and performed some investigative work for comparison.

## **1.0 N641WA Incident**

On January 19, 2021, about 1615 eastern standard time, a Piper PA-46-600TP, N641WA, sustained minor damage when it departed the left side of Runway 35 during landing at Manchester Airport (MHT), Manchester, New Hampshire. The pilot and passenger were not injured. The airplane was operated as a Title 14 Code of Federal Regulations Part 91 personal flight.

The pilot reported that the airplane underwent its 50-hour inspection in late December 2020, after which he flew to Arizona where he completed 20 hours of flight training in the airplane. The incident flight was the second leg of a cross country flight from California to New Hampshire. Prior to leaving California on January 18, he stated that the tire pressures were checked and found to be low. A mechanic added air to the tires bringing the MLG tire pressures to 95 psi and the NLG tire pressure to 92 psi. He recalled that the NLG tire pressure was about 80 psi before being filled. He stated the MLG touchdown was smooth during the incident landing and as soon as he selected beta simultaneous with the NLG touchdown, the airplane immediately jerked right. He released beta and applied left rudder and the airplane darted left and departed the runway. His initial impression was that he had hit ice on the runway, but airport operations personnel inspected the runway and found it dry and clear of ice. At the time of the event the pilot reported that he had accrued about 1,000 hours total time and about 30 hours in the incident airplane make and model.

### **1.1 Incident Aircraft Examination N641WA**

The NTSB did not travel to the incident scene due to COVID protocols in place at the time. An inspector from the FAA and a Piper air safety investigator examined the airplane at a maintenance facility at MHT on January 22, 2021. The following information was developed from photos and notes obtained from the FAA inspector, the pilot, and the Piper air safety investigator that examined the airplane.

The NLG collapsed aft and left during the excursion damaging the NLG doors and lower fuselage skin. The NLG trunnion bolts were fractured. All five composite propeller blades were shattered and separated about 1 foot outboard of the hub. The LMLG strut and tire were intact after the incident, but the tire was separated from the bead and deflated when examined later. There was crosswise scuffing and abrasion on the treads of the LMLG tire. The RMLG strut and tire were intact, but the lower strut and fork were deformed inboard such that the tire was offset from vertical. The RMLG tire pressure measured 84 psi. There was crosswise scuffing and abrasion on the outboard sidewall and treads of the RMLG tire and abrasion damage around the perimeter of the outboard bead.

The NLG strut and tire were intact, and the tire pressure measured 78 psi. Incidentally, five days later the NLG tire pressure measured 64 psi. There was crosswise scuffing of the tread and right sidewall of the NLG tire. The steering horn remained installed on the top of the NLG strut and had some areas of chipped and cracked paint. There was chipped paint, but no mechanical damage noted to the right turn and left mechanical stops on the trunnion and strut. There was a small impact mark noted on the aft face of the left side of the steering arm that serves as the left turn mechanical stop. The left and right rudder pedal pushrod forward rod ends had several threads exposed forward of the jam nut. There was white grease protruding

out of the forward end of the steering bungee. Control continuity was established from the rudder pedals to the steering arm.

The NLG steering horn was retained and shipped to the NTSB Materials Laboratory for further examination. See the NTSB Materials Laboratory Factual Report 21-036 in the public docket for the details of the examination.

## 1.2 Runway Examination

The airplane came to rest in the grass and dirt adjacent to the runway and taxiway F intersection about 1,660 feet from the displaced threshold of runway 35. There were two distinct ground scars in the grass and dirt coincident with the locations of the LMLG and NLG. The RMLG remained on the paved surface. There were distinct rubber transfer marks on the paved surface of Runway 35 that matched the locations of the two ground scars and the RMLG. The rubber transfer marks were traced back to a point about 330 feet from the airplane resting location where they became indiscernible from all the other rubber transfer on the runway. All three transfer marks were dark, wide lines with no visible tread pattern consistent with skidding tires. The three marks arced to the left throughout their length. The NLG mark was initially to the right of the LMLG mark and crossed over the LMLG mark about halfway along the length to end up on the left side of the LMLG mark, figure 12.



Figure 12-Tire skid marks on runway 35 from N641WA.

## 1.3 N641WA Maintenance Records Examination

The incident airplane, S/N 4698141, had accrued 85.8 hours total time at the time of the incident.

The airplane received its airworthiness certificate on August 27, 2020. The airplane manufacturer's Warrantable 1<sup>st</sup> 50-hour inspection was completed by Western Aircraft in Boise, Idaho, on December 29, 2020. During this maintenance visit the detailed work order showed that the wheels were removed and deflated so the wheel bolts could be retorqued. There was a separate item in the work order to check the tires for proper pressure. The airplane had accrued 56.4 hours total time at the time of the maintenance. There was no other documented maintenance between the time of the inspection and the incident.

#### **1.4 N641WA Steering Horn Examination**

The steering horn assembly from the incident airplane was shipped to the NTSB Materials Laboratory for examination. There was chipped and disbonded white paint noted in many areas but there were no other anomalies or defects noted. There were no part markings on the steering horn. The horn appeared to have been repainted with overspray on the rub block and faces of the steering pads. The steering horn was shipped to Piper for a dimensional inspection. The following is a summary of the airplane manufacturer's inspection.

The incident steering horn assembly was consistent with PN 46N32A009-001. The left steering pad face measured 0.013-inch forward of the left (large) roller tangent line. The right steering pad face measured 0.011-inch forward of the right (small) roller tangent line. The left roller hole location measured 0.001-inch aft of its maximum tolerance. The right roller hole location measured 0.005-inch aft of its maximum tolerance. The left steering pad (PN 85154-010) measured 0.020-inch closer laterally to the center of the base than its maximum tolerance and the right steering pad (PN 85154-011) measured 0.020-inch closer laterally to the center of the base than its maximum tolerance. All other dimensions were within the drawing tolerances. All the steering horn hardware was intact and appeared undamaged.

#### **1.5 N641WA Recorded Flight Data**

Both the CMC and available log data were downloaded from the accident airplane after the incident. The incident airplane did have MLG wheel speed sensors installed but the LMLG sensor was not operational for unknown reasons.

Piper plotted the altitude, groundspeed, heading, track, pitch and lateral acceleration data for the incident landing from the SD card at the request of the NTSB, Figure 13. The RMLG touchdown points was established with the wheel speed information contained in the internal CMC data. The runway departure timing was estimated based on the airplane position information. The NLG touchdown was estimated based on the pitch parameter. The landing appeared nominal with the heading and track aligned and the RMLG touched down at a ground speed about 67 knots. The NLG touched down about 3 seconds after the RMLG at a recorded ground speed about 64 knots. About 2 seconds later there was a noticeable oscillation in the lateral acceleration followed by a significant left lateral acceleration that reached about 0.7 g about 5 seconds after NLG touchdown. During this time the airplane heading and track started to diverge and the heading decreased more than 90° left of the runway heading. The airplane heading and track deviated more than 60° at their maximum point. The airplane departed the runway about 13 seconds after RMLG touchdown and the NLG collapsed causing the pitch to decrease sharply. The airplane departed

the runway at a ground speed about 30 kts and came to rest about 18 seconds after RMLG touchdown on a heading about 280°.

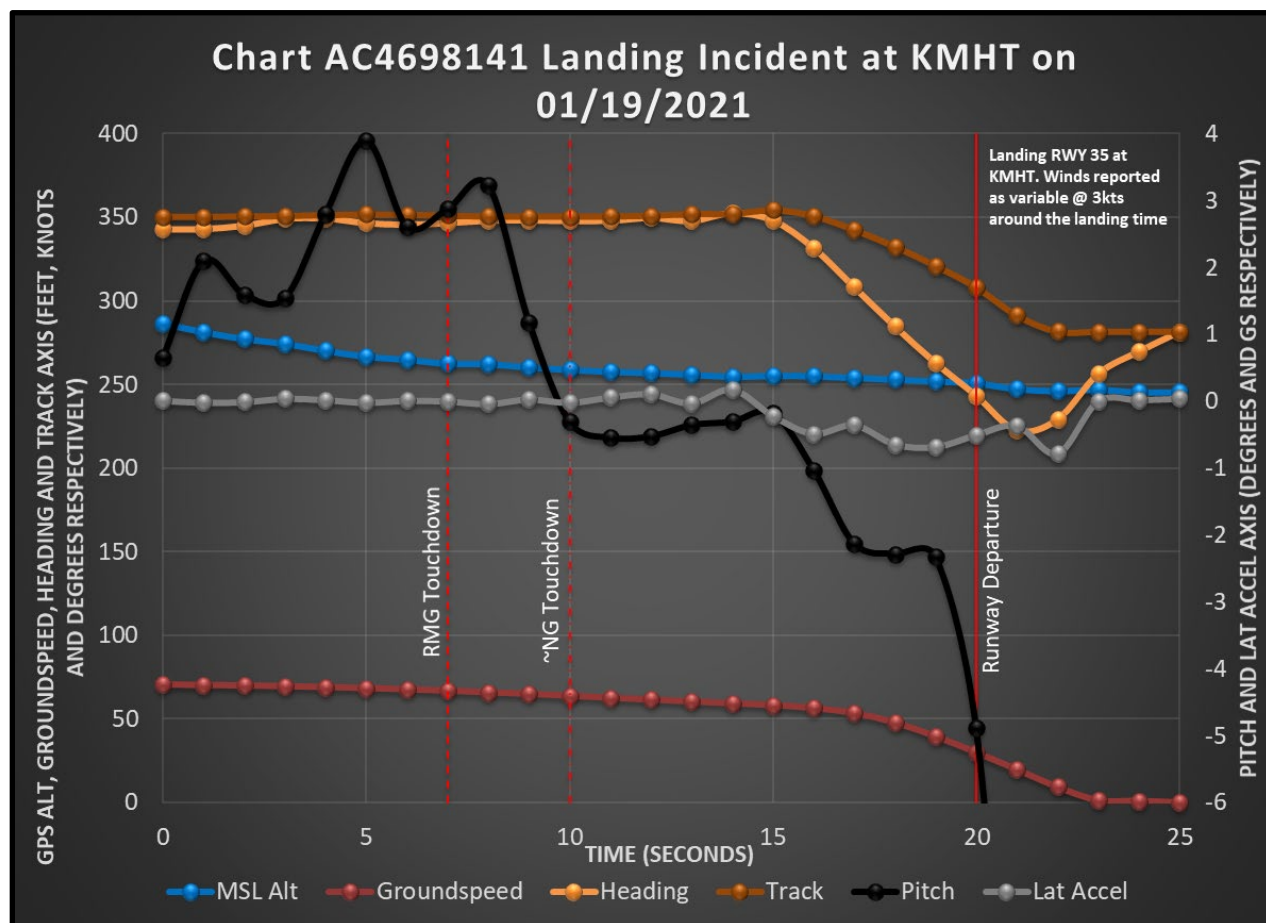


Figure 13-Plot of data from N641WA incident landing.

## 2.0 N831PS Incident

On December 19, 2020, about 1436 eastern standard time, a Piper PA-46-600TP, N831PS, experienced a veer to the left during landing on runway 33 at Martin State Airport (MTN), Middle River, Maryland. The pilot was not injured. The airplane was operated as a Title 14 Code of Federal Regulations Part 91 personal flight.

The pilot reported that the visual approach was normal, and he crossed the runway threshold at 85 knots. The touchdown was normal on the centerline, and he stated he held the nose off per the established POH procedure. When the NLG touched down the airplane veered “hard” to the left. He was able to correct back to the centerline. He did not come close to the runway edge, but the severity of the veer caused him concern. After shutdown, he performed a visual inspection of the landing gear and did not notice anything out of the ordinary. He thoroughly checked the steering on the taxi out and returned to his home airport, Manassas Regional Airport, Manassas, Virginia. He reported no issues on the landing and, after landing, the pilot checked the NLG tire pressure and found it to be 72 psi. He did not check the MLG tire pressures at this time. He reported that

the tire pressures were checked, and the landing gear serviced during a 50 -hour inspection in October 2020.

The pilot reported that he previously owned a PA-46-350, then a PA-46-600TP airplane (SN 4698038) and then purchased the incident airplane (SN 4698120) because of the Autoland feature. He estimated that he had accrued about 1,975 hours total time in all aircraft and about 675 hours in this make and model. He stated he was part of a Piper advisory board for the owners of airplanes with SN 4698100 and above.

## **2.1 Incident Aircraft Examination N831PS**

The NTSB did not travel to the incident scene due to COVID protocols in place at the time. The following information was developed from photos and notes obtained from the pilot.

The NLG strut and tire were intact, and the tire pressure measured 72 psi. The steering horn remained installed on the top of the NLG strut. There was chipped paint, but no mechanical damage noted to the right turn and left mechanical stops on the trunnion and strut. There was no damage noted on the aft face of the left side of the steering arm that serves as the left turn mechanical stop. The left and right rudder pedal pushrod forward rod ends had several threads exposed forward of the jam nut.

## **2.2 N831PS Maintenance Records Examination**

The incident airplane, S/N 4698120, had accrued about 70 hours total time at the time of the incident. The airplane received its airworthiness certificate on July 27, 2020. The airplane manufacturer's Warrantable 1<sup>st</sup> 50-hour inspection was completed by Skytech, Inc. in Westminster, Maryland, on October 9, 2020. There were no discrepancies with the NLG or steering noted during the inspection. There was no other documented maintenance between the time of the inspection and the incident.

After the incident the airplane underwent an annual inspection at Skytech that was completed on January 8, 2021. As part of the inspection Piper SB 1286 and 1350 were performed. The NLG steering horn was replaced with a PN 46N32A009-801 per SB 1350. The NLG steering horn was provided to the NTSB after it was replaced.

## **2.3 N831PS Steering Horn Examination**

The steering horn assembly from the incident airplane was shipped to Piper for a dimensional inspection. The following is a summary of the airplane manufacturer's inspection.

The incident steering horn assembly was marked with PN 46N32A009-805, Rev C, 10-23-19, and the airplane SN 4698120. The left steering pad face measured 0.0015-inch forward of the left (large) roller tangent line. The right steering pad face measured 0.0015-inch aft of the right (small) roller tangent line. The left steering pad (PN 85154-010) measured 0.020-inch closer laterally to the center of the base than its maximum tolerance and the right steering pad (PN 85154-011) measured 0.040-inch closer laterally to the center of the base than its maximum tolerance. All

other dimensions were within the drawing tolerances. All of the steering horn hardware was intact and appeared undamaged.

## 2.4 N831PS Recorded Flight Data

The log data was downloaded from the accident airplane after the incident by the pilot and sent to the NTSB. Since we only received the SD card data there was no wheel speed information.

Piper plotted the altitude, groundspeed, heading, track, pitch and lateral acceleration data for the incident landing from the SD card at the request of the NTSB, Figure 14. The MLG touchdown point was estimated based on the altitude and pitch parameters. The NLG touchdown was estimated based on the pitch parameter. The landing appears nominal with the heading and track aligned and the MLG touches down at a ground speed about 68 knots. The NLG touches down about 5 seconds after the MLG at a recorded ground speed about 61 knots. There was some slight oscillation in the lateral acceleration between MLG and NLG touchdown. When the NLG touches down there is a left lateral acceleration about -0.12 g followed 1 second later by a right lateral acceleration about 0.20 g. The lateral acceleration oscillates slightly for the next 3 seconds before becoming stable. During this time the airplane heading deviated from the track. The remainder of the landing roll appeared normal.

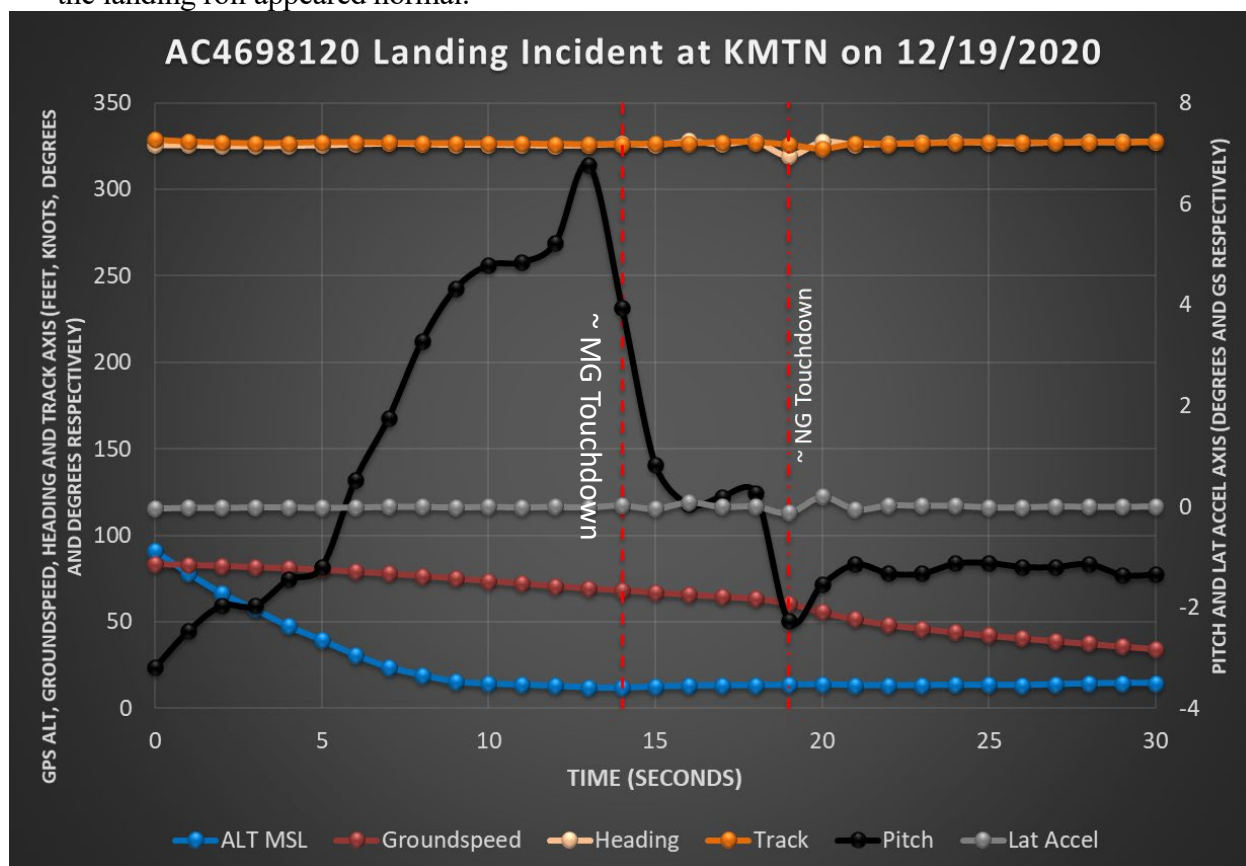


Figure 14-Plot of data from N831PS incident landing.

### 3.0 N115NX Incidents

This particular Piper PA-46-600TP, N115NX, SN 4698115, has experienced three separate steering events that the NTSB was able to obtain information from. On December 23, 2019, about 1013 central standard time, a Piper PA-46-600TP, N115NX, experienced a runway excursion to the right during landing on runway 18 at Johnson County Executive Airport (OJC), Olathe, Kansas. The airplane departed the right side of the runway, crossed a grassy area, and came to stop on taxiway A. The pilot was not injured, and the airplane sustained minor propeller blade nicks and scratches. The airplane was being operated by a Piper engineering flight test pilot as a delivery flight from the factory.

Examination of the airplane after the incident found all tire pressures were about 10 psi low after taking into account the temperature, the NLG rake angle was within tolerance, the movement from NLG strut to trunnion and trunnion to NLG actuator were within tolerance, but the NLG steering pads protruded aft of the roller tangent lines about 0.074-inch. The PN 85154-012 steering horn was replaced with a new unit of the same PN, and the propeller was replaced at an airplane total time of 9.5 hours.

On June 3, 2020, at unknown time, a Piper PA-46-600TP, N115NX, experienced a veer to the right during landing on runway 22 at Driggs-Reed Memorial Airport (DIJ), Driggs, Idaho. The airplane did not leave the paved surface and was not damaged. The airplane was being operated by the owner with a safety pilot present who was a certified flight instructor (CFI).

The pilot reported that he previously owned a PA-46-350 airplane and recently purchased the M600. He had very little experience in the PA-46-600TP at the time of the Driggs event. During the incident landing he reported that the airplane touched down and darted to the right and he fought to keep it on the runway. The CFI reported that the pilot landed with the flaps in the takeoff position about 90-95 kts. The CFI stated that the initial dart was to the left before the pilot corrected to the right. Around 75 kts the "wandering" got worse and the pilot was going "stop to stop" on the rudder.

The pilot and CFI returned to Arizona so the pilot could start training in the incident airplane at Legacy Flight Training. On June 10, 2020, about 1000 mountain standard time, a Piper PA-46-600TP, N115NX, experienced a veer to the right during landing on runway 4 at Winslow-Lindberg Regional Airport (INW), Winslow, Arizona. The pilot reported that the RMLG left the paved surface during the event, but the airplane was not damaged. The airplane was being operated by the owner with a safety pilot present who was a certified flight instructor (CFI).

The pilot reported that it was completely calm during the landing. He recalled touching down left of the centerline and the airplane was drifting left. He applied right rudder and the airplane wasn't responsive. The airplane finally responded and darted right. The CFI took control and was able to regain control as the RMLG left the runway. The pilot was surprised the NLG didn't collapse since the event was so violent. He returned the airplane to the dealer and told them he didn't want to fly it. From his perspective the events seemed to be random since he had a couple of landings with no issues.

The CFI reported that he flew with the pilot for 5 flights. During the incident landing he had his feet on the rudder pedals to feel the pilot inputs. The pilot experienced a normal left deviation during the landing and the CFI felt the application of right rudder before NLG touchdown. As the NLG wheel touched down the airplane veered sharply to the right. He took control of the airplane, lifted the nose, and regained control. He stated there was no damage evident and there were no handling issues, so they returned to Phoenix where the pilot decided not to continue training. The CFI stated the tire pressures were in the normal range prior to the flight.

### **3.1 Incident Aircraft Examination N115NX**

The NTSB was able to examine the incident airplane on April 6, 2021, with representatives from Piper and the FAA present. The airplane was examined at Westwind Air Service at Phoenix Deer Valley Airport (DVT), Phoenix, Arizona. The pilot reported that he parked the airplane on July 16, 2020 and had not flown it since.

At the time of the inspection the Hobbs meter indicated 57.0 hours. The NLG strut extension measured 2.05 inches, the LMLG extension measured 3.0 inches, the RMLG extension measured 3.05 inches, and the angle of the lower fuselage measured 0.05° nose down. There was 230 lb of fuel in left wing and 220 lb in right wing. The new placards recommended per SL 1285A had not been installed. The NLG tire pressure measured 62 psi, the RMLG tire pressure measured 53 psi, and the LMLG tire pressure measured 38 psi. The LMLG wheel cover was clocked incorrectly so the valve stem was not accessible when examined initially but was removed and reinstalled correctly. The RMLG tire had a flat spot. The tread depth on the NLG tire measured 0.115-inch, on the RMLG tire measured 0.130-inch, and on the LMLG tire measured 0.105-inch. The MLG alignment was checked and had a 0.1° toe out. There was rotational free play in the NLG strut that measured 3.6° with the rudder pedals centered. The steering horn installed was PN 46N32A009-001, Rev A. The steering arm installed was PN 83625-7. There was minor chipping of the paint on the NLG strut to trunnion stops. The gap between the left and right steering horn rollers and steering arm measured simultaneously 0.036-inch with weight on wheels and 0.037-inch on jacks. The gap between the steering pads on the steering horn and the steering arm measured simultaneously 0.045-inch with the weight on wheels and on jacks. The left and right steering pushrod ends has 0.35-inch of threads exposed. The NLG strut axis of rotation measured 0.040-inch right of the steering arm access of rotation. The NLG rake angle measured 90.3° with weight on wheels and 90.1° on jacks. The rake angle play measured 0.2° with the airplane on jacks. With the right rudder pedal on the primary stop, the steering pad to steering arm gap on the right side measured 0.092-inch. With the left rudder pedal on the primary stop, the steering pad to steering arm gap on the left measured 0.049 inch. The steering bungee was removed and disassembled; the spring diameter measured 0.245-inch. The NLG camber measured 2.01° right as viewed looking forward.

### **3.2 N115NX Maintenance Records Examination**

The incident airplane, S/N 4698115, received its airworthiness certificate on December 11, 2019. After the first incident, the steering horn was replaced with a new PN 85154-012 steering horn, the NLG tire was serviced, and the NLG rake angle was checked per the AMM on February 20, 2020, at an airplane total time of 9.5 hours. The NLG free play was also checked per a Piper

engineering request. After the third incident, the steering horn was again replaced with a new PN 46N32A009-001 steering horn, the steering arm was adjusted to 0.030-inch on each roller, and the NLG tire was replaced on June 26, 2020, at a total time of 31.30 hours. The airplane manufacturer's Warrantable 1<sup>st</sup> 50-hour inspection was completed by Cutter Aviation, Inc. in Phoenix, Arizona, on July 27, 2020, at a total time of 56.8 hours.

### **3.3 N115NX Steering Horn Examination**

The steering horn assemblies removed from the incident airplane after the first and third incidents were shipped to Piper for dimensional inspections. The following are summaries of the airplane manufacturer's inspections.

The first incident steering horn assembly was marked with PN 85154-012, MFG date code M0080010059, and was installed at manufacture. There were no rollers installed on this assembly since they were used on the replacement steering horn. The top plate (PN 85154-013) measured 0.004-inch further above the base (PN 85154-004) than the maximum tolerance but remained parallel with the base. The right (small) roller hole measured 0.002-inch further aft than the maximum tolerance. The left (large) roller hole measured 0.004-inch further aft than the maximum tolerance. The left steering pad (PN 85154-010) measured 0.020-inch closer laterally to the center of the base than its maximum tolerance and the right steering pad (PN 85154-011) measured 0.010-inch closer laterally to the center of the base than its maximum tolerance. All other dimensions were within the drawing tolerances.

The third incident steering horn assembly was marked with PN 85154-012, MFG date code M00908122, and was installed after the first incident with the original rollers. The tangent line from the left and right rollers measured 0.004-inch forward of the steering pad faces which was within drawing tolerance. One steering pad measured 0.016-inch closer laterally to the center of the base than its maximum tolerance and the other steering pad measured 0.010-inch closer laterally to the center of the base than its maximum tolerance. All other dimensions were within the drawing tolerances.

### **3.4 N115NX Recorded Flight Data**

The log and CMC data was downloaded from the incident airplane after the first and third incidents by Piper. There was no wheel speed information in the CMC data since the unit software was not updated.

Piper plotted the groundspeed, heading, track, pitch and lateral acceleration data for the incident landing at DIJ from the SD card at the request of the NTSB, Figure 15. The NLG touchdown was estimated based on the pitch parameter. The landing appeared nominal with the heading and track aligned and the NLG touched down at a ground speed about 78 knots. Immediately after NLG touchdown there was a left lateral acceleration that was followed by lateral acceleration oscillations right and left for the next 5 seconds. About 5 seconds after NLG touchdown the heading and track reached their maximum difference with the heading about 9° right of the track. About 6 seconds after NLG touchdown there was a noticeable increase in pitch followed by a decrease in the lateral acceleration oscillation. The remainder of the landing then appeared

nominal with the heading and track aligned.

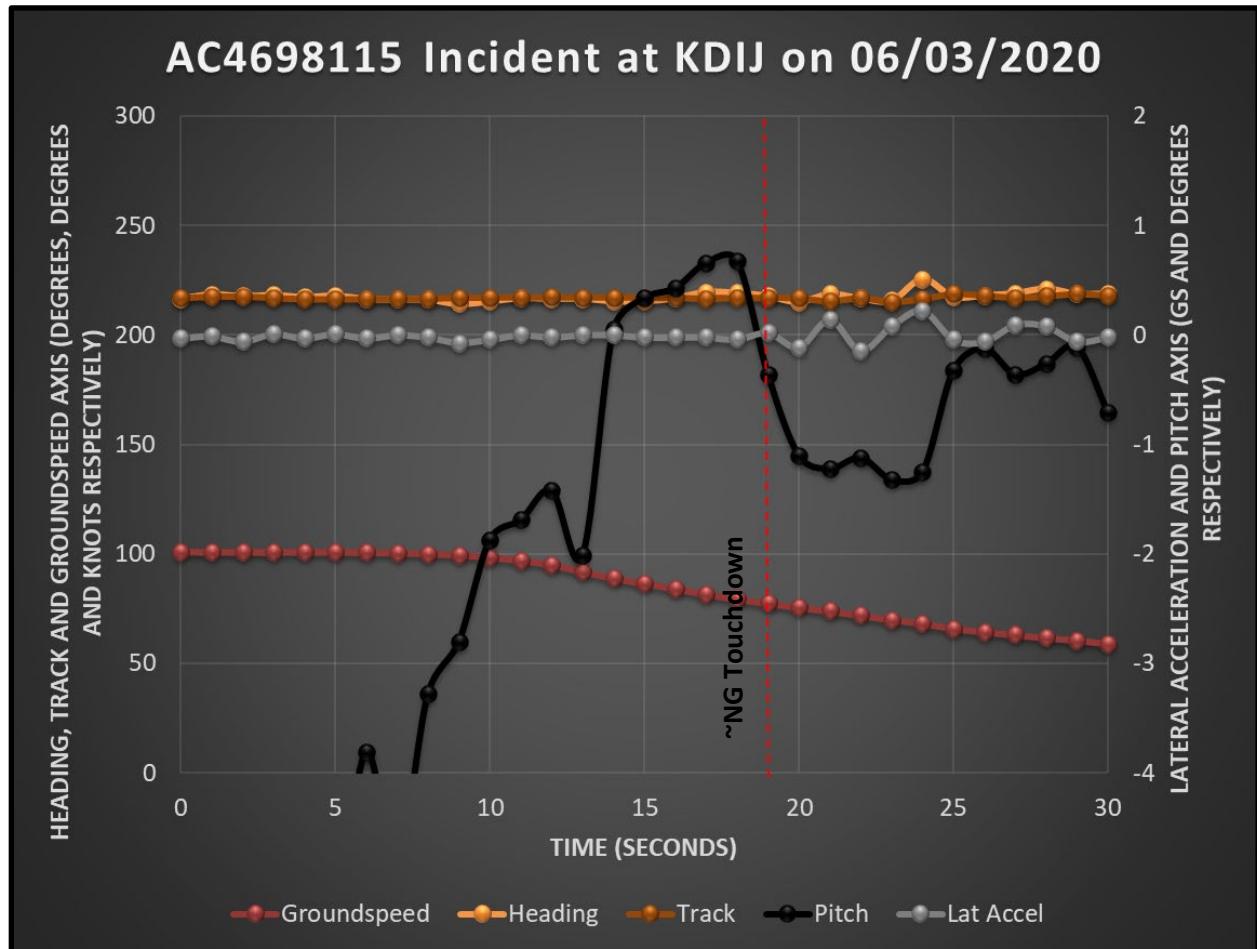


Figure 15-Plot of data from N115NX incident landing at DIJ.

Piper plotted the groundspeed, heading, track, pitch, and lateral acceleration data for the incident landing at INW from the SD card at the request of the NTSB, Figure 16. The NLG touchdown was estimated based on the pitch parameter. The landing appeared nominal with the heading and track aligned and the NLG touched down at a ground speed about 81 knots. Prior to NLG touchdown there was a slight left lateral acceleration that continued as the NLG touched down. About 1 second after NLG touchdown there was a significant veer to the right with the right lateral acceleration reaching a maximum of about 0.73 g about 3 seconds after NLG touchdown. At this time, the deviation between heading and track was maximum with the heading about 20° right of the track. About 5 seconds after NLG touchdown the pitch began to increase, and the heading and track became aligned again. The remainder of the landing then appeared nominal with the heading and track mostly aligned.

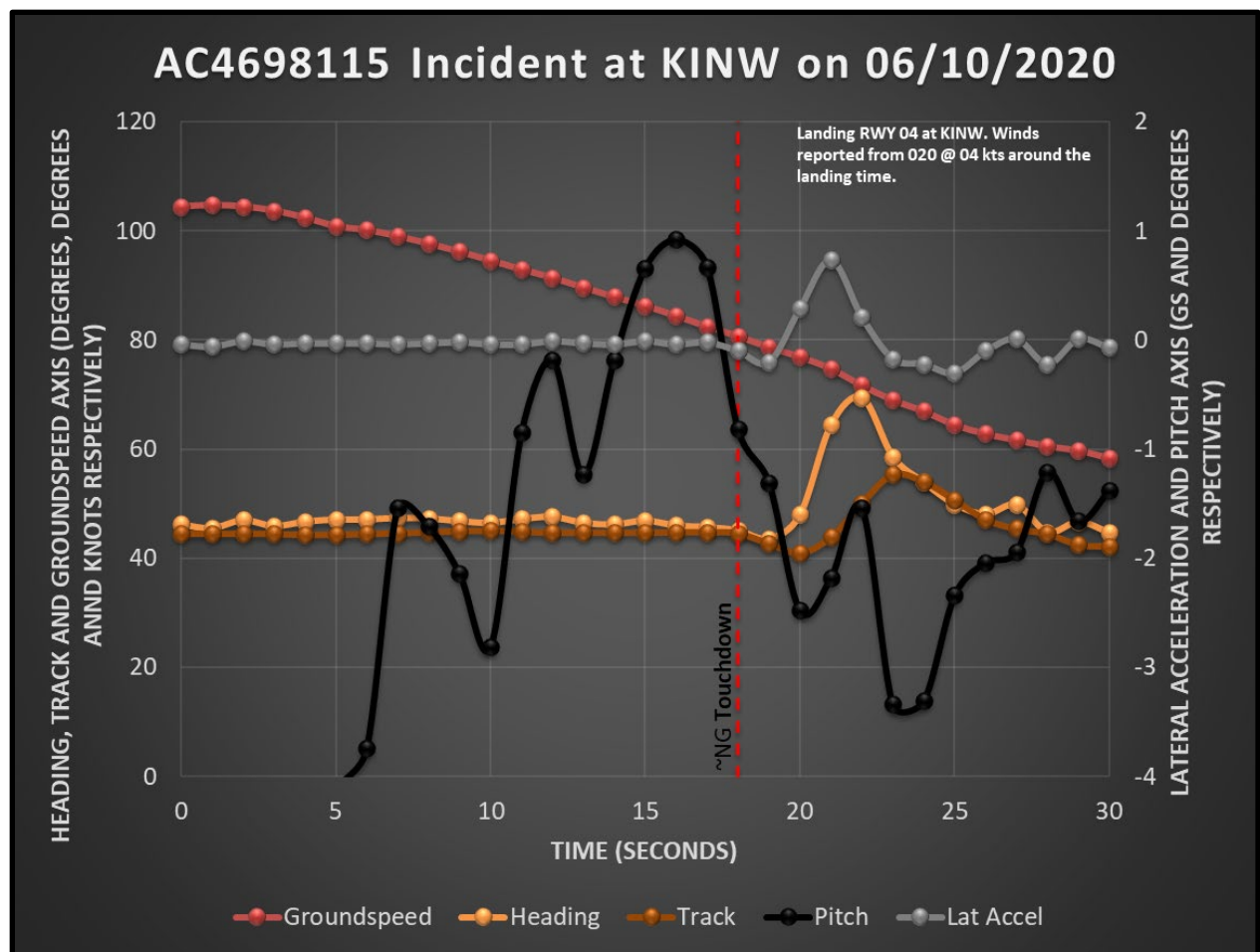


Figure 16-Plot of data from N115NX incident landing at INW.