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"Zero/Zero" Rotorcraft Certification Issues

Advanced System
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Volume III Working Group Results

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CERTIFICATION ISSUES. VOLUME 3: WORKING		
GROUP RESULTS Final Report (Systems Control		
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Final Report

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16. Abstract This report analyzes the "Zero/Zero" Rotorcraft Certification Issues from the perspectives of manufacturers, operators, researchers and the FAA. The basic premise behind this analysis is that "zero/zero", or at least extremely low visibility, rotorcraft operations are feasible today from both a technological and an operational standpoint. The questions and issues that need to be resolved are: What certification requirements do we need to ensure safety? Can we develop procedures which capitalize on the performance and maneuvering capabilities unique to rotorcraft? Will extremely low visibility operations be economically feasible? Volume I of this report provides an overview of the Certification Issues Forum held in Phoenix, Arizona in August of 1987. It presents a consensus of 48 experts from the government, manufacturer, and research communities on 50 specific Certification Issues. The topics of Operational Requirements, Procedures, Airworthiness and Engineering Capabilities are discussed. Volume II presents the operator perspectives (system needs), applicable technology and "zero/zero" concepts developed in the first 12 months of research of this project. Volume III provides the issue-by-issue deliberations of the experts involved in the Working Groups assigned to deal with them in the Issues Forum.					
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1.0 FORUM AGENDA

AGENDA

AHS / FAA / HAI / NASA "Zero / Zero" Certification Issues Forum

TUESDAY, AUGUST 11, 1987 (PLENARY SESSION)

- 7:30 Welcome
 - Rich Adams, AAC
- 7:35 Administrative Remarks
 - Bill Endter, SCT
- 7:50 Opening Remarks
 - Rick Weiss, FAA
- 8:00 NASA/FAA "Zero/Zero" Perspectives
 - Barry Scott, FAA
- 8:15 Operator Perspectives
 - Frank Jensen, HAI
- 8:40 Technological Perspectives
 - John Zugschwert, AHS
- 9:05 Certification Perspectives
 - Jim Honaker, FAA
- 9:30 Coffee Break
- 9:50 Overview of NAV & LANDING Program, Low Airspeed, and "Zero/Zero" Project
 - Systems Control Technology
- 11:30 Manufacturer Perspectives
 - Various Presentations

TUESDAY, AUGUST 11, 1987 (CONTINUED)

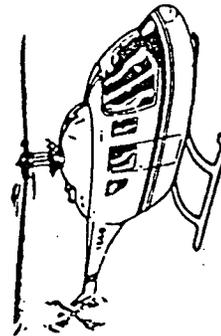
- 12:30 Lunch Break
- 1:30 Convene Working Groups
 - Organization
- 3:30 (Approximate) Adjourn
- 6:30 Reception
 - North Pointe Poolside

WEDNESDAY, AUGUST 12, 1987 (WORKING GROUP SESSION)

- 7:30 Convene Working Groups
 - Discussion of Issues
- 9:30 Coffee Break
- 10:30 Management Committee/ Working Group Chairmen Meeting
- 11:30 Lunch Break
- 12:30 Convene Working Groups
 - Resolution of Issues
- 3:30 (Approximate) Adjourn

THURSDAY, AUGUST 13, 1987 (W.G./PLENARY SESSIONS)

- 7:30 Convene Working Groups
 - Summary of Results
- 9:30 Coffee Break
- 10:30 Management Committee/ Working Group Chairmen Meeting
- 11:30 Lunch Break
- 12:30 Convene Joint Working Groups - (Plenary Session) Presentation of Issues Resolution Summaries and General Discussion
- 3:30 (Approximate) Adjourn



2.0 SUMMARY LIST OF ISSUES DISCUSSED

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TABLE 2.1
LIST OF ISSUES

<u>Issue No.</u>	<u>Title</u>
1.	IMC Hover Capability, Pilot Training & Certification Requirements
2.	IMC Autorotation - Training & Proficiency Requirements
3.	Multi-directional Approach Path Requirements
4.	Helicopter Productivity Limits under Current Regulations
5.	TERPs Obstruction Clearance Planes
6.	ITO Abort Procedures
7.	IMC Hover - Required Control Inputs Through Translational Lift
8.	ITO Abort Procedures - Emergency Landing Facility Requirements
9.	Ground/Airborne Equipment Requirement vs. TERPs and Heliport Design Criteria
10.	ATC Concepts for Low Altitude Random Routing
11.	City-Center and Terminal Area Flight Corridors (Evaluate ATC Procedures)
12.	Analysis of Necessary ATC Handbook (7110.65) Changes
13.	Analysis of FAR Part 91 & 93 Applicability to Future Rotorcraft Operation
14.	Acquisition and Maintenance Costs for On-Board Electronic Systems
15.	Performance Penalties Associated with Current Regulations
16.	Operating Cost Reduction with Improved Reliability/Mission Effectiveness
17.	Pilot Training and Proficiency Regulatory Requirements
18.	Pilot Certification - Exam and Check Ride Requirements
19.	Visual Cues for Attitude Reference During Low Speed, Low Visibility Flight
20.	Accurate Ground Speed (or Closure Rate) Sensing and Display
21.	Minimum Required Cockpit Field for Visual Acquisition of Landing Environment
22.	Minimum OEI Performance Requirements
23.	Requirement for a Highly Responsive Autopilot with Stable Heading Hold
24.	Requirement for Accurate and Reliable Advanced Navigation and Guidance Systems
25.	Advanced Systems and Displays for Terminal Guidance and Obstruction Avoidance
26.	Requirements for Autonomous Precision Approach Guidance Systems
27.	IFR Heliport Marking and Lighting
28.	Criteria for Airborne Imaging Technologies
29.	Single-Engine vs. Multi-Engine Hover and Autorotation Performance
30.	Effect of Engine Reliability Improvements on OEI Requirements
31.	Requirements for Advanced Onboard Navigation and Landing Systems
32.	Requirements for Advanced Control Systems
33.	Accuracy Criteria for Low Visibility Systems
34.	Requirements for All Weather Terrain and Obstacle Avoidance
35.	Requirements and Cost/Benefit Analysis for Coverage Below 2000' AGL
36.	Analysis of FAR Part 71 for Low Visibility Certification Impact
37.	Acquisition and Operating Costs Associated with More Powerful Engines
38.	Low Speed Stability and Control in IMC

TABLE 2.1
LIST OF ISSUES (Continued)

<u>Issue No.</u>	<u>Title</u>
39.	Certification Procedures/Guidelines for Hover Through Translational Lift
40.	Pitch Control in IMC Hover
41.	Yaw Control at Low Airspeeds in Crosswind/IMC Conditions
42.	Heading Control during Low Airspeed Maneuvers
43.	Power Settling During Hover in IMC
44.	Requirements for Engine Condition Monitoring
45.	Subsystem Failure-Mode Redundancy Requirements
46.	Requirements for Minimum IFR Lateral and Longitudinal Airspeed Components
47.	Minimum Requirements for Abstract vs. Processed Data (Flight Director) Display System
48.	Low Visibility Certification Requirements for Manual Backup for Automatic IMC Guidance
49.	Identification and Specification of Minimum Flight Critical Systems
50.	Simulation Needs for Certification

Each issue discussed by the working groups was documented using a standardized form. The information on the forms was then entered into an R-Base V data base ROTOMP provided by Aviation Systems Concepts, Inc. A description of the data elements is shown below:

Issue Number: (Sequential Number)
Updated: (Last Input)

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Code: TR*

Related Issues: (Maximum of 3)

Updated: 08/10/88

Retrieval Date: 08/20/87

Priority: **

* TR - Training
PR - Procedures
EC - Economics
HQ - Handling Qualities
HP - Heliport
AT - Air Traffic Control

DI - Displays
SS - Sensor Systems
PW - Pilot Workload
CE - Certification
NG - Navigation/Guidance
SI - Simulation

** H - High
M - Medium
L - Low

3.0 ISSUE DESCRIPTIONS, TECHNICAL COMMENTS AND RECOMMENDATIONS

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0001 Issue Code: TR Related Issues: 2 17 18

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: L

Issue: IMC HOVER CAPABILITY, PILOT TRAINING & CERTIFICATION REQUIREMENTS

Description:

Hovering a helicopter with limited or no reference to the ground will require new types of displays and sensors to provide information and efficient information transfer techniques that are very intuitive. Even with the use of coupled control systems and flight director type displays, the pilots will need training in their use, particularly in emergency and failure-mode situations. Training methodologies and certification standards need to be developed.

Technical Comment:

It is assumed the pilot performs the actual touchdown at the completion of the approach. Basic studies should be performed using simulator and aircraft to determine how the pilot visually performs the hover task in VMC conditions. The research should focus heavily on the human factors issues associated with the task. Close coordination with military advances in this area is required. Following research basic issues to be addressed are:

1. What are the new piloting techniques required?
2. How are airmen certified for these operations?
3. What is required in simulators to train/practice and evaluate these pilot procedures?

Recommended/Implemented Approach:

(1) Evaluate current military training methods: FAA/SCT. (2) Scope the magnitude of the training: FAA/SCT. (3) Identify pilot tasks: FAA/SCT. (4) Determine display/flight control requirements: Industry. (5) Establish requirements for pilot takeover in failure modes. (6) Investigate human factors elements in system design: NASA/FAA. (7) Review regulatory changes required to certify pilots/operations/systems: Industry/FAA. (8) Involve user groups in system development.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0002 Issue Code: TR Related Issues: 1 17 18

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: L

Issue: IMC AUTOROTATION - TRAINING & PROFICIENCY REQUIREMENTS

Description:

A successful autorotation to a landing is usually the result of a series of carefully coordinated pilot control inputs based on reference to cockpit instrumentation and external conditions in the landing area. In IMC, reference to the ground is gone and workload correspondingly much higher. Nevertheless, a pilot must be able to demonstrate and maintain an ability to safely deal with a loss of engine power under the most adverse conditions. What those conditions are may well become the minimum certification criteria.

Technical Comment:

System reliability and integrity must be increased considerably , to even consider single engine near "zero/zero" operation. Region of operation may preclude safe autorotation necessitating approach abort and proceed to alternate. If low speed autorotation is possible and necessary then proper display augmentation is required to permit the pilot to perform the touchdown maneuver in very low visibility conditions.

Recommended/Implemented Approach:

(1) Strengthen basic autorotation entry procedures training; emphasis on IMC. (2) Increase use of simulator to train pilots for IMC autorotations. (3) Expand research to increase reliability of all aircraft systems: NASA/FAA. (4) Establish standards to certify airmen for "zero/zero" operations: FAA.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0003 Issue Code: PR Related Issues: 5 9 27

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: M

Issue: MULTIDIRECTIONAL APPROACH PATH REQUIREMENTS

Description:

Unlike instrument approaches to airports with a fixed orientation to a runway, an approach to a given heliport may be made from several directions. In fact the number of available approach paths should only be limited by the necessity to avoid obstacles, other traffic and/or noise sensitive areas. Approach procedures should be developed with this inherent operational flexibility in mind.

Technical Comment:

This concept is a total departure from existing procedures used to establish instrument approaches and departures. Obstruction data will be very difficult to obtain and evaluate. In some locations competition for the airspace would preclude the implementation of this concept except for very steep approach angles and/or high hover altitudes. The competition for the airspace comes from at least 2 sources. Air traffic has established flow paths that utilizes some of the airspace and the community itself competes for the airspace from a development sense. This issue not only applies to heliports but to airports where procedures should be established to separate helicopter IFR flow from the primary fixed wing flow. Off boresight azimuth (MLS) approaches terminating at the heliport located away from the primary instrument runway should be implemented. Related issues include the development of flight inspection procedures and upgrading the operations Inspector's Handbook. New approach charting procedures also may be necessary.

Recommended/Implemented Approach:

(1) Establish minimal length approach segments: FAA. (2) Establish criteria for operations with special equipment, e.g. "visual" systems, etc. (3) Investigate off runway approaches at airports with MLS: FAA. (4) Revise FAR 77 to account for advanced approach capabilities: FAA. (5) Develop a document to provide guidance for development of heliports supporting "zero/zero" operations: FAA/USER.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0004 Issue Code: EC Related Issues: 14 15 37

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: M

Issue: HELICOPTER PRODUCTIVITY LIMITS UNDER CURRENT REGULATIONS

Description:

Federal Aviation Regulations and FAA certification criteria, in an effort to assure adequate margins of safety, impose a severe penalty in the productivity of helicopters operating under IFR. Adequate HIGE and climb-out capabilities with one engine inoperative (OEI) is a factor of the ratio between the available power and the gross weight of the helicopter. However, increasing engine reliability, time between overhauls and new technologies suggest trade offs may be considered to enhance productivity without jeopardizing safety.

Technical Comment:

There is no data to indicate that engine-out requirements should be relaxed. We should support any new current technology to aid the safety level. The 30-second contingency rating is nearing NPRM status and efforts on it should be continued. No special autorotation rate, undercarriage stress limits, crashworthiness requirements needed now. Reference should be made to EH-101 program for guidance and policy. (1) We do not see a need now to change or relax current requirements. (2) We do not want to lessen safety levels. (3) If other power ratings are required, it would be a time consuming effort to implement.

Recommended/Implemented Approach:

Present or equivalent levels of safety must be maintained. The petition effort for the 30 sec contingency rating should continue as well as any new technology. A study is needed to determine the regulatory framework for excess power capacity. ADL should conduct such a study, under contract, which should be completed within five years. FAA headquarters, namely APM-450, should be used for contracting work related to excess power issues and new studies on the impact of helicopters with more than two engines and regulatory credit impacts.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0005 Issue Code: PR Related Issues: 3 9 27

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: H

Issue: TERPS OBSTRUCTION CLEARANCE PLANES

Description:

The imaginary obstacle clearance planes established by TERPs define the clear airspace associated with a given approach to a heliport. An engine failure (in a multiengine helicopter) does not relieve the pilot of the responsibility for compliance even though the slope gradient requires a climbout capability that is twice that which is available in most 10+ passenger helicopters.

Technical Comment:

TERPS does not provide obstacle clearance when the aircraft cannot maintain established profiles during approach and departure. Operational procedures not TERPS charting procedures are required to account for conditions such as one engine inoperative. Criteria will be published shortly for up to 9 degree approach angles. Even these require the pilot to learn new tasks such as vertical tracking on the back side of the power curve.

The Advisory Circular on Instrument Flying should be upgraded to include the new piloting techniques required for steep angle approaches. Steeper angles and lower airspeed may require more than one helicopter approach category. Reduced maximum airspeeds may reduce airspace required. Studies should be conducted to evaluate the benefits of non constant glide slope angles.

Recommended/Implemented Approach:

(1) Determine the potential advantages for procedure design for low airspeed approaches: FAA/NASA. (2) Establish definition(s) for rotorcraft categories-equipment, speed, etc. (3) Investigate pilot performance for operations at lower airspeeds, maneuvering and non-standard rates of turn.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0006 Issue Code: HQ Related Issues: 7 38 40

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: M

Issue: ITO ABORT PROCEDURES AND REQUIRED CONTROL INPUTS THROUGH TRANSLATIONAL L

Description:

See Issue Number 7.

Technical Comment:

-0-

Recommended/Implemented Approach:

-0-

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0007 Issue Code: HQ Related Issues: 6 38 40

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: M

Issue: IMC HOVER - REQUIRED CONTROL INPUTS THROUGH TRANSLATIONAL LIFT

Description:

At low speed, turn coordination may be neither necessary nor even desirable, so this control input could be "phased out" with computers (Black Boxes) at airspeeds below 40 knots. Cyclic control displacements should be isolated to control lateral or longitudinal movement only in a precision hover and rudder pedals should only be used to control yaw about the vertical axis. The rate of displacement (airspeed) would also be a function of cyclic input (particularly longitudinal input) through translational lift.

Technical Comment:

Sophisticated sensors to measure airspeed, groundspeed, position relative to the hover "spot", altitude and heading will be required in the control system in order to provide correct feedback to the pilot. These sensors, and the flight computer must be designed so that no one failure (or two by some rules) can cause an accident. The consensus was reached that: (1) Agreement that the issue described is probably valid. (2) Present R/D programs (FAA, NRC, NASA, ARMY) are okay and no new special programs or actions are needed now. (3) Need for establishing some guidance material for pilot-in-the-loop requirements for the slow speed flight regime with candidate systems, e.g. look at effect of collective-to-yaw coupling for missed approaches and instrument takeoff departures, -- heading hold issues. (4) There could be significant problems associated with rearward flight if encountered.

Recommended/Implemented Approach:

Southwest Region will monitor existing R&D programs (FAA, NRC, NASA, Army) and testing, and develop changes as dictated by the data. Region will also request additional work in low speed handling qualities as required.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0008 Issue Code: HP Related Issues: 3 27 -0-

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: M

Issue: ITO ABORT PROCEDURES - EMERGENCY LANDING FACILITY REQUIREMENTS

Description:

In the event of an engine failure - for a single engine helicopter - there is only one course of action: i.e., land. Even if the nature of the emergency is something less than a total loss of power, there may be situations where an immediate landing becomes necessary. Since this may occur at any point between the initial hover check and level off for cruise, there is no way to specify all (or any, for that matter) suitable emergency landing sites, even if they could be seen (which they can't) in IMC.

Technical Comment:

There will be only one landing site known to a pilot during an ITO under "zero/zero" conditions - the one the helicopter just took off from. However, procedures may be designed using "natural routes" without major obstructions. Expansion of helicopter IMC capability to extreme low visibility flight (0' ceiling and 300'-1200' RVR) may be possible for those operators who can do it safely. This may be achievable by electronically extending the visual range and accomplishing the last segment of the autorotation under VFR in IMC (previously discussed in Volume I Section B and illustrated in Figure 1 of that volume).

Recommended/Implemented Approach:

It would seem that the only logical alternative would be to develop procedures and guidance capabilities that would enable a helicopter to safely return to the original point of takeoff in an emergency situation. Alternatives to this should be investigated. For example: (1) Developing sensors and displays for instrument takeoff abort procedures. (2) Survey of heliport egress routes (What is out there?) and what percent of accidents occur due to aborted takeoffs. (3) Operating procedures for VFR in IMC with electronic visual aids could be developed.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0009 Issue Code: PR Related Issues: 3 5 27

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: M

Issue: GROUND/AIRBORNE EQUIP. REQUIREMENT VS. TERPS & HELIPORT DESIGN CRITERIA

Description:

The Chapter 11 TERPs criteria for obstacle clearance, control zones and clear airspace will set the minimum acceptable performance criteria for the advanced systems developed to operate within them. Heliport design standards will set the minimum adequate real estate (surface area) requirements. The minimum acceptable standards for heliport real and imaginary surfaces will have to be set with a realistic regard for the capabilities and limitations of onboard equipment.

Technical Comment:

The FAA should be "official" and active participants in ICAO heliops panel sessions. The use of angular navigation systems located at heliports will necessitate airborne tailoring of the guidance signal to provide a linearized guidance signal in at least the lateral guidance component. Studies are required to verify DME/P signal accuracies in order to provide accurate alongtrack and alongtrack rate information at low aircraft speeds.

Ground system error components should be studied in the flight regions required for low speed near "zero/zero" approaches. Issues include course width linearization, operation extremely close to the azimuth/elevation transmitter (within 300 feet), switching of the high frequency error component at slow airspeed into the low frequency regions which can cause actual aircraft displacement and methods for providing offset guidance.

Recommended/Implemented Approach:

(1) FAA become official member of ICAO heliops. (2) Investigate course width linearization. (3) Determine Cat II, and lower, accuracy "window" requirements.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0010 Issue Code: AT Related Issues: 11 12 13

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: H

Issue: ATC CONCEPTS FOR LOW ALTITUDE RANDOM ROUTING

Description:

The combination of adequate communication and navigation coverage to the surface with advanced onboard systems for collision avoidance, obstacle clearance and precision/non-precision approaches will allow helicopters to operate in IMC with comparable performance as under VMC only if ATC techniques and procedures for flight below or beyond radar coverage are developed.

Technical Comment:

This is an immediate issue today. Local users and Air Traffic personnel should discuss low altitude routing alternatives which would expedite helicopter flow in the terminal areas to both heliports and airports. At a minimum shorter segment legs are needed.

Implementation and use for radar like preparation standards resulting from dependent surveillance systems such as LOFF should be expedited. This will result in lowering the floor of surveillance coverage. Tilt Rotor applications will require increased low level navigation, communication and surveillance coverage. LORAN C for the most part provides terminal area low level navigation. However existing surveillance and communications coverage limits route structure development. Associated issues include flight planning, route charting and VFR/IFR traffic mixes.

Recommended/Implemented Approach:

(1) Investigation application and limitations of "LOFF-type" surveillance. (2) Determine where "to-the-surface" surveillance is needed. (3) Investigate application and limitations of fully automatic dependent surveillance.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0011 Issue Code: AT Related Issues: 10 12 13

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: M

Issue: CITY-CENTER AND TERMINAL AREA CORRIDORS (EVALUATE ATC PROCEDURES)

Description:

Improved ATC procedures for better integration of the helicopter in terminal areas, including city-center heliports, and the design of the terminal area itself need to be evaluated to accommodate the lower airspeeds, steeper descents, and improved instrument capabilities of advanced rotorcraft.

Technical Comment:

This is an issue now that becomes even more limiting as helicopter/tilt-rotor IFR operations increase. It is assumed that positive control to the surface is required for CAT II and lower operations. The types of to the surface service required at heliports must be identified. Whatever is done to support the IFR operation will effect the VFR operation also.

It maybe necessary to establish heliport control zones which have different dimensional operating rules than standard control zones. Helicopters can legally, and do, operate VFR in lower than the standard 1000'/3 mi required for VFR in control zones. Studies should be conducted to identify possible methods for handling the IFR/VFR traffic mix that will be found in the vicinity of heliports

Recommended/Implemented Approach:

(1) Task local ATC/user to identify need for procedures and implement to expedite helicopter flow to heliports and airports. (2) Identify where positive control to the surface from both a weather and operations sense is needed. (3) Identify methods to make procedures public.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0012 Issue Code: AT Related Issues: 10 11 13

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: L

Issue: ANALYSIS OF NECESSARY ATC HANDBOOK (7110.65) CHANGES

Description:

The increasing complexity of operations brought about by helicopter "zero/zero" certification will necessitate a mutual understanding of the unique operational characteristics of rotorcraft on the part of pilots and ATC controllers alike. The ATC handbook represents one of the best ways to provide that information. The resulting changes to it must be carefully considered.

Technical Comment:

A start in addressing these issues would be the possible reduction in the number of letters of agreement and public dissemination of the information. A review of existing local ATC practices to expedite helicopter traffic may reflect procedure changes identified in the Air Traffic Control Handbook. Immediate issues to be addressed include different gate vectoring requirements and segment lengths to make use of the unique helicopter flight characteristics. Changes in the Air Traffic Controller's Handbook must also be reflected with changes in the Airman's Information Manual.

Recommended/Implemented Approach:

(1) Review local procedures/policies for input to air traffic controller handbook changes. (2) Reduce local letters of agreement - replace with published procedures where possible. (3) Develop (expedite) standards for VFR/IFR charting guidelines for low altitude helicopter operations. (4) Include industry/user in developing helicopter low altitude VFR/IFR charting standards.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0013 Issue Code: AT Related Issues: 10 11 12

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: M

Issue: ANALYSIS OF FAR PART 91 & 93 APPLICABILITY TO FUTURE ROTOCRAFT OPERATION

Description:

Existing flight rules may be too restrictive or inadequate for future rotorcraft operations, (e.g., minimum flight visibility for visual operations, right-of-way rules, IFR operations, etc.) and certain unique traffic situations, (e.g., proximity of airports/heliports, concentration of operation, etc.) are not provided for in the general flight rules.

Technical Comment:

Developing IFR procedures cannot be done without considering the impact on VFR operations. Advances in helicopter IFR will require new operating rules concerning control zones at heliports. Weather reporting and positive control of the heliport airspace may require staffing at the heliport. It is also noted that radar altimetry becomes unreliable and increasingly more difficult in a heliport environment than at an airport.

Recommended/Implemented Approach:

(1) Establish standards for heliport control zones. (2) Evaluate using single frequency concept during low-visibility approach.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0014 Issue Code: EC Related Issues: 4 15 37

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: M

Issue: ACQUISITION AND MAINTENANCE COSTS FOR ON-BOARD ELECTRONIC SYSTEMS

Description:

One of the most important considerations for an advanced navigation and guidance system is its cost feasibility; does the increased operating time which the system permits produce the additional revenue necessary to make a profit on the system? There are other considerations, of course, such as improved safety and convenience but the financial trade-off is very important. Seven to ten percent of total aircraft acquisition cost seems to be about the average acceptable level of expenditure operators are willing to pay provided a significant improvement in operating minima (as close to zero/zero as possible) is achieved.

Technical Comment:

This is a subject area which is treated by individual operators.

Recommended/Implemented Approach:

Working Group Consensus: Not an issue for future study.

Reviewers Comment: This area is important to determine FAA/government priorities.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0015 Issue Code: EC Related Issues: 4 14 37

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: L

Issue: PERFORMANCE PENALTIES ASSOCIATED WITH CURRENT REGULATIONS

Description:

Today's helicopters incur a severe productivity penalty during IFR operations due to OEI engine power limitations. Basically two limits are the crux of the problem. First, the ability to get onto or off of a small heliport requires single engine hover in ground effect capability. Second, engine failure during missed approach and departure requires compliance with TERPs clear zone planes. These planes mandate a climb gradient of approximately twice the capability of current 10+ passenger twin engine helicopters. These two criteria impose a requirement for up to a 50% increase in excess power for some helicopters. This means that either greatly improved (very big) engines will be needed (which have a proportionally high cost) or severe productivity/payload penalties will be incurred.

Technical Comment:

At least two related technological alternatives currently exist. First, oversized engines could be specified but operated derated 99% of the time. This would enhance reliability, reduce maintenance and overhaul/replacement costs. Second, recent advances in single crystal turbine blades offer up to 200 degree increases in turbine inlet temperature. This translates into a 20% increase in maximum power. These advances indicate that the power required for zero/zero operations is available and the tradeoffs between increased acquisition costs, reduced life cycle costs and increased reliability should be evaluated.

Recommended/Implemented Approach:

This issue should be combined with #4.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0016 Issue Code: EC Related Issues: 4 14 15

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: M

Issue: OPERATING COST REDUCTION WITH IMPROVED RELIABILITY/MISSION EFFECTIVENESS

Description:

One way to increase engine reliability (and consequently reduce regulatory/economic penalties) is to specify oversized engines that can be operated at a "derated" level most of the time but are capable of providing extra emergency power when needed. This would enhance reliability, reduce maintenance and overhaul/replacement costs, and provide a safety margin at the same time. Unfortunately, the old adage applies: "If you want economy, you have to pay for it."

Technical Comment:

See Issue Number 4.

Recommended/Implemented Approach:

This issue should be combined with, and covered by, #4.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0017 Issue Code: TR Related Issues: 1 2 18

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: M

Issue: PILOT TRAINING AND PROFICIENCY REGULATORY REQUIREMENTS

Description:

As advanced systems are developed to allow "zero/zero" approaches in helicopters, pilots will, of course, need to learn how to use them safely. Until the eventual goal of "IFR like VFR" is realized, where the pilot simply applies already mastered VFR techniques and skills, the transition period will severely test the instrument rated helicopter pilot's abilities. Standards development will largely depend on system reliability and the degree of "pilot-in-the-loop", i.e.: from fully automated approach to a hands off touchdown (pilot as a systems monitor) to manual control using processed (or even raw) data.

Technical Comment:

Long term issues concern pilot-in-the loop handling qualities characteristics. It is recognized that CAT II and lower procedures will place additional skill requirements on the pilot. This is true in at least the reversionary mode sense. New display concepts will require new pilot tasks be learned. HUD may be the ultimate device for information transfer to the pilot.

In the near term there are at least three new instrument tasks required for steep angle Category I approaches in the heliport. These new tasks include, vertical tracking on the back side of the power available curve, missed approach go around procedures when initiated on the back side of the power available curve and application of side slip techniques for lateral tracking.

Recommended/Implemented Approach:

(1) Establish pilot training guidelines and educational materials for low-visibility approach/departure (2) Evaluate training requirement for new displays/control systems/"visionics". (3) Determine feasibility of simulator training for "new" techniques & low-visibility operations.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0018 Issue Code: TR Related Issues: 1 2 17

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: M

Issue: PILOT CERTIFICATION - EXAM AND CHECK RIDE REQUIREMENTS

Description:

Once basic "zero/zero" instrument rating standards are established for airman certification, examination and functional checks should be based on essentially the same concepts and principles used today. However, as "IFR like VFR" becomes a reality and pilots can fly VFR or like VFR all the time, the question arises: Is an "instrument" rating necessary?

Technical Comment:

It is assumed any operation to minima below CAT I will require some type of flight certification of the pilot to fly that procedure. The new pilot tasks to perform such tasks should be identified and appropriate minima certification guidance developed.

Near term precision instrument procedures to heliports require new pilot tasks - these include: vertical tracking on the back side of the power available curve, current instrument flight check requirements should be reviewed and updated to reflect those activities an instrument pilot might be exposed to making precision approaches to heliports.

Recommended/Implemented Approach:

(1) Establish pilot certification and recurrency requirements. (2) Develop appendix for aircraft and helicopter IFR flying.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0019 Issue Code: DI Related Issues: 47 -0- -0-

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: M

Issue: VISUAL CUES FOR ATTITUDE REF DURING LOW SPEED, LOW VISIBILITY FLIGHT

Description:

The handling qualities of current helicopters at slow speeds are very susceptible to headwind or crosswind changes. Any change in the wind magnitude or direction can change the nature of the handling qualities problem. Therefore, pilots cannot learn to compensate procedurally for unstable attitude characteristics. Pilots use attitude as a speed reference, therefore, when attitude is rapidly changing or unstable an accurate reliable airspeed and/or groundspeed system is a requirement.

Technical Comment:

Primary activities are research in handling qualities and "visionics". Relates to Issue #7. Display sophistication can be traded for flight control system complexity during low speed, low visibility flight. If properly designed, displays can be certified, then VFR handling qualities may be acceptable in IMC low visibility approaches, hovers and departures.

Recommended/Implemented Approach:

Survey and analysis of state-of-the-art in displays should be performed. This should include: (1) Innovative artificial horizon. (2) Optronics and visionics systems. (3) Head-up display (4) Computer generated images.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0020 Issue Code: SS Related Issues: 20 23 28

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: H

Issue: ACCURATE GROUNDSPED (OR CLOSURE RATE) SENSING AND DISPLAY

Description:

Normal pitot-static type airspeed sensing systems suffer a drastic loss of accuracy and effectiveness at airspeed under 50 knots. Helicopter pilots have traditionally compensated for this by using visual cues gained by reference to the ground. The single greatest engineering challenge in helicopter "zero/zero" certification will be the development of an accurate and reliable system to sense and display closure rate to the intended point of landing as well as airspeed.

Technical Comment:

Low airspeed and groundspeed sensors and displays may be required and further studies should be accomplished. However such display may not be required if "adequate" vision aids are provided. In that case, the same airspeed information as is currently used for VMC operations is felt to be adequate. Accurate groundspeed sensing and display will be received. A low airspeed or groundspeed sensor must sense lateral and longitudinal components of speed. Issues are: (1) when to switch from airmass to ground reference speed; (2) is airspeed required for aircraft control?; (3) is airspeed required to achieve certified performance?; (4) low airspeed data would be required to provide vertical or steep angle descent control laws with a margin for vortex ring states. This capability will be available with DME-P and other systems (e.g., LORAN-C or maybe GPS). However, different low speed flight inspection procedures will be required. You will still need groundspeed in 0-20 kt. Single engine performance gains with OEI between 20-40 kts. should be considered.

Recommended/Implemented Approach:

(1) Continued studies are needed for sensors, displays and definition of limits. (2) Investigation of synthetic data should be analyzed to "aid" during short sensor dropouts.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0021 Issue Code: PW Related Issues: 29 30 45

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: M

Issue: MINIMUM REQUIRED COCKPIT FIELD OF VIEW FOR VISUAL ACQUISITION OF LDG ENV

Description:

At some point during an approach to a landing in IMC, the helicopter pilot will need to acquire the touchdown (landing) point visually. This may occur at very low altitude (a few feet above the ground) and at very low airspeed (a relatively high "pitch-up" nose attitude). Therefore, it will be necessary to determine the minimum ergonomic requirements for visibility (field of view) in helicopter cockpit design for "zero/zero" certification.

Technical Comment:

(1) FAA does not stipulate specific requirements for field of view, but an Advisory Circular is recommending field of view data on VFR flight. (2) Designers should pay attention to visual cockpit cut-off angles. (3) Issue is impacted by deceleration rates, approach angles, and the design of the heliport approach setup, e.g., "offset" type approach. (4) Issue is impacted by helicopter trim attitudes and by Tilt-Rotor changes and side force generation by lateral cyclic maneuvering. (5) Designers should pay attention to glare shield issues related to large Electronic Flight Instrument System (EFIS) displays.

Recommended/Implemented Approach:

Southwest Region will include guidance information in an Advisory Circular rather than dictate design or address changes in the regulations.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0022 Issue Code: CE Related Issues: 21 29 30

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: M

Issue: MINIMUM OEI PERFORMANCE REQUIREMENTS

Description:

The minimum acceptable "margin of safety" represented by the amount of excess power available to compensate for the loss of one engine in order to maintain (at least) level flight while in IMC will be a critical factor in "zero/zero" certification. While the rated output of the power plant may be beyond the determination of the pilot, the maximum takeoff weight for a given set of conditions can be managed in order to maintain a safe power-to-weight ratio.

Technical Comment:

- (1) There are no operating rules for performance relative to helicopter operations.
- (2) There is still a question of how to train for short term power requirements.
- (3) Current level of safety should not be decreased. (4) Simulation techniques are required. (5) If fuel limiting (black box) is used it must be certified.

Recommended/Implemented Approach:

- (1) The power-to-weight ratio of helicopters should be increased. (2) A study should be conducted to develop concepts for the use/certification of short term takeoff and landing power ratings. (3) As relates to minimum OEI performance, a study should be conducted to coordinate certification rules, operating rules and airspeed matters.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0023 Issue Code: SS Related Issues: 7 20 28

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: M

Issue: REQUIREMENT FOR HIGHLY RESPONSIVE AUTOPILOT WITH STABLE HEADING HOLD

Description:

See Issue Number 7.

Technical Comment:

This is another part of the low-speed handling qualities issue.

Recommended/Implemented Approach:

Combine with Issue #7.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0024 Issue Code: NG Related Issues: 25 31 32

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: H

Issue: RQMNT FOR ACCURATE & RELIABLE ADVANCED NAVIGATION & GUIDANCE SYSTEM

Description:

Precision navigation and guidance have been assumed for terminal area operations, approach and missed approach.

Technical Comment:

Angular course width is unacceptable at close ranges from the antenna (1000'). This characteristic necessitates low speed flight inspections. Accurate, linear precision navigation and guidance systems are required to insure reliable and safe low visibility approaches.

Recommended/Implemented Approach:

(1) System specifications and flight inspection procedures should be developed. (2) The FAA Technical Center should investigate requirements and test procedures. (3) Accuracy values for various windows, known for fixed-wing aircraft, need to be developed for helicopter decelerating approaches.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0025 Issue Code: DI Related Issues: 34 -0- -0-

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: H

Issue: ADVANCED SYSTEMS FOR TERMINAL GUIDANCE & OBSTRUCTION AVOIDANCE

Description:

Extensive work has been done by NASA, Army, DARPA and the FAA in advanced systems and displays. The application of this work to helicopter terminal guidance and obstruction avoidance should be examined.

Technical Comment:

Need to separate the issues associated with "see and avoid" i.e. collision avoidance from those associated with "see to land" i.e. obstruction avoidance. Relates to Issue #24

Recommended/Implemented Approach:

See Issue #24

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0026 Issue Code: NG- Related Issues: 24 33 35-

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: H

Issue: REQUIREMENTS FOR AUTONOMOUS PRECISION APPROACH GUIDANCE SYSTEM

Description:

In order to maximize the operational potential of VTOL aircraft, particularly with respect to search and rescue (SAR) and medical evacuation missions, the capability to make instrument approaches, with vertical as well as directional guidance, to unprepared remote landing sites will be necessary.

Technical Comment:

(1) A portable, radar based Beacon Landing System (BLS) has been developed by NASA for the Army. (2) This is a desirable goal. (3) Issue: How to certify onboard systems - precision approach -- aircraft only system to be certified -- How to insure integrity. (4) Precision - vertical guidance. (5) Autonomous on-board systems? (6) Synthesize a glideslope - Accuracy equivalent of CAT II/III level must be achieved. (7) Protection of airspace for precision minimum at remote sites. (8) Technology exists or is being developed. (9) Need definition of "remote landing site". (10) EMS type operations (11) How to handle obstruction clearances at remote sites. (12) What information about remote site must be available to pilot. (13) Evaluate what USAF is doing in this area. (14) Obstruction Issue -- Obstruction avoidance system on board aircraft? (15) Existing FLIR's still have some problems -- eg; wires. (16) Onboard obstruction avoidance system is high cost. Also far term issue. DOD development near-term. (17) Will require extensive development. (18) FAA needs confidence of the courtroom to certify. (19) Studies are being conducted - human factors - tracking and obstruction avoidance. (20) Electronic VFR ? (21) New regulations required.

Recommended/Implemented Approach:

(1) Review & Evaluate DoD/USCG methods for applicability. (2) Recommend "remote landing site" definition be established. (3) Determine on-board equipment required to operate IMC to remote site.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0027 Issue Code: HP Related Issues: 3 8 -0-

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: M

Issue: IMC HELIPORT MARKING AND LIGHTING

Description:

Helicopter design and engineering criteria needs to be refined in order to enhance the transition from IFR "head-down" reference cues in the cockpit to VFR "head-up" external references during the approach. Particular emphasis should be placed on providing good visual references for attitude (pitch) control at low (nose-high) airspeed.

Technical Comment:

(1) Airports issue - Flight Standards issue. (2) Low visibility approaches. (3) Steeper angle - less benefit for existing lighting aids. (4) Shorter approach lighting - Less land. (5) Slower approach - picking up visibility question somewhat less critical. (6) High angle lighting required. (7) Need simulator testing - Parametric study - cut-off angle, deceleration distance, decision height, glidepath angle - pilot preference, work load reduced. (8) Firm Requirement/Standards for IFR Helicopter approach operations. (9) Manufacturers need to have standards to build to. (10) Human factors - moving lights, strobes, light scatter. (11) Need more lighting research. (12) Pilot needs to know what to expect in lighting. (13) VASI - steeper angles. PLASI - to be evaluated. (14) CAT I/II lighting vs. zero/zero approach. (15) Good candidate for testing. (16) Test both day and night conditions. (17) City center - lights other than those associated with operations may be problem - evaluate. (18) Lighting - multiple direction approaches, aiming lights. (19) Marking - precision heliport - edge marking - obstruction protection. (20) Marking - VFR Issue? (21) Ultra-steep angles: a) Cut off angles; b) Lighting effectiveness; and c) Low hover - touchdown. (22) Zero/Zero - use of FLIRs, etc. - where do lights fit in? (23) Orientation markings for approach/departure - Low vs Hover orientation markings.

Recommended/Implemented Approach:

(1) Additional testing to (review and possibly) determine requirement for low-visibility lighting/standards for heliports - any credit for lights.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0028 Issue Code: SS Related Issues: 20 23 34

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: M

Issue: CRITERIA FOR AIRBORNE IMAGING TECHNOLOGIES

Description:

Explore the potential for onboard illumination and/or electronic (radar, FLIR, etc.) systems that act interactively or passively to help the pilot acquire the landing environment in low visibility conditions sooner than what would otherwise be possible without them.

Technical Comment:

See Issue Number 34.

Recommended/Implemented Approach:

This issue should be combined with and covered by #34.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0029 Issue Code: PW Related Issues: 4 30 45

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: M

Issue: SINGLE-ENGINE VS. MULTI-ENGINE HOVER & AUTOROTATION PERFORMANCE

Description:

Due to a low priority assignment, this issue was not reviewed at the forum.

Technical Comment:

See related issues.

Recommended/Implemented Approach:

See related issues.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0030 Issue Code: PW Related Issues: 21 29 45

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: M

Issue: EFFECT OF ENGINE RELIABILITY IMPROVEMENTS ON OEI REQUIREMENTS

Description:

Today's helicopters flying corporate executives to CBDs or flying personnel logistical support to coal mines in remote areas incur a severe productivity penalty in IFR operations due to OEI power requirements. Basically two limits are the crux of the problem. First, the ability to get onto or off of a small heliport requires single engine hover in ground effect capability. Second, engine failure during missed approach and departure requires compliance with TERP's clear zone planes. These planes mandate a climb gradient of approximately twice the capability of current 10+ passenger twin engine helicopters. These two criteria impose a requirement for up to a 50% increase in excess power for some helicopters.

Technical Comment:

Part 91 does not require the performance stated in the description of issues. Such performance is used by Part 91 operators to achieve an equivalent level of safety with commercial operations. At least two related technological alternatives currently exist. First, oversized engines could be specified but operated derated 99% of the time. This would enhance reliability, reduce maintenance and overhaul/replacement costs. Second, recent advances in single crystal turbine blades offer up to 200 degree increases in turbine inlet temperature. This translates into a 20% increase in maximum power. These advances indicate that the power required for zero/zero operations is available and the tradeoffs between increased acquisition costs, reduced life cycle costs and increased reliability should be evaluated.

Recommended/Implemented Approach:

This issue is related to, and impacts Issue #4. The major recommendation for #4 applies. However a minority opinion was expressed that "improvements in reliability could possibly be traded-off for certification requirements at some future date." The group felt that this was not realistic today given the current state of the art in engine/transmission design/maintenance.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0031 Issue Code: NG Related Issues: 24 25 32

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: M

Issue: REQUIREMENT FOR ADVANCED ONBOARD LANDING SYSTEMS

Description:

In order to take maximum advantage of the flexibility that is uniquely characteristic of helicopter operations, systems that will permit approaches (both precision, with vertical guidance and nonprecision, without visual guidance) to unimproved remote sites with little or no reference to ground-based guidance will need to be developed.

Technical Comment:

The FAA would be reluctant to allow IFR approaches to remote sites when obstruction clearance and traffic avoidance cannot be guaranteed. However, if vision aids are available (e.g. millimeter wave radar) such approaches may be safely accomplished. Aircraft may be certified for low speed IMC and capability for autonomous approaches to remote sites would possibly be treated as an add-on. Accuracy and flight technical error are also important considerations to include: (1) ability to create the proper paths; (2) ability to follow that path; (3) ability to avoid obstacles.

Recommended/Implemented Approach:

The FAA should define the program that would be required to get, (1) the system approved and, (2) define (or determine) airspace requirements.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0032 Issue Code: NG Related Issues: 24 25 31

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: M

Issue: REQUIREMENTS FOR ADVANCED NAVIGATIONAL GUIDANCE AND CONTROL SYSTEMS

Description:

Difficulties in navigation and control of helicopters in IMC stem chiefly from the line-of-sight limitations of reference signals generated by ground-based systems. Rotorcraft will require adequate CNS coverage from 2000' AGL to the surface for a "zero/zero" approach capability.

Technical Comment:

Precision guidance to a "point" will be required. The location of the "point" and the systems required for the approval need to be defined. GPS and LORAN-C integration with inertial systems offer a solution. This solution would contribute to smaller heliports if done totally onboard the helicopter. Inexpensive systems are required and may include some type of vertical flight display.

Recommended/Implemented Approach:

System concepts, specifications and performance limits need to be analyzed.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0033 Issue Code: NG Related Issues: 26 35 -0-

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: M

Issue: ACCURACY CRITERIA FOR LOW VISIBILITY SYSTEMS

Description:

The advanced system functions of information sensing and display of necessary control inputs to enable the pilot to navigate through the terminal area or to the remote site, to identify the landing site, and to perform and approach to a hover safely will require greater accuracy than what is available in present systems. A reasonable and realistic set of criteria for such accuracy needs to be developed.

Technical Comment:

(1) Accuracy increases for lower minima. (2) MLS Accuracy - Adequate for CAT III fixed wing. (3) Will MLS support sensor inputs for auto-deceleration? Auto-hover? (4) Heliport MLS - Accuracy standards for some gates need to be estimated. (5) Low speed affects path following error (PFE) and control motion noise (CMN) so MLS accuracy standards must account for this. Helicopter control systems - accuracy values for PFE and CMN. (6) Flight inspection problems may result for close in checks. (7) Along track distances and rates are critical parameters. (8) DME/P recommended standards need to be examined. - DME/P for high speed turn off has been estimated. (9) DME/P would likely support zero/zero requirements. - granularity needs to be examined. (10) Critical areas need to be protected. (11) Other nav aids need to be examined. - GPS, Loran-C, etc..

Recommended/Implemented Approach:

(1) Establish total limits for lower than Cat II window(s). (2) Determine along track accuracy and granularity required for low airspeed operations. (3) Determine MLS equipment (as installed at heliports) critical areas. (4) Examine other nav aids for possible application to low-visibility operations.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0034 Issue Code: DI Related Issues: 25 -0- -0-

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: H

Issue: REQUIREMENTS FOR ALL WEATHER TERRAIN AND OBSTACLE AVOIDANCE SYSTEM

Description:

The routes in the terminal area designed for IFR traffic separation, collision avoidance, and best noise abatement profile will need greater 4-dimensional precision than has been required of present systems. In addition, a multisensor low visibility airborne system may be required to allow all weather, day or night operations under conditions which include heavy fog, smoke, smog, etc. These systems may be required in order to detect obstacles and/ or vehicles on the landing site once a 20-50 ft hover has been established. Under these conditions, terrain and obstacle avoidance (including wires) become additional factors.

Technical Comment:

(1) Need to minimize the operating range requirement for a visual enhancement sensor-display system. This will allow the cost of the system to be minimized. (2) The shorter the "distance required to see," the easier it will be to reliably achieve the specified performance. It will probably be possible to use the systems discussed in the requirements statement to expand the visual segment of an IFR approach.

Recommended/Implemented Approach:

The FAA (APM-450) should collaborate with ACT-330 to follow and evaluate related visual enhancement (sensor-display) program developments and support other related projects. All types of visualization systems (FLIR, MM wave radar, LLTV, etc.) should be investigated. Civil, DoD and NASA efforts should all be included.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0035 Issue Code: NG Related Issues: 26 32 33

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: M

Issue: CNS* REQUIREMENTS & COST/BENEFIT ANALYSIS FOR COVERAGE BELOW 2000' AGL

Description:

See issue number 32.

* CNS = Communication, Navigation and Surveillance.

Technical Comment:

(1) Not just a zero/zero issue - Applies for VFR and other navaid/IFR operations (e.g. Loran-C) (2) In the National Airspace System Plan, the floor of coverage goes up to 6000'. - System will degrade. (3) Surveillance: Can we live with dependent surveillance (e.g. LOFF)? - Must separate traffic. (4) Loran-C coverage - extended over total U.S. (5) Support enroute IFR at 2000' and below. (6) Loran-C/GPS failures - Impact on ATC system. (7) Communication data linking. (8) Priority: navigation, communication, surveillance. (9) Cellular telephones. (10) Satellite surveillance? to surface - Spy-in-sky - Total coverage - No altitude capability - Cost/reliability of satellite systems.

Recommended/Implemented Approach:

(1) Closing mid-continent gap for Loran-C. (2) Evaluate/review previous studies on this subject. (3) Determine where to-the-surface surveillance is required. (4) Investigate use of data-link communication for ATC.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0036 Issue Code: AT Related Issues: 10 11 12

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: L

Issue: ANALYSIS OF FAR PART 71 FOR LOW VISIBILITY CERTIFICATION IMPACT

Description:

None - not discussed.

Technical Comment:

(1) New structure required. (2) Route width. (3) Public, not special use procedure. (4) Needed for routing to heliports. (5) Different obstruction requirements? (6) Charting - width criteria for obstructions? (7) Charting accuracy and resolution - Additional detail. (8) Problems with pictorials. (9) Standard enroute width eliminates Special Use Restrictions. (10) Some segments of Northeast Corridor should be placed on low level enroute charts. (11) More use of descent-to-VFR to off-primary flow locations and identify these locations.

Recommended/Implemented Approach:

(1) Determine areas where minimum altitude routing can be established using Loran-C or equivalent.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0037 Issue Code: EC Related Issues: 4 14 15

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: M

Issue: ACQUISITION AND OPERATING COSTS ASSOCIATED WITH MORE POWERFUL ENGINES

Description:

More powerful engines (which allow IFR operations) command a correspondingly more "powerful" cost, in terms of both initial acquisition and continuing operating costs for fuel, maintenance, etc. The tradeoffs between the increased mission (schedule) reliability they buy and their costs should be evaluated.

Technical Comment:

See Issue Number 4.

Recommended/Implemented Approach:

Combine with Issue #4.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0038 Issue Code: HQ Related Issues: 6 7 40

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: M

Issue: LOW SPEED STABILITY AND CONTROL IN IMC

Description:

Low speed operation at the beginning and at the end of a flight subjects the helicopter to some aerodynamic effects which are more stringent than those experienced during the high speed, enroute segment of the trip. Most of these effects are associated with the fact that at low speed the main and the tail rotors are both generating wakes with high induced velocities in order to produce the required thrust. As these wakes impinge on each other, the airframe, or the ground, they can produce changes in forces and moments for which the pilot must compensate with the controls. All of the phenomena which can be attributed to these various wake effects are known as "interactional aerodynamics".

Technical Comment:

See Issue #7, #19 and #20.

Recommended/Implemented Approach:

See Issue #7.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0039 Issue Code: CE Related Issues: 48 49 -0-

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: M

Issue: CERT. PROCEDURES/GUIDELINES FOR HOVER THROUGH TRANSLATIONAL LIFT

Description:

See Issue Number 7.

Technical Comment:

See Issue Number 7.

Recommended/Implemented Approach:

Combine with Issue #7

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0040 Issue Code: HQ Related Issues: 6 7 38

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: M

Issue: PITCH CONTROL IN IMC HOVER

Description:

In hover, the main rotor generates a downwash which impinges on the airframe components directly below it. As the helicopter moves into forward flight (or is hovering in a head wind), the wake moves rearward and impinges on components near the tail. If one of these components is a large horizontal stabilizer, the suddenly generated download will tend to pitch the helicopter nose-up unless the pilot compensates with forward stick motion. The opposite action is required during a slow approach to hover.

Technical Comment:

Pitch attitudes versus airspeed can be highly nonlinear and is aggravated by increasing the size of the horizontal tail. There is some concern that the existing requirement for static longitudinal stability will encourage upsizing the horizontal tail.

Recommended/Implemented Approach:

Pitch attitude trim and transient behavior should be included as part of the low speed handling qualities investigation.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0041 Issue Code: HQ Related Issues: 6 7 38

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: M

Issue: YAW CONTROL AT LOW AIRSPEEDS IN CROSSWIND AND IMC CONDITIONS

Description:

A tail rotor is a good directional control device in almost all flight conditions. The exception is in left sideward flight (for helicopters with the "American" or counter clockwise -- main rotor rotation) at speeds where the motion of the helicopter is trying to stagnate the wake coming out of the tail rotor. For most current helicopters, this sideward speed is in the 10 to 30 knot region. Since only relative velocities are significant, hovering over a spot on the ground with the wind blowing from the left can also tend to stagnate the tail rotor wake as can a right hovering turn. This condition is known as the "vortex ring state" and generally, but not always, is a condition of erratic control of heading.

Technical Comment:

(1) The problem involves dynamic oscillatory characteristics on approach and departures in yaw during high cross winds and inadequate lateral transitions. (2) Current VFR certification requires a demonstration of directional controllability out to 17 kts. although higher speeds are often demonstrated (generally 30 kts.). (3) When IFR approach to hover is certified for a given model, the need to operate in a cross wind is probably a function of location (oil rig vs NYC city center) and weather patterns.

Recommended/Implemented Approach:

The FAA should include yaw controllability in the minimum handling qualities and display studies with consideration for identifying guidance relative to the maximum allowable yaw oscillatory characteristics and the need to avoid aperiodic departures in yaw during the approach and the post-approach IMC hover phase.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0042 Issue Code: HQ Related Issues: 7 38 41

Updated: 08/20/87 Retrieval Date: 03/15/88 Priority: M

Issue: HEADING CONTROL DURING LOW AIRSPEED MANEUVERS

Description:

A directional control problem which is characteristics of some helicopters is a main rotor-tail rotor-vertical fin interaction at low speeds. This occurs when the direction of flight or the ambient wind blows the high energy portion of the main rotor wake across the tail rotor and the vertical fin. When this occurs, on those helicopters which are sensitive to it, the directional control may be so degraded that the pilot cannot hold a heading.

Technical Comment:

See Issue Number 41.

Recommended/Implemented Approach:

This issue should be combined with and covered by #41.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0043 Issue Code: PW Related Issues: 21 29 30

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: M

Issue: POWER SETTLING DURING HOVER IN IMC

Description:

Power settling occurs when a helicopter gets "caught" in its own vortex ring. The resulting gradual descent is not arrested by the application of more power, in fact, it is worsened by it. Without outside references, this condition, if it should occur, may not be immediately noticeable to the pilot. The normal power setting for a hover is not producing the desired results and the aircraft is actually getting dangerously lower. A simple "low altitude" warning would logically be responded to with a power increase which could be disasterous.

Technical Comment:

Vertical descent guidance systems should preclude operation in this regime. Pilot should be advised if aircraft approaches this flight condition.

Recommended/Implemented Approach:

FAA should provide guidance material relating to step approaches which identifies issue and requirement to avoid vortex ring state.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0044 Issue Code: SS Related Issues: 20 23 28

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: L

Issue: REQUIREMENTS FOR ENGINE CONDITION MONITORING

Description:

The best way to deal with the issues of adequate OEI capability and/or instrument autorotations is to minimize (or eliminate) the potential for partial or total power failure. The criteria for certification of the method to allow the pilot to accurately assess engine health, and probable reliability, may greatly reduce the economic impact of compliance with other requirements in the areas of operations and equipment acquisition.

Technical Comment:

(1) Do not envision use of engine and systems health monitoring systems will eliminate the need to consider OEI power deficiencies. (2) The overall system reliability requirements, including the engine, are a function of the type of operation and approach approvals requested. (3) Health monitoring equipment should not be classified as flight critical items without substantial justification.

Recommended/Implemented Approach:

Continue to support work on health monitoring systems.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0045 Issue Code: NG Related Issues: 4 24 25

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: M

Issue: SUBSYSTEM FAILURE-MODE REDUNDANCY REQUIREMENTS

Description:

See Issue Number 4.

Technical Comment:

See Issue Number 4.

Recommended/Implemented Approach:

This issue is premature at this time since precise airborne system requirements for functions, procedures and accuracy are not specified. Retain as a long term issue and combine with Issue #4.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0046 Issue Code: SS Related Issues: 20 23 28

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: M

Issue: REQUIREMENTS FOR MINIMUM IFR LATERAL & LONGITUDINAL AIRSPEED COMPONENTS

Description:

See Issue Number 20.

Technical Comment:

See Issue Number 20.

Recommended/Implemented Approach:

Combine with Issue Number 20.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0047 Issue Code: DI Related Issues: 19 -0- -0-

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: M

Issue: MIN REQMT FOR ABSTRACT VS. PROCESSED DATA (FLIGHT DIRECTOR) DISPLAY SYS

Description:

See Issue Number 19.

Technical Comment:

See Issue Number 19.

Recommended/Implemented Approach:

(1) FAA should support abstract data display system studies (by industry and NASA) and provide advisory circular guidance, as available, for use by rotorcraft. (2) FAA should also establish an FAA and industry team to provide standardization guidance for abstract data displays.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0048 Issue Code: CE Related Issues: 39 49 -0-

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: M

Issue: CERTIFICATION REQUIREMENTS FOR MANUAL BACKUP OF AUTOMATIC GUIDANCE

Description:

See Issue Number 4.

Technical Comment:

See Issue Number 4.

Recommended/Implemented Approach:

Premature issue; retain, but combine with Issue #4

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0049 Issue Code: CE Related Issues: 4 39 48

Updated: 08/27/87 Retrieval Date: 03/15/88 Priority: M

Issue: IDENTIFICATION AND SPECIFICATION OF MINIMUM FLIGHT CRITICAL SYSTEMS

Description:

See Issue Number 4.

Technical Comment:

Current FAA rules are okay. Potential display and control system malfunctions must be identified. The consequences of these malfunctions must be addressed during certification and safe recovery procedures defined. (1) There are conflicting opinions on the establishment, identification, and specification of minimum flight critical systems. (2) Probably okay to list some combinations of specific equipment recommendations for an aircraft. (3) There is some resistance to detailing these issues in regulations --- better result would be to issue any recommendations as guidance material in an Advisory Circular.

Recommended/Implemented Approach:

FAA provide guidance material for low speed handling qualities and display requirements for both normal and degraded mode operation. (1) Present FAA research activities should continue. Southwest Region should continue to monitor all pertinent research and work with DoD, NRC, NASA and industry data to provide guidance on minimum systems, equipment, flying qualities and workload certification requirements. (2) FAA headquarters should continue funding in these areas. (3) Southwest Region should incorporate changes and amendments as indicated by the results and conclusions.

ROTORCRAFT LOW VISIBILITY LANDING SYSTEM ISSUE IDENTIFICATION

Issue Number: 0050 Issue Code: SI Related Issues: 1 2 7

Updated: 08/27/86 Retrieval Date: 03/15/88 Priority: H

Issue: SIMULATION

Description:

For training and certification of aircrews.

Technical Comment:

Definition: Slowspeed = nominally 40 knots airspeed in any direction and up to 60 knots forward airspeed. Will require more stability and control and performance data than normally obtained in airworthiness certification.

Recommended/Implemented Approach:

(1) Helicopter manufacturers should work with simulator people and provide the necessary data during development of new designs to produce simulators suitable for training and aircrew certification for "zero-zero" operations.