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Design and pilot evaluation of the RAH-66 Comanche selectable control modes

The RAH-66 Comanche helicopter has been designed to possess superior handling qualities over a wide range of flight conditions. The control laws have been tailored to satisfy the requirements of ADS-33C and the Weapon System Specification (WSS). This paper addresses the design of the Comanche Selectable Mode control laws (Velocity Stabilization/Hover Hold and Altitude Hold), which provide the additional stabilization and control augmentation needed when flying in a Degraded Visual Environment (DVE). An overview of the RAH-66 control laws is presented, including a detailed description of the Selectable Modes design. The primary focus of this paper is the results of piloted evaluation of these control laws in the Boeing motionbase simulator. These tests substantiate the detailed design of the Comanche Selectable Mode control laws. All tested DVE tasks (ADS-33C, sections 4.4 and 4.5) were rated Level 1. Other evaluation tasks confirmed the mission suitability of the control system. These control laws are ready for formal ADS-33C compliance testing in the Sikorsky Full Mission Simulator (FMS).

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DESIGN AND PILOT EVALUATION OF THE RAH-66 COMANCHE SELECTABLE CONTROL MODES

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ABSTRACT

The RAH-66 Comanche helicopter has been designed to possess superior handling qualities over a wide range of flight conditions. The control laws have been tailored to satisfy the requirements of ADS-33C and the Weapon System Specification (WSS). This paper addresses the design of the Comanche Selectable Mode control laws (Velocity Stabilization / Hover Hold and Altitude Hold), which provide the additional stabilization and control augmentation needed when flying in a Degraded Visual Environment (DVE). An overview of the RAH-66 control laws is presented, including a detailed description of the Selectable Modes design. The primary focus of this paper is the results of piloted evaluation of these control laws in the Boeing motion-base simulator. These tests substantiate the detailed design of the Comanche Selectable Mode control laws. All tested DVE tasks (ADS-33C, sections 4.4 and 4.5) were rated Level 1. Other evaluation tasks confirmed the mission suitability of the control system. These control laws are ready for formal ADS-33C compliance testing in the Sikorsky Full Mission Simulator (FMS).

NOMENCLATURE

AC/AH	Attitude Command/Attitude Hold
AC/VH	Attitude Command/Velocity Hold
AFCS	Automatic Flight Control System
AGL	Above Ground Level
ALTHLD	Altitude Hold
BMR	Bearingless Main Rotor
DEM/VAL	Demonstration/Validation
DVE	Degraded Visual Environment
FOV	Field of View
FMS	Full Mission Simulator
HAC	Helicopter Air Combat
HMD	Helmet Mounted Display
HQR	Handling Qualities Rating
LSTC	Low Speed Turn Coordination
MEP	Mission Equipment Package
NOE	Nap of the Earth
PFCS	Primary Flight Control System
PIO	Pilot Induced Oscillations
PMGW	Primary Mission Gross Weight
RC/AH	Rate Command/Attitude Hold
RFOV	Restricted Field of View
TC	Turn Coordination
UCE	Usable Cue Environment

VCR	Visual Cue Rating
VC/PH	Velocity Command/Position Hold
VELSTAB	Velocity Stabilization
WSS	Weapon System Specification

INTRODUCTION

Control Law Design

The RAH-66 control system consists of a Primary Flight Control System (PFCS) and an Automatic Flight Control System (AFCS). The PFCS and AFCS use explicit model-following control laws to provide both control and stability augmentation. The PFCS is the flight critical portion of the flight control system while the AFCS is the mission critical portion. The AFCS augments the performance of the PFCS in order to meet the requirements of ADS-33C (Reference 1) by providing Level 1 handling qualities for all mission task elements in a Usable Cue Environment (UCE) of 1 or 2 and at least Level 2 handling qualities in a UCE of 3. To provide these capabilities, the AFCS consists of both automatic and manually selected modes which allow the pilot to tailor the control system for the existing flight conditions. These modes provide increasing levels of vehicle augmentation combined with improved control precision to produce superior flight performance and low pilot workload. The Core AFCS is the basic operational mode of the control system and allows the pilot to make full use of the maneuverability / agility of the Comanche.

The Comanche Selectable Modes, Velocity Stabilization (VELSTAB) and Altitude Hold (ALTHLD), can be engaged anywhere in the flight envelope in order to respond to changing flight/visual conditions or when reduced pilot workload is desired. VELSTAB provides air and ground referenced Velocity Hold, Hover Hold with linear Velocity Command, and ground referenced Low Speed Turn Coordination. ALTHLD provides either radar or barometric referenced Altitude Hold with automatic reference switching and Rate of Climb Command. A simplified block diagram of the longitudinal VELSTAB axis and its integration with the PFCS and Core AFCS, is presented in Figure 1. In the PFCS, pilot inputs are passed through appropriate command shaping to generate a high authority, high frequency command path. Rate