Flight Inspection Airborne Processor Application (FIAPA), RNAV Approach Mode Lessons Learned

Bradley W. Elliott
Mission Specialist
FAA Flight Program Operations
Oklahoma City, Oklahoma, USA
E-mail: Bradley.W.Elliott@FAA.Gov

Jay Sandwell
Mission Specialist
FAA Flight Program Operations
Oklahoma City, Oklahoma, USA
E-mail: Jay.Sandwell@FAA.Gov

ABSTRACT

The Federal Aviation Administration's (FAA) primary flight inspection system, Flight Inspection Airborne Processor Application (FIAPA), received initial operational approval in 2017. The updated flight inspection system uses a new method of measuring and analyzing data for area navigation (RNAV) procedures. FIAPA measures the confidence of the runway threshold and runway end latitude, longitude, and vertical data and validates the coded data.

This paper presents results and lessons learned from verifying the threshold and runway end data collected over the seven years using FIAPA. Based on testing, the FAA determined that the up error was too restrictive and had to be increased to ensure the precise measurement of vertical data. In addition, the FAA shifted responsibility for coding preflight validation (CPV) from a small team to the crew members conducting the procedure validation. This approach has yielded benefits as crew members decide to continue to inspect the procedure or to reject the procedure.

INTRODUCTION

FIAPA was released with an RNAV mode that measured the uncertainty of a runway threshold and runway end coordinates. The RNAV mode was initially described in an FAA paper at the 19th International Flight Inspection Symposium (IFIS) titled *An Inside Look at Flight Inspection Airborne Processor Application (FIAPA) – RNAV Approach Mode* [1]. Since the 19th IFIS in 2016, there have been changes to the RNAV mode. The biggest change was moving from one set of criteria for all RNAV approach lines of minimums to three separate criteria. The criteria are separated into sets for: localizer performance with vertical guidance (LPV), localizer performance (LP), lateral navigation (LNAV) with vertical navigation (VNAV), and required navigation performance (RNP); LNAV; and circling landing minimums. The FAA changed the criteria after determining that one set of criteria does not fit all procedures. This change allows LNAV or circling landing minimums to be published if the LPV, LP, LNAV/VNAV or RNP landing minimums are not satisfactory for that runway.

The tolerance for along track, cross track, and vertical spatial data is a statistical confidence of 95 percent or greater. The statistical confidence is calculated by the criteria for the specified parameter, the measurement error of the parameter, and the system error. Gary Flynn of the FAA presented a paper at the 19th IFIS titled *Dynamic Measurement Uncertainty for Runway Fix* [2] that described FIAPA's measurement error and the system errors for survey verification.

While using FIAPA, crew members complete the CPV instead of a dedicated CPV team. The requirements to validate the RNAV Aeronautical Radio, Inc (ARINC) coding is now part of the crew requirements. Changing the CPV requirement from the CPV team to the crew members was implemented in 2021.

RUNWAY SURVEY VERIFICATION CRITERIA

FIAPA was initially released with criteria listed in Table 1 below for all RNAV landing minimums. It was recognized in the first years of using FIAPA that these criteria values were too stringent. Too many RNAV procedures were being denied. In 2017 and 2018, 8.6 percent of the runway survey verifications completed did not meet the initial criteria. That was out of 1,148 runway survey verifications completed.

Table 1. FIAPA Initial RNAV Survey Verification Criteria

Parameter	**Criteria**
Threshold Along Track	± 10 feet
Threshold Cross Track	± 10 feet
Threshold Up	± 6 feet

Criteria Changed

Researching the results from the initial two years of FIAPA survey verification data, the up error parameter caused the most discrepancies. The 6 feet criteria, the distribution value for the threshold up parameter, was too restrictive. The automated flight inspection system (AFIS) used by the FAA prior to FIAPA had a threshold crossing height (TCH) tolerance of +12 feet and -10 feet. The TCH value from the previous AFIS is roughly translated into the threshold up criteria value of FIAPA. With the average confidence interval for the up error being ±3.6 feet, the 6 feet criteria meant that the error would be 3 feet or below to meet the 95 percent confidence. At those values, the TCH could be as much as 6.6 feet for the up error and 0.5 feet for the maximum along track error for a maximum TCH value of 7.1 feet. That is 71 percent of the TCH tolerance value from the previous AFIS at the most stringent requirement of -10 foot value.

It was determined that the threshold up criteria could be increased to 10 feet. With the criteria changed to 10 feet, the maximum threshold up value could be as much as 11.1 feet, average confidence interval of ±3.6 feet, and an error of 7.0 feet. Accounting for the maximum along track error effects on the TCH would be 0.5 feet. This resulted in the threshold up value being 111 percent of the TCH tolerance from the previous AFIS for the -10 foot value.

Criteria Added

The initial release of FIAPA had one set of criteria for all runway survey verification results; therefore, different procedure landing minimums used the same criteria. It was determined the criteria could be expanded for LNAV and circling landing minimums. The criteria amount for LNAV landing minimums was 10 times for along track and cross track, and twice for the vertical data from the updated LPV, LP, LNAV/VNAV, and RNP landing minimums. Then the circling landing minimums doubled the along track and cross track values from the LNAV criteria.

The circling does not validate the threshold up parameter because circling procedure minimum descent altitude (MDA) is based on the height above airfield, or “the highest point of an airport's usable runways measured in feet from mean sea level” [3]. FIAPA’s survey verification measures the threshold up value not the airport elevation.

Table 2 shows the changes in the criteria for the LPV, LP, LNAV/VNAV, and RNP landing minimums, and the added criteria added for LNAV and circling landing minimums.

Table 2. FIAPA Updated RNAV Survey Verification Criteria

Parameter	**LPV, LP, LNAV/VNAV, RNP Criteria**	**LNAV Criteria**	**Circling Criteria**
Threshold Along Track	± 10 feet	± 100 feet	± 200 feet
Threshold Cross Track	± 10 feet	± 100 feet	± 200 feet
Threshold Up	± 10 feet	± 20 feet	N/A

Figure 1 below is an example of the current FIAPA runway survey results. Each column is presented for the different types of RNAV lines of minimums. The survey column is based on the initial survey verification criteria. Tolerances are not applied to the survey column. The survey column is presented for information and possible future use.

Error & Confidence

	Error	Survey	LPV, LP, LNAV/VNAV, RNP	LNAV	Circling
THLD Atk	-13.6 ft	2%	2%	100%	100%
THLD Xtk	7.3 ft	96%	96%	100%	100%
THLD Up	12.4 ft	0%	15%	100%	
RE Atk	5.7 ft	99%	99%	100%	100%
RE Xtk	0.0 ft	100%	100%	100%	100%
RE Up	11.4 ft	1%	27%	100%	

Figure 1. Updated Runway Survey Verification Results

All criteria changes or additions described in this paper were implemented in compliance with International Civil Aviation Organization Annex 10 and were coordinated through the applicable Safety Management System.

SURVEY VERIFICATION INSPECTION PROCEDURES

Survey verification has unique inspection procedures because of the confirmation process and the different criteria for the different landing minimums. A survey verification could be completed in one run, or it could take up to three runs. If the first run has satisfactory threshold results (≥ 95 percent confidence for the lowest landing minimum procedure) the inspection is complete. If the first run results in any threshold result that is ≤ 94 percent, a confirming run is required. If the second run, when combined with the first run, results in all threshold parameters being satisfactory, the inspection is complete. If the second run, when combined with the first run, results in a parameter ≤ 94 percent, a third run is required. If the parameter is either along track or cross track being ≤ 94 percent, the third run is completed in the direction of the procedure. If the first and second run combined is ≤ 94 percent for the threshold up parameter, an opposite direction run should be completed.

The opposite runway survey verification on the up parameter is necessary because the aircraft changes altitudes from a descent to a level run over the runway threshold when in the direction of the approach induces some measurement errors. Completing an opposite direction survey verification addresses the error caused by aircraft positioning.

Figure 2 below is a flow chart for completing a survey verification. If a procedure survey verification is unsatisfactory for LPV, LP, LNAV/VNAV or RNP and the procedure has LNAV or circling landing minimums on the same procedure, then the flow chart is completed using the results for the respective line of minimums. Completing the inspection runs again for the lower minimums is not required because FIAPA provides the results for the lower minimums during all runs.

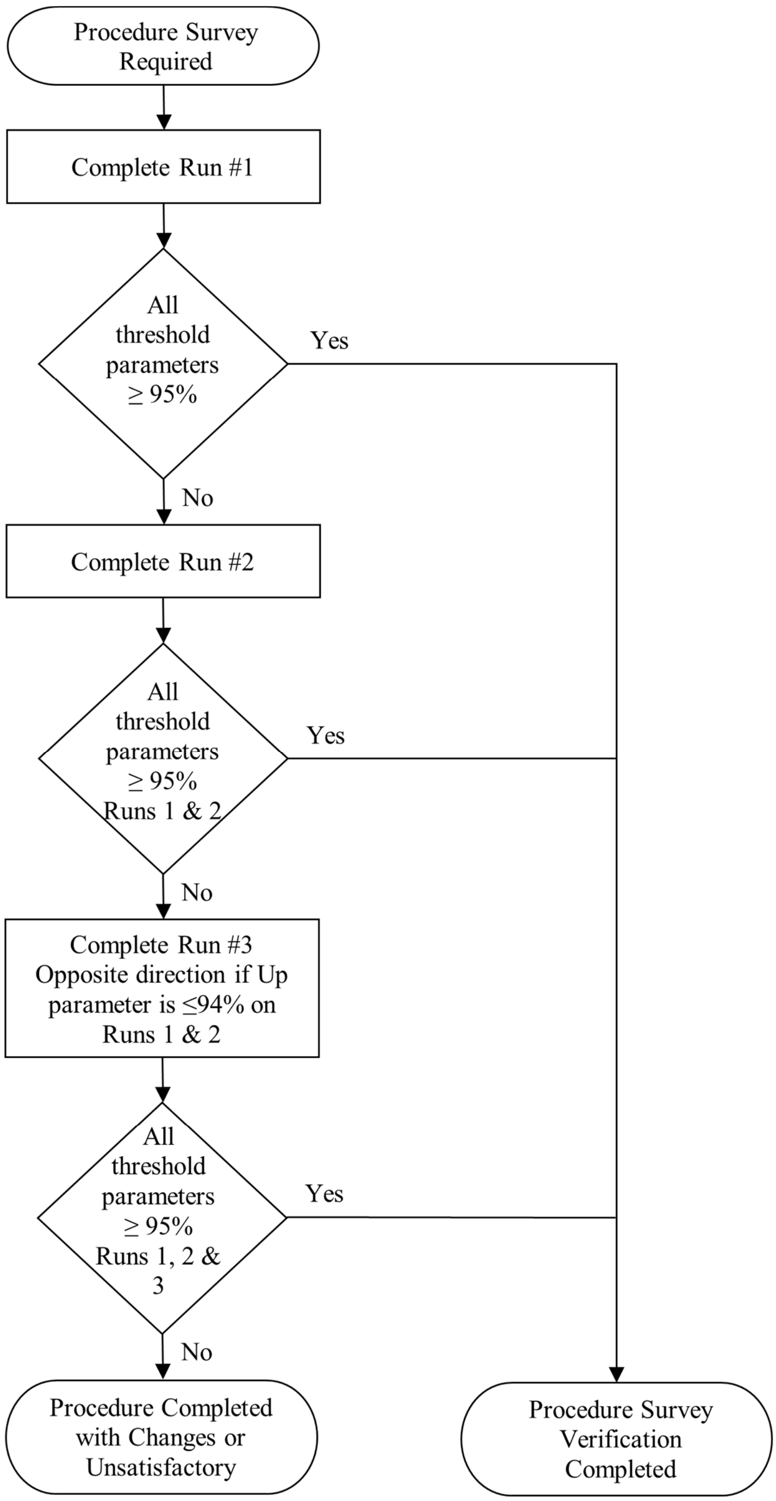

Figure 2. Procedure Survey Verification Flow Chart

If the procedure survey verification is unsatisfactory for one line of minimums but satisfactory for another line of minimums, the procedure is completed with changes. This means that the LPV, LP, LNAV/VNAV, or RNP and possibly the LNAV lines of minimums would not be published, but the circling minimums could be published. If the survey verification is unsatisfactory for all proposed lines of minimums, then the procedure is unsatisfactory.

CODING PREFLIGHT VALIDATION (CPV)

CPV is a process to verify the ARINC 424 coding prior to flight validation. Richard Montgomery described the FAA CPV process in the 2008 15th IFIS paper titled *Verification of Final Approach Segment Data Prior to SBAS Flight Inspection* [4], as CPV was completed prior to FIAPA. FIAPA was developed with embedded CPV tools; therefore, removing the requirement to manually calculate the final approach segment (FAS) data for the LPV and LP lines of minimums and the final approach course (FAC) data for the LNAV/VNAV, RNP, LNAV, and circling lines of minimums.

The FAS and FAC coding validation processes in FIAPA were discussed in *Inside Look at Flight Inspection Airborne processor Application (FIAPA) – RNAV Approach Mode* [1] and remain unchanged since FIAPA's initial release.

Since the initial release, FIAPA was revised to add a PDF document with the ARINC 424 coding for the whole procedure. The PDF file lists the pertinent ARINC 424 data textually. The textual data is used to manually compare against the procedure package to ensure the coding is correct before completing the flight validation.

Procedures ARINC 424 Coding Team

FIAPA was loaded to the computers of the FAA ARINC 424 coding team. The ARINC 424 coding team verifies the FAS and FAC data on FAA-developed procedures prior to sending procedures to the be flight validated. This step reduced most of the ARINC 424 data errors prior to FAA Flight Program Operations receiving the coded data.

Approximately 80 percent of the procedures flight validated are developed by the FAA. The other 20 percent are developed by the U.S. Navy, U.S. Air Force, U.S. Army, and third-party developers. The procedures developed by entities other than the FAA do not validate the FAS and FAC data in FIAPA prior to submitting the procedures to be flight validated.

FAA Flight Program Operations Crew Members

FAA Flight Program Operations crew members complete the CPV process as they mission plan the inspection task. Crew members load the ARINC 424 data into FIAPA, and FIAPA validates the FAS and FAC data. FIAPA checks the coding against the survey data that is kept in the airports and navigational aids (AIRNAV) database. If FIAPA detects discrepancies in the data verification, the specific item is highlighted red. When the computer cursor is hovered over the discrepancy item, FIAPA displays the items being used for the validation, the error amount, and the tolerance. This information is used to assist in correcting the discrepancies.

Figure 3 below provides a sample of the data displayed by FIAPA for the FAS and FAC data verification. The top data is the AIRNAV data and the bottom data is the ARINC data.

These FIAPA tools allowed the FAA to reassign the CPV team to other tasks in the organization, and to move the CPV to crew members as part of their mission planning.

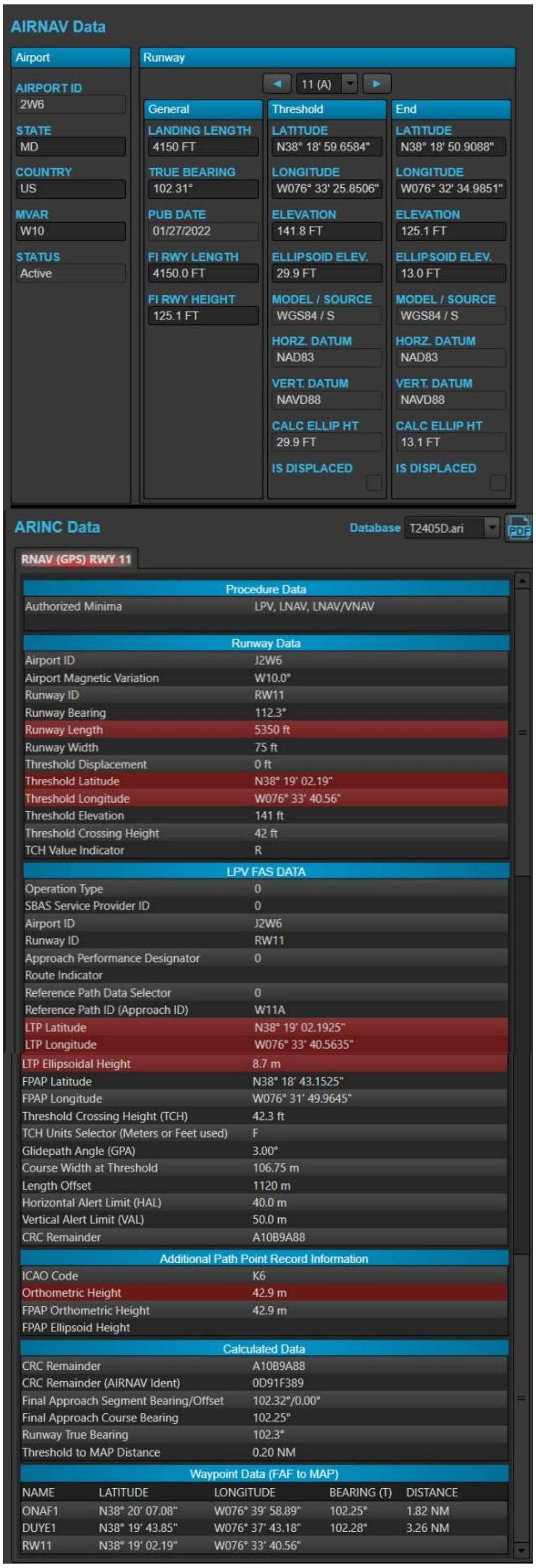

Figure 3. Sample Ground FAS and FAC Validation Results

RECOMMENDATIONS

Revised FIAPA software and updated sensors are scheduled to be released by the end of 2024. One of the new sensors is a Trimble BX992 GNSS. The BX992 provides a real-time kinematic (RTK) precision solution from a subscription service. This solution will increase system measurement accuracy. Crew members will monitor the runway survey verification results after the release for changes in the confidence intervals (i.e., system errors) and areas where the BX992 could be used for increased accuracy.

FUTURE WORK

In the future, crew members must determine how FIAPA runway survey verification could be integrated into ground based augmentation system (GBAS), determine how to accurately complete survey verification at runways without runway markings (i.e., gravel runways), and determine a method to verify survey data for heliports/vertiports.

REFERENCES

[1] IFIS2016, Inside Look at Flight Inspection Airborne processor Application (FIAPA) – RNAV Approach Mode, Brad Snelling and Brad Elliott.

[2] IFIS2016, Dynamic Measurement Uncertainty for Runway Fix, Gary A. Flynn.

[3] United States. Federal Aviation Administration. (April 2023), Aeronautical Information Manual, U.S. Dept. of Transportation, Federal Aviation Administration.

[4] IFIS2008, Verification of Final Approach Segment Data Prior to SBAS Flight Inspection, Richard Montgomery.