FAA Rotorcraft Research, Engineering, and Development Bibliography, 1962-1989

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Washington, D.C. 20591

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Bibliography

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This document is disseminated under the sponsorship of the U.S. Department of Transportation in the interest of information exchange. The United States Government assumes no liability for its contents or use thereof.
This is a bibliography of FAA rotorcraft reports published from 1962 through 1989. This report is a supplement to 'FAA Helicopter/Heliport Research, Engineering, and Development - Bibliography, 1964 - 1986' (FAA/PM-86/47) published in November 1986 (NTIS accession number ADA 174 697) and to 'FAA Rotorcraft Research, Engineering, and Development Bibliography, 1962-1989' (FAA/DS-89/03) published in March 1989 (NTIS accession number ADA 207 162). Both bibliographies are limited to documents in which the research, engineering, and development elements of the FAA were involved as sponsors, participants, or authors.

This bibliography contains the abstracts of 68 technical reports. The indexes in this document address these 68 reports as well as the 53 reports in FAA/DS-98/03 and the 133 reports in FAA/PM-86/47. 

**Keywords:**
- Helicopter
- Bibliographies/Indexes
- Helicopters
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1. **INTRODUCTION.** This bibliography has been assembled as an aid for those who are interested in rotorcraft research, engineering, and development. The intended audience includes people within the Federal Aviation Administration (FAA), in industry, and in state and local governments. This report is a supplement to "FAA Helicopter/Heliport Research, Engineering, and Development - Bibliography, 1964 - 1986" (FAA/PM-86/47) published in November 1986 (NTIS accession number ADA 174 697) and to "FAA Rotorcraft Research, Engineering, and Development Bibliography, 1962 - 1988" (FAA/DS-89/03) published in March 1989 (NTIS accession number ADA.207 162). The bibliography and indexes in this report include all of what was published in the earlier documents. However, Appendix F of this report does not contain any abstracts which were included in FAA/PM-86/17 or in FAA/DS-89/03. Abstracts herein are only for those reports which have been published subsequent to the earlier bibliography plus any earlier reports which had been overlooked inadvertently.

2. **SCOPE.** In selecting technical reports to be included in this bibliography, two limitations have been observed. First, the reports are specifically related, in whole or in part, to rotorcraft. Second, they are limited to reports in which the research, engineering, and development elements of the FAA have been involved as sponsors, participants, or authors.

3. **AVAILABILITY OF REPORTS.** The technical reports listed in this bibliography are readily available from three sources:

   a. **National Technical Information Service (NTIS).** Many of the technical reports listed in this bibliography are available through NTIS. These documents can be identified by the accession number given after the listing of the document in Appendixes A and B. (In the example below, the accession is shown in bold.)

      Example: Heliport Surface Maneuvering Test Results
      (Rosanne M. Weiss, Christopher J. Wolf, Scott L. Erlichman, John G. Morrow, Walter E. Dickerson)
      (NTIS: ADA 214 116)

      NTIS is located at 5285 Port Royal Road, Springfield, VA 22161. The NTIS telephone sales desk is available between 8:30 AM and 5:30 PM EST, telephone: (703) 487-4650. NTIS FAX telephone number: (703) 321-8547. NTIS telex number: 64617. In ordering a document from NTIS, the accession number should be used. The cost is dependent on the number of pages in the document (table 1). Documents are available from NTIS both in microfiche and paper copy. Generally, the paper copies are printed from microfiche. For additional information, write or call the telephone sales desk and ask for the NTIS Product and Services Catalog, PR-827/360.
b. American Helicopter Society (AHS). Copies of virtually all of the technical reports listed in this bibliography have been given to AHS. Both AHS members and nonmembers may obtain copies of reports for a fee.

c. Helicopter Association International (HAI). Copies of virtually all of the technical reports listed in this bibliography have been given to HAI. HAI members may obtain copies of reports for a fee.

4. ORDER OF THE LISTING. In the chronological listing (Appendix B), technical reports are listed in order of the year in which they were published. Within the year of publication, reports are listed sequentially according to report number. Some reports do not include the year of publication as part of the document number. Such a report is listed after other reports published in the same year. (e.g., NAE-AN-26, published in 1985, is listed after the other reports published in 1985.)

5. NEW REPORTS OF PARTICULAR INTEREST. The following new technical reports cover topics of wide spread interest.

a. FAA/PM-86/46 Aeronautical Decision Making - Cockpit Resource Management

Commentary: Document a is the last of a family of six technical reports addressing judgment training for various pilot groups. The other reports in this family are shown below. One of these six training manuals specifically focuses on helicopter pilots. Industry spokesmen have stated that the implementation of this training has led to a significant reduction in their accident rates. The other five training reports are generic in nature and apply to both fixed-wing and rotary-wing pilots.

FAA/PM-86/41 Aeronautical Decision Making for Student and Private Pilots
FAA/PM-86/42 Aeronautical Decision Making for Commercial Pilots
FAA/PM-86/43 Aeronautical Decision Making for Instrument Pilots
FAA/PM-86/44 Aeronautical Decision Making for Instructor Pilots
FAA/PM-86/45 Aeronautical Decision Making for Helicopter Pilots
Table 1. NTIS PRICE SCHEDULE
(Effective January 1, 1990, updated yearly)

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ORDERS FOR SUBSCRIPTION ONLY, OR STANDING ORDER PRODUCTS ONLY
NOTE: Each additional delivery address on an order requires a separate shipping and handling charge.
b. FAA/DS-88/7  Risk Analysis for Air Ambulance Helicopter Operators

c. FAA/DS-88/8  Aeronautical Decision Making for Air Ambulance Administrators

Commentary: Documents b and c are the last of a family of four technical reports addressing judgment training for people involved with air ambulance helicopter operations. These two documents supplement the material contained in the following three reports:

- FAA/PM-86/45  Aeronautical Decision Making for Helicopter Pilots
- FAA/DS-88/5  Aeronautical Decision Making for Air Ambulance Helicopter Pilots: Learning from Past Mistakes

d. FAA/CT-TN88/30  Heliport Surface Maneuvering Test Results

Commentary: In the current Heliport Design advisory circular, there are no specific minimum dimensions for parking areas at private heliports (paragraph 16). At public heliports, the Heliport Design AC recommends a tip clearance of 1/3 rotor diameter but not less than 10 feet (paragraph 26a). Both this report and recent analysis of heliport parking area accidents indicate a need to reexamine minimum parking area requirements and markings.

e. FAA/AAM-89/9  Human Factors Issues in Aircraft Maintenance and Inspection

Commentary: Document e contains the presentations made by government and industry at a two day public meeting in October 1988. It also contains recommendations regarding communication of maintenance information, consolidation of certain data bases of interest, expedited review of Federal Air Regulation (FAR) Part 147, and future research on maintenance concepts.

f. FAA/DS-89/37  An Early Overview of Tiltrotor Aircraft Characteristics and Pilot Procedures in Civil Tiltrotor Applications
Commentary: Document f provides a preliminary look at the tiltrotor and procedures for vertiport approaches and departures. This report is based on limited analysis using a fixed-base flight simulator. The tiltrotor shows promise of steeper approach and departure maneuvers than what is possible with either an airplane or a helicopter.

6. HELIPORT/VERTIPORT PLANNING/DESIGN REPORTS. This is a list of FAA technical reports of particular interest to heliport planners and designers. Reports are listed sequentially according to the report number.

a. FAA/PM-84/22, Heliport Snow and Ice Control Methods and Guidelines. These guidelines provide a methodology to assist heliport planners and designers with the selection of the most appropriate snow and ice control method. The guidelines consider manual methods of snow and ice control such as plowing and chemical application, and automated methods such as pavement heating systems.

b. FAA/PM-84/23, Structural Design Guidelines for Heliports. Structural design guidelines for heliports are analyzed using data obtained from literature and from surveys of helicopter manufacturers, helicopter design consultants, and helicopter operators. Primary topics of interest are the loads on heliport structures caused by helicopter hard landings, rotorwash, and helicopter vibrations. Guidelines for appropriate load combinations for heliport structural design are also presented. This document could be useful in the design of rooftop heliports.

c. FAA/PM-84/25, Evaluating Wind Flow Around Buildings on Heliport Placement. Descriptions and illustrations of wind flow patterns and characteristics for both isolated and multiple building configurations are provided to assist heliport planners, operators, and helicopter pilots in understanding the problems associated with building-induced winds. Based on geometric flow patterns, guidelines for ground level and rooftop heliport placement are provided. Recent rotorcraft accident analyses indicates that we, the rotorcraft community, could prevent a number of rotorcraft accidents at heliports and airports by paying more attention to these issues. This document would also be useful in evaluating the effect that a proposed building would have on operations at a particular heliport.

d. FAA/PM-86/28, Investigation of Hazards of Helicopter Operations and Root Causes of Helicopter Accidents. The acid test, of whether we (the rotorcraft community) are doing things correctly, is in our daily operations. Accident records can tell us when we have failed this test
and where we need to improve. This report documents a broad investigation of helicopter accidents. Based in part on the results of this effort, the FAA has three rotorcraft accident analyses ongoing. Each is focused on specific subsets of accidents. One of them is looking specifically at heliport accidents and incidents.

e. FAA/PM-86/30, The Siting, Installation, and Operational Suitability of the Automated Weather Observing System (AWOS) at Heliports. This document provides the basis for FAA recommendations on the installation and siting of AWOS at heliports. These recommendations can also be found in FAA Advisory Circular AC150/5220-16, Automated Weather Observing Systems (AWOS) for Non-Federal Applications. Both documents would be of interest to anyone considering the installation of an AWOS at a heliport.

f. FAA/CT-TN87/4, Simulation Tests of Proposed Instrument Approach Lighting Systems for Heliport Operations. This report documents some of the testing done to develop the configuration of the heliport approach light system (HALS). Testing documented in this report involved the use of a terrain board as the principal part of the simulation. Other documents in this list (see documents n and q) address flight testing of HALS.

g. FAA/PM-87/31, Analysis of Heliport System Plans. This study analyzed the strengths and weaknesses of four state and four metropolitan heliport system plans. Planning concepts are identified and defined to include: (1) baseline parameters for evaluating the plans, (2) identifying the data (and their sources) needed for planning purposes at any jurisdictional level, and (3) developing criteria for assessing the feasibility and economic viability of proposed heliport facilities.

h. FAA/PM-87/32, Four Urban Heliport Case Studies. This study developed case histories of four heliports built in the central business districts of major cities. The effort identified six essential elements of a successful heliport. Consideration of these elements would aid in the prediction of whether a proposed heliport will succeed or fail.

i. FAA/PM-87/33, Heliport System Planning Guidelines. This report provides recommendations on the content of a state or metropolitan heliport system plan. A subset of this information has been formatted to become a heliport system planning chapter in the FAA advisory circular on state airport system planning.
j. FAA/CT-TN87/40, Heliport Visual Approach and Departure Airspace Tests, Vol. 1 Summary, Vol. 2 Appendixes. This report contains measured data on the airspace consumed during heliport approaches and departures under VFR conditions. Data collection primarily addressed straight-in approaches and straight-out departures. However, a limited amount of curved approach and departure data were collected and additional collection of such data was recommended. This testing is part of an effort to determine objectively the minimum airspace required at a VFR heliport.

k. FAA/CT-TN87/54, Analysis of Heliport Environmental Data: Indianapolis Heliport, Wall Street Heliport, Vol. 1 Summary, Vol. 2, Wall Street Heliport Data Plots, Vol. 3 Indianapolis Downtown Heliport Data Plots. The measured data in these documents describe the magnitude of the rotor downwash generated by different types of helicopters in actual operations. Using these data, the FAA has developed computer software that show real time variation in the magnitude and direction of rotor downwash during these heliport operations. The next step in this effort is to analyze accidents caused by rotor downwash and to develop guidance on how to prevent such accidents. A separate document is being prepared to document similar tests at Intercostal City, Louisiana.

l. FAA/CT-TN88/5, Heliport Visual Approach Surface High Temperature and High Altitude Test Plan. This was the plan for conducting flight tests at Albuquerque, NM. The Albuquerque tests were very similar to the (low altitude) tests conducted at the FAA Technical Center and documented in FAA/CT-TN87/40, Heliport Visual Approach and Departure Airspace Tests. Results of the Albuquerque tests are in preparation.

m. FAA/DS-88/12, Minimum Required Heliport Airspace Under Visual Flight Rules. This report is part of an effort to determine objectively the minimum airspace required at a VFR heliport. Industry has recommended that the FAA strive to be less subjective and more quantitative with regard to issues on heliport design. FAA testing has been conducted or is underway in several areas in response to this recommendation. A key element in making effective use of such quantitative data is the determination of an objective criteria for safety. This report discusses one method for developing such a basis: "target level of safety".

n. FAA/CT-TN88/19, Test Plan for Helicopter Visual Segment Approach Light System (HALS). This effort involved flight testing of MLS precision approaches both with and without a heliport approach lighting system (HALS). The intent was to make some judgments as to the precision approach minimums
with and without the HALS. Results are documented in FAA/CT-TN89/21. This flight testing took place at the FAA Technical Center Heliport.

o. FAA/CT-Tx-21, Heliport Surface Maneuvering Test Results. This report documents two ways of approaching the issue of minimum parking area requirements. The first involves daylight flight tests of 13 pilots in a UH-1 helicopter. The second involves industry pilot responses to questions on how close to an object they would be comfortable in operating.

Flight testing was done in a UH-1. The subject pilots were either National Guard pilots, FAA test pilots, or both. When interviewed after their flight testing, the majority of these pilots stated that they were comfortable with rotor tip clearances of one third the rotor diameter.

Industry pilots in the NY/NJ area, Louisiana, and Texas responded to questions concerning rotor tip clearances. Depending on wind conditions and on whether or not the object was an aircraft, only 19 to 41 percent of these pilots said that they were comfortable with rotor tip clearances of one third rotor diameter. Between 19 and 43 percent said that they were uncomfortable with less than one half rotor diameter tip clearances. Between 5 to 17 percent said that they were uncomfortable with less than a full rotor diameter tip clearance. Taken at face value, the results of the industry pilot questionnaires would support minimum parking area dimensions that provide a minimum tip clearance of one full rotor diameter for air taxi maneuvers.

In the current Heliport Design advisory circular, there are no specific minimum dimensions for parking areas at private heliports (paragraph 16). At public heliports, the Heliport Design AC recommends a tip clearance of 1/3 rotor diameter but not less than 10 feet (paragraph 26a). Both this report and recent analysis of heliport parking area accidents indicate a need to reexamine minimum parking area requirements and markings.

p. FAA/CT-TN88/45 Heliport Night Parking Area Criteria Test Plan. This is the plan to test heliport parking separations at night under various wind conditions. This effort is similar to a portion of the day time test effort documented in FAA/CT-TN88/30, Heliport Surface Maneuvering Test Results. This testing is underway at the FAA Technical Center.

q. FAA/CT-TN89/21, Helicopter Visual Segment Approach Lighting System (HALS) Test Report. This report documents flight testing of the heliport approach light system (HALS).
The HALS works very well in support of MLS precision approaches in an environment relatively devoid of city lights. In the absence of the HALS, several pilots were well inside the Decision Height (DH) when they made decisions to initiate a missed approach. This resulted in flights through airspace that present rules do not require to be obstacle free. Additional testing is planned to determine the appropriate weather minimums for precision approach operations in the absence of a HALS.

The FAA looks at lighting as one alternative for ensuring the safe operation of rotorcraft under lower minimums than what would otherwise be possible. The number of places that will require such a system is uncertain. However, the more alternatives available, the better the position the industry will be in to pick the combination of alternatives that make sense for each application of interest. As other alternatives become apparent, the FAA will test them to determine their benefits and limitations.
### APPENDIX A: ALPHABETICAL LIST OF REPORT TITLES

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<td>FAA/DS-89/17</td>
<td>Accident/Incident Data Analysis Database Summaries (2 Volumes) (Thomas P. Murphy, Richard J. Levendoski)</td>
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<td>FAA/PM-86/46</td>
<td>Aeronautical Decision Making - Cockpit Resource Management (Richard S. Jensen)</td>
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<td>FAA/DS-88/5</td>
<td>Aeronautical Decision Making for Air Ambulance Helicopter Pilots: Learning from Past Mistakes</td>
<td>(Richard J. Adams and Jack T. Thompson)</td>
<td>(NTIS: ADA 197 694)</td>
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<td>FAA/PM-86/42</td>
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<td>FAA/PM-86/41</td>
<td>Aeronautical Decision Making for Student and Private Pilots</td>
<td>(Alan E. Diehl, Peter V. Hwochinsky, Gary S. Livack, Russell S. Lawton)</td>
<td>(NTIS ADA 182 549)</td>
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Appendix A: Alphabetical Listing


FAA-RD-80-22  Airborne Radar Approach (Cliff Mackin) (NTIS: ADA 103 347)

FAA-RD-80-60  Airborne Radar Approach Flight Test Evaluating Various Track Orientation Techniques (Larry D. King) (NTIS: ADA 088 426)


FAA-RD-78-143 Aircraft Wake Vortex Takeoff Tests at Toronto International Airport (Thomas Sullivan, James Hallock, Berl Winston, Ian McWilliams, David C. Burnham) (NTIS: ADA 068 925)

FAA/PM-83/4 Alaska LORAN-C Flight Test Evaluation (Larry D. King, Edwin D. McConkey) (NTIS: ADA 123 633)

FAA/CT-82/120 All Weather Heliport (Paul H. Jones)

FAA/CT-TN83/50 and Addendum 1 Altitude Aided GPS (George Paolacci)


FAA/CT-TN87/54 Analysis of Heliport Environmental Data: Indianapolis Downtown Heliport, Wall Street Heliport (Rosanne M. Weiss, John G. Morrow, Donald Gallagher, Mark DiMeo, Scott Erlichman) Vol-I: Summary (NTIS: ADA 206 708)
Appendix A: Alphabetical Listing

Vol-II: Wall Street Heliport Data Plots (NTIS: ADA 212 312)
Vol-III: Indianapolis Downtown Heliport Data Plots (NTIS: ADA 217 412)

FAA/PM-87/31 Analyses of Heliport System Plans (Deborah Peisen, Jack T. Thompson) (NTIS: ADA 195 283)
FAA/PP-88/1 Analysis of Rotorcraft Crash Dynamics for Development of Improved Crashworthiness Design Criteria (Joseph W. Coltman, Akif O. Bolukbasi, David H. Laananen) (NTIS: ADA 158 777)
NA-67-1 Analysis of the Helicopter Height Velocity Diagram Including a Practical Method for its Determination (William J. Hanley, Gilbert Devore) (NTIS: AD 669 481)
RD-64-55 Analytical Determination of the Velocity Fields in the Wakes of Specified Aircraft (W.J. Bennett) (NTIS: AD 607 251)
FAA/CT-86/35 Analytical Study of Icing Similitude for Aircraft Engine Testing (C. Scott Bartlett) (NTIS: ADA 180 863)
FAA/RD-82/40 Application of the MLS to Helicopter Operations (Edwin D. McConkey, John B. McKinley, Ronald E. Ace) (NTIS: PB-84 116458)
FAA/CT-87/19 Avionics System Design for High Energy Fields (Roger A. McConnell) (NTIS: ADA 199 212)
Appendix A: Alphabetical Listing

FAA-EM-77-15 **Bibliography: Airports** (Transportation Research Board) (NTIS: ADA 049 879)


FAA-NA-72-41 **Collision Avoidance: An Annotated Bibliography, September 1968 --- April 1972** (Dorothy E. Bulford) (NTIS: AD 746 863)

FAA-RD-76-146 **Comparison of Air Radionavigation Systems (For Helicopters In Off-Shore Areas)** (George H. Quinn) (NTIS: ADA 030 337)

FAA-EE-81-4 **Comprehensive Bibliography of Literature on Helicopter Noise Technology** (A.M. Carter, Jr.) (NTIS: ADA 103 331)

FAA-RD-75-79 **Comprehensive Review of Helicopter Noise Literature** (B. Magliozzi, F.B. Metzger, W. Bausch, R.J. King) (NTIS: ADA 014 640)

FAA/CT-TN85/63 **Computed Centerline MLS Approach Demonstration at Washington National Airport** (James H. Remer) (NTIS: ADA 163 722)

FAA/PM-83-32 **Conus LORAN-C Error Budget: Flight Test** (Larry D. King, Kristen J. Venezia, Edwin D. McConkey) (NTIS: ADA 140 264)

FAA-EE-80-42 **Correlation of Helicopter Noise Levels with Physical and Performance Characteristics** (J. Stephen Newman) (NTIS: ADA 093 428)

FAA/CT-TN85/15 **Course Width Determination for Collocated MLS at Heliports** (James H. Enias)


### Appendix A: Alphabetical Listing

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<td>Development of a Heliport Classification Method and an Analysis of Heliport Real Estate and Airspace Requirements</td>
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<td>Evaluation of Sikorsky S-76A, 24 Missed Approach Profiles Following Precision MLS Approaches to a Helipad at 40 KIAS</td>
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<td>Evaluation of the Usefulness of Various Simulation Technology Options for Terminal Instrument Procedures (TERPS) Enhancements</td>
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<td>Flight Evaluation of a Radar Cursor Technique as an Aid to Airborne Radar Approaches</td>
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<td>FAA-RD-72-133</td>
<td>Flight Test and Evaluation of Heliport Lighting for IFR</td>
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FAA-EE-79-03  Noise Levels and Flight Profiles of Eight
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FAA-EE-84-05  Noise Measurement Flight Test for the
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Report of Investigative Testing of Global Positioning System Slant Range Accuracy
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FAA/CT-TN86/40 Signal Coverage and Characteristics of the Atlantic City Heliport MLS (Barry R. Billmann, Donald W. Gallagher, Christopher Wolf, John Morrow, Scott B. Shollenberger, Paula Maccagnano) (NTIS: ADA 178 389)


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FAA/CT-TN87/16  Test Plan for Helicopter GPS Applications (Michael Magrogan) (NTIS: ADA 183 299)

FAA/CT-TN88/19  Test Plan for Helicopter Visual Segment Approach Lighting System (Scott B. Schollenberger, Barry R. Billmann)


FAA/CT-TN85/23  Test Plan for Siting, Installation, and Operational Suitability of the AWOS at Heliports (Rene' A. Matos)

FAA-RD-81-7-LR  Three Cue Helicopter Flight Directors: An Annotated Bibliography (Tosh Pott, J.P. McVicker, Herbert W. Schlickenmaier)

FAA/RD-82/16  (Three) 3D LORAN-C Navigation Documentation (Eric H. Bolz, Larry D. King) (NTIS: ADA 120 106)


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HELIPORT LIGHTING/MARKING

FAA/CT-82/120  FAA/CT-TN84/34 FAA/CT-TN86/22
FAA/CT-TN87/4  FAA/CT-TN88/19 FAA/CT-TN89/21
FAA/CT-TN89/31

HELIPORT NOISE MODEL (HNM) (See also Noise, Noise Modeling)

FAA/EE-88-2

HELIPORT PARKING AREAS AND TAXIWAYS

FAA/CT-TN87/10 FAA/CT-TN87/54,1 FAA/CT-TN88/30
FAA/CT-TN88/45

HELIPORT PLANNING

FAA-RD-80-107  FAA/RD-81/35 FAA/PM-84/22
FAA/PM-84/25   FAA/PM-87/31 FAA/PM-87/32
FAA/PM-87/33   FAA/DS-89/32

HELIPORT SNOW AND ICE CONTROL

FAA/PM-84/22

HELIPORT VFR AIRSPACE

FAA-RD-80-107  FAA/RD-81/35 FAA/CT-TN86/61
FAA/CT-TN87/40 FAA/CT-TN88/5 FAA/DS-88/12

HIGH FREQUENCY (HF) COMMUNICATION

FAA-RD-78-150
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HOLDING PATTERNS

FAA-RD-80-86  FAA-RD-80-88  FAA/CT-TN86/63

HUMAN FACTORS (See also Emergency Medical Service, Flight Controls, Flight Displays, TCAS and Training)

FAA-RD-81-59  FAA/CT-83/6  FAA/CT-83/40
FAA/PM-86/28  FAA/PM-86/45  FAA/DS-89/17

ICING (See also Weather and Weather Forecasting)

FAA/CT-81/35  FAA/CT-83/7  FAA/CT-83/21
FAA/CT-83/22  FAA/PM-84/22  FAA/CT-85/26
FAA/CT-TN86/11  FAA/CT-86/35  FAA/CT-87/37

INERTIAL NAVIGATION SYSTEM (INS)

FAA-RD-76-146  FAA-RD-80-85  FAA/PM-83/25
FAA/RD-82/24

INSTRUMENT LANDING SYSTEM (ILS)

FAA/RD-82/6  FAA/CT-TN85/24  FAA/PM-86/14
FAA/PM-86/15  FAA/PM-86/25,1

LIGHTING (See Heliport Lighting)

LIGHTNING AND ELECTROMAGNETIC INTERFERENCE (EMI)

FAA/CT-86/8  FAA/CT-87/19  FAA/CT-88/10
FAA/CT-89/22

LORAN-C (See also LOFF)

FAA-RD-70-10  FAA-RD-76-146  NA-78-55-LR
FAA-RD-80-47  FAA-RD-80-85  FAA-RD-80-87
FAA-RD-80-88  FAA-CT-80-175  FAA-RD-81-27
FAA-RD-81-59  FAA/RD-82/6  FAA/RD-82/7
FAA/RD-82/78  FAA/PM-83/4  FAA/PM-83/32
FAA/CT-TN85/5  FAA/CT-TN85/17  FAA/PM-86/14
FAA/PM-86/15
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LORAN-C VERTICAL NAVIGATION (VNAV)

FAA/RD-82/16 FAA/CT-TN86/56

LORAN FLIGHT FOLLOWING (LOFF)

FAA/RD-80-85 FAA/RD-80-87 FAA/RD-80-88
FAA/RD-81-55 FAA/RD-81-59 FAA/CT-TN86/17
FAA/CT-TN88/8

LOW-ALTITUDE COMMUNICATIONS (See also Northeast Corridor)

FAA/RD-80-20 FAA/RD-80-80 FAA/RD-80-87
FAA/CT-80-198 FAA/RD-81-9 FAA/RD-81/40
FAA/RD-81-59 PM-85-2-LR FAA/PM-85/8
FAA/DS-89/9

LOW-ALTITUDE NAVIGATION (See also LORAN-C, Northeast Corridor, and GPS)

FAA/RD-76-146 NA-78-55-LR FAA/RD-78-101
FAA/RD-78-150 FAA/CT-80-18 FAA/RD-80-20
FAA/RD-80-80 FAA/RD-80-87 FAA/RD-81-59
FAA/PM-83/32

LOW-ALTITUDE SURVEILLANCE (See also LOFF)

FAA/RD-78-150 FAA/RD-80-20 FAA/RD-80-80
FAA/RD-80-87 FAA/RD-81-59 FAA/DS-89/9

LOW-SPEED APPROACHES (See also Decelerating Approaches, Steep Approaches/Departures)

FAA/PM-86/14 FAA/PM-86/15 FAA/CT-TN86/31
NAE-AN-26 (1985) FAA/CT-TN86/42

MARKING/LIGHTING OF HELIPORTS (See Heliport Lighting/Marking)

MICROWAVE LANDING SYSTEM (MLS) FLIGHT INSPECTION (See Flight Inspection)
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MICROWAVE LANDING SYSTEM, GENERAL (See also DME and other MLS listings below)

FAA-RD-78-101    FAA/RD-82/6    FAA/RD-82/40
FAA/CT-TN84/16    FAA/CT-TN84/20 FAA/CT-TN84/40
FAA/PM-85/7       FAA/CT-TN85/15 FAA/CT-TN85/53
FAA/CT-TN85/55    FAA/CT-TN85/58 FAA/CT-TN85/63
FAA/CT-TN85/64    FAA/CT-86/14 FAA/CT-TN85/64
FAA/PM-86/15      FAA/CT-TN86/30 FAA/CT-TN86/40
FAA/CT-TN89/21

MICROWAVE LANDING SYSTEM RNAV (See also other MLS listings)

FAA-RD-80-59      FAA/RD-82/40 FAA/PM-85/7
FAA/CT-TN85/43    FAA/CT-TN85/63 FAA/PM-86/25, I
FAA/CT-TN87/19

MICROWAVE LANDING SYSTEM SITING (See also other MLS listings)

FAA/CT-TN84/40    FAA/CT-TN85/53 FAA/CT-85/58
FAA/CT-TN85/64    FAA/CT-TN86/64

MICROWAVE LANDING SYSTEM TERPS (See also TERPS and other MLS listings)

FAA-RD-80-59      FAA-RD-81-167 FAA/CT-TN84/16
FAA/CT-TN84/20    FAA/CT-TN85/53 FAA/CT-TN85/55
FAA/CT-TN86/31    FAA/CT-TN86/63
FAA/AVN-200-25 (1986)

MID-AIR COLLISIONS (See Near Mid-air Collisions)

MILITARY TRAINING ROUTES

FAA-RD-80-88, I

MISSED APPROACH

FAA/DS-89/37

NAVIGATION SATELLITE TIMING AND RANGING (NAVSTAR) (See GPS)

NEAR MID-AIR COLLISIONS (See also TCAS)

FAA-RD-80-88, I   FAA/CT-83/40   FAA/PM-85/6
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**NIGHT TESTING** (See also Heliport Lighting/Marking)

FAA/CT-TN88/45

**NOISE**

| FAA-RD-73-145 | FAA-RD-75-79 | FAA-RD-75-125 |
| FAA-RD-75-190 | FAA-RD-76-1 | FAA-RD-76-49 |
| FAA-RD-79-107 | FAA-EE-80-5 | FAA-AEE-80-34 |
| FAA-EE-80-41 | FAA-EE-80-42 | FAA-EE-81-4 |
| FAA-EE-81-10 | FAA-EE-81-13 | FAA-EE-81-16 |
| FAA-EE-82-16 | FAA-EE-82-20 | FAA-EE-83-2 |
| FAA-EE-83-5 | FAA-EE-83-6 | FAA-EE-84-1 |
| FAA-EE-84-2 | FAA-EE-84-3 | FAA-EE-84-04 |
| FAA-EE-84-05 | FAA-EE-84-6 | FAA-EE-84-7 |
| FAA-EE-84-15 | FAA-EE-85-3 | FAA-EE-85-6 |
| FAA-EE-85-7 | CERL TR N-85/14 | FAA-EE-86-01 |
| FAA-EE-86-04 | FAA-EE-87-2 |

**NOISE ABATEMENT** (See also Fly Neighborly)

FAA-EE-85-7

**NOISE CONTOURS**

| FAA-EE-80-41 | FAA-EE-81-16 | FAA-EE-82-16 |
| FAA-EE-84-1 | FAA-EE-84-2 | FAA-EE-84-3 |
| FAA-EE-84-04 | FAA-EE-84-05 | FAA-EE-84-6 |
| FAA-EE-84-7 | FAA-EE-85-7 |

**NOISE MODELING**

| FAA-EE-79-03 | FAA-EE-80-41 | FAA-EE-80-42 |
| FAA-EE-81-4 | FAA-EE-82-16 | FAA/EE-88-2 |

**NOISE REDUCTION**

| FAA-EE-80-5 | FAA-EE-81-4 | FAA-EE-81-10 |

**NOISE SURVEYS**

| FAA-EE-82-20 | FAA-EE-83-2 | FAA-EE-83-5 |
| FAA-EE-83-6 | FAA-EE-84-15 | FAA-EE-85-3 |
| FAA-EE-86-04 | | |
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NONDIRECTIONAL BEACON (NDB)

FAA-RD-76-146 FAA-RD-78-101 FAA-RD-78-150
FAA-RD-80-85 FAA/RD-82/6 FAA/PM-86/25,I

NONPRECISION APPROACHES (See also Airborne Radar Approaches)

NA-80-34-LR FAA-CT-80-175 FAA-RD-81-27
FAA/RD-82/71 FAA/RD-82/78 FAA/CT-82/103
FAA/CT-TN83/03 FAA/CT-TN84/34 FAA/CT-TN85/17
FAA/PM-86/25,I FAA/CT-TN86/56

NORTHEAST CORRIDOR

FAA-RD-80-17 FAA-RD-80-59 FAA-RD-80-80
FAA-CT-80-175 FAA-RD-81-59 FAA/CT-82/57
FAA/RD-82/78 FAA/CT-TN85/17

OBSTRUCTION AVOIDANCE (See also Airborne Radar Approaches, Heliport VFR Airspace, and TERPS)


OFFSHORE OPERATIONS (See also Gulf of Mexico and Airborne Radar Approaches)

FAA-RD-76-146 NA-78-55-LR FAA-RD-79-123
FAA-RD-80-20 NA-80-34-LR FAA-RD-80-87
FAA/RD-82/6 FAA/PM-83/4

OMEGA

NA-78-55-LR FAA-RD-78-101 FAA-RD-78-150
FAA/PM-86/14 FAA/PM-86/15

PARKING AREAS (See Heliport Parking Areas and Taxiways)

PILOT WORKLOAD (See Workload)

POWERED-LIFT AIRCRAFT (See also Tiltrotor)

FAA-RD-76-100 FAA-RD-78-100 FAA-RD-79-59

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PRECISION APPROACH RADAR (PAR)

FAA-RD-80-107

RISK MANAGEMENT (See also Aeronautical Decision Making)

FAA/DS-88/7 FAA/DS-88/8

RNAV (See Area Navigation and MLS RNAV)

ROTOR BLADE CONTAINMENT (See also Rotor Failures)

FAA-RD-77-100 FAA/CT-86/42 FAA/CT-88/21
FAA/CT-88/23

ROTOR DOWNWASH (See Downwash)

ROTOR FAILURES (See also Rotor Blade Containment)

FAA/CT-86/42 FAA/CT-88/23 FAA/CT-89/5
FAA/CT-89/6 FAA/CT-89/7 FAA/CT-89/30

ROTORCRAFT ICING (See Icing)

ROTORCRAFT OPERATIONS DATA

FAA/CT-83/40 FAA/PM-85/6 FAA/CT-85/11
FAA/PM-86/28 FAA/DS-89/9 FAA/DS-89/32

ROTORCRAFT PERFORMANCE

FAA/DS-89/37

SAFETY (While this topic is addressed in many of the documents in this bibliography, the following documents are of particular interest.)

FAA/CT-82/143 FAA/CT-82/157 FAA/CT-83/6
PM-85-2-LR PM-85-3-LR PM-85-4-LR
FAA/PM-85/6 FAA/CT-86/24 FAA/PM-86/28
FAA/CT-86/42 FAA/PM-86/45 FAA/DS-88/5
FAA/DS-88/6 FAA/DS-88/7 FAA/DS-88/8
FAA/DS-88/12

SATELLITES (See Global Positioning System)
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SIMULATION

115-608-3X NA-68-21 FAA-RD-79-59
FAA-RD-80-64 FAA-RD-80-86 FAA-RD-80-86
FAA-RD-80-88 FAA-RD-81-59 FAA/CT-85/11
FAA/PM-86/14 FAA/PM-86/15 FAA/DS-89/37

SNOW AND ICE (See Heliport Snow and Ice Control, and Icing)

STEEP APPROACHES/DEPARTURES

RD-66-68 FAA/DS-89/37

SURVEILLANCE (See also LOFF)

FAA-EM-73-8 FAA-EM-73-8 (Add. 1)

TACAN

RD-66-46 FAA-RD-76-146 FAA-RD-78-101

TAXIWAYS (See Heliport Parking and Taxiways)

TERMINAL INSTRUMENT PROCEDURES (TERPS)

FAA-RD-78-150 FAA-RD-80-17 FAA-RD-80-58
FAA-CT-81-167 FAA/CT-TN84/16 FAA/CT-TN84/20
FAA/CT-TN85/15 FAA/CT-TN85/24 FAA/CT-TN85/53
FAA/CT-TN85/55 FAA/PM-86/14 FAA/PM-86/15
FAA/AVN-200-25 (1986)

TILTROTOR (See also Powered-Lift Aircraft)

FAA-RD-78-150 FAA/DS-89/37

TRAFFIC ALERT AND COLLISION AVOIDANCE SYSTEM (TCAS)

FAA/RD-82/63 FAA/CT-83/40 FAA/PM-85/6
FAA/PM-85/29 FAA/PM-85/30 FAA/CT-TN85/49
FAA/CT-TN85/60 FAA/CT-TN85/83 FAA/CT-TN86/24
FAA/CT-TN87/21

TRAINING (See also Aeronautical Decision Making)

FAA-RD-78-150 FAA-RD-80-88 FAA-RD-81-59
FAA/CT-83/6 FAA/CT-TN85/55 FAA/PM-86/28
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TURBINE ENGINES (See also Rotor Blade Containment, Rotor Failures)

VERTIPORTS (See Heliports/Vertiports)

VERY LIGHT WEIGHT AIR TRAFFIC MANAGEMENT EQUIPMENT (VLATME)

FAA-RD-80-87

VFR HELIPORT AIRSPACE (See Heliport VFR Airspace)

VNAV (See LORAN-C Vertical Navigation)

VOR

| RD-66-46 | FAA-RD-71-96 | FAA-RD-76-146 |
| FAA-RD-78-101 | FAA-RD-78-150 | FAA-RD-80-17 |
| NA-80-34-LR | FAA-RD-80-64 | FAA-RD-80-85 |
| FAA/RD-82/6 | FAA/RD-82/78 | FAA/CT-TN85/24 |
| FAA/PM-86/14 | FAA/PM-86/15 | FAA/PM-86/25, I |

WAKE VORTEXES (See also Down Wash)

| RD-64-4 | FAA-RD-75-94 | FAA-RD-78-101 |
| FAA-RD-78-143 | FAA-RD-80-94 | FAA/RD-80-88, II |
| FAA-RD-79-59 | FAA-RD-79-64 | FAA/RD-81/22, 92 |
| FAA/CT-83/6 | FAA/PM-84/22 | FAA/PM-84/25 |

WEATHER FORECASTING

| FAA/RD-81/40 | FAA-RD-81-92 | FAA/PM-84/31 |
| FAA/PM-86/10 | FAA/PM-87/2 | FAA/PS-88/3 |

WEATHER OBSERVATIONS

| FAA/RD-81/40 | FAA/CT-TN85/23 |

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| FAA-RD-79-59 |

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BAUSCH, W. (Hamilton Standard, a Division of UTC)
FAA-RD-75-79

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FAA-EE-84-2 FAA-EE-84-3 FAA-EE-84-4 FAA-EE-84-5 FAA-EE-84-6

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  FAA-EE-83-2

BRODERSON, ALVIN B. (Watkins and Associates)
  FAA-AEE-79-13

BRYDER, RALPH B. (Civil Aviation Authority)
  FAA-RD-76-100

BULFORD, DOROTHY E. (FAA, NAFEC)
  FAA-NA-72-41

BURNHAM, DAVID C. (Transportation System Center)
  FAA-RD-78-143

BUCH, GEORGETTE D. (Transport Canada)
  FAA/PM-86/44
CARTER, A.M. (HOPE Associates)
FAA-EE-81-4

CHAMBERS, HARRY W. (FAA Technical Center)
FAA/CT-85/26

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FAA-EE-85-3
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FAA/CT-88/10

CUSHMAN, ARTHUR W. (FAA Technical Center)

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DABOIN, SHARON A. (FAA, Washington Headquarters)

FAA-EE-84-1       FAA-EE-84-2

DADONE, L.U. (Boeing Vertol)

FAA-CT-80-210

DEL BALZO, JOSEPH M. (FAA, Washington Headquarters)

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DeLUCIA, ROBERT A. (Naval Air Propulsion Center)

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DIEHL, ALAN E. (FAA, Washington Headquarters)
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FISHER, F.A. (Lightning Technologies Inc.)

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FORD, DAVID W. (FAA, Headquarters)

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FORREST, R.D. (NASA Ames Research Center)

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GERDES, R.M. (NASA Ames Research Center)

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GIBSON, JOHN S. (Lockheed-Georgia)

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HALE, CHARLES (FAA, Oklahoma City)
  FAA/AVN-200/25 (1986)

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  FAA-RD-78-143

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HARMAN, WILLIAM H. (Lincoln Laboratory)
  FAA/PM-85/29

HARRIGAN, JOSEPH (FAA, NAFEC)
  FAA-RD-80-17

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FAA/CT-82/115

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NAE-AN-55 (1988)

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LORGE, FRANK (FAA, NAPEC)
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    FAA/CT-82/115
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    FAA-RD-80-22
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<td>ROCKHOLT, H.</td>
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<tbody>
<tr>
<td>ABC</td>
<td>Advancing blade concept</td>
</tr>
<tr>
<td>ADF</td>
<td>Automatic direction finder</td>
</tr>
<tr>
<td>ADS</td>
<td>Automatic dependent surveillance</td>
</tr>
<tr>
<td>AGL</td>
<td>Above ground level</td>
</tr>
<tr>
<td>AM</td>
<td>Amplitude modulated</td>
</tr>
<tr>
<td>AMA</td>
<td>Analytical Mechanics Associates</td>
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<tr>
<td>AOPA</td>
<td>Aircraft Owners and Pilots Association</td>
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<td>ARA</td>
<td>Airborne RADAR Approach</td>
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<td>Aeronautical Radio Inc.</td>
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<td>ASF</td>
<td>Air Safety Foundation</td>
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<td>ATC</td>
<td>Air traffic control</td>
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<td>AVARADA</td>
<td>U.S. Army Avionics Research and Development Activity</td>
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<tr>
<td>AWOS</td>
<td>Automated weather observing system</td>
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<tr>
<td>AWOS GEM</td>
<td>AWOS generalized equivalent markov</td>
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<tr>
<td>CAA</td>
<td>Civil Aviation Authority (UK)</td>
</tr>
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<td>CAEP</td>
<td>Committee on Aviation Environmental Problems</td>
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<td>CAN</td>
<td>Committee on Aircraft Noise (ICAO)</td>
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<td>CERL</td>
<td>U.S. Army Construction Engineering Research Laboratory</td>
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<td>DME</td>
<td>Distance Measurement Equipment</td>
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<td>Day/Night Average Sound Level</td>
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<td>Department of Transportation</td>
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<td>E-L</td>
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<td>Acronym</td>
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<td>EMI</td>
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<td>Effective Perceived Noise Level</td>
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<td>Flight Safety Foundation</td>
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<td>GPS</td>
<td>Global positioning system</td>
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<td>HIGE</td>
<td>Hover in ground effect</td>
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<td>International Civil Aviation Organization</td>
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<td>Instrument flight rules</td>
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<td>Instrument landing system</td>
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<td>Inertial navigation system</td>
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<tr>
<td>KIAS</td>
<td>Knots indicated airspeed</td>
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<td>Loran flight following</td>
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<td>MLS</td>
<td>Microwave landing system</td>
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<td>NAVSTAR</td>
<td>Navigation satellite timing and ranging</td>
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<td>Nondirectional beacon</td>
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<td>Visual flight rules</td>
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<td>VLATME</td>
<td>Very light weight air traffic management equipment</td>
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<td>Vertical navigation</td>
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<td>Very high frequency omnidirectional radio range</td>
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<tr>
<td>VTOL</td>
<td>Vertical takeoff and landing</td>
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APPENDIX F: ABSTRACTS

This report is a supplement to "FAA Helicopter/Heliport Research, Engineering, and Development - Bibliography, 1964 - 1986" (FAA/PM-86/47) published in November 1986 (NTIS accession number ADA 174 697) and to "FAA Rotorcraft Research, Engineering, and Development Bibliography, 1962 - 1988" (FAA/DS-89/03) published in March 1989 (NTIS accession number ADA 207 162). The bibliography and the indexes contained in this report include all of what was published in the earlier documents. However, Appendix F of this report does not contain any abstracts which were included in FAA/PM-86/47 and FAA/DS-89/03. Abstracts contained herein are only for those reports which have been published subsequent to the earlier bibliography plus any earlier reports which had been overlooked inadvertently.
This document reports the findings of helicopter noise tests conducted at the FAA National Aviation Facility Experimental Center (NAFEC), located in Atlantic City, New Jersey. The tests were conducted with the following objectives: first, determine the feasibility of a takeoff procedure for helicopter noise certification; second, establish a data base of helicopter noise levels to be used in defining noise standards; third, acquire helicopter acoustical spectral data for a variety of acoustical angles for use in the FAA Integrated Noise Model. This report addresses the first two objectives. Noise data are presented in terms of the corrected Effective Perceived Noise Level (EPNL). Corrections of data are carried out in accordance with FAR 36 procedures and/or procedures considered appropriate for use in possible future noise standards. Position corrections are conducted using unique takeoff reference flight paths for each helicopter; approach and level flyover reference paths are the same for all the helicopters. Correction procedures are evaluated for applicability to helicopter noise sources. Flight profiles and ground tracks are presented for each takeoff event along with ground speed data. Actual cockpit indicated air speed is also reported for most events along with main rotor RPM. A regression analysis is conducted correlating EPNL with helicopter weight for the NAFEC test data. An aggregate regression analysis is also conducted which groups NAFEC helicopter data with data from other sources.
### Abstract

Areas having the heaviest helicopter activity in the U.S. were visited and environmental noise measurements made in order to evaluate the impact of possible relaxed noise emission standards for helicopters restricted to remote regions. Measurement results showed that an average of 10 flyovers per hour produced a one-hour energy-averaged sound level (Leq) of 54.5 dBA, a level 2.5 dBA above ambient. An average of 34 events per hour adjacent to heliports produced a one-hour Leq of 63.1 dBA, which was 13.3 dBA above ambient. If emission levels were increased by 10 dBA, projected Leq values of 57.0 and 71.2 dBA resulted for the flyover and heliport conditions, respectively. Sixty-four percent of those responding to a questionnaire stated that they had not experienced a problem from helicopter noise. The degree to which the remaining respondents were bothered ranged from "slightly" to "very annoyed" with no significant preference for either category.
The V/STOL Rotary Propulsor Noise Prediction Model developed under contract DOT-FA74WA-3477 was updated and evaluated. A three-phase program was conducted. In the first phase, a literature review was conducted to identify and evaluate high-quality noise measurements of propeller, variable pitch fan, fixed pitch fan, helicopter, lift fan, core engine, and jet noise for the preparation of a data base with emphasis on recent measurements of in-flight propulsors. In the second phase, the effects of forward flight on V/STOL propulsor noise were evaluated and the noise prediction model was improved to give better agreement with current measurements. In the third phase, the performance of the noise prediction methodology was evaluated by comparison of calculations with measurements of propulsor noise from the data base.

Although certain aspects of the measured propulsor noise, such as installation and ground reflection effects, caused discrepancies between measured and calculated levels (the calculations assume uninstalled propulsors under free-field conditions), the general correlation was good. Typical correlation between measured and calculated one-third octave band levels was ±5 dB and between measured and calculated dB(A), PNL, PNLT, and EPNL was ±3 dB.
This study investigated cost/benefit tradeoffs using the case histories of four helicopters for which design and development were complete, and in three cases, have undergone substantial flight testing. The approach to quieting each helicopter was an incremental reduction of each source as required to obtain reductions in flyover noise with modifications to other secondary systems only as necessary. The methodology used to predict the effects of the design modifications on acquisition, maintenance, and operating costs were typical of those employed by rotorcraft manufacturers. The reduction of helicopter flyover noise generally was achieved through reductions in rotor tip speed. Performance characteristics were maintained to specified minimums for each aircraft in the study.
Abstract

This report provides uncorrected noise exposure level data measured using an integrating sound level meter at a single measurement location during the recently completed, week long, FAA helicopter noise test. In addition to the measurements herein reported, primary acoustical measurements have been conducted by the Transportation Systems Center Noise Measurement and Assessment Laboratory. This acoustical data (acquired for nine microphones) will be combined with flight path track data processed at the FAA, Dulles Noise Laboratory by D.W. Ford. Meteorological data acquired from surface reading and radiosondes will be processed by U.S. Weather Service Personnel.

The coalation and reporting of these data will require a considerable period of time. Thus, this report has been prepared to provide limited but nevertheless useful information to interested parties.
### Title and Subtitle

**Helicopter Noise Contour Development Techniques and Directivity Analysis**

### Authors

J. Steven Newman

### Performing Organization Name and Address

Department of Transportation, Federal Aviation Admin.  
800 Independence Avenue, S.W.  
Washington, D.C. 20591

### Abstract

This paper briefly summarizes techniques which have been developed for use in creating helicopter air-to-ground, noise-distance relationships. Discussion is provided concerning FAA efforts to establish an accurate and practical method (which considers sources directivity) for modeling the noise impact associated with helicopter operations. Pilots of normalized directivity vectors are provided for eight helicopters in various modes of flight.

### Key Words

Helicopter, Noise Contour, Noise, Directivity

### Distribution Statement

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This report investigates the correlation between physical and performance characteristics of helicopters and the noise levels which they generate in various operational modes. The analysis is generally empirical although several theoretical functions described in the literature have been examined. The EPNL is the acoustical metric employed in this study. One, two, and three-step multiple regression analyses are conducted for takeoff, approach, and level flyover operations. Plots are provided for the three best single variable regression models for each mode of flight.

Key Words
- Helicopter
- Noise
- Noise Prediction
- Correlation
- Regression
- Effective Perceived Noise Level (EPNL)

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Communications, navigation, air traffic control (ATC) procedures, IFR certification and weather and icing are the major issues identified in the Helicopter Operations Development Plan for study and analysis. The communications study and analysis requirements addressed by this project include the methods by which information such as clearances, unique weather conditions, and position reports are conveyed between air and surface elements of the NAS especially where the communications link extends beyond line-of-sight. Line-of-sight considerations are extremely important with helicopter operations due to their unique low-altitude flight characteristics and the remote locations they service such as offshore oil rigs.

A helicopter A/G communications project was established at the Federal Aviation Administration Technical Center to assist the Systems Research and Development Service (SRDS) and FAA regional field facilities in establishing extended-range, low-altitude A/G communications on a priority basis in areas of need. Initial project efforts were directed toward assisting the Eastern Region with the design, acquisition, establishment, test, and evaluation of a low-altitude, extended-range helicopter communications system for the offshore New Jersey oil exploration area. Details of this project are included in Interim Report No. FAA-RD-79-123, dated January 1980. Other geographic-specific areas identified for project assistance include Appalachia and the Gulf of Mexico.
### Abstract

The basic purposes of this report are to provide a comprehensive BIBLIOGRAPHY of Helicopter Noise Technology literature covering the period 1975 through calendar 1980, to present this bibliography arranged by helicopter NOISE TECHNOLOGY AREAS, and to provide ABSTRACTS on literature that appear to make a significant contribution to the field of helicopter noise technology.

The helicopter is recognized as a complex noise generator, with significant contributions from the rotors, the engine and the gearbox. Much progress continues to be made in the noise areas of: (a) Formulations, Math Models and Analytical Procedures; (b) Noise Prediction Methodology; (c) Noise Reduction Techniques; and (d) Subjective Response to helicopter noise. The body of information, data and knowledge has use in many applications, including the reduction of helicopter noise in a cost effective manner and in minimizing annoyance to the civil populace.

This report has been arranged with the objective of being most useful to those having an interest in the individual areas of helicopter noise technology, as well as those having an overall interest in the field. It is intended that this report will be of particular use to those persons involved in: (a) the Formulation, Math Modeling and Analysis related to helicopter noise technology; (b) Prediction Methodology associated with helicopter noise; (c) Helicopter Noise Reduction Techniques; and (d) the Subjective Response to helicopter noise, both from a helicopter certification and community reaction standpoint.

### Key Words

- Helicopter Noise
- Noise Formulations
- Noise Math Models
- Noise Prediction
- Noise Reduction
- Subjective Response
- Rotor Noise
- Gearbox Noise
- Engine Noise
- Annoyance Criteria
- Noise Certification Criteria

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Impact of Prediction Accuracy on Costs – Noise Technology Applications in Helicopters

R. H. Spencer, H. Sternfeld, Jr.

Boeing Vertol Co.
Philadelphia, Pennsylvania

Federal Aviation Administration
Office of Environment and Energy
800 Independence Avenue, S.W.
Washington, D.C. 20591

This study is an extension of the work reported in Reference 1, "A Study of Cost/Benefit Tradeoffs Available in Helicopter Noise Technology Applications", and considers the effect which uncertainties in the prediction and measurement of helicopter noise have on the development and operating costs.

Although the number of helicopters studied is too small to permit generally applicable conclusions the following are the primary results:

The Effective Perceived Noise Levels tended to be overpredicted for takeoffs, underpredicted for approaches, with no general trend noted for level flyovers.

Prediction accuracy for the cases studied ranged from 1 to 6 EPNdB.

Test and measurement repeatability can give a range of up to 3 EPNdB.

Each helicopter must be studied as an individual case and generalization of cost trends should be avoided.

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This report documents the results of an international Round Robin Test on the analysis of helicopter noise. Digital spectral noise data of a 3.5-second simulated helicopter flyover and identical analog test tapes containing helicopter noise data, reference signals, test tones and time code signals were sent to 13 participating organizations. The purpose of the test was to evaluate data reduction systems and procedures; to determine the magnitude of the variability between representative systems and organizations; and to identify potential causes and assist in establishing recommended procedures designed to minimize the variability.
This document presents noise data for the Sikorsky UH-60A Blackhawk, the Sikorsky S-76 Spirit, the Agusta A-109 and the Bell 206-L. The acoustical data are accompanied by phototheodolite tracking data, cockpit instrument panel photo data, and meteorological data acquired from radiosonde balloons. Acoustical metrics include both noise certification metrics (EPNL, PNLT, PNL) as well as community/airport noise assessment metrics (SEL, dBA). Noise data have been acquired systematically to identify variations in level with variations in helicopter airspeed and altitude. Data contained in this report provide essential information for development of helicopter noise exposure contours as well as further evaluation of ICAO helicopter noise certification standards. Accordingly, this information will be of interest to helicopter manufacturers, airport planning consultants, acoustical engineers and airport managers. This report serves as a noise definition document establishing baseline acoustical characteristics of the test helicopters.
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<td>This report establishes the current (1982) FAA helicopter noise data base for use in environmental impact assessment. The report sets out assumptions, methodologies, and techniques used in arriving at noise-exposure-versus-distance relationships. Noise data are provided for 15 helicopters, including five flight regimes each: takeoff, approach, level flyover, hover in-ground-effect (HIGE) and hover out-of-ground effect (HOGE). When possible, level flyover data are presented for a variety of airspeeds. Sound exposure level (SEL) is provided for all operational modes except hover. In the case of hover operations (both HOGE and HIGE), the maximum A-Weighted Sound Level ($L_{A_{max}}$) is identified as a function of distance. The report also includes a discussion of helicopter performance characteristics required for full computer modeling of helicopter/heliport noise exposure.</td>
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### Abstract

The FAA has been conducting controlled helicopter noise measurement programs since 1976. The data have been used for a variety of purposes including evaluation of proposed U.S. and international noise standards, validation of helicopter noise prediction methodologies, and development of practical heliport design guidance.

In order to supplement the results of the controlled tests, field survey data are also being gathered to represent in-service operating conditions. Measurements are intended to represent helicopter noise within the context of urban ambient background noise. The results reported in this document are termed "survey measurements" as opposed to controlled test data, in order to reflect the limited control imposed over factors which contribute to the variability of measured noise levels.

Noise data are presented for the Bell 206-L, Aerospatiale Alouette III, and the Aerospatiale A-Star, SA-350. Operational modes include approach, takeoff, hover, and flat-pitch-idle. Noise data include A-Weighted Sound Level time histories, maximum A-Weighted Sound Level \( L_{ASm} \), Sound Exposure Level \( L_{AE} \), and Equivalent Sound Level \( L_{eq} \).
The purpose of this handbook is to identify techniques, methodologies, tools, and procedures in a systems context that may be applicable to aspects of the validation and certification of digital systems at specific times in the development, and implementation of software-based digital systems to be used in flight control/avionics applications. The application of these techniques in the development of discrete units and/or systems will result in completion of a product or system which is verifiable and can be validated in the context of the existing regulations/orders of the government regulatory agencies. The handbook uses a systems engineering approach to the implementation and testing of software and hardware during the design, development, and implementation phases. The handbook also recognizes and provides for the evaluation of the pilot's workload in the utilization of the new control/display technology, especially when crew recognition and intervention may be necessary to cope with/recover from the effects of faults or failures in the digital systems or the crew introduces errors into the system under periods of high workload due to some inadvertent procedure or entry of incorrect or erroneous data.

(Volume II of this Handbook is Report DOT/FAA/CT-88/10)
The FAA conducted a noise measurement survey of helicopter operations at three principal heliports in the borough of Manhattan in New York City on November 16-17, 1982. The purpose was to gather needed information for defining noise problems with in-service helicopter operations within urban areas. These noise data will be used to further define the environmental problems associated with helicopter operations in urban areas.

Statistical community noise level data, measured over an 8-hour period at each selected site, are provided which reflect the noise levels at these sites from all local sources during that particular day. Noise data from individual helicopter operations are also provided. These data from helicopter "targets of opportunity" are termed "survey data" as opposed to "controlled test data" in order to reflect the limited control over factors which contribute to the variability of the measured noise level. Noise data are presented for the Augusta A-109, Bell 47J, Bell 206L, Bell 222, Bcelkow B-105, and Sikorsky S-76.
16. Abstract
The FAA conducted a noise measurement survey of helicopter operations at three different helipads in the Los Angeles metropolitan area during the period of February 10-14, 1983. The purpose was to gather needed information for defining noise problems with in-service helicopter operations in a suburban and urban area.

Noise level data were sampled for a variety of helicopters for different operating conditions and land use characteristics. The data collected reflect noise levels at these sites from all local sources of noise during that particular sampling period. These data from helicopter "targets of opportunity" are termed "survey data" as opposed to "controlled test data" in order to reflect the limited control over factors which contribute to the variability of the measured noise level.

17. Key Words
Helicopters, $L_{MAX}$, $L_{eq}$, Environmental Noise Impact
# Abstract

The FAA conducted a noise measurement survey of helicopter operations at Norwood, Massachusetts on April 27, 1983. The purpose was to gather needed information for defining noise problems with in-service helicopter operations at a general aviation airport in a suburban area.

Noise level data were sampled over a period of approximately 6 hours. The data collected reflect noise levels at two different residential sites from all local source of noise during that particular sampling period. These data from helicopter "target of opportunity" are termed "survey data" as opposed to "controlled test data" in order to reflect the limited control factors which contribute to the variability of the measured noise.

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**Key Words**

- Helicopters, General Aviation
- Aircraft, Environmental Noise Impact,
  $L_{eq}$, $L_{NAX}$

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This report documents the results of a Federal Aviation Administration (FAA) noise measurement flight test program with the Bell 222 twin-jet helicopter. The report contains documentary sections describing the acoustical characteristics of the subject helicopter and provides analyses and discussions addressing topics ranging from acoustical propagation to environmental impact of helicopter noise.

This report is the first in a series of seven documenting the FAA helicopter noise measurement program conducted at Dulles International Airport during the summer of 1983. The Bell 222 test program involved the acquisition of detailed acoustical, position and meteorological data.

This test program was designed to address a series of objectives including:
1) evaluation of "Fly Neighborly" (minimum noise) operating procedures for helicopters, 2) acquisition of acoustical data for use in heliport environmental impact, 3) documentation of directivity characteristics for static operation of helicopters, 4) establishment of ground-to-ground and air-to-ground acoustical propagation relationships for helicopters, 5) determination of noise event duration influences on energy dose acoustical metrics, 6) examination of the differences between noise measured by a surface mounted microphone and a microphone mounted at a height of four feet (1.2 meters), and 7) documentation of noise levels acquired using international helicopter noise certification test procedures.

Key Words
helicopter, noise, Bell 222, heliport environmental impact, directivity, noise certification standards

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This report documents the results of a Federal Aviation Administration (FAA) noise measurement flight test program with the Dauphin twin-jet helicopter. The report contains documentary sections describing the acoustical characteristics of the subject helicopter and provides analyses and discussions addressing topics ranging from acoustical propagation to environmental impact of helicopter noise.

This report is the second in a series of seven documenting the FAA helicopter noise measurement program conducted at Dulles International Airport during the summer of 1983. The Dauphin test program involved the acquisition of detailed acoustical, position and meteorological data.

This test program was designed to address a series of objectives including:
1) acquisition of acoustical data for use in assessing heliport environment impact,
2) documentation of directivity characteristics for static operation of helicopters,
3) establishment of ground-to-ground and air-to-ground acoustical propagation relationships for helicopters,
4) determination of noise event duration influences on energy dose acoustical metrics,
5) examination of the differences between noise measured by a surface mounted microphone and a microphone mounted at a height of four feet (1.2 meters), and
6) documentation of noise levels acquired using international helicopter noise certification test procedures.

16. Abstract

17. Key Words
   helicopter, noise, Dauphin, heliport, environmental impact, directivity, noise certification standards

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**Title and Subtitle**

Noise Measurement Flight Test for Hughes 500D/E: Data and Analyses

**Abstract**

This report documents the results of a Federal Aviation Administration (FAA) noise measurement flight test program with the Hughes 500D/E helicopter. The report contains documentary sections describing the acoustical characteristics of the subject helicopter and provides analyses and discussions addressing topics ranging from acoustical propagation to environmental impact of helicopter noise.

This report is the third in a series documenting the FAA helicopter noise measurement program conducted at Dulles International Airport during the summer of 1983. The Hughes 500D/E test program involved the acquisition of detailed acoustical, position and meteorological data.

This test program was designed to address a series of objectives including:

1) acquisition of acoustical data for use in assessing heliport environmental impact,
2) documentation of directivity characteristics for static operation of helicopters,
3) establishment of ground-to-ground and air-to-ground acoustical propagation relationships for helicopters,
4) determination of noise event duration influences on energy dose acoustical metrics,
5) examination of the differences between noise measured by a surface mounted microphone and a microphone mounted at a height of four feet (1.2 meters), and
6) documentation of noise levels acquired using international helicopter noise certification test procedures.

**Key Words**

helicopter, noise, Hughes, heliport environmental impact, directivity, noise certification standards

**Distribution Statement**

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**Technological Report Documentation Page**

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<td>(1) U.S. Department of Transportation, Transportation Systems Center, Kendall Square, Cambridge, Mass 021142 (2) ORI, Inc., 1375 Piccard Drive, Rockville, MD 20850</td>
<td>This report documents the results of a Federal Aviation Administration (FAA) noise measurement flight test program with the TwinStar twin-jet helicopter. The report contains documentary sections describing the acoustical characteristics of the subject helicopter and provides analyses and discussions addressing topics ranging from acoustical propagation to environmental impact of helicopter noise. This report is the fourth in a series of seven documenting the FAA helicopter noise measurement program conducted at Dulles International Airport during the summer of 1983. The TwinStar test program involved the acquisition of detailed acoustical, position and meteorological data. This test program was designed to address a series of objectives including: 1) acquisition of acoustical data for use in assessing heliport environmental impact, 2) documentation of directivity characteristics for static operation of helicopters, 3) establishment of ground-to-ground and air-to-ground acoustical propagation relationships for helicopters, 4) determination of noise event duration influences on energy dose acoustical metrics, 5) examination of the differences between noise measured by a surface mounted microphone and a microphone mounted at a height of four feet (1.2 meters), and 6) documentation of noise levels acquired using international helicopter noise certification test procedures.</td>
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<td>helicopter, noise, TwinStar, heliport Environmental impact, directivity, noise certification standards</td>
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4. Title and Subtitle
Noise Measurement Flight Test for Aerospatiale AS 350D AStar Helicopter Data and Analyses

5. Report Date September 1984

Authors: J. Steven Newman, Edward J. Rickley (1) Kristy R. Beattie (2), Tyrone L. Bland (2)

6. Performing Organization Code


8. Performing Organization Name and Address
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Federal Aviation Administration, Office of Environment and Energy, Noise Abatement Division, Noise Technology Branch, (AEE-120), 800 Independence Ave., S.W. Washington, D.C. 20591

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15. Supplementary Notes
(1) U.S. Department of Transportation, Transportation Systems Center, Kendall Square Cambridge, Mass 02142
(2) ORI, Inc., 1375 Piccard Drive, Rockville, MD 20850

16. Abstract
This report documents the results of a Federal Aviation Administration (FAA) noise measurement flight test program with the AStar helicopter. The report contains documentary sections describing the acoustical characteristics of the subject helicopter and provides analyses and discussions addressing topics ranging from acoustical propagation to environmental impact of helicopter noise.

This report is the fifth in a series of seven documenting the FAA helicopter noise measurement program conducted at Dulles International Airport during the summer of 1983. The AStar test program involved the acquisition of detailed acoustical, position and meteorological data.

This program was designed to address a series of objectives including:
1) acquisition of acoustical data for use in assessing heliport environmental impact
2) documentation of directivity characteristics for static operation of helicopters
3) establishment of ground-to-ground and air-to-ground acoustical propagation relationships for helicopters,
4) determination of noise event duration influences on energy dose acoustical metrics,
5) examination of the differences between noise measured by a surface mounted microphone and a microphone mounted at a height of four feet (1.2 meters), and
6) documentation of noise levels acquired using international helicopter noise certification test procedures.

17. Key Words
helicopter, noise, AStar, heliport environmental impact, directivity, noise certification standards

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1. Report No. | FAA-EE-84-6
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2. Government Accession No. | ADA 148 525
3. Recipient's Catalog No. | 
4. Title and Subtitle | Noise Measurement Flight Test for Sikorsky S-76A Helicopter: Data and Analyses
5. Report Date | September 1984
6. Performing Organization Code | 
7. Authors | J. Steven Newman, Edward J. Rickley (1), Tyrone L. Bland (2), Kristy R. Beattie (2)
9. Performing Organization Name and Address | Federal Aviation Administration, Office of Environment and Energy, Noise Abatement Division, Noise Technology Branch, (AEE-120), 800 Independence Ave., SW Washington, DC 20591
10. Work Unit No. (TRAIS) | 
11. Contract or Grant No. | 
12. Sponsoring Agency Name and Address | Federal Aviation Administration, Office of Environment and Energy, Noise Abatement Division, Noise Technology Branch, (AEE-120), 800 Independence Ave., SW Washington, DC 20591
13. Type of Report and Period Covered | 
15. Supplementary Notes | (1) U.S. Department of Transportation Systems Center, Kendall Square, Cambridge, Mass. 02142
(2) ORI, Inc. 1375 Piccard Drive, Rockville, Maryland 20850
16. Abstract | This report documents the results of a Federal Aviation Administration (FAA) noise measurement flight test program with the Sikorsky S-76 helicopter. The report contains documentary sections describing the acoustical characteristics of the subject helicopter and provides analyses and discussions addressing topics ranging from acoustical propagation to environmental impact of helicopter noise.

This report is the sixth in a series of seven documenting the FAA helicopter noise measurement program conducted at Dulles International Airport during the summer of 1983. The S-76 test program involved the acquisition of detailed acoustical, position and meteorological data.

This test program was designed to address a series of objectives including: 1) acquisition of acoustical data for use in assessing heliport environment impact, 2) documentation of directivity characteristics for static operation of helicopters, 3) establishment of ground-to-ground and air-to-ground acoustical propagation relationships for helicopters, 4) determination of noise event duration influences on energy dose acoustical metrics, 5) examination of the differences between noise measured by a surface mounted microphone and a microphone mounted at a height of four feet (1.2 meters), and 6) documentation of noise levels acquired using international helicopter noise certification test procedures.

17. Key Words | helicopter, noise, Sikorsky, heliport, environmental impact, directivity, noise certification standards
18. Distribution Statement | This document is available to the public through the National Technical Information Service, Springfield, VA 22161
19. Security Classif. (of this report) | Unclassified
20. Security Classif. (of this page) | Unclassified
21. No. of Pages | 190
22. Price | 121
This report documents the results of a Federal Aviation Administration (FAA) noise measurement flight test program with the Boeing-Vertol CH-47D helicopter. The report contains documentary sections describing the acoustical characteristics of the subject helicopter and provides analyses and discussions addressing topics ranging from acoustical propagation to environmental impact of helicopter noise.

This report is the seventh in a series of seven documenting the FAA helicopter noise measurement program conducted at Dulles International Airport during the summer of 1983. The BV234/CH-47D test program involved the acquisition of detailed acoustical, position and meteorological data.

This test program was designed to address a series of objectives including:
1) acquisition of acoustical data for use in assessing heliport environment impact,
2) documentation of directivity characteristics for static operations of helicopters,
3) establishment of ground-to-ground and air-to-ground acoustical propagation relationships for helicopters,
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6) documentation of noise levels acquired using international helicopter noise certification test procedures.
**Abstract**

The FAA conducted a noise measurement survey of helicopter operations at Las Vegas during the Annual Helicopter Association International Convention. The survey was performed during the period of January 19-21, 1984. The purpose of this noise survey was to obtain additional noise data for a number of different helicopter models during normal operations in an urban environment. This survey was the first test program which measured sideline noise levels beyond 500 feet. The data collected are classified as survey type data, since the data obtained were from "target of opportunity" as opposed to "controlled test data."

**Key Words**

Helicopter, $L_{MAX}$, $L_{EQ}$, environmental noise impact

**Distribution Statement**

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**Security Classification**

Unclassified
16. Abstract

THE FAA HAS CONDUCTED A SERIES OF NOISE SURVEYS IN THE FOLLOWING URBAN AREAS:
CHICAGO, IL; LONG BEACH, CA; NEW ORLEANS, LA; PORTLAND, OR; AND SEATTLE, WA.
IN EACH METROPOLITAN AREA, NOISE MEASUREMENTS WERE MADE AT THREE OR FOUR HELIPORTS
OR HELIPADS. LAND USE SURROUNDING THE HELIPORTS RANGED FROM RESIDENTIAL TO
INDUSTRIAL. NOISE LEVELS FOR L_{max} WERE RECORDED DURING EACH TEST AT EACH HELIPORT
ALSO RECORDED WERE AMBIENT NOISE LEVELS WHICH WERE USED AS A BASIS FOR COMPARISON
OF NOISE ASSOCIATED WITH HELICOPTER OPERATIONS VERSUS URBAN BACKGROUND NOISE
LEVELS.
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<td>(1) U.S. DOT Transportation Systems Center, Kendall Square, Cambridge, MA 02142</td>
<td>This document reports the findings of the U.S. test team's participation in the Helicopter Noise Measurement Repeatability Program (HNMMP) conducted under the direction of the International Civil Aviation Organization's (ICAO) Committee on Aviation Environmental Problems (CAEP) Working Group II (WG II). The FAA, as the U.S. test team, conducted the HNMMP noise measurement flight test program in concert with a separate measurement team from Canada. The U.S./Canadian flight test was held in August of 1984 at Dulles International Airport near Washington, D.C. The principal objective of this international HNMMP is to refine noise certification testing requirements. Participating nations conducted the test programs on the same type helicopter, the Bell 206L-1 (or the acoustically equivalent 206L-3), using the same test procedures. Analyses in this document include the investigation of source noise adjustments based on increases in noise level with advancing blade tip Mach number, the examination of relative source contributions in the helicopter acoustical spectrum, and source directivity for both in-flight and static operations. This report contains helicopter noise definition information (useful in environmental impact analyses) for level flyovers at various airspeeds and altitudes, and ICAO takeoff and approach procedures. Data are also shown for a noise abatement operation involving dynamic changes in torque, rate of descent and airspeed. This report also provides information for the hover-in-ground effect, flight idle and ground idle static operations. The results reported in this document will be combined with those of other HNMMP participant nations for evaluation by CAEP WG II.</td>
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Flight Operations Noise Tests of Eight Helicopters

This document presents acoustical data and flight path information acquired during the FAA/HAI Helicopter Flight Operations Noise Test Program. "As-measured" noise levels of the Aerospatiale 365N, Agusta 109A, Bell 206L-1 and 222A, Hughes 500D, MBB BK117, Robinson R22, and Sikorsky S76 are presented for various enroute and heliport flight operations. These operations include level flyovers at two altitudes, normal takeoffs, normal and constant-gildeslope approaches, various types of noise abatement approaches, level flight turns and hover (IGE and OGE). The acoustical data are accompanied by radar tracking data and cockpit instrument panel information which document the operational procedures flown, and meteorological measurements to permit data corrections for nonstandard atmospheric conditions. This helicopter operational noise data base can be used in enroute and heliport land use planning, heliport environmental studies and planning guidelines, pilot familiarization and training, verification of noise prediction and estimating methods, and lateral attenuation studies.

Key Words
- helicopter
- noise
- heliport
- flight operations
- noise abatement
- directivity approaches

Distribution Statement
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Security Classification
- Unclassified

No. of Pages
- 728

Price
- Unclassified
The understanding of community reaction to helicopter noise remains incomplete. A technique called "A-weighting" appears to produce realistic data outdoors and at modest noise levels, and the community response in terms of percentage of population highly annoyed can be correlated with respect to the Day/Night Average Sound Level (DNL) descriptor. However, questions remain as to the effect of perceived building vibration and rattle on human response to helicopter noise. Does hearing windows, ceiling tiles, or objects in the room rattle or the general perception of building vibration increase the public's adverse response to helicopter noise? To answer these questions,
this study examined the role of vibration and rattle in human response to helicopter noise.

Many volunteer subjects were tested under real noise conditions. The helicopter noise was generated by an Army UH-1H (Huey) helicopter. Subjects were located either in the living room of a new mobile home, outdoors, or in the living room or dining room of an old frame farmhouse near Champaign, IL. The control or comparison sound was generated electronically through loudspeakers at each location using a 500-Hz octave band of white noise. By performing paired comparison tests between the helicopter and control noises, it was possible to establish equivalency between these two stimuli. The subjects did not know that the role of vibration and rattle was the test's true purpose. USA-CERL researchers and USA-CERL instruments recorded the vibration and rattle levels; the subjects judged only their annoyance to the helicopter noise versus the control noise.

Results showed that the A-frequency-weighting is adequate to assess community response to helicopter noise when no vibration or rattle is induced by the noise and the A-weighted sound exposure level is less than 90 dB. When rattle or vibration is induced by the helicopter noise, however, A-weighting does not assess the community response adequately. Under conditions of "a little" rattle or vibration induced by the helicopter noise, an offset of about 10 dB appears necessary to properly account for community reaction to helicopter noise. When "a lot" of rattle or vibration is induced, the offset necessary to use A-weighting appears to be on the order of 20 dB or more. Moreover, C-weighting offers little or no improvement over A-weighting; the subjective response data still divide based on the levels of vibration and rattle induced by the noise.

In this study, slant distance (distance of closest approach between the helicopter and the location on the ground) offers the best correlation with high levels of rattle. For slant distances in excess of 1000 ft, high levels of rattle usually would not be induced and for slant distances shorter than 500 ft, high levels of rattle would nearly always be produced.

The result suggests a decibel offset of perhaps 5 to 10 dB to assess helicopter noise properly when little vibration or rattle is produced by the noise or when no rattle is produced and the helicopter sound exposure level (SEL) is very high, exceeding about 90 dB. With no rattles and at lower helicopter SELs, there is no offset. No housing or noise-sensitive land uses should be located in zones where high levels of vibration or rattle are induced by helicopter noise; the offset is at least on the order of 20 dB. This high vibration and rattle zone potentially can be delineated by helicopter type and slant distance. For the Army Huey aircraft in level flyover, this zone boundary is at a slant distance somewhere between 500 and 1000 ft. The slant distance zone boundary is expected to differ with type of aircraft and operation.
This report documents the results of a Federal Aviation Administration (FAA) noise measurement flight test program involving seven helicopters and establishes noise levels using the basic testing, reduction and analysis procedures specified by the International Civil Aviation Organization (ICAO) for helicopter noise certification supplemented with some procedural refinements contained in ICAO Working Group II recommendations for incorporation into the standard. The helicopters analyzed in this report include the Hughes 500 D/E, the Aerospatiale AS 350D (AStar), the Aerospatiale AS 355F (TwinStar), the Aerospatiale SA 365 (Dauphin), the Bell 222 Twin Jet, the Boeing Vertol 234/CH 47-D, and the Sikorsky S-76. The document discusses the evolution of international helicopter noise certification procedures and describes in detail the data acquisition, reduction and adjustment procedures. Noise levels are plotted versus the logarithm of maximum gross takeoff weight and are shown relative to the ICAO noise level limits. Data from the ICAO Committee on Aircraft Noise (CAN) Seventh meeting "request for data" are also presented. Reference testing and operational data are provided for each helicopter.

**Key Words**
- helicopter
- noise
- heliport
- environmental impact
- ICAO noise certification standards
- aircraft noise
- heliport
- ICAO Annex 16

**Distribution Statement**
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**No. of Pages**
283
### Abstract

The FAA conducted a noise monitoring program of helicopter operations at the Lakefront Airport in New Orleans, Louisiana. The purpose was to obtain noise measurements from helicopter operations in an urban environment. During this monitoring program the FAA concentrated solely on helicopter approaches to Lakefront Airport. The noise data collected and classified as survey type data, since the monitoring program's measurements data obtained were from "target of opportunity" as opposed to a "controlled test" when the helicopter follow predefined flight path profiles. During the testing period, there were ten different helicopter models. Because of the high frequency of operations an opportunity was provided to determine the consistency between AIM values for the same helicopter model for different events. Since some of the monitoring sites were located in a residential community, an opportunity was provided to gather information on noise levels associated with a high frequency of helicopter operations.
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<td>Fluid ice protection systems are being installed on several new generation aircraft. There are many new considerations that must be taken into account when fluid ice protection systems are used. This Technical Note addresses the fluid ice protection system from the perspective of certification and presents a compendium of information for use by Federal Aviation Administration (FAA) certification engineers, Aircraft Certification Offices (ACO's) and others.</td>
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Aviation accident data indicate that the majority of aircraft mishaps are due to judgment error. This training manual is part of a project to develop materials and techniques to help improve pilot decision making. Training programs using prototype versions of these materials have demonstrated substantial reductions in pilot error rates. The results of such tests were statistically significant and ranged from approximately 10% to 50% fewer mistakes.

This manual is designed to explain the risks associated with Student and Private pilot flying activities, the underlying behavioral causes to typical accidents, and the effects of stress on pilot decision making. It provides a means for the individual pilot to develop an "Attitude Profile" through a self-assessment inventory and provides detailed explanations of preflight and in-flight stress management techniques. The assumption is that pilots receiving this training will develop a positive attitude toward safety and the ability to manage stress effectively while recognizing and avoiding unnecessary risk.

This manual is one of a series on Aeronautical Decision-Making prepared for the following pilot audiences: (1) Student and Private (2) Commercial (3) Instrument (4) Instructor (5) Helicopter (6) Multi-Crew.
### Abstract

Aviation accident data indicate that the majority of aircraft mishaps are due to judgement error. This training manual is part of a project to develop materials and techniques to help improve pilot decision making. Training programs using prototype versions of these materials have demonstrated substantial reductions in pilot error rates. The result of such tests were statistically significant and ranged from approximately 10% to 50% fewer mistakes.

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### Key Words

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### Distribution Statement

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Aeronautical Decision Making for Instrument Pilots

Richard S. Jensen, Janeen Adrion, Russell S. Lawton

Systems Control Technology, Inc. 1611 North Kent Street, Suite 905 Arlington, VA 22209

U.S. Department of Transportation Federal Aviation Administration 800 Independence Avenue, S.W. Washington, DC 20591

AAM-500 Biomedical and Behavioral Sciences Division APM-450 Navigation and Landing Division, Helicopter Program Branch

Aviation accident data indicate that the majority of aircraft mishaps are due to judgment error. This training manual is part of a project to develop materials and techniques to help improve pilot decision making. Training programs using prototype versions of these materials have demonstrated substantial reductions in pilot error rates. The results of such tests were statistically significant and ranged from approximately 10% to 50% fewer mistakes.

This manual is designed to explain the risks associated with instrument flying activities, the underlying behavioral causes of typical accidents, and the effects of stress on pilot decision making. It provides a means for the individual pilot to develop an "Attitude Profile" through a self-assessment inventory and provides detailed explanations of preflight and in-flight stress management techniques. The assumption is that pilots receiving this training will develop a positive attitude toward safety and the ability to effectively manage stress while recognizing and avoiding unnecessary risk.

This manual is one of a series on Aeronautical Decision Making prepared for the following pilot audiences: (1) Student and Private (2) Commercial (3) Instrument (4) Instructor (5) Helicopter (6) Multi-Crew.

Human Factors Judgment
Human Performance Decision Making
Aviation Safety Instrument Pilots
Aviation Training Professional Pilots
Pilot Error

This document is available to the U.S. public through the National Technical Information Service, Springfield, Virginia 22161
Aeronautical Decision-Making For Instructor Pilots

Georgette D. Euch, Russell S. Lawton, Gary S. Livack, Editors

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AAM-500 Biomedical and Behavioral Sciences Division
APM-450 Navigation and Landing Division, Helicopter Program Branch

Aviation accident data indicate that the majority of aircraft mishaps are due to judgment error. This training manual is part of a project to develop materials and techniques to help improve pilot decision making. Training programs using prototype versions of these materials have demonstrated substantial reductions in pilot error rates. The results of such tests were statistically significant and ranged from approximately 10% to 50% fewer mistakes.

This manual is designed to explain the risks associated with flight instruction activities, the underlying behavioral causes of typical accidents, and the effects of stress on pilot decision making. This instructor manual explains the unique aspects of teaching judgment concepts in contrast with the imparting of knowledge and the development of airmanship skills in conventional flight training. It also provides detailed explanations of pre-flight and in-flight stress management techniques. The assumption is that CFI's receiving this training will develop a positive attitude toward safety and the ability to effectively manage stress while recognizing and avoiding unnecessary risk.

This manual is one of a series on Aeronautical Decision Making prepared for the following pilot audiences: (1) Student and Private (2) Commercial (3) Instrument (4) Instructor (5) Helicopter (6) Multi-Crew.
Aeronautical Decision Making - Cockpit Resource Management

Richard S. Jensen

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AAM-500 Biomedical and Behavioral Sciences Division
ADS - 220 Rotorcraft Technology Branch, System Technology Division

Aviation accident data indicate that the majority of aircraft mishaps are due to judgment error. This training manual is part of a project to develop materials and techniques to help improve pilot decision making. Training programs using prototype versions of these materials have demonstrated substantial reductions in pilot error rates. The results of such tests were statistically significant and ranged from approximately 10% to 50% fewer mistakes.

This manual is designed to explain the risks associated with flying activities involving multi-crew aircraft, the underlying behavioral causes of typical accidents, and the effects of stress on pilot decision making. The objective of this material is to enhance interpersonal communication and to facilitate effective leadership and coordination between crewmembers. It provides a sophisticated approach to developing concerted action based on optimal decision making. Several Cockpit Resources Management (CRM) principles are presented in the manual; included are delegation of responsibilities, prioritization, vigilance and monitoring, joint discussion and planning, and receptive leadership techniques.

This manual is one of a series on Aeronautical Decision Making (ADM) prepared for the following pilot audiences:

(1) Student and Private
(2) Instructor
(3) Instrument
(4) Instrument
(5) Helicopter
(6) Multi-crew.

Aviation Training
Pilot Error
Judgment
Cockpit Resource Management

Crew Coordination
Human Factors
Human Performance
Aviation Performance
Decision Making
Communication

Unclassified
Unclassified

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### Technical Report Documentation Page

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<td>16. Abstract</td>
<td>This report summarizes the findings of the Helicopter Noise Measurement Repeatability Program (HNMRP), which was initiated by the International Civil Aviation Organization (ICAO) Committee on Aviation Environmental Protection (CAEP) Working Group II (WG II). The HNMRP was begun with the goal of further developing and refining international helicopter noise certification standards. This international effort has involved the active participation of Australia, Canada, the Federal Republic of Germany, France, Italy, Japan, the United Kingdom, and the United States. The participating ICAO CAEP WG II nations set out to investigate the degree of variability in test results of the existent helicopter noise certification rule by conducting a multinational noise measurement flight test program using a single, widely available helicopter, the Bell 206L-1 (or the acoustically equivalent 206L-3). The HNMRP has provided a large number of certificating authorities and industry participants the opportunity to acquire experience in helicopter noise certification and the opportunity to thoroughly test and review the requirements of Chapter 7 and Appendix 4 of ICAO Annex 16 through implementation experience. As a result of this experience, recommendations for improvements and refinements to Annex 16 were developed, and subsequently adopted as proposed amendments at the CAEP/1 meeting in Montreal in June 1986. The HNMRP also provided ICAO WG II the chance to review the inherent repeatability of noise levels for a single helicopter model tested by different teams at different locations. This report contains: a history of the HNMRP, a summary of the multi-nation comparison data, and discussion of the results of the program, including the refinements proposed for the international helicopter noise certification standard. Future analytical opportunities using HNMRP data are also discussed at the end of the report.</td>
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This document presents the results of an FAA investigation to determine the effects of using de-icing, as opposed to anti-icing, in aircraft turbine engine inlets. A literature search was conducted. Ice protection equipment technology was assessed.

This report describes the icing/de-icing process, discusses de-ice system operation and performance and ice detector characteristics, and presents a method for determining the effects of the de-icing process on the turbine engine and its associated induction system.
During the winter and spring of 1987 flight tests were conducted at the Federal Aviation Administration (FAA) Technical Center's Concepts Development and Demonstration Heliport at the Atlantic City International Airport, NJ. The purpose of these flights was to examine and validate the current heliport approach/departure surfaces criteria as defined in the Heliport Design Guide and to recommend modifications to these surfaces, if appropriate. The flight activities were conducted using aircraft representative of those in the civilian world. Data were collected using approach surfaces of 7.1250, 8.000, 10.000, and 12.000 for straight as well as curved path procedures. Also, departure surfaces of 7.1250, 10.000, and 12.000 for straight and curved path procedures were used. All maneuvers were tracked by ground based tracking systems.

Volume I of this report documents the results of this activity. It describes the flight test and evaluation methodology and addresses technical as well as operational issues. It provides statistical and graphical analysis of pilot performance along with a discussion of pilot subjective opinions concerning the acceptability and perceived workload, safety, and control margins associated with the performance flown. This volume contains the briefing packets, pilot questionnaires, flight logs, and data plots.

The results of this work will be considered in the future modifications of the FAA Heliport Design Advisory Circular, AC 150/5390-2.
During the summer of 1987 heliport environmental data were collected at the Indianapolis Downtown Heliport and at New York's Wall Street Heliport. The purpose of this data collection activity was to obtain measures of rotorwash in the heliport environment due to maneuvering helicopters, and to obtain pilot perceptions and observations concerning maneuvering and parking separation criteria. Ten wind vector transmitters were situated at various locations around the heliport in order to gather information to describe the rotorwash induced wind speed and direction changes. Pilot interviews were also conducted at these heliports.

Volume I of this report documents the results of this activity. It describes the data collection and analysis methodology and addresses technical as well as operational issues. It provides graphical descriptions of the heliport environment and of wind speed changes due to rotorwash from maneuvering helicopters, along with analysis of pilot responses.

Volumes II and III provide the plots generated from the New York and Indianapolis Heliport data.

The results of this study will be considered in future modifications of the Federal Aviation Administration (FAA) Heliport Design Advisory Circular (AC) 150/5390-2.
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Volume I of this report provides a summary of the results of this activity. Volume III provides the plots generated from the wind sensor data collected at the Indianapolis Downtown Heliport.

This volume (Volume II) provides the plots generated from the wind sensor data collected at New York's Wall Street Heliport.

The results of this study will be considered in future modifications of the Federal Aviation Administration (FAA) Heliport Design Advisory Circular, AC 150/5390-2.
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Volume I of this report provides a summary of the results of this activity. Volume II provides the plots generated from the wind sensor data collected at New York's Wall Street Heliport.

This volume (Volume III) provides the plots generated from the wind sensor data collected at the Indianapolis Downtown Heliport.

The results of this study will be considered in future modifications of the Federal Aviation Administration (FAA) Heliport Design Advisory Circular, AC150/5390-2.
This report describes the results of an investigative flight test evaluating the slant range accuracy of Global Positioning System (GPS) user equipment. The report describes flight test facilities, equipment and methodology, and addresses data collection and reduction procedures.

It was concluded that the two-channel, Precision Code GPS receiver provides the ranging accuracy required to support Microwave Landing System (MLS) approaches down to International Civil Aviation Organization (ICAO) Category II minimums of 100 foot ceiling and 1/4-mile visibility. GPS consistently demonstrated range errors less than ±100 feet. GPS ranging accuracy measurements were taken only during periods where four or more GPS satellites were visible.
This document contains the instructions to execute the Heliport Noise Model (HNM), Version 1. HNM Version 1 is a computer tool for determining the total impact of helicopter noise at and around heliports. The model runs on IBM PC/XT/AT personal computers and compatibles. This manual contains a general description of elements of a heliport case study and specific instructions for preparing the case for input.

HNM Version 1 is based upon the FAA's Integrated Noise Model (INM) for noise from fixed-wing aircraft.
This Technical Note identifies procedures to be used during tests to be conducted at the Albuquerque International Airport (ABQ), Albuquerque, New Mexico. These tests are designed to evaluate the applicability of existing heliport approach and departure surface criteria under high temperature and high altitude conditions. A UH-1H aircraft will be used. This project is similar to the work documented in DOT/FAA/CT-TN87/40, "Heliport Visual Approach and Departure Airspace Tests".
## Abstract

This manual is intended to provide an easy reference for dealing with the operating pitfalls, the human frailties, and the risks in managing an air ambulance operation. It is not designed to give the operator step-by-step instructions. Rather, the manual describes techniques and tools that can be used to balance the demands of running a business with the need for maintaining safety. It provides pilot selection and training guidelines, as well as a review of a risk assessment technique that have proven successful for Part 135 operators. In addition, the manual recommends a workable format for establishing standard operating procedures to reduce risks. Finally, it highlights the key concerns that should be carefully considered from a risk management viewpoint.

This operators manual is one of an integrated set of five Aeronautical Decision Making (ADM) manuals developed by the Federal Aviation Administration in a concerted effort to reduce the number of human factor related helicopter accidents. It can be used as one element of a comprehensive program for improving safety, reducing risk and, hopefully, the high cost of helicopter hull and liability insurance. The other four documents of the set are:

1. ADM for Helicopter Pilots (DOT/FAA/PM-86/45)
2. ADM for EMS Helicopter Pilots -- Learning from Past Mistakes (DOT/FAA/DS-88/5)
3. ADM for EMS Helicopter Pilots -- Situational Awareness Exercises (DOT/FAA/DS-88/6)
4. ADM for Air Ambulance Hospital Administrators (DOT/FANDS-88/8)
### Aeronautical Decisionmaking for Air Ambulance Program Administrators

**Abstract**

This manual discusses five of the most critical administrative aeronautical decision areas. The treatment is brief to ensure that the important, basic aeronautical limits will be read and understood by the largest possible audience. The concerns are:

- **ACCIDENT CHARACTERISTICS**
- **PILOT CHARACTERISTICS**
- **WEATHER RESTRICTIONS**
- **TRAINING NEEDS**
- **RISK MANAGEMENT**

Each of these concerns is discussed in a summary format. The summaries begin with a concise statement of the problem. This statement is followed by a discussion of the governing regulations, an explanation of the underlying reasons for the limitation, and recommended solutions an administrator could implement to reduce the impact of, or eliminate, the risk. This summary material is supplemented by appropriate references for use by the reader who would like to explore one or more of these areas in greater detail.

This administrators' manual is one of an integrated set of five Aeronautical Decisionmaking (ADM) manuals developed by the Federal Aviation Administration in a concerted effort to reduce the number of human factor related helicopter accidents. It can be used as one element of a comprehensive program for improving safety, reducing risk and, hopefully, the high cost of helicopter hull and liability insurance. The other four documents of the set are:

1. ADM for Helicopter Pilots (DOT/FAA/PM-86/45)
2. ADM for EMS Helicopter Pilots -- Learning from Past Mistakes (DOT/FAA/DS-88/6)
3. ADM for EMS Helicopter Pilots -- Situational Awareness Exercises (DOT/FAA/DS-88/6)
4. Risk Management for Air Ambulance Helicopter Operators (DOT/FAA/DA-88/7)

**Distribution Statement**

This document is available to the U.S. public through the National Technical Information Service, Springfield, Virginia 22161.
Volume II covers detailed technical topics such as latent faults; data buses; integrated assurance assessment; analytical sensor redundancy; and protection against lightning, electromagnetic interference, and high energy radio frequency fields. These topics are covered in detail to familiarize the certification engineer with the issues involved in implementing the new technologies.

Volume II covers topics that will enable the certification engineer to understand the information presented in type certification and supplemental type certification documentation, to understand variations in the implementation of technologies, and to discuss them with the design engineer.

Volume II also addresses some of the soon-to-be-available technologies in the "Advanced Validation Issues" chapter. The direction of aviation research in the United States is discussed along with challenges and problems that confront the certification engineer in certifying the new technologies.

Since the topics discussed in this Handbook are at the forefront of technological research, some of the concepts presented are subject to discussion by experts in the field. In these areas, the Handbook presents various viewpoints alerting the certification engineer to the various views so that this information will be considered in formulating decisions and developing certification criteria.
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14. **Supplementary Notes**

15. **Abstract**
    - This test plan describes a test designed to obtain subjective pilot data on the Helicopter Visual Segment Approach Lighting System (HALS). Results should identify the performance measures which will most closely correlate with the pilot's ability to visually acquire a HALS equipped heliport and identify if HALS qualifies for visibility credit.

16. **Key Words**
    - Approach Lighting System
    - HALS
    - MLS
    - TERPS

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HELIPORT SURFACE MANEUVERING TEST RESULTS

During late fall 1987 and early spring 1988 flight tests were conducted at the Federal Aviation Administration (FAA) Technical Center's National Concepts Development and Demonstration Heliport. The purpose of these tests was to measure pilot perception of helicopter tip clearances for parking and taxiing maneuvers and to measure pilot performance during these maneuvers.

Over 100 parking and taxiing maneuvers were conducted using a UH-1H helicopter. The parking procedures were conducted under head, tail, and crosswind conditions, both with and without an obstacle in place. The taxiing procedures were carried out with a centerline, with only side markings, and with no ground markings. A ground-based laser tracker system was used to track the taxiing procedures. Pilot subjective data in reference to these maneuvers were collected via a post-flight questionnaire.

Pilot interviews were conducted at heliports across the country. These interviews gathered pilot views concerning rotor tip clearances for parking and hover taxiing maneuvers, ground markings for parking operations, and hover taxiing heights.

This report documents the results of this activity. It describes the data collection and analysis methodology and addresses objective as well as subjective issues. It provides statistical and graphical analysis of pilot performance and perception data and pilot subjective data.
This flight test plan describes the methodology to examine the issue of heliport night parking surface separation criteria. Operational measures will be collected at the Federal Aviation Administration (FAA) Technical Center, Atlantic City International Airport, New Jersey, using an instrumented UH-1H helicopter.

Flight maneuvers will be conducted at the Technical Center to identify night parking area separation criteria under various wind conditions. Wind velocity and direction data will be collected during night parking operations to determine effects at different locations around the parking area. This data will be used to create a baseline for characterizing heliport night parking area separation criteria. The test development, test equipment, data collection, data reduction, and analysis of flight data are discussed. A schedule for the completion of the associated tasks is presented.
An investigation of lateral tracking techniques, flight directors and automatic control coupling on decelerating IFR approaches for rotorcraft.

S. Baillie, S. Kereliuk and R. Hoh

Aeronautical Note

National Research Council Canada
National Aeronautical Establishment
High Speed Aerodynamics Laboratory

Experimental results demonstrated that crab technique approaches were satisfactory for all approach speeds and wind conditions investigated (up to 30 knot crosswinds). A factor not addressed in this study was the visual orientation of the landing pad at breakout to flight with visual references. Sideslipping approaches were also shown to be satisfactory until the steady state lateral acceleration exceeded approximately 0.07 G. While coupling of the collective actuator directly to the flight director provided the best glideslope tracking, evaluations showed that the configuration with a 2-cue (pitch and roll) flight director, using only a raw glideslope presentation, provided satisfactory handling qualities and was considered by FAA and DOT representatives to be certifiable for IFR flight. Coupling of any single axis of control to the flight director was demonstrated to provide slight workload relief benefits and the collective axis was judged to be the most likely candidate axis for this implementation.
This is a bibliography of FAA rotorcraft reports published from 1962 to 1988. This report is a supplement to an earlier bibliography "FAA Helicopter/Heliport Research, Engineering, and Development - Bibliography, 1964-1986" (FAA/PM-86/47) (AD-174697). Both bibliographies are limited to documents in which the research, engineering, and development elements of the FAA were involved as sponsors, participants, or authors.

This bibliography contains abstracts on 53 technical reports. The indexes in this document address these 53 reports as well as the 133 reports in the earlier bibliography (FAA/PM-86/47).
### Abstract

This report presents statistics relating to gas turbine engine rotor failures which occurred during 1983 in commercial aviation service use. One-hundred and seventy-two failures occurred in 1983. Rotor fragments were generated in 96 of the failures and, of these, 9 were uncontained. The predominant failures involved blade fragments, 95.4 percent of which were contained. Five disk failures occurred and four were uncontained. Fifty-nine percent of the 172 failures occurred during the takeoff and climb stages of flight.

This service data analysis is prepared on a calendar year basis and published yearly. The data support flight safety analyses, proposed regulatory actions, certification standards, and cost benefit analyses.

### Keywords
- Air Transportation
- Aircraft Hazards
- Aircraft Safety
- Gas Turbine Engine Rotor Failures
- Containment

### Distribution Statement

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### Key Words

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STATISTICS ON AIRCRAFT GAS TURBINE ENGINE ROTOR FAILURES THAT OCCURRED IN U.S. COMMERCIAL AVIATION DURING 1984

AUTHORS: R. A. Delucia/J. T. Salvino, NAPC
B. C. Fenton, FAA Technical Center

This report presents statistical information relating to gas turbine engine rotor failures which occurred during 1984 in commercial aviation service use. Two hundred and six failures occurred in 1984. Rotor fragments were generated in 114 of the failures and, of these, 18 were uncontained. The predominant failure involved blade fragments, 90.3 percent of which were contained. Seven disk failures occurred and all were uncontained. Seventy percent of the 206 failures occurred during the takeoff and climb stages of flight.

This service data analysis is prepared on a calendar year basis and published yearly. The data are useful in support of flight safety analyses, proposed regulatory actions, certification standards, and cost benefit analyses.
This report presents statistics relating to gas turbine engine rotor failures which occurred during 1985 in U. S. commercial aviation service use. Two hundred and seventy-three failures occurred in 1985. Rotor fragments were generated in 150 of the failures, and of these 14 were uncontained. The predominant failure involved blade fragments, 94.4 percent of which were contained. Six disk failures occurred and all were uncontained. Fifty-seven percent of the 273 failures occurred during the takeoff and climb stages of flight.

This service data analysis is prepared on a calendar year basis and published yearly. The data support flight safety analyses, proposed regulatory actions, certification standards, and cost benefit analyses.
**Abstract**

The Federal Aviation Administration sponsored a two-day meeting in October 1988 to address issues of human factors and inspection. Presentations were given by some 13 individuals representing the full spectrum of interests in commercial aviation. Presentations also were given by three human factors scientists with backgrounds in vigilance and industrial inspection technology. Each presentation, as well as the following question and answer period, was recorded for transcription and study.

The objective of the meeting was to identify human issues of importance, particularly as such issues might contribute to inspection or maintenance error. The desired outcome was to be:

1. an improved understanding of personnel performance in aviation maintenance, and
2. recommendations, as appropriate, to the FAA concerning needed research efforts and/or possible new or revised regulatory actions.

Several recommendations were presented to the FAA in the areas of communications, training, management, regulatory review, and research and development.
Communications, navigation, and surveillance (CNS) services are readily available at the altitudes flown by most fixed-wing aircraft. They are not, however, always available at the lower altitudes at which most rotary-wing aircraft operate. The objective of this study is to determine if there is an economic basis for improvement of these low altitude CNS services within the National Airspace System (NAS) in order to better support rotorcraft operations. The Rotorcraft Master Plan advocates the establishment of additional CNS facilities as well as the analysis and development of systems to satisfy the increasing demand for widespread IFR rotorcraft operations within the NAS. The findings of this study will aid the FAA decisionmaking in that regard. In view of prior implementation decisions on Loran-C, the emphasis in this effort is on communications and surveillance.

This interim report provides background data on the rotorcraft industry as it exists today, as well as forecasts to the year 2007 for the purpose of providing operational data for analyses of long-term CNS benefits and costs. It describes rotorcraft missions; selects those most likely to benefit from increased availability of CNS services; identifies the probability of various ceiling and visibility combinations within selected rotorcraft operating areas; and presents an inventory of rotorcraft activity by mission and location.
**Accident/Incident Data Analysis Database Summaries (Vol. I)**

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**Abstract**
This two volume report provides a compendium of the existence, availability, limitations, and applicability of aviation accident and incident databases for use in human factors research. An aviation and data processing oriented form was used to survey 41 U.S. Government, military, aircraft manufacturers, airlines, special interest groups, and international aviation safety database sources. The compendium in Volume I presents information about 34 aviation safety databases. Recommendations include a feasibility study of a combined master aviation safety database, the convening of a task force to standardize human factors terminology and data collection, the establishment of a limited immunity program to facilitate the flow of air carrier incident data, and a more vigorous effort to present available aviation safety information to pilots.

Appendices are contained in Volume II to provide detailed information about database collection forms, data structures, and human factors information within the database.
This two volume report provides a compendium of the existence, availability, limitations, and applicability of aviation accident and incident databases for use in human factors research. An aviation and data processing oriented form was used to survey 41 U.S. Government, military, aircraft manufacturers, airlines, special interest groups, and international aviation safety database sources. The compendium in Volume I presents information about 34 aviation safety databases. Recommendations include a feasibility study of a combined master aviation safety database, the convening of a task force to standardize human factors terminology and data collection, the establishment of a limited immunity program to facilitate the flow of air carrier incident data, and a more vigorous effort to present available aviation safety information to pilots.

Appendices are contained in Volume II to provide detailed information about database collection forms, data structures, and human factors information within the database.
This Technical Note reports on a test designed to obtain pilot performance subjective pilot data on the Helicopter Visual Segment Approach Lighting System (HALS). Results identify the performance measures which correlate with the pilot's ability to visually acquire a HALS equipped heliport. Conclusions state that HALS can support existing minima to heliports. Pilots reported unacceptable Cooper-Harper ratings for rate of closure and workload without HALS.
This handbook will assist aircraft design, manufacturing, and certification organizations in protecting aircraft against the direct and indirect effects of lightning strikes, in compliance with Federal Aviation Regulations. It presents a comprehensive text to provide the essential information for the in-flight lightning protection of all types of fixed/rotary wing and powered lift aircraft of conventional, composite, and mixed construction and their electrical and fuel systems.

The handbook contains chapters on the natural phenomenon of lightning, the interaction between the aircraft and the electrically charged atmosphere, the mechanism of the lightning strike, and the interaction with the airframe, wiring, and fuel system. Further chapters cover details of designing for optimum protection; the physics behind the voltages, currents, and electromagnetic fields developed by the strike; and shielding techniques and damage analysis. The handbook ends with discussion of test and analytical techniques for determining the adequacy of a given protection scheme.
This report presents statistical information relating to gas turbine engine rotor failures which occurred during 1986 in U.S. commercial aviation service use. Two hundred forty-nine failures occurred in 1986. Rotor fragments were generated in 140 of the failures, and of these 16 were uncontained. The predominant failure involved blade fragments, 93 percent of which were contained. Two disk failures occurred and all were uncontained. Sixty-five percent of the 249 failures occurred during the takeoff and climb stages of flight.

This service data analysis is prepared on a calendar year basis and published yearly. The data are useful in support of flight safety analyses, proposed regulatory actions, certification standards, and cost benefit analyses.
The International Civil Aviation Organization (ICAO) has proposed the adoption of a standard international heliport beacon. This beacon consists of a white strobe light coded to display a sequence of four flashes that signify the Morse code letter "H". For evaluation purposes, the proposed strobe beacon was compared to the United States standard three-color rotating beacon. Pilots completed post-flight questionnaires after viewing both beacons. Without any clear-cut choice as to which beacon was the best, pilot responses indicated that both beacons provide adequate guidance in locating a heliport. From these results, we conclude that there does not appear to be reasonable cause for opposing adoption of the proposed strobe beacon as an ICAO standard. Furthermore, there does not appear to be any compelling reason to change the present United States standard for heliport identification beacons at this time.
In response to increasing helicopter demand, the Federal Aviation Administration (FAA) initiated the FAA Industry National Prototype Heliport Demonstration and Development Program. Four cities were selected for the FAA Demonstration program, these were; New York, New Orleans, Los Angeles and Indianapolis. In January 1985, the Indianapolis Downtown Heliport was the first of the demonstration heliports to open.

This study is an analysis of the operational characteristics of the Indianapolis Downtown Heliport from its opening in 1985 through March 1989, and an investigation of the marketing techniques used during the planning and development stages of the heliport as well as the continuing marketing effort used to retain and increase business. It performs this analysis using data collected by the heliport. The parameters examined concentrate on the types of missions, the variations and trends in the number of operations, the geographic distribution of the helicopters that use the facility, and the types of services required by the helicopter operators using the heliport.

Due to limitations in the amount and accuracy of data available, only generalized trends rather than detailed statistical conclusions could be developed.

A similar analysis is being performed for the Downtown Manhattan Heliport (Wall Street) in New York City.
This document provides a brief description of tiltrotor aircraft and identifies some of their projected operating characteristics. Two operations are of particular interest: 1) steep approaches into a confined metropolitan vertiport, and 2) approaches into a vertiport without sufficient clear airspace for a conventional missed approach from a low DH. Both operations are of interest in order to minimize the airspace needed to conduct such operations.

A brief simulation was conducted to support the analysis using a fixed base simulator. The flight simulation involved a quick look at innovative and tiltrotor unique maneuvers to identify and evaluate operations at or near the operational limits. The tiltrotor shows promise of permitting much steeper approach and departure maneuvers than what can be done with either an airplane or a helicopter.