Appendix C

INSTRUMENT APPROACH PROCEDURE ANALYSIS

Introduction

The evaluation of instrument approach procedures was conducted in accordance with guidance presented in FAA Order 8260.3B, "United States Standard for Terminal Instrument Procedures (TERPS)" and FAA Order 8260.50, "United States Standard for Wide Area Augmentation System (WAAS) LPV Approach Procedure Construction Criteria". The term LPV refers to an approach with localizer precision combined with vertical guidance. The following sources were used to identify potential obstacles to the TERPS surfaces:

- Mapping and survey data produced for the Airport Master Plan Update (AMPU)
- The National Aeronautical Charting Office Digital Obstacle File
- National Geodetic Survey Obstruction Chart
- FAA Form 8260-9, "Standard Instrument Approach Procedure Data Record" for the existing procedures to the runways.

The analysis represents a partial design of the potential procedures, intended to determine their feasibility and possible approach minimums. These findings are intended to be presented to the FAA Flight Procedures Office at the New England Region Office for their consideration in finalizing recommended procedure(s) for formal establishment and publication as determined as part of the AMPU.

The TERPS evaluation was conducted for the following scenarios:

1. Installation of a MALSR on Runway 36.

2. Establishment of LPV minimums to the existing Runway 36 RNAV (GPS) procedure.

3. Establishment of LPV minimums to the existing Runway 18 RNAV (GPS) procedure.

4. Scenario 3 above with the addition of a MALSR.

5. Installation of ODALS on Runway 18 to complement the existing RNAV (GPS) procedure published with LNAV minimums.

LPV approaches rely on the use of the WAAS, which was commissioned on July 10, 2003 by the FAA. Aircraft must be equipped with a Class 3 or Class 4 TSO C-146 WAAS receiver, which is available for purchase from avionics manufacturers. Initial acquisition of these receivers is expected by airlines operating under FAR Part 121 and FAR Part 135 and

corporate business jets used for charter or private service. As sales of these receivers increase, costs will likely decrease, making the units more affordable to the general aviation fleet. Currently, the lowest LPV minimums that will be authorized by the FAA are 250-foot ceiling and ¾-mile visibility. The addition of an appropriate approach lighting system may reduce the visibility component to ½-mile when other standards are met regarding the approach procedure. Lower LPV minimums (200-½) may be authorized in the future based on the established performance record of the WAAS.

The TERPS analyses were conducted for Approach Category D aircraft, which meets the existing and future ARC classification for the Airport. Table C-1 identifies the obstacle controlling the approach minimums for each existing instrument approach procedure.

TABLE C-1 – CONTROLLING OBSTACLE
EXISTING INSTRUMENT APPROACH PROCEDURES

Procedure	Type	Latitude & Longitude		Elevation (MSL)	Accuracy Code**
		Lat. (N)	Long. (W)		
Category I ILS 36	Transmission Tower	41° 28' 01"	73° 07' 55"	747	1A
LOC 36	Transmission Tower	41° 27' 20"	73° 08' 03"	786	1A
RNAV (GPS) 36 – LNAV	Lookout Tower	41° 24' 43"	73° 07' 46"	919	1A
	Tree*	41° 29' 20"	73° 07' 28"	964	2C
NDB 36	100' Tree	41° 28' 23"	73° 05' 48"	929	2C
RNAV (GPS) 18 – LNAV	Tree	41° 29' 07"	73° 08' 12"	960	2C
NDB 18	Tree	41° 29' 20"	73° 07' 28"	964	2C

* Penetrates missed approach surface by 20'
** Accuracy Code refers to the source of the position and elevation of the reported object. Position (latitude and longitude) accuracy is represented by a number (1 = highest accuracy). Elevation accuracy is represented by a letter (A = highest accuracy). Accuracy codes of 2C or higher are acceptable for assessing TERPS surfaces.

The data in Table C-1 presents two situations that warrant further investigation by the ConnDOT and FAA. First, the 150-foot lookout tower that is one of the obstacles that influences the determination of the approach minimums for the RNAV (GPS) 36 with LNAV minimums procedure is sufficiently distant (21,712 feet) from the landing threshold. This situation suggests that a stepdown fix may be incorporated into the procedure to achieve a lower ceiling minimum. Second, based on the latitude and longitude coordinates recorded, the tree controlling the RNAV (GPS) 18 with LNAV minimums procedure is located within a 20-foot radius of the landing threshold. This tree was likely removed during the runway safety area improvement project at the Airport. Certification to the FAA that this specific or possibly group of trees do not exist should result in their re-evaluation of the published approach procedure that could yield a lower ceiling minimum.

Install MALSR on Runway 36

The installation of a MALSR, which is the simplest level of approach lighting system to complement a Category I Instrument Landing System (ILS), could result in a lower visibility component to the approach minimums. In order to install the MALSR and meet its applicable siting standards, it is assumed that the series of transmission line towers that are in a generally northeast-southwest alignment and pass through the approach to Runway 36 would be buried or relocated as part of a separate obstruction removal project. This would allow the Category I ILS approach minimums to be reduced to the lowest achievable for this type of approach (200-½).

In order to assess whether it is cost-justifiable to make an investment to install and maintain a MALSR, a present value, life-cycle benefit/cost analysis (BCA) was performed. Table C-2 summarizes the key issues pertinent to the evaluation.

The BCA is based on the use of a present value analysis that discounts future benefits and costs at the seven percent discount rate required by the U.S. Office of Management and Budget for such analyses. A 20-year period of time was selected as the evaluation period. Establishment and discounted annual operating and maintenance costs are offset by operational and safety benefits achieved through the reduction of the approach minimums. Benefit values for avertable flight disruptions and safety by type of aircraft activity as identified in the FAA publication, "Establishment and Discontinuance Criteria for Precision Landing Systems" were updated to current levels and the evaluation process adapted to meet the needs of this specific improvement scenario.

The analysis essentially translates the incremental number of annual instrument approaches on the runway end that can be realized as a consequence of the lower approach minimums over a 20-year period. This activity is then allocated as either air taxi, which for the Airport was selected as all operations conducted by business jet and turboprop aircraft, or other general aviation operations. Discounted unit benefit values for each type of aircraft approach are then applied to determine the total 20-year benefit associated with the lower approach minimums. A benefit/cost ratio of 1.00 or greater suggests a project worth pursuing.

In this scenario, installation of a MALSR on Runway 36 to complement the existing ILS yields a benefit/cost ratio of 1.03. This is sufficient to warrant further investigation into investment in the MALSR.

TABLE C-2 INSTALL MALSR ON RUNWAY 36 BCA	
Evaluation Factor	**Value**
Existing Approach Minimums	250-1
Potential Approach Minimums	200-½
20-Year Discounted Benefit Value ($)	**1,003,518**
MALSR Installation Cost ($)	700,000
20-Year Discounted Operations and Maintenance Cost ($)	274,016
Total Life-Cycle Cost ($)	**974,016**
Benefit / Cost Ratio	**1.03**

Note: Costs listed are estimated and will vary depending on the construction type, cost for right-of-way/easements, and environmental permitting. Relocation/burial of the transmission line is a prerequisite for MALSR development.

RNAV (GPS) 36 with LPV Minimums

TERPS evaluation criteria for RNAV (GPS) procedures with LPV minimums differ from those applicable to traditional ground-based Category I ILS. The evaluation determined that:

1. Obstacles do not penetrate the glidepath qualification surface (GQS) based on the 3.00-degree glidepath angle (GPA). Thus, removal of the transmission tower lines and burial of the power lines is not a prerequisite for developed of a RNAV (GPS) LPV approach to Runway 36. In order to proceed to the TERPS analysis, the GQS must be clear of penetrations. As such, the clear GQS enables the TERPS analysis to continue, and consider the obstacle clearance surface (OCS) and achievable approach minimums.

2. The controlling obstacle to the OCS is Transmission Tower 1444 at an elevation of 747' MSL with a 1A accuracy code located at latitude 41° 28'01.51629"N and longitude 73° 07'55.44686"W. The tower penetrates Section 1 of the OCS by 61.6 feet.

3. Penetration of the OCS in Section 1 requires, in order of preference, the removal of the obstacle, reduction of the obstacle height, or an increase to the decision altitude (DA) or approach ceiling. In the event the tower and those to which it is linked cannot be removed or reduced in elevation, the DA is increased from 200' to 259' above the Runway 36 touchdown zone elevation of 721' MSL. Thus the DA would be 980' MSL (259' + 721'). The visibility will be limited to 1-mile without the installation of a MALSR.

4. Transmission Tower 1444 penetrates the 34:1 obstacle identification surface applied to the visual portion of the final approach segment by 9.7 feet. Therefore, the tower must be marked and lighted (as is currently the case) and the visibility minimum limited to not less than ¾-mile.

5. Removal of the transmission line towers and burial of the power lines can yield approach minimums of 259-¾. The addition of a MALSR can yield minimums of 259-½. Once the FAA deems the WAAS fully operational, these approach minimums can be expected to be lowered to 209-¾ or 209-½, without and with a MALSR, respectively.

6. Publication of an RNAV (GPS) 36 with LPV minimums provides Airport users with an alternate approach with lateral and vertical guidance in the event the existing Category I ILS is out of service. There is no cost to establish this procedure, without a MALSR. As such, no cost-benefit review is applicable.

RNAV (GPS) 18 with LPV Minimums

The evaluation of a RNAV (GPS) procedure to Runway 18 with LPV minimums assumed that the previously mentioned tree at elevation 960' MSL located within 20 feet of the landing threshold does not exist. The evaluation determined that:

1. The GQS is clear of obstacles and thus the OCS may be evaluated and approach minimums determined.

2. Another tree or group of trees at elevation 881' MSL and located at latitude 41° 30'01.29"N and longitude 73° 08'23.55"W with an accuracy code of 1A penetrates Section 2 of the OCS by 38.42'. Penetration in this section of the OCS may be addressed by first attempting to remove or reduce the elevation of the obstacle. When these actions are not feasible, the GPA can be increased to provide the required obstacle clearance, or as a last measure the DA can be adjusted.

3. Removal or reduction in elevation of the tree or trees is not considered feasible as they are located off-airport property and not controlled by ConnDOT.

4. The GPA would need to be increased to 3.99 degrees, a value that exceeds the maximum allowable for approaches conducted by approach C and higher aircraft. This is not an acceptable outcome for the purposes of this analysis.

5. The DA can be increased to 1140' MSL, which yields a height of 414' MSL above the touchdown zone elevation of 726' MSL.

6. The 34:1 slope surface of the visual approach portion of the final approach segment is not penetrated and thus visibility minimums can be as lows as ¾-mile.

7. The resulting approach minimums for all approach category aircraft are 414-1 without an approach lighting system. This is an improvement over the existing approach minimums of 494-1½ for Approach Category D aircraft.

8. The present value, life-cycle benefit-cost ratio for this procedure need not be evaluated because there is no establishment, maintenance or operating costs.

9. This procedure enables the Airport to provide an alternate approach with lateral and vertical guidance in the event the Category I ILS serving Runway 36 is out of service. It also yields lower approach minimums than those presently available and enhances the potential utilization of the Airport at no capital cost.

RNAV (GPS) 18 with LPV Minimums and MALSR

The addition of a MALSR to the RNAV (GPS) 18 with LPV minimums scenario results in a reduction in the approach minimums to 414-½ for all approach categories of aircraft. As illustrated in Table C-3 below, the present value, life-cycle benefit/cost ratio is 0.64. This result suggests that the installation of the MALSR to gain a ½-mile reduction in the approach visibility minimum is not cost-beneficial.

TABLE C-3
INSTALL MALSR ON RUNWAY 18 BCA

Evaluation Factor	Value
LPV Approach Minimums	414-1
Potential Approach Minimums	414-½
20-Year Discounted Benefit Value ($)	**618,547**
MALSR Installation Cost ($)	700,000
20-Year Discounted Operations and Maintenance Cost ($)	274,016
Total Life-Cycle Cost ($)	**974,016**
Benefit / Cost Ratio	**0.64**

Note: Costs listed are highly generalized. Actual costs would depend on the selected construction alternative. Costs do not including property acquisition or environmental permitting.

RNAV (GPS) 18 with LNAV Minimums and ODALS

This scenario considers the installation of ODALS to complement the existing RNAV (GPS) with LNAV minimums to Runway 18. The ODALS is the least sophisticated level of approach lighting system that can usually yield a ¼-mile reduction to the visibility minimums. The present value, life-cycle benefit/cost analysis for this scenario is summarized in Table C-4 and illustrates that the installation of the ODALS is not cost-beneficial.

TABLE C-4 INSTALL ODALS ON RUNWAY 18 BCA	
Evaluation Factor	**Value**
Existing Approach Minimums	494-1½
Potential Approach Minimums	494-1¼
20-Year Discounted Benefit Value ($)	**252,645**
ODALS Installation Cost ($)	250,000
20-Year Discounted Operations and Maintenance Cost ($)	109,606
Total Life-Cycle Cost ($)	**359,606**
Benefit / Cost Ratio	**0.70**

Note: Costs listed are highly generalized. Actual costs would depend on the selected construction alternative. Cost does not including property acquisition or environmental permitting.

Summary

Five scenarios were evaluated to enhance the use of the Airport during poor weather conditions by achieving lower instrument approach minimums.

The installation of a Runway 36 MALSR and associated reduction in minimums appears to be cost-beneficial and is recommended. However, this assumes that the transmission towers beyond the runway end can first be removed as a separate project.

Notwithstanding the outcome of the Runway 36 MALSR installation, the publication of RNAV (GPS) procedures with LPV minimums is recommended for both runway ends. There is no capital cost associated with this type of procedure at the Airport (without the MALSR) and they offer an operational benefit should the existing Category I ILS be out of service. The RNAV (GPS) 18 with LPV minimums can also yield lower approach minimums than those presently available for those aircraft equipped with the required avionics.

The final two scenarios associated with a MALSR or ODALS installation on Runway 18 do not appear to be cost-beneficial, and are not recommended.