TERMINAL INSTRUMENT PROCEDURE (TERPS) ANALYSIS
GROTON-NEW LONDON AIRPORT

Note: This appendix is highly technical in nature developed for FAA review and analysis. No attempt was made to write it in laymen's terms. Abbreviations and acronyms used in this appendix can be found in Appendix A.

INTRODUCTION

The potential of establishing new instrument approach procedures is presented in the following sections. Inasmuch as Runway 5 is currently served with a Category I ILS that offers the lowest approach minimums that can be authorized for such a procedure (200-½), it was determined to limit the analysis to Runways 15, 23 and 33. Presently, with the exception of Runway 15, instrument approach procedures based on the use of Area Navigation (RNAV) Global Positioning System (GPS) technology are available to these runway ends. However, these nonprecision procedures offer only Lateral Navigation (LNAV) capability to the landing runway threshold. Another type of nonprecision instrument approach that provides both lateral and vertical navigation guidance is termed Localizer Performance with Vertical Guidance (LPV). These procedures require the use of a Wide Area Augmentation System (WAAS) receiver, and general aviation aircraft are becoming more frequently equipped with this capability.

The analyses consider an RNAV (GPS) LNAV to Runway 15, and RNAV (GPS) LPV procedures to Runways 15, 23 and 33. These analyses were based on the guidance presented in applicable FAA orders:

- 8260.3B United States Standard for Terminal Instrument Procedures (TERPS)
- 8260.54A The United States Standard Area Navigation (RNAV)

FAA Order 8260.3B is the primary document associated with instrument procedures design. FAA Order 8260.54A addresses procedures designed to LNAV, LNAV/Vertical Navigation (VNAV), Localizer Performance (LP) and LPV minimums. There are a series of other FAA orders that complement these basic documents and are specific to different design features of the procedures. The Terminal Instrument Procedure (TERPS) analyses reviewed below represent a partial design of the potential instrument approach procedures and are intended to determine their feasibility and possible approach minimums.

BASIC TERPS METHODOLOGY

TERPS prescribes a complex series of approach and missed approach imaginary surfaces that serve as obstacle identification or clearance surfaces and are employed to assess the impact that an obstacle may have on achievable approach minimums. Obstacles that penetrate these surfaces result in increases to the approach minimums from initially set levels. TERPS guidance provides means, within defined limits, to potentially eliminate or minimize the impact of obstacle penetrations. Instrument approach procedures include four basic segments – initial, intermediate, final and missed. The imaginary surfaces differ in size and slope among these segments and the procedure must also consider the descent gradients that result when transitioning from one segment to another. TERPS analyses begin with the assessment of the final and missed approach segments and then continue in reverse order to the intermediate and initial

approach segments. In these latter segments, primary emphasis is placed on setting elevations for each fix that provide the Required Obstacle Clearance (ROC) and acceptable descent gradients between them. The resultant minimums are published for approach category A through E aircraft, as appropriate. These minimums may differ depending on TERPS standards.

The extent to which an obstacle is defined with respect to its horizontal and vertical data is indicated by an accuracy code. These codes, identified by a number and letter, indicate tolerance levels that range from 1 through 9 (20 feet to Unknown) for horizontal data, and from A through I (3 feet to Unknown) for vertical data. The minimum acceptable accuracy code for obstacles in the final approach segment is 2C (50 feet horizontal and 20 feet vertical). Obstacles with lesser accuracy codes are assigned the associated tolerance level during TERPS evaluations until a survey can certify more exact data.

TERPS approach surfaces for RNAV (GPS) procedures with LNAV minimums are the least complex and generally involve an Obstacle Clearance Surface (OCS) that is level. The missed approach segment incorporates an OCS that rises as the aircraft climbs during the missed approach procedure. The TERPS surfaces for an RNAV (GPS) LPV procedure incorporate level and sloping surfaces. The TERPS algorithms for procedures providing lateral and vertical navigation guidance also incorporate adjustments for earth curvature.

The LPV final approach segment OCS is comprised of three sloping areas (W, X and Y) that begin 200 feet from the runway landing threshold. Its width increases as it extends to the precise final approach fix. The W surface rises at slope of 34:1 based on a 3.00º glidepath angle for its entire length. The X and Y surfaces rise at slopes of 4:1 and 7:1, respectively, from the adjacent elevation of the W surface. Obstacles that are not located within or penetrate the W, X or Y OCS need not be considered in determining the achievable approach minimums. When there are penetrations to the OCS, the instrument approach procedure may be modified in one or more of several ways to eliminate or reduce the amount of the penetration. Aside from removal of the obstacle or reducing its height, these mitigation measures include one or a combination of actions – realignment of the final approach course within a range of 3.00° to either side of the runway centerline extended, displacing the landing threshold, raising the Glidepath Angle (GPA), adjusting the Decision Altitude (DA) and increasing the Threshold Crossing Height (TCH). TERPS guidance prioritizes the use of these mitigation measures.

To achieve LPV minimums for a RNAV (GPS) procedure, a defined GQS must be clear of penetrations. The GQS is a trapezoidal shape with variable dimensions and a slope rising at an angle equal to ⅔ of the GPA. The width of the GQS increases as it extends further from the landing runway threshold to the decision altitude point. Obstacles that penetrate the GQS may either be removed or lowered in elevation, the landing threshold may be displaced and/or the GPA may be increased within limits. In the latter case, the lowest achievable approach minimums may be raised for all or specific aircraft approach categories depending on the required GPA value.

The visual portion of the final approach segment is a TERPS criterion that is used to assess the need for limiting the visibility component or restricting use of the approach procedure at night. There are two Obstacle Identification Surfaces (OIS) defined for the visual portion. Penetration of the 20:1 OIS requires that the obstacle be removed or lowered in elevation. Otherwise they are to be marked and lighted, and the instrument approach procedure is not to include a visual descent point, the visibility minimum is

limited to 1 statute mile (s.m.) and nighttime landings are prohibited. The nighttime landing restriction can be lifted only for obstacles that cannot be marked and lighted if a Visual Guidance Slope Indicator System (VGSI) is provided at an angle ≥3° to clear the penetrating obstacle. A 34:1 OIS penetration will require that the visibility minimum be limited to ¾-mile if the obstacle cannot be removed or lowered in elevation.

The missed approach segment for obstacle evaluation associated with procedures that provide lateral and vertical guidance differs from that associated with that offering only lateral navigation information, particularly with respect to the location of the missed approach point and its elevation. Missed approach procedures can be designed with straight-out alignments, climbing turns and combinations. Under certain circumstances, the missed approach surface can be the greatest factor in the determination of approach minimums, especially in obstacle-rich environments.

The TERPS analysis considers natural and man-made obstacles that underlie the initial, intermediate, final and missed approach segments to determine the potential minimums, fix altitudes and descent gradients. Additionally, the runway layout needs to meet a number of landing surface requirements applicable to the achievable minimums in order to establish an instrument approach procedure.

PREMISE OF THE TERPS ANALYSIS

The conduct of the TERPS feasibility analyses was based on the use of currently available mapping and data as indicated below.

- National Aeronautical Charting Office Digital Obstacle File, October 2008
- National Geodetic Survey Aeronautical Data Sheet, August 4, 2004, Preliminary Airport Layout Plan

Table D.1 presents a summary of the key data associated with each runway threshold at the Airport.

Table D.1 - Runway End Data

Runway Landing End	Latitude	Longitude	True Bearing	Landing Threshold Elevation (AMSL)
5	41º19'30.1176"N	72º02'52.8977"W	33º58'18.067"E	5.3'
23	41º20'11.0870"N	72º02'16.2705"W		6.4'
15*	41º19'57.0693"N	72º03'08.0054"W	315º03'22.151"E	8.6'
33*	41º19'32.6827"N	72º0235.7131""W		5.9'

* Displaced Threshold

Source: QED with data from Federal Aviation Administration

The text that follows is, by necessity, technical and reflects the complexity associated with the use of TERPS design criteria. The key elements of the procedure design as discussed above are presented. These include:

- The obstacle that controls the determination of the approach minimums
- The location and elevation of approach fixes
- The characteristics of the missed approach procedure and obstacle impacts on the missed approach surface
- The visual portion of the final approach segment

Depending on the situation, the controlling obstacle may change as the procedure design progresses through its iterative process. TERPS design allows a measure of flexibility to minimize or eliminate the impact of obstacles. It is this iterative process that adds to the complexity of the procedure design and often results in identifying obstacles other than that initially controlling the determination of the achievable approach minimums.

RNAV (GPS) LNAV 15

Controlling Obstacle and Approach Fixes

A tower located at 41°22'40"N latitude, 72°06'35"W longitude and an elevation of 324 feet AMSL (84 feet above ground level - AGL) without an assigned accuracy code was initially determined to be the controlling obstacle for this RNAV (GPS) LNAV procedure. To account for the unassigned accuracy code, the tower was evaluated at an elevation of 374 feet above mean sea level (AMSL). Because this tower is located 22,824 feet or about 3.8 nautical miles (n.m.) from the Runway 15 landing threshold, as measured along the extended runway centerline, the potential to establish a stepdown fix (SDF) at this location to eliminate it from consideration in the analysis was evaluated and found to be viable.

The SDF elevation was set at 1,260 feet AMSL in order to provide the ROC at the tower and to meet the required descent gradient between it and the Precise Final Approach Fix (PFAF) based on a 3.00º glidepath angle. Additionally, this elevation meets the required descent gradient between the SDF and the landing threshold incorporating a 45-foot threshold crossing height. The PFAF altitude of 2100 feet AMSL is established by a tower located at 41º25'03.00"N latitude and 72º11'53.28"W at an elevation of 1,511 feet AMSL (accuracy code 1A) and is 6.43 n.m. from the landing threshold. The resulting descent gradients between the PFAF and SDF and between the SDF and the landing threshold are 298 feet/n.m. and 322 feet/n.m., respectively. These values are near optimum for RNAV nonprecision approaches in the final approach segment.

Ultimately, the controlling obstacle for the RNAV (GPS) LNAV procedure is a tower at 41°21'13"N latitude, 72°05'52"W longitude and an elevation of 254 feet AMSL (84 feet AGL) with an assigned accuracy code of 2D. Consequently, this tower was evaluated at an elevation of 304 feet AMSL. This factor and a penalty due to the excessive length of the final approach segment set the approach minimums at 571-1 (height above threshold, or HATh, and visibility – VIS, in statute miles) for approach category B aircraft as shown in **Table D.2.**

The intermediate approach fix altitude is 2,400 feet AMSL at the optimum distance of 10 n.m. from the landing threshold, and the initial approach fix at 3,700 feet AMSL and 5 n.m. from the intermediate fix. These altitudes and distances between fixes yield acceptable descent gradients. Transition from one fix to the next is unencumbered in the terminal and en route airspace. Two separate initial approach fixes should be positioned at about a 90° angle to the northwest and a 90° angle to the southeast as measured from the extended runway centerline.

Missed Approach

The missed approach point is the Runway 15 runway departure end and the missed approach surface is clear of obstacles. The missed approach procedure provides for a straight climb to a fix that can be positioned southeast of the Airport at an elevation of 2,000 feet AMSL. The SUFOK waypoint, which is associated with the RNAV (GPS) approach procedure to Runway 33, may serve this function.

Visual Portion of the Final Approach Segment

There are several obstacles (poles, railroad and trees) that penetrate the 20:1 OIS and, therefore, nighttime operations are restricted unless these obstacles are removed or lowered in elevation, marked or lighted, or a VGSI is installed at an angle to clear the most critical obstacle. This obstacle is a tree or a cluster of trees southeast of Thomas Road at 41º20'03.94"N latitude, 72º03'13.40"W longitude at an elevation of 52 feet AMSL (accuracy code 1A). The railroad penetrates the 20:1 OIS by 8 feet. These and several additional obstacles penetrate the 34:1 OIS; however, inasmuch as the lowest achievable visibility minimum is 1 s.m., the penetration of this OIS is moot.

Approach Minimums

Based on the above factors, the approach minimums for an RNAV (GPS) LNAV procedure to the Runway 13 end is presented in **Table D.2**.

Table D.2 - RNAV (GPS) LNAV Minimums - Runway 15

Approach Minimums (HATh -VIS) for Aircraft Approach Category			
A	**B**	**C**	**D**
571 – 1	571 – 1	571 – 1½	571 – 1½

RNAV (GPS) 15 LPV

The analysis was initially premised on the use of a 3.00° GPA and a 45-foot threshold crossing height that are the optimum values for the type aircraft regularly using the Airport.

Controlling Obstacle and Approach Fixes

Numerous obstacles within 5,000 feet of the landing runway threshold penetrate the W surface of the OCS. Of these, the most critical is a tree or a cluster of trees located at 41º20'26.17"N latitude, 72º03'58.07"W longitude at an elevation of 176 feet AMSL (accuracy code 1A). This set the ceiling

approach minimum at 353 feet AMSL, which incorporates a slight penalty to account for the location of the PFAF at 6.20 n.m.

Evaluation of the GQS identified several penetrations that, as a consequence, preclude the establishment of the LPV procedure. Mitigation of these obstacle penetrations to the GQS addressed the alternatives of increasing the GPA or further displacement of the landing runway threshold. The required increases to the GPA were between 3.11º and 4.76º depending on the obstacle under consideration. These results limit the use of the runway to certain aircraft types as well as the achievable approach minimums. The required additional displacement of the landing runway threshold ranged between 78 feet and 462 feet, which results in landing runway lengths of between 3,231 feet and 3,615 feet.

Given the outcomes described above, consideration was given to increasing the GPA to 3.10º and the TCH to 50 feet. The higher GPA allows for unrestricted use of the RNAV (GPS) LPV procedure to approach category A through E aircraft. The 50-foot TCH is an acceptable value for general aviation aircraft. The results of this evaluation identified that the same tree/cluster is the controlling obstacle and yields a ceiling minimum of 355 feet AMSL. This outcome is essentially equivalent to that obtained in the initial analysis. The basis for the nominal increase in the ceiling minimum is a function of the algorithms used in the TERPS guidance and in particular the distance from the runway landing threshold to the start of the OCS. The higher GPA and TCH do not eliminate obstacle penetrations to the GQS; however, the extent is slightly less and the required additional landing threshold displacements range between 6 feet and 419 feet. This yields a slightly longer, landing runway length of between 3,274 feet and 3,687 feet.

The initial, intermediate and final approach fixes determined for the RNAV (GPS) LNAV procedure are also applicable to the RNAV (GPS) LPV procedure.

Missed Approach Segment

The missed approach segment for the RNAV (GPS) LPV to the Runway 15 landing threshold is clear of obstacles. The missed approach procedure provides for a straight climb to a fix that can be positioned southeast of the Airport at an elevation of 2,000 feet AMSL, similar to that for the RNAV (GPS) LNAV procedure evaluated for Runway 15.

Visual Portion of the Final Approach Segment

The 20:1 OIS and 34:1 OIS of the visual portion of the final approach segment are equivalent for RNAV (GPS) LNAV and RNAV (GPS) LPV procedures. Consequently, under current conditions VIS is limited to 1 sm.

Approach Minimums

Table D.3 presents the approach minimums for the RNAV (GPS) LPV procedure to the Runway 15 landing threshold.

Table D.3 - RNAV (GPS) LPV Minimums - Runway 15

Approach Minimums (HATh -VIS) for Aircraft Approach Category			
A	**B**	**C**	**D**
346-1	346-1	346-1	346-1

RNAV (GPS) LPV 23

Application of the TERPS guidance was based on the use of a 3.00º GPA and 45 feet TCH, which are those commonly applied at general aviation airports.

Controlling Obstacle and Approach Fixes

The obstacle environment in the approach to Runway 23 is less severe than that to Runway 15 and Runway 33. Nonetheless, the W surface of the OCS is penetrated by several obstacles including trees or clusters of trees, bushes, terminal navigation aids (localizer), a road, a pole and terrain within 2,500 feet of the Runway 23 landing threshold. However, these penetrations to the OCS do not generate a need to raise the ceiling approach minimum above that defined under TERPS criteria for such circumstances. The initial achievable ceiling approach minimum is 256 feet AMSL and the VIS is ¾ s.m. for all aircraft approach categories.

The GQS is clear of obstacles, thereby allowing the establishment of an RNAV (GPS) LPV procedure.

The PFAF is set an elevation of 2,100 feet AMSL based on a tower located at 41º27'39"N latitude, 71º55'44"W longitude at an elevation of 793 feet AMSL (353 feet AGL) with an accuracy code of 1D, and as adjusted to yield the optimum descent gradient of 318 feet/n.m. to the Runway 23 landing threshold. This sets the intermediate approach fix at 2,400 feet AMSL, which is located 10 n.m. from the landing threshold.

The initial approach fix is positioned 5 n.m. from the intermediate approach fix at an altitude of 3,700 feet AMSL. This altitude and distance between fixes yields an acceptable descent gradient of 260 feet/n.m.. Two initial approach fixes, each about 90º to either side of the final approach course should be incorporated into the procedure. This is similar to those fixes (Norwich VOR/DME and LAFAY waypoint) specified in the existing RNAV (GPS) LNAV procedure to Runway 23.

Because the PFAF location is 6.23 n.m. from the landing runway threshold, the initially determined ceiling minimum is increased to 278 feet AMSL to account for the excessive length of the final approach segment and results in an increase of the VIS to 1 sm.

Missed Approach

The missed approach surface is penetrated by a light on a building located at 41º20'25.57"N latitude, 72º01'52.07"W at an elevation of 79 feet AMSL (accuracy code 1A) and a tree or cluster of trees at 41º20'32.02"N latitude, 72º01'59.49"W longitude at an elevation of 71 feet AMSL (accuracy code 1A).

These penetrations, on the order of 0.6 feet to 1.5 feet, have an impact on the achievable approach minimums. Unless these penetrations can be mitigated, the ceiling component of the approach minimum is increased to 280 feet AMSL and the VIS remains at 1 sm.

The missed approach provides can incorporate a straight climb to 2,000 feet AMSL to the PINET waypoint as defined for the existing RNAV (GPS) LNAV procedure to Runway 23.

Visual Portion of the Final Approach Segment

Three obstacles (a tree or cluster of trees, bush and the DME equipment) penetrate the 20:1 OIS by between 1 and 2 feet. This triggers a requirement to eliminate or reduce the elevation of these obstacles in order to enable nighttime instrument approaches. Absent that ability, the obstacles are to be marked and lighted the obstacles if nighttime landings are to be allowed. In the event marking and lighting is not viable, then a VGSI set at the appropriate angle is to be provided to enable nighttime landings. Because the VASI-4 serving Runway 23 is set at 3.00º (as is the GPA for the evaluated procedure) and a 49.1 feet TCH, which is slightly higher than the 45-foot standard utilized in the analysis, it is likely that this VASI-4 provides adequate clearance such that nighttime approaches need not be restricted. These same obstacles penetrate the 34:1 OIS; however, inasmuch as the lowest achievable visibility minimum is 1 s.m., the penetration of this OIS is not a factor.

Approach Minimums

Based on the above factors, the approach minimums for a RNAV (GPS) LPV procedure to Runway 23 are presented in **Table D.4**.

Table D.4 - RNAV (GPS) LPV Minimums - Runway 23

Approach Minimums (HATh -VIS) for Aircraft Approach Category			
A	**B**	**C**	**D**
280-1	280-1	280-1	280-1

RNAV (GPS) LPV 33

The evaluation utilized the same GPA (3.05º) and TCH (47 feet) as that for the design of the existing RNAV (GPS) LNAV procedure to Runway 33.

Controlling Obstacle and Approach Fixes

The controlling obstacle is a tree or cluster of trees at 41º19'13.37"N latitude, 72º01'59.76"W at an elevation of 156 feet AMSL (accuracy code 1A). This obstacle as well as others (bushes, trees and the glide slope antenna serving Runway 5) that are located within 3,800 feet of the landing runway threshold penetrate the W surface of the OCS. It is noted that obstacles located within the along-track tolerance are considered in the approach surface. This applies to the glide slope antenna mentioned above. Although the W surface of the OCS is penetrated, no adjustment to the approach minimums is required

by the TERPS guidance. This initially sets the ceiling component of the approach minimums at 335 feet AMSL and the VIS component at 1 sm.

Evaluation of the GQS identified several penetrations that, as a consequence, preclude the establishment of the LPV procedure. These obstacles are trees or clusters of trees located within an area of some 3,200 feet to 3,800 feet out from the runway landing threshold and along its extended centerline, and between 200 feet left of and 260 feet right of that course. This is an area is generally described as residential and educational/recreational northwest of Midway Oval and Fort Hill Road.

Mitigation of these obstacle penetrations to the GQS addressed the alternatives of increasing the GPA or further displacement of the landing runway threshold. The required increases to the GPA were between 3.24º and 3.88º depending on the obstacle under consideration. These results limit the use of the runway to certain aircraft types as well as the achievable approach minimums. The required additional displacement of the landing runway threshold ranged between 235 feet and 895 feet, which results in a landing runway length of between 2,900 feet and 3,560 feet.

The PFAF can be set as utilized in the existing RNAV (GPS) LNAV procedure to Runway 33. This continues the use of an intermediate approach fix at 2,000 feet AMSL. The initial approach fix can be similarly set at 2,000 feet AMSL as provided in the current LNAV procedure, which also allows for two courses to the intermediate approach fix based on the SEY VOR/DME and JORDN waypoint.

Missed Approach

A tank located at 41º20'28"N latitude, 72º04'07"W at an elevation of 226 feet AMSL (accuracy code 1B) penetrates the missed approach surface by 6.3 feet. The tank is sufficiently close to the beginning of the missed approach surface that it cannot be eliminated from consideration by incorporating an immediate turn. Consequently, the penetration has the effect of increasing the achievable approach minimums to 341 feet AMSL, and the visibility remains at 1 s.m. Another obstacle, a tower located at 41º25'03"N latitude, 72º11'53.28"W longitude at an elevation of 1,511 feet AMSL (1,202 feet AGL) with an accuracy code of 1A, also penetrates the straight-out missed approach procedure. However, unlike the tank above, this tower is located sufficiently distant (some 9.7 n.m.) from the start of the missed approach and nearly 1.1 n.m. offset from the extended runway centerline. This affords the opportunity to incorporate a climbing left turn that will allow the missed approach course and associated surface to avoid inclusion of or penetration by the tower.

Visual Portion of the Final Approach Segment

A bush located at 41º19'29.22"N latitude, 72º02'35.52"W at an elevation of 11 feet AMSL (accuracy code 1A) penetrates the 20:1 OIS by 2.2 feet. If this bush cannot be eliminated or lowered in elevation, it must marked and lighted to avoid the prohibition of nighttime approaches. If lighting and marking is not a viable option, a VGSI should be installed. Runway 33 is currently equipped with a PAPI-4. It is likely that this PAPI-4 will provide adequate clearance to maintain 24-hour operations. This PAPI-4 is set at 3.75º, which is significantly higher than the 3.05º GPA used in the evaluation, and the TCH is lower at 33.5 feet. This same bush and other obstacles that penetrate the GQS penetrate the 34:1 OIS by between 3 feet and 59 feet. This outcome limits the achievable VIS component of the approach minimums to 1 s.m.

Approach Minimums

Based on the above factors, the approach minimums for a RNAV (GPS) LPV procedure to Runway 33 are presented in **Table D.5**.

Table D.5 - RNAV (GPS) LPV Minimums - Runway 33

Approach Minimums (HATh -VIS) for Aircraft Approach Category			
A	**B**	**C**	**D**
341-1	341-1	341-1	341-1

COMPARISON WITH APPLICABLE LANDING SURFACE REQUIREMENS

The FAA has established a set of landing surface requirements that airports are to meet when seeking a new instrument approach procedure. These design standards are presented in FAA Advisory Circular 150/5300-13, Airport Design. They are related to achievable approach minimums as determined in this analysis. The results of the compliance review are summarized in **Table D.**6 and **Table D.7** on the following pages for each runway end.

FINDINGS AND RECOMMENDATIONS

The results of these analyses suggest that an RNAV (GPS) procedure with LNAV minimums to Runway 15 has merit. The achievable approach minimums are appropriate for this type of instrument approach and an improvement over the current visual-only capability that is afforded to aircraft operators, especially when strong winds are from the southeast. The runway meets applicable landing surface requirements, although it would be desirable to mark and light those obstacles that penetrate the 20:1 OIS of the visual portion of the final approach segment.

Establishing an RNAV (GPS) LPV procedure to Runway 15 is not recommended unless the GQS can be cleared of all penetrations. Otherwise, the required runway landing threshold displacement results in a less than desirable, although acceptable, landing runway length. This same conclusion applies to the potential upgrade of the RNAV (GPS) LNAV procedure to LPV minimums on Runway 33, particularly as the potential approach minimums (341-1) are not sufficiently lower than those currently available (452-1).

The establishment of an RNAV (GPS) LPV procedure to Runway 23 offers an improved operational capability when the achievable approach minimums of 280-1 are compared to the existing 522-1 levels. This outcome demonstrates the benefit of the smaller and upward sloping obstacle clearance surface associated with the LPV procedure design. It would be prudent to pursue the RNAV (GPS) LPV for this reason and because it provides aircraft operators with a second instrument approach offering lateral and vertical navigation guidance in the event that the Category I ILS serving Runway 5 is unavailable for maintenance or other reasons. The installation of an omni-directional approach lighting system (ODALS) can lower the approach minimums to 280-¾. The benefit/cost of this improvement should be evaluated and if shown to be viable, the ODALS should be installed.

Table D.6 - Compliance with Applicable FAA Landing Surface Requiremens - LNAV Minimums

Landing Surface Requirement	Runway 15 DT (571 – 1)	Comments
TERPS ¶ 251 - Visual Portion of the Final Approach Segment	20:1 and 34:1 OIS	Poles, railroad and trees penetrate 20:1 and 34:1 OIS. Mark and light 20: penetrations. If not marked and lighted, install a VGSI set at 7.75º to provide a clear VGSI obstacle clearance surface to maintain nighttime approaches. 34:1 OIS penetrations are not a factor as lowest VIS achievable is 1 sm.
Airport Layout Plan	Yes	In process
Runway Length	Normally, 3,200' minimum	3693' landing length available
Runway Markings	Nonprecision	None required
Holding Position Signs and Markings	Nonprecision	None required
Runway Edge Lights	MIRL / LIRL	HIRL
Parallel Taxiway	Recommended	Partial parallel T/W to R/W 15; T/W access to R/W 33
Approach Lights	Recommended	None required. TERPS ¶251 limits to 1 mile VIS
Runway Design Standards	≥ ¾-mile VIS	Meets ARC B-II with 307' threshold displacement
Threshold Siting Criteria	Appendix 2, Table A-2-1, Rows 1-5 (straight-in night operations by A and B aircraft only)	Poles, railroad and trees penetrate 20:1 threshold siting surface. Displace threshold an additional 285'or apply TERPS ¶251 restrictions (see above)
Survey Required for Lowest Minima	571 - 1	Conduct non-vertically guided airport airspace analysis survey

Source: QED with FAA Data

In order to implement these instrument approach procedures, appropriate aeronautical surveys (airport airspace analysis surveys) are to be conducted. This ensures that the FAA has the latest and most accurate data when it initiates the final design, flight check and publication of the instrument approach procedures. These surveys will update the obstacle information utilized in the TERPS feasibility analyses presented above, especially with respect to the status and elevation of trees and other natural growth that were last surveyed in August 2004.

The TERPS analyses conducted for reflect an initial assessment of the potential instrument approach minimums achievable for RNAV (GPS) procedures based on readily available data. The results are subject to review by the FAA, which may have access to other information related to the runway end environment and obstacles. Further, the FAA may opt to modify the potential approach and missed approach procedures, fix locations and altitudes. Any published instrument approach procedure is also subject to the conduct of a flight check by the FAA, the results of which may necessitate revisions to the procedure design.

Table D.7 - Compliance with Applicable FAA Landing Surface Requirements - LPV Minimums

Landing Surface Requirement	Runway 15 DT (346 – 1) Runway 23 (280 – 1) Runway 33 DT (341 – 1)	Comments
TERPS ¶ 251 - Visual Portion of the Final Approach Segment	20:1 and 34:1 OIS	Runway 15 – Poles, railroad and trees penetrate 20:1 and 34:1 OIS. Mark and light penetrations the 20:1 penetration obstacles. If not marked and lighted, install a VGSI set at 7.75º to provide a clear VGSI obstacle clearance surface to maintain nighttime approaches. 34:1 OIS penetrations are not a factor as lowest VIS achievable is 1 sm. Runway 23 – 20:1 OIS clear. Trees and DME penetrate 34:1. VIS limited to ¾ sm.
Airport Layout Plan	Yes	Currently under revision
Runway Length	Normally, 3200' minimum	Runway 15 – Additional displacement required to meet GQS. Resultant runway landing length can range between 3274' and 3687' depending on obstacle mitigation. Runway 23 – 5000' Runway 33 – Additional displacement required to meet GQS. Resultant runway landing length can range between 2900' and 3560' depending on obstacle mitigation
Runway Markings	Nonprecision	None required
Holding Position Signs and Markings	Nonprecision	None required
Runway Edge Lights	MIRL / LIRL	HIRL (Runway 15-33 and Runway 5-23)
Parallel Taxiway	Recommended	Partial parallel T/W to Runway 15; T/W access to Runway 33 Parallel T/W to Runway 23
Approach Lights	Recommended	Runway 15, Runway 33 – VIS limited to 1 sm Runway 23 – Approach lights may be cost-beneficial
Runway Design Standards	≥ ¾-mile VIS	Runway 15 – Meets ARC B-II with 307' displacement Runway 23 – Does not meet RSA requirement; 445' threshold displacement required Runway 33 – Meets ARC B-II with 205' displacement