Australian Government
Department of Defence
Defence Science and
Technology Organisation

Progress Towards a Maritime Aeronautical Design Standard 33 Addendum

Sylvain Manso and Steven Arney

Air Operations Division

Defence Science and Technology Organisation

DSTO–TN–0936

ABSTRACT

The Aeronautical Design Standard 33 (ADS-33) is a performance specification for the handling qualities requirements of military rotorcraft. The handling qualities criteria and metrics of ADS-33 depend primarily on the mission the helicopter has to execute rather than its role or size. ADS-33 requires that the specifications of the Mission Task Element (MTE), the Usable Cue Environment (UCE) and the response type are defined. The current criteria and specifications defined in ADS-33 relate to scout, attack, utility and cargo helicopters for land operations; however there are no requirements related to maritime operations. This technical note provides an overview of work by the Aircraft Maintenance And Flight Trials Unit (AMAFTU) and DSTO, that are collaboratively progressing towards the definition of a maritime hover Mission Task Element (MTE). This involves an over water manoeuvre flown to a floating buoy. Flight tests were performed by AMAFTU, though the current data set is not sufficient to draw any conclusions. Further work is planned to demonstrate the viability of the maritime hover MTE through AMAFTU flight tests and DSTO simulations.

APPROVED FOR PUBLIC RELEASE

Published by

DSTO Defence Science and Technology Organisation
506 Lorimer St,
Fishermans Bend, Victoria 3207, Australia

Telephone: (03) 9626 7000
Facsimile: (03) 9626 7999

© *Commonwealth of Australia 2010*
AR No. 014-718
March, 2010

APPROVED FOR PUBLIC RELEASE

Progress Towards a Maritime Aeronautical Design Standard 33 Addendum

Executive Summary

The objective of this work was in support of Navy Task NAV 07/071 to progress international development towards a maritime addendum to Aeronautical Design Standard 33 (ADS-33). ADS-33 is a performance specification for the handling qualities requirements of military rotorcraft. The handling qualities criteria and metrics of ADS-33 depend primarily on the mission the helicopter has to execute rather than its role or size. ADS-33 requires that the specifications of the Mission Task Element (MTE), the Usable Cue Environment (UCE) and the response type are defined. The current criteria and specifications defined in ADS-33 relate to scout, attack, utility and cargo helicopters; however there are no requirements related to maritime operations. An addendum to ADS-33 that specifies maritime operations will assist the Australian Defence Force in quantifying the handling qualities, and hence safety, performance and utility of Navy rotorcraft. This includes current rotorcraft that are modified by Australia, or future platforms such as the MRH 90.

Most of the profiles flown by maritime rotorcraft are the same as those flown in the battlefield or land-based environment. The differences identified primarily relate to low level maritime hover and maritime deck operations. To date there has been good progress from the international community in defining a maritime addendum to ADS-33. The US and Canada have proposed the Superslide as a candidate for the shipboard recovery MTE that will represent maritime deck operations. The Superslide target can emulate the positional variations of a moving ship deck in the lateral and vertical axes. This technical note provides an overview of work by the the Aircraft Maintenance And Flight Trials Unit (AMAFTU) and the Defence Science and Technology Organisation (DSTO), that are collaboratively progressing towards the definition of a maritime hover MTE.

AMAFTU has proposed a maritime hover MTE involving an over water manoeuvre flown to a floating buoy. The flight tests performed to date only represent that from two pilots and one sortie. ADS-33 requires visual cue ratings from a minimum of three pilots to measure the Usable Cue Environments (UCEs) correctly. The current data set is not sufficient to draw any conclusions; therefore further work is planned to demonstrate the viability of the Maritime Hover MTE through AMAFTU flight tests and DSTO simulations. A future experiment in the Air Operations Simulation Centre is planned with the objective to investigate and validate the proposed MTE, determine a relationship between UCEs and sea conditions, and investigate the fidelity of using the DSTO simulator as a means for providing UCEs.

DSTO does not recommend the independent development of the deck operations MTE (which was originally planned) due to the high resources required. Australia's involvement in the TTCP AER-TP2 Rotorcraft Technologies and Operations gives AMAFTU and DSTO the scope to share and learn from the research with the Canadian National Research Council Superslide target. This is deemed to be a more efficient exercise than developing an independent MTE for maritime deck operations.

Table of Contents

Appendices

List of Figures

Abbreviations

ACAH - Attitude Command, Attitude Hold

ADF - Australian Defence Force

ADS - Aeronautical Design Standard

AMAFTU - Aircraft Maintenance And Flight Trials Unit

AOD - Air Operations Division

AOSC - Air Operations Simulation Centre

DSTO - Defence Science & Technology Organisation

HIL - Human In the Loop

HMI - Human Machine Interface

HQR - Handling Qualities Ratings

JB - Jervis Bay

MTE - Mission Task Element

NAS - Naval Air Station

NRC - National Research Council

OFE - Operational Flight Envelope

RAN - Royal Australian Navy

RCDH - Rate Command, Direction Hold

RCHH - Rate Command, Height Hold

SAS - Stability Augmentation System

SBIR - Small Business Innovation Research

TTCP - The Technical Cooperation Program of Australia, Canada, New Zealand, the United Kingdom, and the United States of America

UCE - Usable Cue Environment

VMS - Vertical Motion Simulator

1 Introduction

The Aeronautical Design Standard 33 (ADS-33), version E [1], Performance Specification of Handling Qualities Requirements for Military Rotorcraft is currently the most comprehensive set of handing qualities requirements available to the rotorcraft engineer. The requirements of the ADS-33 specification are applied in order to assure that no limitations on flight safety or on the capability to perform intended missions will result from deficiencies in flying qualities of the rotorcraft. The handling qualities criteria and metrics of the ADS-33 depend primarily on the mission the helicopter has to execute rather than its role or size. ADS-33 includes definitions of aircraft response characteristics dependent on the visible cues of the environment, quantitative criteria in both the frequency and time domains, and qualitative criteria based on pilot ratings. However the current criteria and specifications defined in ADS-33 relate to scout, attack, utility and cargo helicopters; there are no requirements related to Maritime operations.

Accurate definition of a maritime handling qualities task has eluded the international community to date. There has been some success but the dynamics of the maritime environment make it very difficult to capture all variables. AMAFTU combined efforts with DSTO to develop a single set of maritime handling qualities manoeuvres. This resulted in identifying two Mission Task Elements (MTEs) flown by maritime rotorcraft that are not represented in the current ADS-33; low level maritime hover and deck operations. International efforts to date have focused on deck operations. This report describes our progress towards the development of the maritime hover MTE.

2 An Overview of ADS-33

The requirements of the ADS-33 specification are applied in order to assure that no limitations on flight safety or on the capability to perform intended missions will result from deficiencies in flying qualities. First introduced in the 1980's, it supersedes the previous MIL-H-8501A specifications [1, 2].

The handling qualities criteria and metrics of ADS-33 depend primarily on the mission the helicopter has to execute rather than its role or size. ADS-33 includes definitions of aircraft response characteristics dependent on the visible cues of the environment, quantitative criteria in both the frequency and time domains, and qualitative criteria based on pilot ratings. The qualitative criteria, in the form of demonstration manoeuvres, assure a comprehensive and independent assessment of the handling qualities of the helicopter during certain well defined tasks. These tasks are representative of actual tasks which might occur as part of the missions foreseen for a helicopter. The assessment of a vehicle's handling qualities during these particular tasks is made by three pilots, who individually evaluate and rate the handling qualities of the aircraft using the Cooper Harper scale [3] (Figure 1).

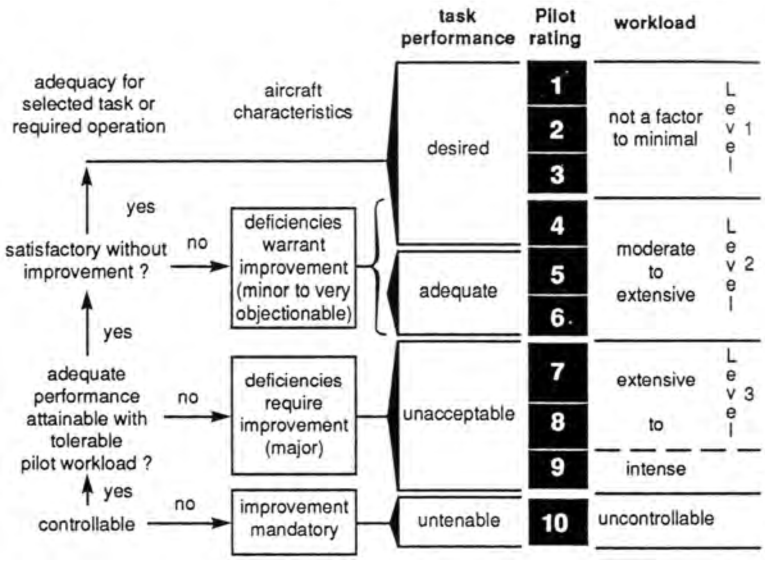


Figure 1: *Summary of the Cooper-Harper handling qualities rating scale [2]*

Subjective pilot ratings are given on the Cooper-Harper scale as Handling Qualities Ratings (HQR). For flight within the operational flight envelope, Level 1 handling qualities are required. Level 2 is acceptable in the case of failed and emergency situations, but Level 3 is considered unacceptable. To ensure Level 1 handling, ADS-33 requires that the specifications of the Mission Task Element (MTE), the Usable Cue Environment (UCE) and the response type are defined. Figure 2 links these concepts together.

UCE	*response types in hover/low speed flight*	*response types in forward flight*
UCE 3	TRC + RCDH + RCHH + PH	RC + TC
UCE 2	ACAH + RCDH + RCHH + PH	
UCE 1	RC	

response types

- RC - rate command
- TC - turn coordination (applies to yaw and pitch response)
- ACAH - attitude command, attitude hold (roll and pitch)
- RCDH - rate command, direction hold (yaw)
- RCHH - rate command, height hold (heave)
- PH - position hold (horizontal plane)
- TRC - translational rate command

selected MTEs

rapid bob up/down, hover turn, rapid transition to precision hover, sonar dunking, rapid sidestep, rapid accel-decel, target aquisition and tracking, divided attention tasks

Figure 2: *Response type requirements in different usable cue environments for selected MTEs [2]*

UCEs relate to the need for different flying qualities in different visual conditions. A UCE of 1 corresponds to very good visual cues that support the aircraft control of attitude and velocity, whereas a UCE of 3 relates to a deficiency in visual cues such that only small and gentle corrections of aircraft flight can be safely achieved.

The response type relates to the short-term aircraft response following a pilot's step control input. Figure 3 shows how the attitude varies for the different response types. An acceleration command relates to a pure conventional helicopter without any stabilisation system. Typically a helicopter will provide rate command stability augmentation, with attitude command and translational command provided by modern control systems. With translational rate command, the piloting is essentially reduced to a steering task.

Response types can be classified further in terms of their frequency and amplitude characteristics. Figure 4 illustrates this, where the zero frequency motion is identified as the trim line. A third dimension can be added representing cross coupling, but to date these requirements are much more immature. The boundary curve indicates the limits of the operational flight envelope. From this representation, quantitative response criteria are defined that are used to break down an MTE into its dynamic constituents. For example, Figure 5 describes types of quantitative analysis related to various MTEs.

The current criteria and specifications defined in ADS-33 relate to scout, attack, utility and cargo helicopters. There are no requirements for maritime operations.

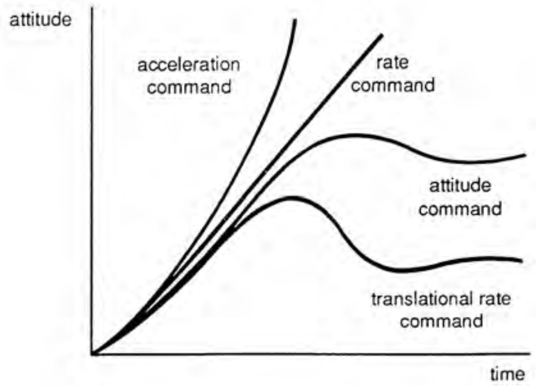


Figure 3: *Attitude response type following step cyclic control input [2]*

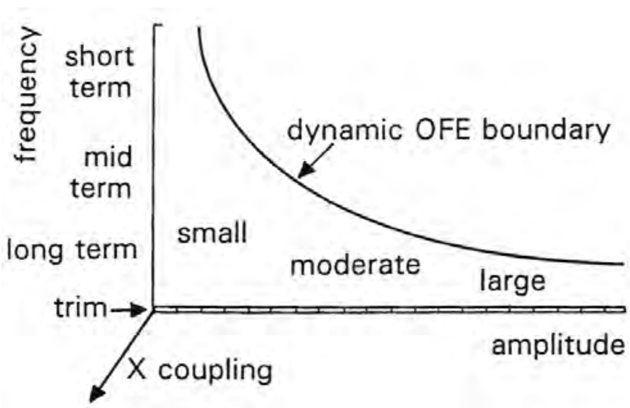


Figure 4: *Frequency and amplitude characterisation of aircraft response within its Operational Flight Envelope (OFE) [2]*

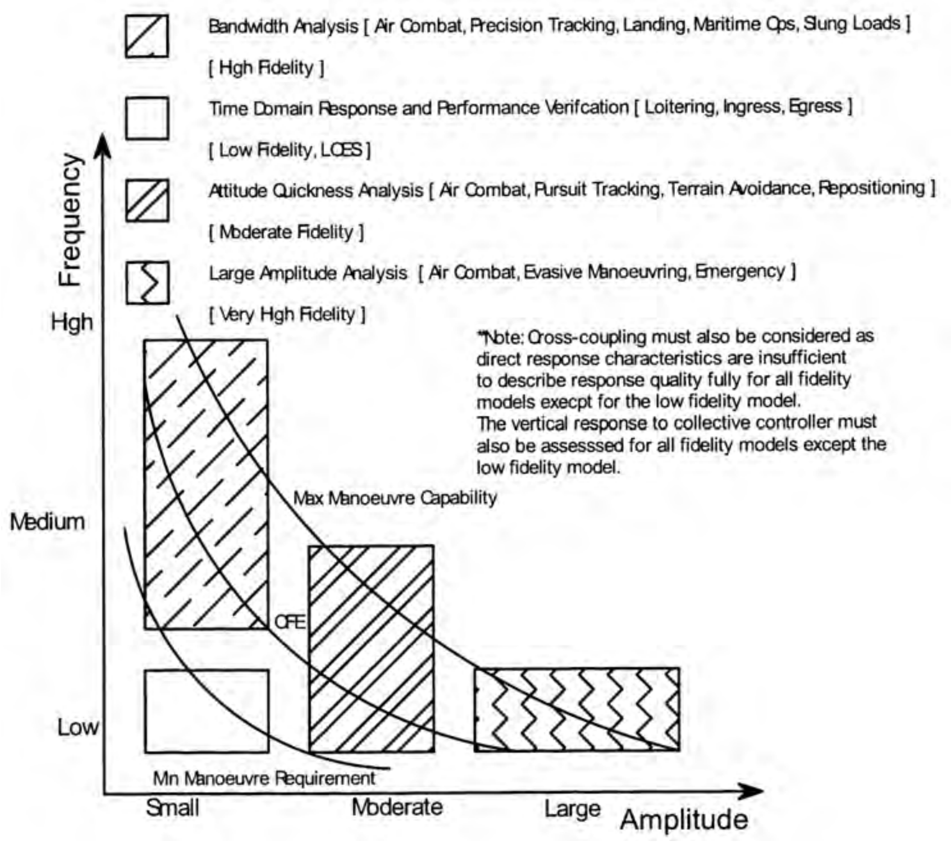


Figure 5: Analysis types applicable for various MTEs [2]

3 Development towards a Maritime ADS-33 Addendum

3.1 The Maritime Hover Task

Accurate definition of a maritime handling qualities task has eluded the international community to date [4, 5, 6]. There has been some good progress, but the dynamics of the maritime environment make it very difficult to capture all variables. Thus, AMAFTU combined their efforts with DSTO to develop a single set of maritime handling qualities manoeuvres. This started by identifying the generic roles performed by the maritime rotorcraft. These roles were then broken down into their constituent missions and then further broken down into flight profile elements.

Most of the profiles flown by maritime rotorcraft are the same as those flown in the battlefield or land-based environment. The differences are identified to primarily relate to low level hover and deck operations. Figure 6 presents an overview of maritime mission task elements.

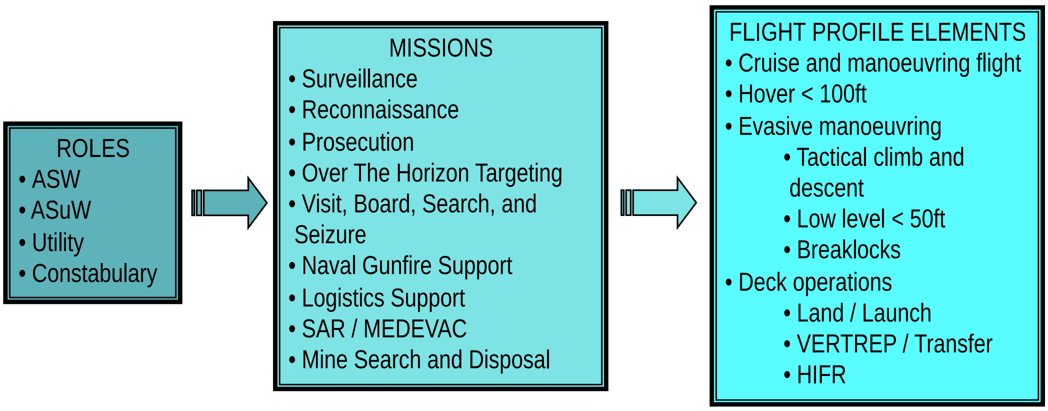


Figure 6: *Maritime flight profile elements*

Current international efforts have focused on deck operations [4, 5, 6]. However, deck operations are resource intensive and as such, our effort was instead focused on the hover case.

The aim was to develop a maritime hover MTE. This can be broken down into two sub objectives. Firstly, to identify and analyse the handling qualities issues associated with a maritime hover task, and secondly to develop a test course that provides equivalency to the actual maritime hover mission and its environment. Ideally this surrogate test course would be set up at an airfield with the currently defined ADS-33 course.

Initial points of consideration are the handling qualities issues and performance criteria related to a maritime hover MTE. Determination of handling qualities issues are based on a consideration of the aircraft characteristics, the environment, and the required level of precision or aggressiveness for the task. Significant differences in either aircraft characteristics or task gain between the maritime and the land-based environments are not expected. However, the visual cues differ substantially from those in the land-based environment and may vary significantly with sea conditions, relative swell direction, ambient winds, and hover height. In terms of performance criteria, transition to hover is largely covered by the current ADS-33 hover MTE and is unlikely to differ between the land-based and maritime environment. Therefore, our focus is on the performance criteria related to hover maintenance.

The proposed maritime hover MTE is to maintain precise position, heading, and altitude to a fixed or floating buoy in an open water environment with limited or no land-based visual references. To determine the validity of the proposed MTE, actual flights will be conducted in as many aircraft as possible with a number of test pilots. Simulator flights will also be conducted in the DSTO AOSC facility for comparison and further investigation. The test will consist of the following:

1. Perform a baseline MTE over land.
2. Perform the maritime MTE over water in varying sea states.
3. Perform both baseline and maritime MTE in the DSTO simulator for comparison.

One difficulty in defining the task for over water utility work is that the pilot typically relies on the crewman to cue him onto the target and maintain position. Of course, the objective is not to develop a task that assesses the cueing abilities of the crewman, or the ability of the pilot to be cued. Rather, if the pilot can achieve desired performance independently under these conditions then there should not be any difficulty during utility operations.

For each of the test locations, land-based or over water, the pilots made an assessment of the visual cues available. Assessment of the usable cue environment requires the pilot to determine the level of control input correction required to maintain aircraft attitude and translational rate. To be completed correctly, ADS-33 requires assessments from at least three pilots. Results are then averaged to provide a single UCE rating. This rating can then be used to determine the required aircraft response type to achieve level 1 or level 2 handling qualities for each particular MTE.

3.1.1 Proposed Maritime Hover MTE

Objective

Check ability to maintain precise position, heading, and altitude in the presence of calm winds and moderate winds from the most critical direction.

Description of manoeuvre

Establish and maintain hover over the target point. For moderate wind, orient the aircraft with wind at the most critical azimuth.

Description of test course

Over water the manoeuvre should be flown to a fixed buoy with only open water visual references available. For baselining, the manoeuvre should be flown to an appropriate land-based target point.

Performance criteria

Criteria	Desired	Adequate
Maintain plan position within $\pm X$ ft of the target point	3	6
Maintain altitude within $\pm X$ ft	4	6
Maintain heading within $\pm X$ deg	5	10
Maintain hover for $\pm X$ min	2	2

3.1.2 Preliminary Results

The baseline and maritime hover MTE were conducted at Naval Air Station (NAS) Nowra and on Jervis Bay in November 2007 (Appendix A). The crew consisted of two test pilots (Pilot A and Pilot B) in an AS350BA Squirrel (N22-019). Baselining manoeuvres were conducted over grassed areas at the NAS and the maritime manoeuvres conducted at Jervis Bay to a fixed buoy with open water visual references. Test conditions at Jervis Bay were short moderate swell on nose with aircraft on South-East heading, and moderate sea state.

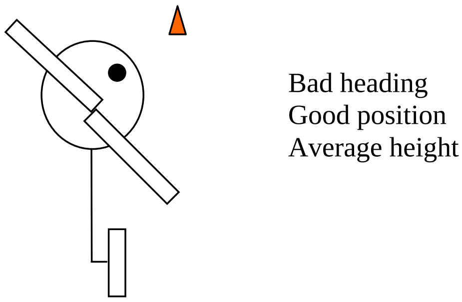
As expected, the baseline manoeuvre environment returned a UCE value of 1, therefore requiring the aircraft to achieve at minimum a rate command response type. The baselining was conducted over grassland with external features that provided excellent attitude cues, and very good translational cues. The baseline was conducted with both the Stability Augmentation System (SAS) IN and SAS OUT. With SAS IN, desirable performance was achieved for plan position, altitude hold, and heading hold with only minimal pilot compensation. SAS OUT resulted in a marginal change, although moderate compensation was required to maintain desirable performance for altitude hold.

In contrast, the maritime hover MTE returned a UCE value of 2. The horizon provided excellent pitch and roll attitude references; however the heading references were limited. The translational rate command references were also particularly poor and heavily dependent on factors such as sea state and swell. As defined by ADS-33, to achieve level 1 handling qualities the aircraft requires various attitude, rate, and height holds (ACAH, RCDH and RCHH respectively).

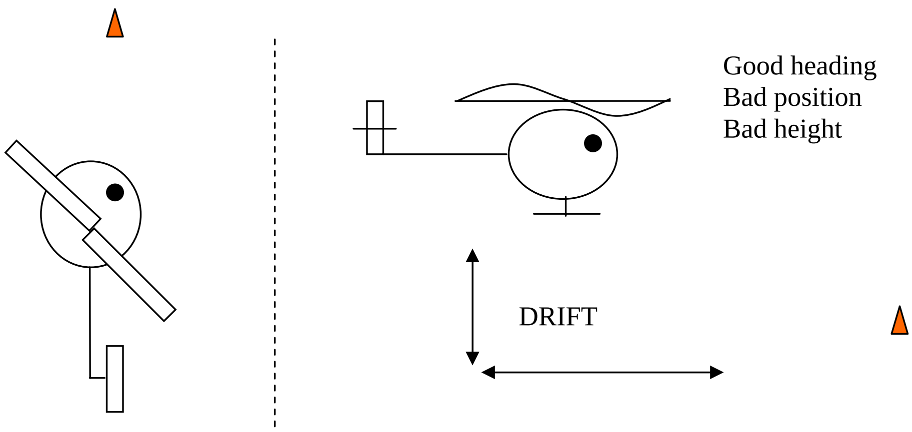
The maritime hover MTE presented itself with two different strategies that could be employed to hold visual reference with the floating buoy. Pilot A employed a diagonal visual reference strategy in contrast to the boresight visual reference strategy employed by Pilot B.

Strategies employed

- The diagonal visual reference strategy showed no appreciable deterioration in position and height maintenance performance when compared to the baseline manoeuvre (<=1 HQR difference). However the heading maintenance deteriorated by 2 HQRs.



- The boresighting visual reference strategy presented no change in heading maintenance performance when compared to the baseline manoeuvre. However there were appreciable differences in height and longitudinal position maintenance due to drift.



The baseline and maritime hover MTEs were also test flown using the DSTO AOSC simulator. However, due to difficulty with hardware limitations and the availability of only a Black Hawk flight dynamic model, this limited comparison with AMAFTU data or any relevant analysis. A future experiment will overcome these deficiencies.

Simulators can be very effective tools in assessing and prototyping MTEs and test courses before spending significant resources on the final capability. The objective in this case will be to determine any relationships between the UCEs and the Sea State. However, one will first need to quantify the fidelity of the simulator by comparing results with simulated baseline and maritime hover MTE cases.

3.2 Maritime Deck Operations

To date there has been good progress from the international community in defining an MTE that can represent maritime deck operations. Hovering behind a ship, in most cases, is similar to hovering over a landing position behind a hangar, except that a ship will roll, pitch and yaw, creating a sway and heave motion that the helicopter must match. To capture the random nature of the ship following task, it is necessary to generate a means of describing a moving hover reference position. The Canadian National Research Council (NRC) developed such a means with a *Superslide* target to emulate the positional variations of a moving ship deck in the lateral and vertical axes (Figure 7).

Figure 7: *Canadian NRC Superslide Target [1]*

Through a US Navy's Small Business Innovation Research (SBIR) contract, the Superslide was selected as the candidate for the shipboard recovery MTE [4, 6]. A series of flight and simulation trials were performed to verify the efficacy of this system, including ground-based simulation with the NASA Ames Vertical Motion Simulator (VMS). This research has found that the Superslide is a reasonable representation for shipboard hover and recovery, and that the current land-based Hover MTE, as defined in ADS-33, is sufficient for evaluation of handling qualities when ship motions are low. Of particular interest is that during high ship motions, Level 1 handling qualities cannot be achieved.

Current limitations of the Superslide include the fact that it does not adequately capture the effects of reduced torque margins on handling qualities. Also, a proposal from the Canadian studies is that the concept of Sea State as a metric should be replaced by a more measurable quantity. A proposed quantity, based on root-mean-square vertical velocity of the landing spot, has been developed by Mitchell and Nicoll [4], and proposed for application to ADS-33.

Australia's involvement in the TTCP AER-TP2 Rotorcraft Technologies and Operations gives AMAFTU and DSTO the scope to share and learn from the research with the Canadian NRC Superslide target. This is deemed to be a more efficient exercise than developing an independent Australian MTE for maritime deck operations.

4 Concluding Remarks and Recommendations for Further Work

Efforts by TTCP nations have shown good progress in the development of a maritime addendum to ADS-33. The USA and Canada have proposed the Superslide as a candidate for the shipboard recovery MTE that will represent maritime deck operations. AMAFTU and DSTO are progressing towards the definition of a maritime hover MTE.

AMAFTU has proposed a maritime hover MTE involving an over water manoeuvre flown to a floating buoy. The flight tests performed to date only represent that from two pilots and one sortie. ADS-33 requires visual cue ratings from a minimum of three pilots to measure the UCEs correctly. The current data set is not sufficient to draw any conclusions, therefore further work is planned to demonstrate the viability of the Maritime Hover MTE through AMAFTU flight tests and DSTO simulations. A future experiment in the AOSC is planned with the objective to investigate and validate the proposed MTE, determine a relationship between UCE and sea conditions, and investigate the fidelity of using the DSTO simulator as a means for providing UCEs.

DSTO does not recommend the independent development of the deck operations MTE due to the amount of resources required. Australia's involvement in the TTCP AER-TP2 Rotorcraft Technologies and Operations gives AMAFTU and DSTO the scope to share and learn from the research with the Canadian NRC Superslide target. This is deemed to be a more efficient exercise than developing an independent MTE for maritime deck operations.

5 Acknowledgments

For their work in providing quantitative and qualitative feedback in flight tests, I would like to sincerely thank Lieutenant Commander David Ostler and Lieutenant Commander Kimble Taylor of the Royal Australian Navy.

6 References

1. *Aeronautical Design Standard, Handling Qualities Requirements for Military Rotorcraft*, AMCOM ADS-33E-PRF, February 2000.

2. Padfield, G.D., *Helicopter Flight Dynamics: The Theory and Application of Flying Qualities and Simulation Modeling*, AIAA education series, 1999.

3. Cooper, G.E., and Harper, Jr., R.P., *The Use of Pilot Rating in the Evaluation of Aircraft Handling Qualities*, NASA TN D-5153, April 1969.

4. Mitchell, D.G. and Nicoll, T.K., 'New ADS-33 Requirements for Cargo and Maritime Operations,' presented at the American Helicopter Society 65th Annual Forum, Grapevine, Texas, May 27-29, 2009.

5. Carignan, S., Gubbels, A.W. and Ellis, D.K., 'Assessment of Handling Qualities for the Shipborne Recovery Task – ADS 33 (Maritime),' presented at the American Helicopter Society 56th Annual Forum, Virginia Beach, Virginia, May 2000.

6. Mitchell, D.G., Nicoll, T.K., Gubbels, A.W., Carignan, S. and Ellis, D.K., 'NRC's Superslide as a Mission Task Element for ADS-33 (Maritime),' presented at the American Helicopter Society Aeromechanics Specialists Conference, San Francisco, California, January 2008.

Appendix A Maritime Hover MTE Test Cards

Included here are the test cards completed by AMAFTU during their initial maritime hover MTE exercise.

MARITIME HOVER MTE TEST CARDS

Aircraft Type:	AS350BA	**Test location:**	NAS and JB
Tail No:	819	**Date:**	Nov 07
Weight:	Unknown	**Crew**	Ostler/Taylor
CoG:			
Weather: Short, moderate swell on nose with a/c on SE heading. Moderate sea state.			

NOTES:

1. Each pilot must provide visual cue ratings once at each location
2. Each pilot must conduct a land based baseline manoeuvre

USEABLE CUE ENVIRONMENT

See Figures 1 and 2 for VCR and UCE definitions

Pilot	Location	Visual Cue Ratings					UCE	Comments
		Attitude			Translational Rate			
		Pitch	Roll	Yaw	Horiz	Vert		
A	NAS Grass	1	1	1	2	2	1	Fairly even textured surface. Grass provided good references.
A	JB over water	1	1	2	3	4	2	Horizon provided good attitude references
								Note: Sea state, swell, and relative swell direction influence translational rate cues. Glassy seas provide very little references. Increases in sea state can improve visual cues but swell can give illusion that your moving

MARITIME HOVER MTE

Objective: Check ability to maintain precise position, heading, and altitude in the presence of calm winds and moderate winds from the most critical direction

Description of manoeuvre: Utilising aircrewman/loadmaster conning, establish and maintain hover over the target point. For the moderate wind test orient the aircraft with wind at the most critical azimuth.

Description of test course: Over water the manoeuvre should be flown to a fixed buoy with only open water visual references available. For base lining the manoeuvre should be flown to an appropriate land based target point.

Performance

	Desired	Adequate
Maintain plan position within ±Xft of the target point	3	6
Maintain altitude within ±Xft	4	6
Maintain heading within ±Xdeg	5	10
Maintain hover for Xmin	2	2

Results

See Figures 3 and 4 for sea state and swell definitions.

Pilot	Location	SAS	Strategy	HQRs				Comments
				Plan pos.	Altitude	Heading	Time	
A	NAS	IN	-	3	3	3	Unknown	
A	NAS	OUT	-	3	4	3	Unknown	
A	JB	IN	Diagonal	3	4	5	Unknown	
A	JB	OUT	Diagonal	4	5	5	Unknown	
B	JB	IN	Bore sight	4	4	3	Unknown	
B	JB	OUT	Bore sight	5	5	3	Unknown	

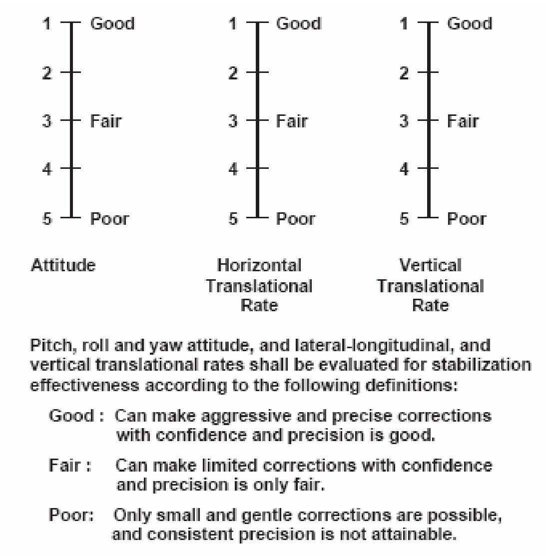


Figure 1; Visual cue rating scale

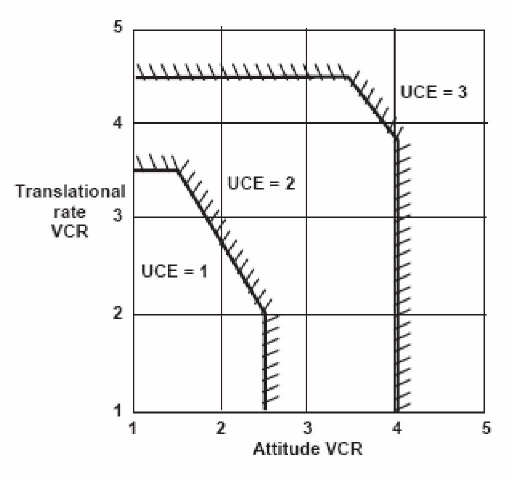


Figure 2; Useable cue environments

Sea State	Sea Description	Height (m)	Height (ft)	Abbrev
0	Calm	0	0	C
1	Rippled	0 - 0.1	0 – 1	C
2	Smooth	0.1 - 0.5	0 – 2	SM
3	Slight	0.5 - 1.25	2 – 4	SL
4	Moderate	1.25 - 1.5	4 – 8	M
5	Rough	2.4 - 4.0	8 – 13	R
6	Very rough	4.0 - 6.0	13 – 20	VR
7	High	6.0 - 9.0	20 – 30	H
8	Very high	9.0 - 14.0	30 – 45	VH
9	Phenomenal	> 14	Over 45	PH

Figure 3; Sea state definitions

LENGTH

Desc'n	Lth (m)	Lth (ft)	Period (sec)
Short	0-100	< 300	< 7.6
Average	100-200	300-600	7.6-10.8
Long	> 200	> 600	> 10.8

HEIGHT

Very low	0 - 1m
Low	1 - 2 m
Moderate	2 - 4 m
Heavy	>4 m

CHART SWELL DESCRIPTORS

Abbrev	State of Swell
	No swell
LS	Low swell of short or ave length
LL	Long low swell
MS	Short swell of moderate height
MA	Average swell of moderate height
ML	Long swell of moderate height
HS	Short heavy swell
HA	Average length heavy swell
HL	Long heavy swell
CONF	Confused swell

Symbol	Direction of Swell
	Calm
↙	From Northeast
←	East
↖	Southeast
↑	South
↗	Southwest
→	West
↘	Northwest
↓	North
	Confused

Figure 4; Swell definitions

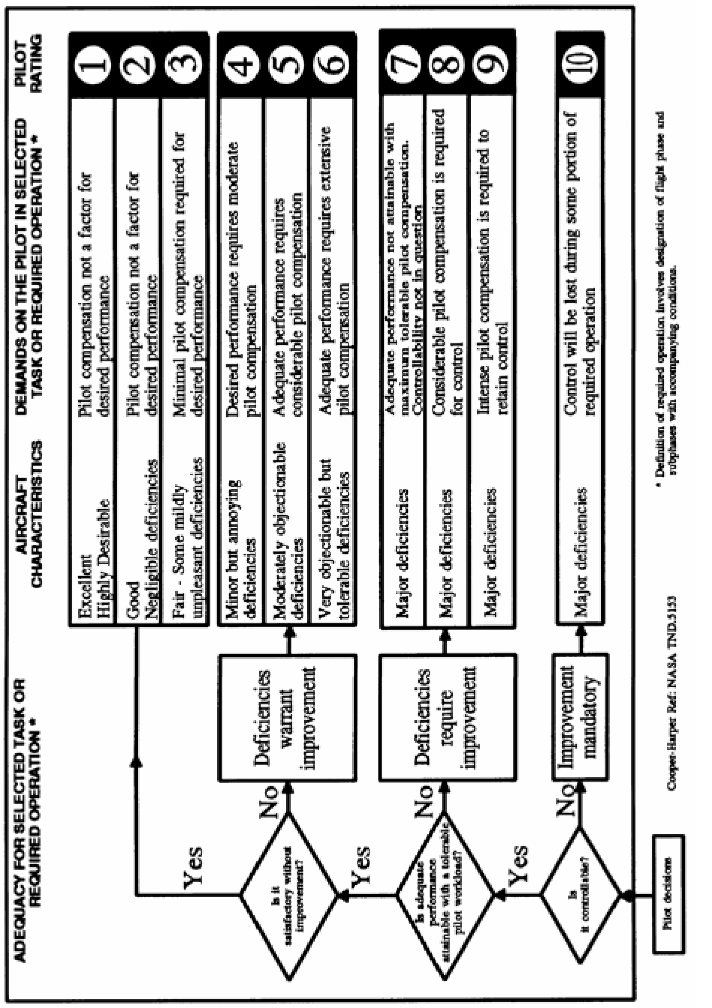


Figure 5; Cooper Harper handling qualities rating scale

DEFENCE SCIENCE AND TECHNOLOGY ORGANISATION DOCUMENT CONTROL DATA					1. CAVEAT/PRIVACY MARKING
2. TITLE Progress Towards a Maritime Aeronautical Design Standard 33 Addendum			3. SECURITY CLASSIFICATION Document (U) Title (U) Abstract (U)		
4. AUTHORS Sylvain Manso and Steven Arney			5. CORPORATE AUTHOR Defence Science and Technology Organisation 506 Lorimer St, Fishermans Bend, Victoria 3207, Australia		
6a. DSTO NUMBER DSTO–TN–0936	6b. AR NUMBER 014-718		6c. TYPE OF REPORT Technical Note		7. DOCUMENT DATE March, 2010
8. FILE NUMBER 2009/1135504/1	9. TASK NUMBER NAV 07/071	10. SPONSOR HQFAA (CA DEV)	11. No OF PAGES 18		12. No OF REFS 6
13. URL OF ELECTRONIC VERSION http://www.dsto.defence.gov.au/corporate/reports/DSTO–TN–0936.pdf			14. RELEASE AUTHORITY Chief, Air Operations Division		
15. SECONDARY RELEASE STATEMENT OF THIS DOCUMENT *Approved For Public Release* OVERSEAS ENQUIRIES OUTSIDE STATED LIMITATIONS SHOULD BE REFERRED THROUGH DOCUMENT EXCHANGE, PO BOX 1500, EDINBURGH, SOUTH AUSTRALIA 5111					
16. DELIBERATE ANNOUNCEMENT No Limitations					
17. CITATION IN OTHER DOCUMENTS No Limitations					
18. DSTO RESEARCH LIBRARY THESAURUS ADS-33 helicopter maritime handling qualities mission task element					

19. ABSTRACT

The Aeronautical Design Standard 33 (ADS-33) is a performance specification for the handling qualities requirements of military rotorcraft. The handling qualities criteria and metrics of ADS-33 depend primarily on the mission the helicopter has to execute rather than its role or size. ADS-33 requires that the specifications of the Mission Task Element (MTE), the Usable Cue Environment (UCE) and the response type are defined. The current criteria and specifications defined in ADS-33 relate to scout, attack, utility and cargo helicopters for land operations; however there are no requirements related to maritime operations. This technical note provides an overview of work by the Aircraft Maintenance And Flight Trials Unit (AMAFTU) and DSTO, that are collaboratively progressing towards the definition of a maritime hover Mission Task Element (MTE). This involves an over water manoeuvre flown to a floating buoy. Flight tests were performed by AMAFTU, though the current data set is not sufficient to draw any conclusions. Further work is planned to demonstrate the viability of the maritime hover MTE through AMAFTU flight tests and DSTO simulations.