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**EVALUATION OF THE DYNASPEAK SPEECH
RECOGNITION SYSTEM FOR USE IN THE
JOINT STRIKE FIGHTER**

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**Air Force Research Laboratory
Human Effectiveness Directorate
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Collaborative Interfaces Branch
Wright Patterson AFB OH 45433**

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AFRL-HF-WF-TR-2006-0152

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FOR THE DIRECTOR

//signed//

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TABLE OF CONTENTS

	PAGES
LIST OF TABLES	iv
LIST OF FIGURES	v
EXECUTIVE SUMMARY	vi
INTRODUCTION	1
VISTA SPEECH RECOGNITION SYSTEM.....	2
VISTA 2006 FLIGHT TEST AUDIO DATABASE.....	3
Lab Condition Testing	5
Ground Condition Testing	6
Flight Condition Testing	7
DISCUSSION	8
REFERENCES.....	10
APPENDIX A: DYNASPEAK VISTA GRAMMAR FILE	11
APPENDIX B: 400 VISTA TEST PROMPTS.....	32
APPENDIX C: LAB CONDITION WORD AND SENTENCE ERROR RATES BY PARAMETER COMBINATION	35
APPENDIX D: GROUND CONDITION WORD AND SENTENCE ERROR RATES BY PARAMETER COMBINATION	51
APPENDIX E: FLIGHT CONDITION WORD AND SENTENCE ERROR RATES BY PARAMETER COMBINATION	59

LIST OF TABLES

TABLE	PAGE
1: VISTA Vocabulary Words	4

LIST OF FIGURES

FIGURE	PAGE
1: Custom designed VISTA Speech Recognition System	2
2: VISTA NF-16 Test Aircraft.....	2
3. Typical Lab Test Setup and Environment.....	3
4. Lab Condition Word Error Rates for 14 Speakers.....	5
5. Ground Condition Word Error Rates for 6 Test Pilots	6
6. Flight Condition Word Error Rates for 6 Test Pilots (7 flights)	7
7. Overall Word Error Rates by Flight Condition.....	8

EXECUTIVE SUMMARY

The F-35 Lighting II Joint Strike Fighter (JSF) aircraft, currently in development by the United States and nine partner nations for their Navy, Air Force, and Marine components, is implementing an automatic speech recognition system for use by the pilot to efficiently control various aircraft subsystems. The Air Force Research Laboratory's Human Effectiveness Directorate, working with the JSF Program Office at Wright-Patterson AFB and the Air Force Test Pilot School at Edwards AFB, conducted a preliminary ground and flight test evaluation of the Stanford Research Institute DynaSpeaktm speech recognition engine proposed for integration into the F-35 avionics suite. All flight tests were conducted using the Variable stability In-flight Simulation Test Aircraft (VISTA) NF-16 aircraft based at Edwards AFB. The ground tests were conducted at both Edwards AFB and at Wright-Patterson AFB.

The primary goals of the evaluation were to 1) determine the recognition accuracy of the system under varying noise, g-loading, and non-native English conditions, 2) determine what recognition accuracy improvement might be made by adjusting the recognition engine's Word Transition Weight and Beam Width parameters, and 3) gauge the robustness of the proposed F-35 aircraft vocabulary and grammar. This report documents the results of the recognition tests and parameter tuning trials accomplished at AFRL. A final report which documents the results of the NF-16 flight tests was written by the Air Force Flight Test Center and published under separate cover (AFFTC-TM-06-05).

INTRODUCTION

Automatic Speech Recognition (ASR) technology, which transforms an operator's spoken words into machine text, has been around for over 50 years [1]. Investigating this technology for use in military systems has been ongoing for over 30 years. In the early 1970s, researchers quickly realized that along with the rapidly advancing computer technology came the equally rapid proliferation of knobs, dials, switches and other traditional interface devices needed by operators to control that technology. Not only would these conventional controls begin to take up large amounts of physical space, but their sheer numbers would also quickly overwhelm the human operator's ability to effectively manage them all, especially in time critical situations. For these reasons, researchers began to explore the possibilities of using ASR, also known as Direct Voice Input (DVI), in addition to speech synthesis technology, which translates text into machine-spoken words, to control and display information [2, 3, 4].

Much of the early research in the military use of speech recognition technology was applied to the single-seat aircraft cockpit [5, 6, 7, 8, 9] where pilots must not only use stick, throttle and rudders to keep the aircraft in the air, but must also manage an increasing number of sophisticated onboard computer systems for offensive, defensive, surveillance, and a myriad of other tasks. It was becoming increasingly clear that without another crewmember in the cockpit, the complexity of these systems would eventually overwhelm the single pilot's ability to effectively manage the system. If an accurate DVI system were used, the pilot could verbally ask the aircraft to accomplish simple tasks like changing a radio frequency or navigate to a new waypoint [10, 11]; much the same way a pilot might ask their copilot to accomplish these tasks.

This report discusses the results of an evaluation of release version 1.5 of DynaSpeak™ conducted at the Air Force Research Laboratory's Human Effectiveness Directorate at Wright-Patterson AFB. DynaSpeak™ is a speech recognition software system developed by Stanford Research Institute for small-scale, embedded applications. This technology was chosen by Lockheed Martin through their F-35 Program partner, Adacel Inc., for inclusion into the speech-enabled cockpit control system as part of the System Development and Demonstration phase of the JSF F-35 program. The following sections summarize the results of the evaluation.

VISTA SPEECH RECOGNITION SYSTEM

The VISTA Speech Recognition System (VSRS), shown in Figure 1, was designed, developed and built at AFRL for a custom installation in the front cockpit, right side console of the VISTA NF-16 aircraft.

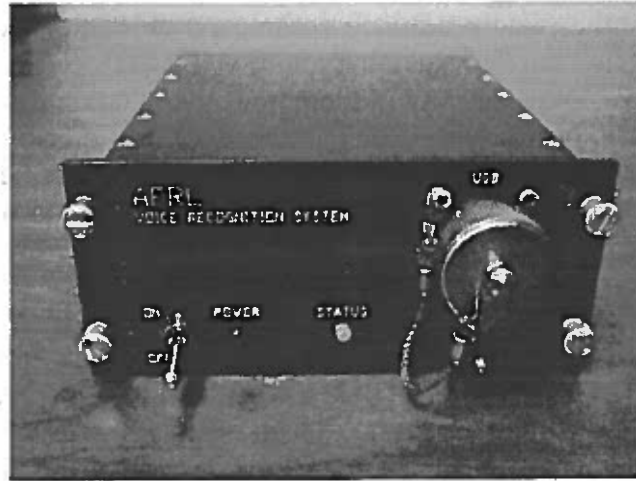


Figure 1. Custom designed VISTA Speech Recognition System

The system was developed as a form, fit and function replacement of an older Voice Recognition System (VRS) previously installed in the VISTA by AFRL. The NF-16 aircraft is a highly modified, two-seat F-16D (Figure 2), configured with Block 40 avionics, a production Digital Flight Control System, variable feel system, side controllers, and dual-bus architecture, allowing for both core avionics and simulation flight.



Figure 2. VISTA NF-16 Test Aircraft

The VSRS was built using off-the-shelf commercial components, including a PC-104 micro-computer system running the Microsoft Windows XP operating system. The system communicates with the aircraft computers via an RS-232 serial interface. Audio input and output is provided to and from the VSRS on a custom designed audio module to interface with the aircraft's intercom system. A USB interface in the control head of the VSRS allows the aircrew or maintenance personnel easy access to the audio and other test data storage capabilities of the system.

The DynaSpeak™ recognition software running on the VSRS is a speaker-independent (no voice training required), continuous-speech recognition system with programmable grammar, and vocabulary capabilities. In addition, Microsoft text-to-speech software provides fully programmable audio response capability to provide verbal feedback to the pilot. All speech commands received by the system, as well as aircraft state information sampled at the time of the command, are digitally recorded for later retrieval. It is these recorded speech commands that comprise the VISTA 2006 Flight Test Audio Database used for VSRS tuning and analysis back in the laboratory.

VISTA 2006 FLIGHT TEST AUDIO DATABASE

The DynaSpeak™ system was tested, and audio data were collected, at both AFRL at Wright-Patterson AFB and at the Air Force Flight Test Center (AFFTC) at Edwards AFB. Data collected at the AFFTC was done by six test pilots dedicated to this effort as part of their Test Management Project required for graduation from the school. The DynaSpeak™ speech recognition system was tested in three different environments:

- 1) "Lab" - a relatively quiet room
- 2) "Ground" - onboard the VISTA aircraft while sitting on the tarmac with the engine running
- 3) "Flight" - in the air during 1g, 3.2g and 6g maneuvering.

Figure 3 shows a typical Lab test setup using a VSRS flight system connected to a standard monitor and keyboard. While Lab condition data were collected at both sites, Ground and Flight condition tests were conducted exclusively at the AFFTC at Edwards AFB.

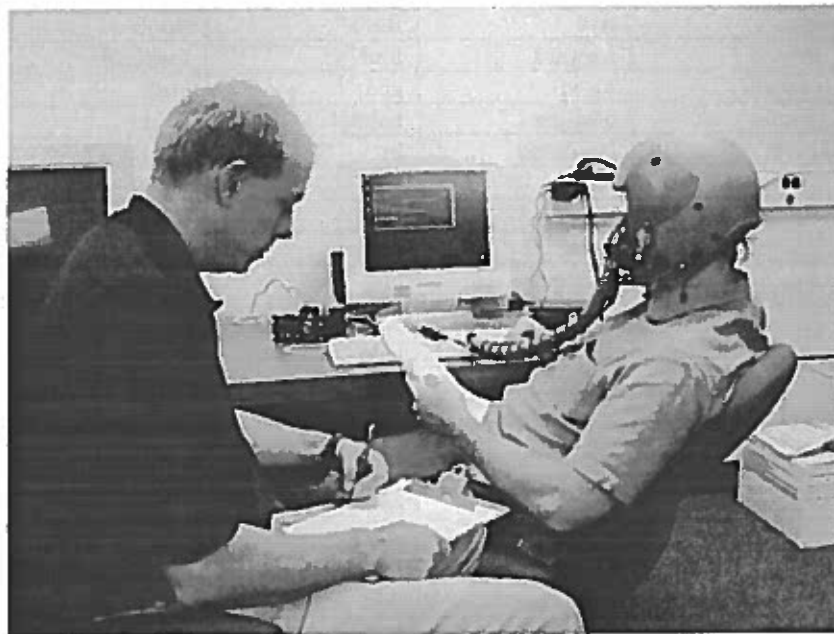


Figure 3. Typical Lab Test Setup and Environment

During all tests, speakers used a Push-to-Recognize (PTR) switch while speaking command phrases to VSRS, with the system responding immediately with the recognition result displayed either on an aircraft system display (Flight and Ground conditions) or a computer monitor (Lab

condition). Standard Air Force issued oxygen masks with M-169 microphones were used for all tests. All utterances by the subjects were digitally recorded and saved as 8 kHz, 16-bit, linear PCM WAV files on the VSRS. At the conclusion of each trial, the resulting audio recordings were downloaded from the VSRS, via the built-in USB interface, and added to the VISTA 2006 Flight Test Audio Database. The audio database recordings were then used in the speech laboratory at AFRL to retest the speech recognizer in re-created lab, ground and flight test conditions. The recordings allowed for multiple post-hoc parameter tuning and other tests to be run using DynaSpeak's "batchrecog" procedure. Two parameters in particular, Beam Width and Word Transition Weight, were varied in these post-hoc experiments. The Beam Width parameter is used to expand or constrain the grammar search space during recognition. Low values (< 700) favor speed over accuracy while higher values (> 1200) favor accuracy over speed. The Word Transition Weight parameter balances insertion and deletion errors with lower values (< 0) decreasing insertions at the expense of increasing deletions and higher values (> 0) decreasing deletions while increasing insertions. The VISTA vocabulary consisted of 180 words, shown in Table 1. The grammar file defining the allowable command sentences is provided in Appendix A.

Table 1. VISTA Vocabulary Words

admin	aid	air	airspeed	all	altitude
assign	auto	bar	bay	best	bingo
black	both	bravo	bright	caged	cal
cancel	charlie	check	clear	confirm	console
continue	course	dec	delta	dim	director
disabled	dogfight	dump	echo	eight	eighteen
eighty	eleven	enabled	engine	expand	fence
fifteen	fifty	five	flash	flood	fold
formation	forty	forward	four	fourteen	frequency
fuel	function	fused	geo	golf	grapefruit
ground	guard	heading	helmet	hold	hot
hotel	hours	hundred	in	increment	india
info	is	juliet	land	landing	latency
launch	left	lights	mach	mag	manual
mark	meters	mike	minus	missile	mode
mute	niner	nineteen	no	normal	november
of	off	on	one	open	orange
oscar	out	override	partial	peel	plus
point	position	previous	program	purge	range
recall	receive	results	retract	right	romeo
rotate	route	sar	say	secure	set
seven	seventeen	seventy	sierra	six	sixteen
sixty	software	speed	split	spread	start
steady	step	stop	store	strobe	surface
swap	tab	tactical	tadpole	take	tango
target	ten	thirteen	thirty	this	thousand
threat	time	track	transmit	true	twelve
twenty	two	uniform	version	victor	voice
volume	weapon	west	which	whiskey	white
wings	x-ray	yankee	yes	zero	zulu

From these words, 400 test prompts were developed to be used during the Lab, Ground and Flight test conditions. These test prompts can be found in Appendix B.

Lab Condition Testing

A total of 14 speakers participated in the evaluation. Eight speakers participated at AFRL and the remaining six were test pilots from the Air Force Test Pilot School at Edwards AFB. Of the eight AFRL speakers (six males, two females), six had native North American accents, while the remaining two speakers were males from the United Kingdom. Four of the test pilots (three males, one female) had native North American accents, one test pilot was a male from Italy and the other was a male from Japan.

All 14 speakers participated in the Lab test condition, where the 400 phrases were prompted as commands to the VSRS. While the speakers issued commands to the recognizer, the system responded both audibly and visually with the actual recognized result. At times when the speaker verbally stumbled, or otherwise mis-spoke, the command was simply re-issued. When the recognition result was not correct, the speaker was asked to repeat the phrase, giving the VSRS a maximum of three tries to recognize the utterance correctly. This was done to provide additional data for error post analysis and also to increase the probability of recording a valid utterance when the speaker might have previously used the PTR switch incorrectly by clipping the command on the front or back end. The Lab test was completed after the speaker uttered all 400 test phrases. Following the test, the digital recordings of all utterances were downloaded from the VSRS system and transferred to a speech laboratory computer for additional analysis and batch processing. Figure 4 summarizes the Word Error results obtained from the Lab test.

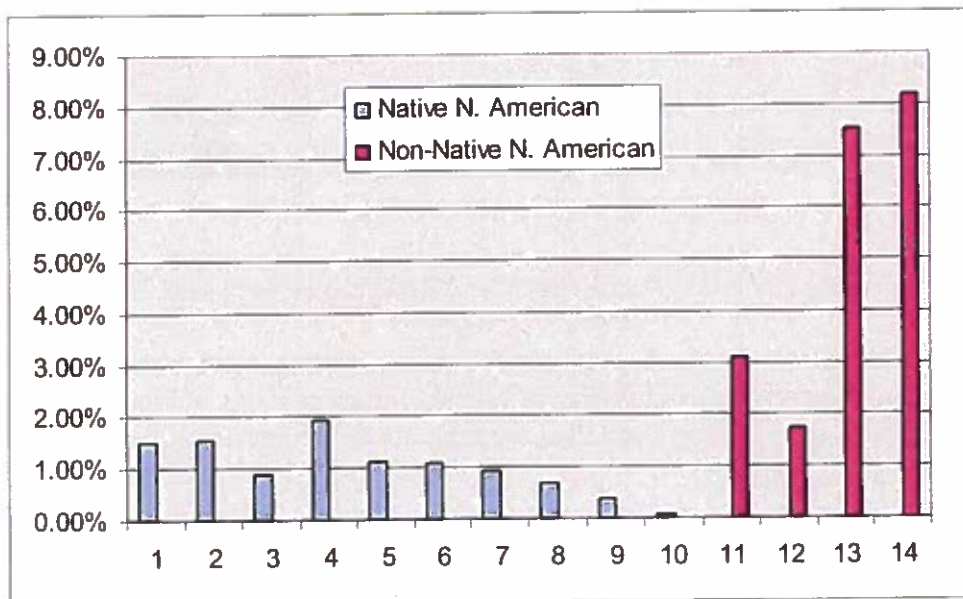


Figure 4. Lab Condition Word Error Rates for 14 Speakers

These optimized results were obtained using a Dynaspeak Beam Width setting of 1200 and a Word Transition Weight of -150 parameter combination (see Appendix C for detailed results using other parameter combinations). The overall Word Error Rate for the 10 native North-American English speakers was 1.03%, while the remaining four non-native North American

speakers had an overall Word Error rate of 5.33%. The Word Error rate for all speakers combined was 2.32% for the Lab condition.

Ground Condition Testing

Ground testing was conducted onboard the VISTA aircraft at the Air Force Flight Test Center by the six test pilots assigned to this project. The 400 test prompts were spoken while the pilot was in the aircraft, on the tarmac, with the engine running. Recognition results were displayed on the aircraft Heads-up Display (HUD) and Multi-Function Display (MFD) after the VSRS recognized each command. At the completion of the test, all audio and recognition result data were transferred to an FTP site, where AFRL engineers could then download the data to the speech lab at Wright-Patterson AFB. The recognizer was configured with various parameter combinations and the recordings were played back into the Dynaspeak system for re-recognition using a batch recognition process. Figure 5 shows the results of the Ground condition recognition test using an optimized Beam Width of 1000 and Word Transition Weight of -100 parameter combination.

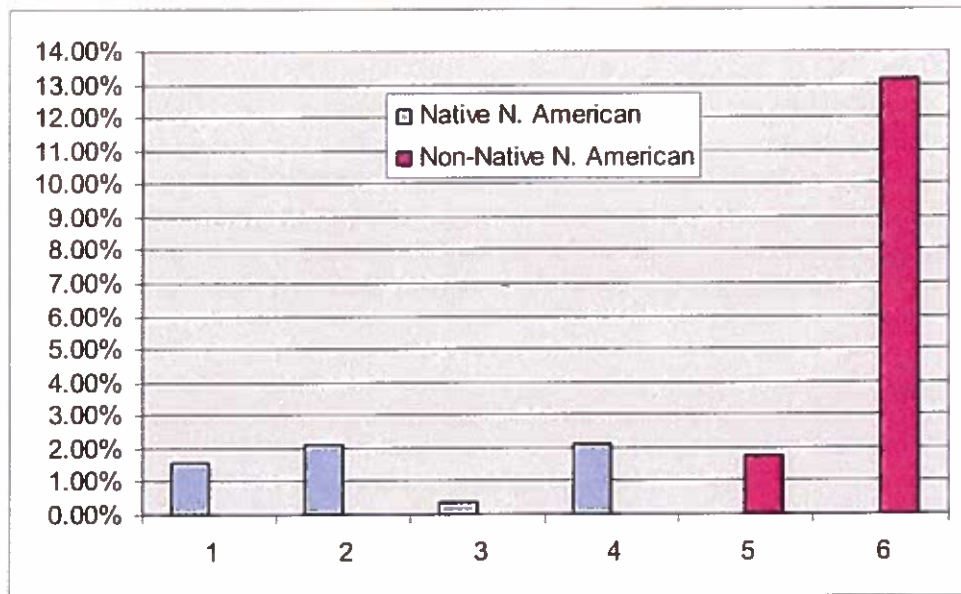


Figure 5. Ground Condition Word Error Rates for 6 Test Pilots

The overall Word Error rate in the Ground test for the four native North-American English test pilots was 1.54%, while the Italian pilot had a 1.78% Word Error rate and the Japanese pilot had a Word Error rate of 13.16%. Error rates for other parameter combinations used in the Ground test can be found in Appendix D.

Upon further inspection of the audio data for the Japanese test pilot, it was discovered that not only did his limited experience with, and pronunciation of, the English language have a negative effect on the system's recognition accuracy, but it was also determined that much of the audio was corrupted due to a faulty microphone in the pilot's oxygen mask.

Flight Condition Testing

Seven separate flights of the VISTA aircraft were dedicated to the VSRS data collection effort. The six test pilots each flew a 1 to 2 hour sortie in the jet while issuing commands to the recognition system. A seventh flight was accomplished by the female test pilot (her second VSRS flight). Pre-planned flight profiles called for issuing speech commands while in 1g, straight and level flight and while pulling 3.2 and also 6.5 gs during spiraling dive maneuvers. Audio and recognition result data were collected by the VSRS for each speech command. Aircraft state parameters, including altitude, mach number, g, pitch, bank, and time, were also sampled and recorded along with the recognition result. After landing, all data were downloaded from the aircraft and transferred to the FTP site, where AFRL could then collect the data for analyses in the speech laboratory.

As was done for the Ground test condition, the best Dynaspeak parameter combination of Beam Width and Word Transition Weight to be used during flight was determined through batch recognition testing. A combination of Beam Width = 1000 and Word Transition Weight = -50 was found to be optimal for the flight condition. Using this parameter combination, an additional Dynaspeak batch process was used to feed audio recordings back into the recognizer to gauge the system accuracy for inflight use. The individual word error rates obtained by each pilot in flight are shown in Figure 6, while Figure 7 shows the overall error rates broken down by flight condition.

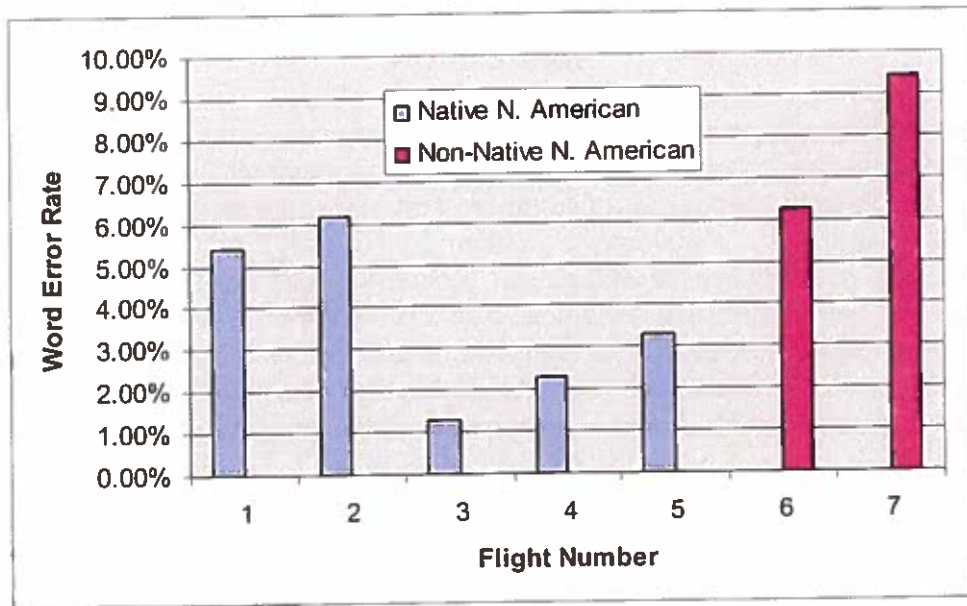


Figure 6. Flight Condition Word Error Rates for 6 Test Pilots (7 flights)

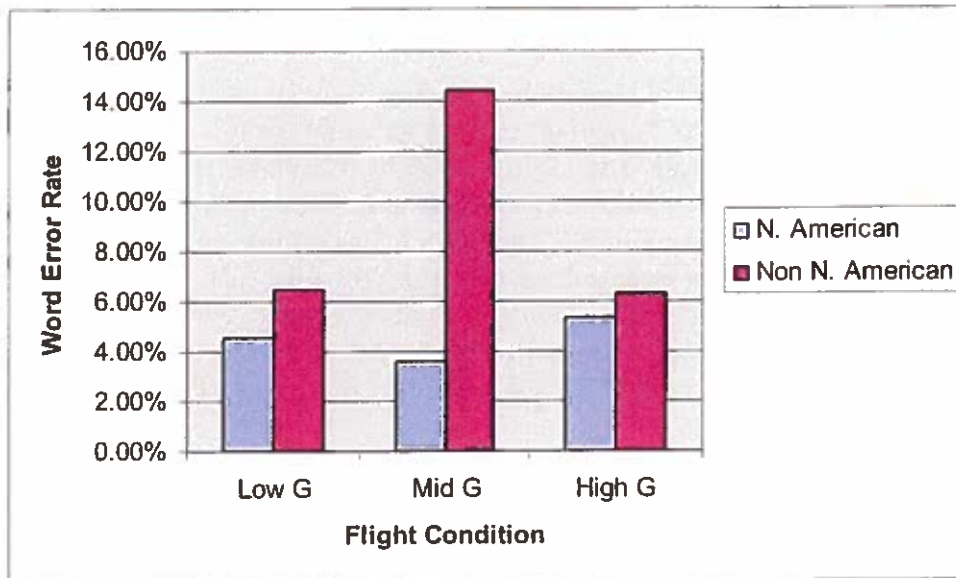


Figure 7. Overall Word Error Rates by Flight Condition

The overall Word Error rate in the Flight test for the four native North-American English test pilots (over 5 flights) was 3.99%. The Italian pilot had a 6.28% Word Error rate, while the Japanese pilot achieved a Word Error rate of 9.42%. Error rates for other parameter combinations used in the Flight test are found in Appendix E.

DISCUSSION

The test data represented here provided a good initial benchmark of the Dynaspeak system using the new VSRS enclosure and proposed JSF vocabulary and grammar structure. It was hoped that a total of twelve flights would be flown for the Test Management Project at the AFFTC, but due to scheduling and aircraft maintenance problems, only seven flights were actually flown. Speech recognition performance for all tests was generally considered to be good, even though several audio issues were identified. The first issue was the appearance of electrical noise found in the audio recordings during post-flight analyses. It is suspected that the noise could be due to a grounding issue with the VSRS unit. VISTA maintenance personnel have investigated this issue and have somewhat reduced, but not yet eliminated this problem. Another issue was a microphone problem experienced by the Japanese pilot on the TMP team. Upon review of the flight test audio, it was readily apparent that the M-169 microphone in his mask was producing intermittent distortion. This was brought to the attention of the TMP team but due to aircraft and scheduling problems, the Japanese pilot did not fly another sortie with the VSRS.

One difference between the VISTA audio configuration and the proposed JSF configuration is the oxygen mask microphone. The VISTA testing was performed using the standard M-169 dynamic microphone. JSF is proposing to use the Navy's M-176 electret microphone which, from preliminary testing and comparing specifications, has better frequency response characteristics which may improve speech recognition performance. A follow-on test with the new microphone could be performed at the discretion of the JSF Program Office in HEC noise chamber facilities to benchmark its performance, if desired.

Several opportunities exist to improve upon the baseline performance of the Dynaspeak system. One area for improvement would be to modify the vocabulary and grammar structure to reduce possible confusions. One such improvement would be to find an alternative to using the words "on" and "off". In a noisy environment, the intelligibility of these two words is low and would be difficult for even a human listener to accurately identify which word was spoken. Another area for improvement would be to adapt the acoustic models of the Dynaspeak system to be more characteristic of the target environment. The models tested in this evaluation were standard acoustic models generated using a general US English population recorded over telephone lines. The speech data collected from this flight test in addition to data collected in HEC noise chamber facilities could be used to adapt the acoustic models prior to integration into the JSF aircraft.

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APPENDIX A

DYNASPEAK VISTA GRAMMAR FILE

```
#####
# File: vista.grm
# Date: 08 March 2006
#
# This grammar is used on the VISTA NF-16 aircraft based at Edwards AFB. The
# grammar primarily represents the JSF grammar provided by Lockheed-Martin
# with the addition of phrases used by the previous VISTA VRS system. Use of
# the JSF grammar in VISTA will provide an initial measure of Dynaspeak's
# performance in a jet cockpit environment for the JSF program, while the
# legacy VISTA grammar continues to provide cockpit control functionality
# originally provided by the previous Verbex VRS system.
#
# Mod History:
# 08 Mar 2006 - T. Barry
#   - Added or modified dictionary pronunciations for reject, record,
#     calibrated, disregard, minutes, quebec, lima, close, extend,
#     emergency, restore and ninety
# 07 Mar 2006 - T. Barry
#   - Modified pronunciation for "tflir"
# 06 Mar 2006 - T. Barry
#   - Added pronunciations for "los", "kilo", and "papa"
# 03 Mar 2006 - T. Barry
#   - Cleaned up some formatting of JSF returned values for MFD display
#   - Fixed Place TSD and Place ASR commands
#   - "CALIBRATED", rather than "CAL" now returned for better TTS
#     pronunciation
#   - Fixed grammar for joker and bingo settings
# 27 Feb 2006 - T. Barry
#   - Added a missing ")" in the com grammar which caused BUR commands to
#     be recognized without first saying "com"
#   - Added dictionary entries from Adacel's vrs.dictionary file
# 24 Feb 2006 - T. Barry
#   - All acronyms (ILS, CNI, etc) separated into individual letters for
#     better pronunciation by the TTS
# 23 Feb 2006 - T. Barry
#   - Grammar restructured based on new JSF grammar received from Adacel
# 22 Feb 2006 - T. Barry
#   - Merged JSF and vista subgrammars
#   - Fixed various jsf grammar problems with bingo, joker, fta, fti,
#     steerpoint, vloume, ZeroToOneHundred, changed unmute to restore
#   - Added declutter hmd and normal hmd to vista legacy
#
#####
# DICTIONARY
#
aar = ey ey aa r;
alow = ey l ow;
alpha = ae l f ax | aa l f ax;
asr = ey eh s aa r;
autopilot = ao dx ao p ay l ax t | ao dx ow p ay l ax
            | ao t ow p ay l ax t | ah t ao p ay l ax;
azimuth = ae z eh m ah th | ae z m ah th | aa z eh m ax th | aa z m ax th |
aa z eh m ax t;
```

baro = b ae r ow | b aa r ow | b er ow;
 bur = b er;
 baro = b ae r ow | b aa r ow | b er ow | b eh r ow;
 calibrated = k ae l ax b r ey dx ax d;
 cdi = s iy d iy ay;
 close = k l ow z;
 cni = s iy eh n ay;
 com = k aa m;
 das = d iy ey eh s | d ae s;
 decimal = d eh s ah m ax l | d eh s m ax l;
 declutter = d iy k l ah dx er | d iy k l ah t er;
 decrement = d ih k r ax m eh n t | d iy k r ax m eh n t | d ih k r ax m ax n
 t | d iy k r ax m ax n t;
 default = d ax f ao l t | d ax f ao t | d iy f aa t
 | d ih f ao l t | d ih f ao t;
 degrees = d ih g r iy z | d eh g r ih z;
 display = d ax s pl ey | d ax s pl ey z;
 displays = d ih s pl ey | d ih s pl ey z;
 disregard = d ih s r iy g aa r d | d ih s r ax g aa r d;
 east = iy s t | iy s;
 electrical = ih l eh k t r ih k ah l | ih l eh t ih k ah l
 | ax l eh k t r ax k ax l | ax l eh t ax k ax l;
 elevation = eh l ax v ey sh ax n | eh l ax v ey sh;
 emcon = eh m k aa n;
 emergency = iy m er jh ax n s iy | ax m er jh ax n s iy;
 enter = eh n t er | eh n er;
 extend = eh k s t eh n d | ax k s t eh n d;
 fcs = eh f s iy eh s | f l ih k ax s;
 feet = f iy t | f iy;
 flir = f l er | f l ih r;
 foxtrot = f aa k s t r aa t;
 hmd = ey ch eh m d iy;
 hsi = ey ch eh s ay;
 hud = hh ah d;
 iff = ay eh f eh f;
 ils = ay eh l eh s | ay l eh s;
 icaws = ay k ao z;
 ident = ay d eh n t | ay d eh n ah;
 identify = ay d eh n t ax f ay | ay d eh n ax f ay | ay d eh n t;
 inc = ih ng k | ih k;
 joker = jh ow k er | jh ao k er;
 jsf = jh ey eh s eh f;
 kilo = k iy l ow | k ih l ow;
 latlon = l ae t l ao n | l ae t l ao n g;
 lima = l iy m ax;
 los = eh l ow eh s | l ao s;
 mfd = eh m eh f d iy;
 minutes = m ih n ax t | m ih n ax t s;
 mle = eh m eh l iy;
 nav = n ae v;
 nine = n ay n | n ay n er;
 ninety = n ay n t iy | n ay n dx iy;
 north = n ao r th | n ao r t;
 papa = p aa p ax;
 phm = p iy ey ch eh m;
 place = p l ey s;
 postcontact = p ow s t k aa n t ae k t;
 precontact = p r iy k aa n t ae k t;

```

quebec = k w a x b e h k | k i y b e h k | k e y b e h k;
radalt = r a a d a x l t;
record = r i y k a o r d | r a x k a o r d;
refuel = r i y f y u w a x l | r a x f y u w l;
reject = r i y j h e h k t | r a x j h e h k t | r i y j h e h k | r a x j h e h k;
restore = r i y s t a o r | r a x s t a o r;
seconds = s e h k a x n d | s e h k a x n d z;
sms = e h s e h m e h s | s m i h z;
south = s a w t h | s a w t;
steerpoint = s t i h r p o y n t;
sti = e h s t i y a y;
stovl = s t o w v l | s t o w v e h;
tacan = t i y e y s i y e y e h n | t a e k a e n | t a e k a x n;
tflir = t i y f l e r | t i y f l i h r;
three = t h r i y | t r i y;
tos = t i y o w e h s | t a o s;
tsd = t i y e h s d i y;
unmute = a x n m y u w t;
untab = a x n t a e b;
utm = y u w t i y e h m;
vista = v i h s t a x;
waypoint = w e y p o y n t;

# Simulate longer words for rejection:
@reject@ = rej rej rej rej;

#####
#####
#####

#=====
# Dynamic grammar *PLACEHOLDER*
#=====

public <DynamicFix>= -pau-;

#=====
# Numbers
#=====

### Currently not used?
# <Point> = point {.} | decimal {.};
#
# <AllDigits>= <ZeroToNine> | <Point>;
#
#<ZeroToOneEighty>=
#   <ZeroToNine>
# | <ZeroToNine> <ZeroToNine>
# | <One> <ZeroToSeven> <ZeroToNine>
# | <One> <Eight> <Zero>
#;
#
###

<Zero>= zero {0};
<One>= one {1};
<Two>= two {2};
<Three>= three {3};
<Four>= four {4};

```

```

<Five>= five {5};
<Six>= six {6};
<Seven>= seven {7};
<Eight>= eight {8};
<Nine>= nine {9};

<ZeroToOne> = <Zero> | <One>;
<ZeroToTwo> = <ZeroToOne> | <Two>;
<ZeroToThree> = <ZeroToTwo> | <Three>;
<ZeroToFour> = <ZeroToThree> | <Four>;
<ZeroToFive> = <ZeroToFour> | <Five>;
<ZeroToSix> = <ZeroToFive> | <Six>;
<ZeroToSeven> = <ZeroToSix> | <Seven>;
<ZeroToEight> = <ZeroToSeven> | <Eight>;
<ZeroToNine> = <ZeroToEight> | <Nine>;

<OneToTwo> = <One> | <Two>;
<OneToThree> = <One> | <Two> | <Three>;
<OneToFour>= <OneToThree> | <Four>;
<OneToFive>= <OneToFour> | <Five>;
<OneToSix>= <OneToFive> | <Six>;
<OneToNine>= <OneToSix> | <Seven> | <Eight> | <Nine>;

<ZeroToSixty>=
    <ZeroToNine>
    | <ZeroToFive> <ZeroToNine>
    | <Six> <Zero>
;

<ZeroToNinety>=
    <ZeroToNine>
    | <ZeroToEight> <ZeroToNine>
    | <Nine> <Zero>
;

<ZeroToNinetyNine>=
    <ZeroToNinety>
    | <Nine> <OneToNine>
;

<ZeroToOneHundred>=
    <ZeroToNinetyNine>
    | <One> <Zero> <Zero>
;

<ZeroToThreeSixty>=
    <ZeroToNine>
    | <ZeroToNine> <ZeroToNine>
    | <ZeroToTwo> <ZeroToNine> <ZeroToNine>
    | <Three> <ZeroToFive> <ZeroToNine>
    | <Three> <Six> <Zero>
;

=====
# Altitude is said in feet. Ranges from 100 feet to 17,500 feet..
=====
<TenToSeventeen> =
    ten {10}

```

```

| eleven {11}
| twelve {12}
| thirteen {13}
| fourteen {14}
| fifteen {15}
| sixteen {16}
| seventeen {17}
;

<TenToNineteen> =
  <TenToSeventeen>
  | eighteen {18}
  | nineteen {19}
;

<Twenty> = twenty {20};
<Thirty> = thirty {30};
<Forty> = forty {40};
<Fifty> = fifty {50};
<Sixty> = sixty {60};
<Seventy> = seventy {70};
<Eighty> = eighty {80};
<Ninety> = ninety {90};

<TwentyToFiftyNine>=
  (<Twenty> | <Thirty> | <Forty> | <Fifty>)
  | (twenty {2} | thirty {3} | forty {4} | fifty {5}) <OneToNine>
)
;

<TwentyToEightyNine>=
  (<TwentyToFiftyNine> | <Sixty> | <Seventy> | <Eighty>)
  | (sixty {6} | seventy {7} | eighty {8}) <OneToNine>
)
;

<TenToNinetyDoubles>=
  <TenToNineteen>
  | <TwentyToEightyNine>
  | <Ninety>
;

<TenToSixtyDoubles>=
  <TenToNineteen>
  | <TwentyToFiftyNine>
  | <Sixty>
;

#=====
# GENERIC TERMINAL RULES
#=====

<NorthSouth>= north {N} | south {S};
<EastWest>= east {E} | west {W};

<Feet>= (feet {%20FEET} | enter);
<Meters> = (meters {%20METERS} | enter);
<FeetMeters>= <Feet> | <Meters>;

```

```

<OnOff>= on {ON} | off {OFF};
<LeftRight>= left {LEFT} | right {RIGHT};

<Elevation>= <PositiveElevation> | <NegativeElevation>;

<PositiveElevationFeet>=
(
  <ZeroToNine> [<ZeroToNine> [<ZeroToNine> [<ZeroToNine> [<ZeroToNine>]]]]
) (<Feet> | enter);

<NegativeElevationFeet>=
(
  <ZeroToNine> [<ZeroToNine> [<ZeroToNine> [<ZeroToNine>]]]
) (<Feet> | enter);

<PositiveElevationMeters>=
(
  <ZeroToNine> [<ZeroToNine> [<ZeroToNine> [<ZeroToNine> [<ZeroToNine>]]]]
) (<Meters> | enter);

<NegativeElevationMeters>=
(
  <ZeroToNine> [<ZeroToNine> [<ZeroToNine>]]
) (<Meters> | enter);

<Heading> = <ZeroToNine> [<ZeroToNine> [<ZeroToNine>]];

<PositiveElevation> =
  [plus]
  (
    <PositiveElevationFeet>
  | <PositiveElevationMeters>
  )
;

<NegativeElevation> =
  minus {-}
  (
    <NegativeElevationFeet>
  | <NegativeElevationMeters>
  )
;

=====
# SUB-COMMANDS
=====

<AssignNames>=
  one {%201}
  | two {%202}
  | three {%203}
  | four {%204}
  | purge {%20PURGE}
;

<TSDTrackOpts>=
  geo {GEO}

```

```

| heading {HEADING}
| north {NORTH}
;

<Altitude>=
#100-900
<OneToNine> hundred {00}
|
#1000,2000,...9000
<OneToNine> thousand {000}
|
#1100,1200,...9800,9900
<OneToNine> thousand <OneToNine> hundred {00}
|
#10100...16900
<One> <ZeroToSix> thousand <OneToNine> hundred {00}
|
#10000...17000
<TenToSeventeen> thousand {000}
|
<One> <ZeroToSeven> thousand {000}
|
#17100...17500
<One> <Seven> thousand <OneToFive> hundred {00}
;

<AutopilotAltitude>=
(
  minus {-} <ZeroToNine> [<ZeroToNine> [<ZeroToNine> [<ZeroToNine> ]]]
  | <ZeroToNine> [<ZeroToNine> [<ZeroToNine> [<ZeroToNine> [<ZeroToNine> ]]]]
)
;

<AutopilotHeading>= <ZeroToThreeSixty>;

<Frequency>=
<ZeroToNine> [<ZeroToNine> [<ZeroToNine> [ [decimal {.} | point (.)]
<ZeroToNine> [<ZeroToNine> [<ZeroToNine>]]]]];

<Latitude> =
(
  <NorthSouth>
  (
    <ZeroToNinetyNine> [degrees]
    |
    (<ZeroToNine> <ZeroToNine> [degrees] | <ZeroToNine> degrees)
    [
      {.}
      (
        <ZeroToNinetyNine>
        |
        (<ZeroToNine> <ZeroToNine> [decimal] | <ZeroToNine> decimal) (.)
      )
    ]
  )
)
;

```

```

<Longitude> =
(
  <EastWest>
  (
    <ZeroToNinetyNine> [degrees]
    |
    (<ZeroToNine> <ZeroToNine> <ZeroToNine> [degrees] | <ZeroToNine>
[<ZeroToNine>] degrees)
    {
      {
        {
          <ZeroToNinetyNine>
          |
          (<ZeroToNine> <ZeroToNine> [decimal] | <ZeroToNine> decimal)
        }
      }
    }
  )
)
;

```

```

=====
# COMMANDS
=====

```

```

-----
# 2. PORTAL MANAGEMENT COMMANDS
-----

```

```

<PortalManagementCmd> =
(
  <PlaceCmd>
  | <ExpandCmd>
  | <RestoreCmd>
  | <RotateCmd>
  | <TabCmd>
  | <UnTabCmd>
  | <SwapCmd>
  | <DisplaysCmd>
)
;

```

```

<PlaceCmd>=
place {PLACE%20}
(
  (
    hsi {H%20S%20I%20}
    | hud {HUD%20}
    | electrical {ELECTRICAL%20}
    | engine {ENGINE%20}
    | fuel {FUEL%20}
    | icaws {I%20CAWS%20}
    | sms {S%20M%20S%20}
    | phm {P%20H%20M%20}
    | weapon air {WEAPON%20AIR%20}
  )
)

```

```

    | weapon surface {WEAPON%20SURFACE%20}
    | fcs {F%20C%20S%20}
    | cni {C%20N%20I%20}
    | das {D%20A%20S%20}
    | tflir {T%20FLIR%20}
    | aar {A%20A%20R%20}
    | dim {DIM%20}
  ) <PortalPositionNumber>
)
|
(
  asr {A%20S%20R%20} <ASRPositionNo>
)
|
(
  tsd {T%20S%20D%20} <TSDPositionNo>
)
)
;

<ASRPositionNo>= <OneToTwo>;
<TSDPositionNo>= <OneToThree>;
<PortalPositionNumber>= <OneToFour>;
<ExpandCmd>= expand {EXPAND%20} <PortalPositionNumber>;
<RestoreCmd>= restore {RESTORE%20} <PortalPositionNumber>;
<RotateCmd>= rotate {ROTATE%20} <PortalPositionNumber>;
<TabCmd>= tab {TAB%20} <PortalPositionNumber>;
<UnTabCmd>= untab {UNTAB%20} <PortalPositionNumber>;
<SwapCmd> = swap {SWAP};

<DisplaysCmd> = displays {DISPLAYS%20}
(
  take off {TAKE%20OFF}
| landing {LANDING}
| tactical {TACTICAL}
)
;

#-----
# 3. COM COMMAND
#-----
<ComCmd>=
  com {COM%20}
  (
    (
      <ComSwitch> {%20}
      (
        (<ComFrequency> enter)
        |
        <ComPreset>
      )
    )
  )
  |
  (
    bur {BUR%20}
    (
      (guard (uniform {GUARD%20UNIFORM}) | victor {GUARD%20VICTOR}))
    )
  )

```

```

        (transmit {TRANSMIT%20} <ComFrequency> enter)
    )
)
;

<ComSwitch> = (alpha {ALPHA} | bravo {BRAVO} | charlie {CHARLIE} | delta
{DELTA});
<ComFrequency>= <ZeroToNine> [<ZeroToNine> [<ZeroToNine> [[{decimal} | point]]
{.} <ZeroToNine> [<ZeroToNine> [<ZeroToNine>]]]]];
<ComPreset>=
    (
        previous {PREVIOUS}
        | inc {INCREMENT}
        | dec {DECREMENT}
        | secure {SECURE}
        | clear {CLEAR}
        | guard {GUARD}
    )
;

#-----
# 4. VOLUME COMMAND
#-----
<VolumeCmd> =
    volume {VOLUME%20}
    (
        <MuteUnmute> all {%20ALL}
        | <Source> {%20} ( <MuteUnmute> | <VolumeSourceValue> enter )
    )
;

<Source> =
    (
        alpha {ALPHA}
        | bravo {BRAVO}
        | charlie {CHARLIE}
        | delta {DELTA}
        | bur {BUR}
        | threat {THREAT}
        | nav aid {NAV%20AID}
        | icaws {I%20CAWS}
        | voice {VOICE}
    )
;

<MuteUnmute> = (mute {MUTE} | restore {RESTORE});
<VolumeSourceValue> = <ZeroToNine> [<ZeroToNine> [<ZeroToNine>]];

#-----
# 5. SET COMMAND
#-----
<SetCmd>=
    set {SET%20}
    (
        emcon {EMCON%20} <EmconLevel>
        | alow {A%20LOW%20} <AlowChoice> <AlowValue>
        | (

```

```

    joker {JOKER%20}
    | bingo {BINGO%20}
    ) <Setting>
)
;

<EmconLevel> = <OneToFive>;
<AlowChoice> = (<One> |<Two>);
<AlowValue> = <ZeroToNine> [<ZeroToNine> [<ZeroToNine> [<ZeroToNine>
[<ZeroToNine>]]]] <FeetMeters>;
<Setting>=
(
    ( (.) <ZeroToNine> )
    | (<ZeroToNine> [decimal | point] {.) <ZeroToNine> )
    | (<One> <ZeroToNine> [decimal | point] {.) <ZeroToNine> )
    | (<Two> <Zero> [decimal | point] {.) [<Zero>] )
)
;

```

```

#-----
# 6. SAY COMMAND
#-----

```

```

<SayCmd> =
    say {SAY%20}
    (
        emcon {EMCON}
        #TPB 22Feb06 | fuel {FUEL}
        | joker {JOKER}
        | bingo {BINGO}
    )
;

```

```

#-----
# 7. STEERPOINT COMMAND
#-----

```

```

<SteerpointCmd> =
(
    steerpoint {STEERPOINT%20}
    (
        <SteerPointNumber> enter
        | ( inc | increment ) {INCREMENT}
        | ( dec | decrement ) {DECREMENT}
        | manual {MANUAL}
        | auto {AUTO}
        | <Latitude> enter
        | <Longitude> enter
        | elevation {ELEVATION%20} <Elevation>
        | tos {T%20O%20S%20} <HHMMSS> enter
    )
)
;

```

```

<SteerPointNumber> = <ZeroToNine> [<ZeroToNine> [<ZeroToNine>]];

```

```

<HHMMSS>=
(

```

```

[<ZeroToNine>] <ZeroToNine> [hours]
[ [<ZeroToNine>] <ZeroToNine> [minutes] ]
[ [<ZeroToNine>] <ZeroToNine> [seconds] ]
)
;

```

```

#-----
# 8. WAYPOINT COMMAND
#-----

```

```

<WaypointCmd>=
(
  waypoint {WAYPOINT%20}
  (
    <WayPointNumber> enter
    | <Latitude> enter
    | <Longitude> enter
    | elevation {ELEVATION%20} <Elevation>
  )
)
;

```

```

<WayPointNumber> = <ZeroToNine> [<ZeroToNine>];

```

```

#-----
# 9. IFF COMMAND
#-----

```

```

<IffCmd> =
  iff {I%20F%20F%20}
  (
    identify {IDENTIFY}
    | emergency {EMERGENCY}
    | (
        mode {MODE%20}
        (
          charlie {CHARLIE%20} <OnOff>
          | sierra {SIERRA%20} <OnOff>
          | (<One> {%20} | <Five> {%20}) (<OnOff> | [on] {ON%20}
<IFFTwoDigitCode> enter)
          | (<Two> {%20} | <Three> {%20}) (<OnOff> | [on] {ON%20}
<IFFFourDigitCode> enter)
          | <Four> {%20} (auto {AUTO} | manual {MANUAL} | off {OFF})
        )
      )
  )
;

```

```

<IFFTwoDigitCode> = <ZeroToNine> <ZeroToNine>;

```

```

<IFFFourDigitCode> =<ZeroToNine> <ZeroToNine> <ZeroToNine> <ZeroToNine>;

```

```

#-----
# 10. ILS COMMAND
#-----

```

```

<IlsCmd> =
  ils {I%20L%20S%20}
  (
    frequency {FREQUENCY%20} <ILSFrequency>
  )

```

```

| course {COURSE%20} <Heading>
) enter
;

<ILSFrequency>= <ZeroToNine> [<ZeroToNine> [<ZeroToNine> [[decimal] (.)
<ZeroToNine> [<ZeroToNine>]]]];

#-----
# 11. TACAN COMMAND
#-----
<TacanCmd>=
  tacan {TACAN%20}
  (
    x-ray {X-RAY}
    | yankee {YANKEE}
    | air {AIR}
    | receive {RECEIVE}
    | transmit {TRANSMIT}
    | <TacanStation> (enter | x-ray {%20X-RAY} | yankee {%20YANKEE})
    | course {COURSE%20} <TacanValue> enter
  )
;

<TacanStation> = <ZeroToNine> [<ZeroToNine> [<ZeroToNine>]];
<TacanValue> = <Heading>;

#-----
# 12. AUTOPILOT COMMAND
#-----
<AutopilotCmd> =
  autopilot {AUTOPILOT%20}
  (
    altitude hold {ALTITUDE%20HOLD}
    | heading hold {HEADING%20HOLD}
    | steerpoint hold {STEERPOINT%20HOLD}
    | route hold {ROUTE%20HOLD}
    | speed hold {SPEED%20HOLD}
    | altitude {ALTITUDE%20} <AutoPilotAltitude>
    | heading {HEADING%20} <Heading> (enter | true {%20TRUE} | mag {%20MAG})
    | speed {SPEED%20} <AutoPilotSpeed> (enter | true {%20TRUE} | cal
    {%20CALIBRATED}) | ground {%20GROUND})
    | speed {SPEED%20} <MachSpeed>
  )
;

<Baro> = baro {%20BARO};
<Radalt> = radalt {%20RADALT};

<AutoPilotSpeed> = <OneToSix> <ZeroToNine> <ZeroToNine>;
<MachSpeed> = (<ZeroToNine>) (decimal | point) (.) <ZeroToNine>
[<ZeroToNine>] mach {%20MACH};

<PositiveAutoPilotAltitudeFeet>=
  (
    <ZeroToNine> [<ZeroToNine> [<ZeroToNine> [<ZeroToNine> [<ZeroToNine>]]]]
  ) (<Feet> | <Baro> | <Radalt> | enter);

```

```

<NegativeAutoPilotAltitudeFeet>=
(
  <ZeroToNine> [<ZeroToNine> [<ZeroToNine> [<ZeroToNine>]]]
) (<Feet> | <Baro> | <Radalt> | enter);

<PositiveAutoPilotAltitudeMeters>=
(
  <ZeroToNine> [<ZeroToNine> [<ZeroToNine> [<ZeroToNine> [<ZeroToNine>]]]]
) (<Meters> | <Baro> | <Radalt> | enter);

<NegativeAutoPilotAltitudeMeters>=
(
  <ZeroToNine> [<ZeroToNine> [<ZeroToNine> [<ZeroToNine>]]]
) (<Meters> | <Baro> | <Radalt> | enter);

<AutoPilotAltitude>= <PositiveAutoPilotAltitude> |
<NegativeAutoPilotAltitude>;
<PositiveAutoPilotAltitude>=
[plus]
(
  <PositiveAutoPilotAltitudeFeet>
|
  <PositiveAutoPilotAltitudeMeters>
)
;

<NegativeAutoPilotAltitude> =
minus (-)
(
  <NegativeAutoPilotAltitudeFeet>
|
  <NegativeAutoPilotAltitudeMeters>
)
;

#-----
# 13. TSD COMMAND
#-----
<TSDCmd>=
tsd {T%20S%20D%20} <TSDdisplay>
(
  hsi {H%20S%20I}
| range {RANGE%20} ((inc | increment) {INCREMENT} | (dec | decrement)
{DECREMENT})
| track {TRACK%20} (geo {GEO} | heading {HEADING} | north {NORTH})
)
;

<TSDdisplay> = <OneToThree> {%20};

#-----
# 14. ASR COMMAND
#-----
<ASRCmd>=
asr {A%20S%20R%20} <ASRradar>
(

```

```

transmit {TRANSMIT}
|
|   (
|     store {STORE%20}
| | recall {RECALL%20}
| | sar {SAR%20}
|   ) <ASRNumber>
|
;
<ASRradar> = <OneToTwo>;
<ASRNumber> = <OneToFive>;

```

```

#-----
# 15. TFLIR COMMAND
#-----
<TFLIRCmd>=
  tflir (T%20FLIR%20)
  (
  | los {LOS}
  | mle {M%20L%20E}
  | (black hot) {BLACK%20HOT}
  | (white hot) {WHITE%20HOT}
  | position {POSITION%20} (latlon {LATLON} | utm {U%20T%20M} | off {OFF})
  )
;

```

```

#-----
# 16. DAS COMMAND
#-----
<DASCmd> =
  das (D%20A%20S%20)
  (
  | forward {FORWARD}
  | (check six) {CHECK%20SIX}
  | land {LAND}
  | air {AIR}
  | surface {SURFACE}
  | stovl {STOVL}
  | flir {FLIR}
  | (black hot) {BLACK%20HOT}
  | (white hot) {WHITE%20HOT}
  )
;

```

```

#-----
# 17. WINGS COMMAND
#-----
<WingsCmd>=
  wings {WINGS%20}
  (
  | fold {FOLD}
  | spread {SPREAD}
  | stop {STOP}
  | continue {CONTINUE%20} (fold {FOLD} | spread {SPREAD})
  )
;

```

```

#-----
# 18. LAUNCH BAR COMMAND
#-----
<LaunchbarCmd>=
  (launch bar) {LAUNCH%20BAR%20}
  (
    extend {EXTEND}
    | retract {RETRACT}
  )
;

#-----
# 19. MACROS COMMANDS
#-----
<MacrosCmd>=
  (
    <FenceCmd>
    | <RefuelCmd>
    | <DumpCmd>
  )
;

<FenceCmd>= fence {FENCE%20} (in {IN} | out {OUT} );

<RefuelCmd>=
  refuel {REFUEL%20}
  (
    precontact {PRECONTACT}
    | postcontact {POSTCONTACT}
    | open {OPEN}
    | close {CLOSE}
  )
;

<DumpCmd>= dump {DUMP%20} ( open {OPEN} | close {CLOSE} );

#-----
# 20. TARGETING AND ASSIGNMENT COMMANDS
#-----
<TargetingAndAssignmentCmd> =
  (
    <TargetCmd>
    | <RejectCmd>
    | <AssignCmd>
  )
;

<AthruZ>=
  (
    alpha {ALPHA} | bravo {BRAVO} | charlie {CHARLIE} | delta {DELTA} | echo
{ECHO}
    | foxtrot {FOXTROT} | golf {GOLF} | hotel {HOTEL} | india {INDIA} | juliet
{JULIET}
    | kilo {KILO} | lima {LIMA} | mike {MIKE} | november {NOVEMBER} | oscar
{OSCAR}
    | papa {PAPA} | quebec {QUEBEC} | romeo {ROMEO} | sierra {SIERRA} | tango
{TANGO}
    | uniform {UNIFORM} | victor {VICTOR} | whiskey {WHISKEY} | x-ray {X-RAY}
  )

```

```

    | yankee {YANKEE} | zulu {ZULU}
    )
;

<Wingman> = <OneToFour>;
<TargetCmd> = target {TARGET%20} <AthruZ>;
<RejectCmd> = reject {REJECT%20} <AthruZ>;
<AssignCmd> = assign {ASSIGN%20} <Wingman> {%20} <AthruZ>;

```

```

#-----
# 21. RECORD COMMAND
#-----

```

```

<RecordCmd>=
  record {RECORD%20}
  (
    geo {GEO}
    | time {TIME}
    | off {OFF}
    | start {START}
    | stop {STOP}
    | (
      left {LEFT%20}
      | right {RIGHT%20}
      | helmet {HELMET%20}
      | all {ALL%20}
      ) <OnOff>
  )
;

```

```

#-----
# 22. LIGHTS COMMAND
#-----

```

```

<LightsCmd>=
  lights {LIGHTS%20}
  (
    <ControllableLight> {%20} <LiteValue> enter
    | <AnyLight> {%20} <OnOff>
    | <LightPositionOption>
    | strobe {STROBE%20}
      (
        <StrobeOption>
        | program {PROGRAM%20} <StrobeProgramValue>
      )
  )
;

```

```

<ControllableLight>=
  (
    console {CONSOLE}
    | flood {FLOOD}
    | formation {FORMATION}
    | refuel {REFUEL}
  )
;

```

```

<LiteValue> = <ZeroToNinetyNine>;
<AnyLight> = <ControllableLight> | weapon bay {WEAPON%20BAY};
<StrobeOption> = <OnOff> | dim {DIM} | bright {BRIGHT};

```

```
<LightPositionOption> = <StrobeOption> | flash {FLASH} | steady {STEADY};
<StrobeProgramValue> = <OneToFour> | alpha {ALPHA} | bravo {BRAVO} | charlie
{CHARLIE};
```

```
#-----
# 23. CONFIRMATION DIALOGUE
#-----
```

```
<YesCmd>= yes {YES};
<NoCmd>= no {NO};
```

```
#####
#
# VISTA Legacy grammar functionality is provided below
#
#####
```

```
<VD0>= (zero) {0};
<VD1>= (one) {1};
<VD2>= (two) {2};
<VD3>= (three) {3};
<VD4>= (four) {4};
<VD5>= (five) {5};
<VD6>= (six) {6};
<VD7>= (seven) {7};
<VD8>= (eight) {8};
<VD9>= (nine | niner) {9};
<VDPoint> = (point | decimal) {.};

<VDZeroToTwo>= (<VD0> | <VD1> | <VD2>);
<VDOneToThree>= (<VD1> | <VD2> | <VD3>);
<VDZeroToFive>= (<VDZeroToTwo> | <VD3> | <VD4> | <VD5>);
<VDFiveToNine>= (<VD5> | <VD6> | <VD7> | <VD8> | <VD9>);
<VDThreeToNine>= (<VD3> | <VD4> | <VDFiveToNine>);
<VDZeroToNine>= (<VD0> | <VD1> | <VD2> | <VDThreeToNine>);
<VDTenToThirtyNine> = (<VDOneToThree> <VDZeroToNine>);
<VDSeventyFiveToThreeHundred>=
(
    (<VD0> <VD7> <VDFiveToNine>)
    | (<VD0> (<VD8> | <VD9>) <VDZeroToNine>)
    | ((<VD1> | <VD2>) <VDZeroToNine> <VDZeroToNine>)
    | (<VD3> <VD0> <VD0>)
)
;

<VDZeroToThreeSixty>=
(
    (<VDZeroToTwo> <VDZeroToNine> <VDZeroToNine>)
    | (<VD3> <VDZeroToFive> <VDZeroToNine>)
    | (<VD3> <VD6> <VD0>)
)
,

<VistaFinishUHF>=
(
    (<VDZeroToNine> (<VD0> | <VD2> | <VD5> | <VD7>) enter)
    | (<VDZeroToNine> enter)
```

```

    | (enter)
  )
;

<VistaUHFFreq>=
(
    (<VD2> <VD2> <VDFiveToNine>)
    | (<VD2> <VDThreeToNine> <VDZeroToNine>)
    | (<VD3> <VDZeroToNine> <VDZeroToNine>)
)
<VistaFinishUHF>
;

=====
# PUBLIC F16 (Vista) GRAMMAR
=====

public <VistaLegacyCmd>=
(
    (uniform) {CMD=cmdF16,VALUE1=UNIFORM%20} <VistaUHFFreq>
    | (missile override) {CMD=cmdF16,VALUE1=MISSILE%20OVERRIDE}
    | (missile step) {CMD=cmdF16,VALUE1=MISSILE%20STEP}
    | (nav mode) {CMD=cmdF16,VALUE1=NAV%20MODE}
    | (declutter hud) {CMD=cmdF16,VALUE1=DECLUTTER%20HUD}
    | (declutter helmet) {CMD=cmdF16,VALUE1=DECLUTTER%20HELMET}
    | (declutter hmd) {CMD=cmdF16,VALUE1=DECLUTTER%20H%20M%20D}
    | (normal hud) {CMD=cmdF16,VALUE1=NORMAL%20HUD}
    | (normal helmet) {CMD=cmdF16,VALUE1=NORMAL%20HELMET}
    | (normal hmd) {CMD=cmdF16,VALUE1=NORMAL%20H%20M%20D}
    | (dogfight) {CMD=cmdF16,VALUE1=DOGFIGHT}
    | (say altitude) {CMD=cmdF16,VALUE1=SAY%20ALTITUDE}
    | (say heading) {CMD=cmdF16,VALUE1=SAY%20HEADING}
    | (say mach) {CMD=cmdF16,VALUE1=SAY%20MACH}
    | (say fuel) {CMD=cmdF16,VALUE1=SAY%20FUEL}
    | (say true) {CMD=cmdF16,VALUE1=SAY%20TRUE}
    | (say true airspeed) {CMD=cmdF16,VALUE1=SAY%20TRUE%20AIRSPEED}
    | (say calibrated) {CMD=cmdF16,VALUE1=SAY%20CALIBRATED}
    | (say calibrated airspeed)
{CMD=cmdF16,VALUE1=SAY%20CALIBRATED%20AIRSPEED}
    | (say airspeed) {CMD=cmdF16,VALUE1=SAY%20AIRSPEED}
    | (say target) {CMD=cmdF16,VALUE1=SAY%20TARGET}
    | (say target info) {CMD=cmdF16,VALUE1=SAY%20TARGET%20INFO}
    | (mark) {CMD=cmdF16,VALUE1=MARK}
    | (nav course) {CMD=cmdF16,VALUE1=NAV%20COURSE%20}
<VDZeroToThreeSixty>
    | (nav tadpole) {CMD=cmdF16,VALUE1=NAV%20TADPOLE}
    | (nav cdi) {CMD=cmdF16,VALUE1=NAV%20C%20D%20I}
    | (nav ils) {CMD=cmdF16,VALUE1=NAV%20I%20L%20S}
    | (nav director) {CMD=cmdF16,VALUE1=NAV%20DIRECTOR}
    | (hmd split) {CMD=cmdF16,VALUE1=H%20M%20S%20P%20L%20I%20T}
    | (hmd fused) {CMD=cmdF16,VALUE1=H%20M%20F%20U%20S%20E%20D}
    | (hmd latency best) {CMD=cmdF16,VALUE1=H%20M%20L%20A%20T%20E%20N%20C%20Y%20B%20E%20S%20T}
    | (hmd two zero) {CMD=cmdF16,VALUE1=H%20M%20T%20Z%20E%20R%20O}
    | (hmd three zero) {CMD=cmdF16,VALUE1=H%20M%20T%20H%20R%20E%20Z%20E%20R%20O}
    | (hmd four zero) {CMD=cmdF16,VALUE1=H%20M%20F%20O%20U%20R%20Z%20E%20R%20O}
    | (hmd latency) {CMD=cmdF16,VALUE1=H%20M%20L%20A%20T%20E%20N%20C%20Y%20}
<VDZeroToNine> <VDZeroToNine> <VDZeroToNine>

```

```

    | (hmd spread)          {CMD=cmdF16,VALUE1=H%20%20%20SPREAD%20}
<VDZeroToNine> <VDZeroToNine>
    | (declutter one)      {CMD=cmdF16,VALUE1=DECLUTTER%201}
    | (declutter two)     {CMD=cmdF16,VALUE1=DECLUTTER%202}
    | (declutter three)   {CMD=cmdF16,VALUE1=DECLUTTER%203}
    | (orange peel)       {CMD=cmdF16,VALUE1=ORANGE%20PEEL}
    | (grapefruit)        {CMD=cmdF16,VALUE1=GRAPEFRUIT}
    | (display hud)        {CMD=cmdF16,VALUE1=DISPLAY%20HUD}
    | (display hmd)        {CMD=cmdF16,VALUE1=DISPLAY%20H%20%20%20D}
    | (display both)      {CMD=cmdF16,VALUE1=DISPLAY%20BOTH}
    | (normal)             {CMD=cmdF16,VALUE1=NORMAL}
    | (caged)              {CMD=cmdF16,VALUE1=CAGED}
    | (function)           {CMD=cmdF16,VALUE1=FUNCTION%20} <VDZeroToNine>
<VDZeroToNine>
    | <OOG>
)
[disregard {%20#DISREGARD#}]
;

```

```

#=====
# PUBLIC JSF GRAMMAR
#=====

```

```

public <JSFCommand>=
( {CMD=cmdJSF,VALUE1=}
(
    <PortalManagementCmd>
    | <ComCmd>
    | <VolumeCmd>
    | <SetCmd>
    | <SayCmd>
    | <SteerpointCmd>
    | <WaypointCmd>
    | <IffCmd>
    | <IlsCmd>
    | <TacanCmd>
    | <AutopilotCmd>
    | <TSDCmd>
    | <ASRCmd>
    | <TFLIRCmd>
    | <DASCmd>
    | <WingsCmd>
    | <LaunchbarCmd>
    | <MacrosCmd>
    | <TargetingAndAssignmentCmd>
    | <RecordCmd>
    | <LightsCmd>
)
)
| <OOG>
)
[disregard {%20#DISREGARD#}]
;

```

```

<OOG> = (@reject@+);
#####
# SayGrammarVersionCmd causes the VRS to vocalize the current software
# version information

```

```

#####
<SaySoftwareVersionCmd>=
  (which version of software is this) {CMD=SAYVERSION}
;

#####
#
# VISTA "switch grammar to" used by the pilot to switch between JSF and VISTA
# F16 grammars
#
#####

#<SwitchGrammarCmd>=
# (switch grammar to
# (
# jsf
{CMD=SWITCHTO, VALUE1=JSFCommand, CONFIRM=confirm%20switch%20to%20j%20s%20f, RES
PONSE=j%20s%20f}
# | vista
{CMD=SWITCHTO, VALUE1=VistaLegacyCmd, CONFIRM=confirm%20switch%20to%20vista, RES
PONSE=vista}
# | admin
{CMD=SWITCHTO, VALUE1=Admin, CONFIRM=confirm%20switch%20to%20add%20men, RESPONSE
=add%20men}
# ))
#;
public <Admin>=<OOG>| admin (
  |<SaySoftwareVersionCmd>
  | (partial results {CMD=PRSWITCH, VALUE1=} ( enabled
{true, CONFIRM=enabling.%20say%20confirm%20or%20cancel, RESPONSE=enabled} |
disabled
{false, CONFIRM=disabling.%20say%20confirm%20or%20cancel, RESPONSE=disabled}))
  )
;

public <TopLevel>=<VistaLegacyCmd> | <JSFCommand> | <Admin>;

public <CONFIRM> = <OOG> |
  (confirm {CMD=CONFIRM_OK}) |#no response needed here because
it uses the previous commands response tag
  (cancel {CMD=CONFIRM_CANCEL, RESPONSE=canceled});

```

APPENDIX B

400 VISTA TEST PROMPTS

caged	declutter helmet	declutter hmd	declutter hud
declutter one	declutter three	declutter two	display both
display hmd	display hud	dogfight	function four two
function four zero	function six six	function one eight	function one nine
grapefruit	hmd four zero	hmd fused	hmd latency best
hmd latency four four zero	hmd split	hmd spread eight nine	hmd three zero
hmd two zero	mark	missile override	missile step
nav cdi	nav course one four five	nav course three two zero	nav course two five zero
nav course two six five	nav director	nav ils	nav mode
nav tadpole	normal	normal helmet	normal hmd
normal hud	orange peel	say airspeed	say altitude
say calibrated	say calibrated airspeed	say fuel	say heading
say mach	say target	say target info	say true
say true airspeed	uniform three eight six nine seven enter	uniform two four one enter	uniform two two six zero enter
asr one recall two	asr two recall three	asr one sar one	asr two sar four
asr one store three	asr two store two	asr one transmit	asr two transmit
assign four alpha	assign four charlie	assign one echo	assign one golf
assign three india	assign two kilo	assign two mike	assign three victor
assign four zulu	autopilot altitude one eight three two radalt	autopilot altitude hold	autopilot altitude minus nine zero zero enter
autopilot altitude two four five zero baro	autopilot altitude one nine zero zero enter	autopilot altitude six zero zero feet	autopilot heading two five six mag
autopilot heading three four eight mag	autopilot heading hold	autopilot heading two nine zero true	autopilot heading one six five enter
autopilot route hold	autopilot speed five seven six ground	autopilot speed four six seven cal	autopilot speed hold
autopilot speed two decimal seven mach	autopilot speed one point two mach	autopilot speed six eight seven enter	autopilot speed two seven eight ground
autopilot speed zero decimal six one mach	autopilot speed zero point seven six mach	autopilot steerpoint hold	com alpha clear
com alpha dec	com alpha three zero four decimal seven enter	com bravo inc	com bravo previous
com bravo six seven enter	com bur guard uniform	com bur guard victor	com bur transmit eight enter
com bur transmit five enter	com bur transmit three eight zero decimal six enter	com bur transmit three seven eight decimal two five enter	com bur transmit two six one point three enter
com bur transmit two six nine point four seven five enter	com charlie eight seven enter	com charlie secure	com charlie two seven six decimal four five enter
com delta clear	com delta dec	com delta eight enter	com delta guard
com delta inc	com delta seven enter	das air	das black hot
das check six	das flir	das forward	das land
das stovl	das surface	das white hot	displays landing
displays tactical	displays take off	dump close	dump open
expand four	fence in	fence out	iff emergency
iff identify	iff mode charlie off	iff mode charlie on	iff mode five seven four enter
iff mode five on	iff mode five on three six enter	iff mode four auto	iff mode four manual

iff mode one two five enter	iff mode one off	iff mode sierra off	iff mode sierra on
iff mode three on four seven five two enter	iff mode two six three zero seven enter	iff mode two off	iff mode two on zero five three seven enter
iff mode two on six six five zero enter	ils course one eight seven enter	ils course two seven five enter	ils course nine zero enter
ils course one three enter	ils course three four seven enter	ils course one seven six enter	ils course six enter
ils course six nine enter	ils course two nine five enter	ils frequency one zero eight eight enter	ils frequency one one seven decimal nine five enter
ils frequency one zero nine eight enter	ils frequency one zero eight four five enter	ils frequency one one six decimal three enter	ils frequency one zero nine decimal seven enter
ils frequency one one four five enter	launch bar extend	launch bar retract	lights bright
lights console eight enter	lights console on	lights dim	lights flash
lights flood four enter	lights flood nine zero enter	lights formation four enter	lights formation nine seven enter
lights formation on	lights off	lights on	lights refuel five enter
lights refuel nine zero enter	lights refuel off	lights steady	lights strobe off
lights strobe on	lights strobe program alpha	lights strobe program bravo	lights strobe program charlie
lights strobe program one	lights strobe program three	lights weapon bay off	lights weapon bay on
place aar three	place asr one	place cni four	place das one
place dim four	place electrical three	place engine four	place fcs three
place fuel one	place hsi one	place hud two	place icaws two
place phm four	place sms three	place tflir two	place tsd two
place weapon air one	place weapon surface two	record all off	record all on
record geo	record helmet off	record helmet on	record left off
record left on	record off	record right on	record start
record stop	record time	refuel close	refuel open
refuel postcontact	refuel precontact	reject lima	reject mike
reject november	reject oscar	reject papa	reject quebec
reject romeo	reject sierra	reject tango	reject uniform
reject whiskey	reject zulu	restore four	restore one
rotate one	rotate three	rotate two	say bingo
say emcon	say joker	set alow one eight nine enter	set alow one nine enter
set alow one nine five nine feet	set alow one seven enter	set alow one zero nine six enter	set alow two five enter
set alow two nine enter	set alow two nine meters	set bingo six decimal three	set bingo one five seven
set bingo four	set bingo one	set bingo six five	set bingo three eight
set emcon five	set emcon four	set emcon one	set emcon three
set emcon two	set joker eight seven	set joker seven two	set joker five eight
set joker one four nine	set joker three three	set joker one zero nine	steerpoint auto
steerpoint dec	steerpoint decrement	steerpoint east one seven four degrees enter	steerpoint eight eight enter
steerpoint elevation minus eight feet	steerpoint elevation four six zero meters	steerpoint elevation minus nine enter	steerpoint elevation minus six six enter
steerpoint elevation plus nine nine enter	steerpoint elevation three feet	steerpoint inc	steerpoint increment
steerpoint manual	steerpoint nine eight enter	steerpoint north four one degrees five two decimal zero three enter	steerpoint north two seven three six enter

steerpoint one nine nine enter	steerpoint south three six degrees four seven decimal zero two enter	steerpoint tos eight nine enter	steerpoint tos four eight nine six enter
steerpoint tos nine enter	steerpoint tos one two enter	steerpoint tos seven eight hours enter	steerpoint tos two eight seven seconds enter
steerpoint west one seven five degrees two decimal zero enter	steerpoint west one three four degrees two eight decimal five zero enter	steerpoint west three six degrees enter	steerpoint west one six four enter
steerpoint west zero seven degrees four eight seven five two enter	swap	tab four	tab one
tab three	tab two	tacan air	tacan course two six enter
tacan course one four seven enter	tacan course zero five seven enter	tacan course zero zero eight enter	tacan eight enter
tacan one two four x-ray	tacan five eight yankee	tacan nine x-ray	tacan receive
tacan transmit	tacan one two four x-ray	tacan three seven yankee	target bravo
target delta	target foxtrot	target hotel	target juliet
target lima	target november	target oscar	target papa
target quebec	target kilo	tflir black hot	tflir los
tflir mle	tflir position latlon	tflir position off	tflir position utm
tflir white hot	tsd one hsi	tsd one range dec	tsd one track heading
tsd one track north	tsd three range decrement	tsd three range inc	tsd three track geo
tsd three track heading	tsd two hsi	tsd two range increment	tsd two track geo
tsd two track north	untab four	untab three	volume alpha eight eight nine enter
volume alpha restore	volume bravo six two enter	volume bur five enter	volume bur mute
volume charlie mute	volume charlie restore	volume delta mute	volume delta nine enter
volume delta six enter	volume icaws mute	volume icaws restore	volume icaws two seven enter
volume mute all	volume nav aid mute	volume nav aid nine enter	volume nav aid restore
volume restore all	volume threat restore	volume voice mute	volume voice nine seven six enter
waypoint east seven six degrees eight decimal five four enter	waypoint eight enter	waypoint three eight enter	waypoint elevation five zero zero enter
waypoint elevation one four six two enter	waypoint elevation minus eight eight five enter	waypoint elevation plus five eight seven enter	waypoint elevation seven nine meters
waypoint elevation one six zero zero zero enter	waypoint elevation three five zero zero feet	waypoint four enter	waypoint north eight degrees one seven decimal five enter
waypoint north four three degrees nine decimal six enter	waypoint south eight two degrees enter	waypoint south five eight degrees two zero decimal one four enter	waypoint south one four degrees five eight decimal two enter
waypoint west one six eight degrees enter	waypoint west five six degrees two seven decimal seven enter	waypoint west one four two degrees five seven decimal six enter	wings continue fold
wings continue spread	wings fold	wings spread	wings stop

APPENDIX C

**LAB CONDITION WORD AND SENTENCE ERROR RATES
BY PARAMETER COMBINATION**

	Beam Width 600, WordTransitionWeight 0						
N American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 1	7	3	31	1790	454	2.29%	5.95%
Speaker 2	7	7	14	1541	390	1.82%	4.62%
Speaker 3	6	3	13	1663	419	1.32%	3.82%
Speaker 4	15	1	34	1746	431	2.86%	9.98%
Speaker 5	5	0	21	1708	430	1.52%	5.81%
Speaker 6	4	17	40	1565	393	3.90%	6.11%
Speaker 7	8	1	19	1622	413	1.73%	3.39%
Speaker 8	8	0	12	1563	398	1.28%	3.27%
Speaker 9	10	13	16	1523	384	2.56%	4.43%
Speaker 10	4	0	1	1635	419	0.31%	1.19%
NA Totals	74	45	201	16356	4131	1.96%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	10	11	49	1549	395	4.52%	7.34%
Speaker 12	4	19	39	1705	429	3.64%	7.69%
Speaker 13	85	50	118	1558	394	16.24%	29.19%
Speaker 14	37	34	178	2153	532	11.57%	29.51%
Non NA Totals	136	114	384	6965	1750	9.10%	
Total Both	210	159	585	23321	5881	4.09%	

APPENDIX C (CONTINUED)

Beam Width 600, WordTransitionWeight -50							
N American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 1	5	3	30	1790	454	2.12%	5.51%
Speaker 2	5	9	15	1541	390	1.88%	4.87%
Speaker 3	3	6	13	1663	419	1.32%	3.58%
Speaker 4	9	2	31	1746	431	2.41%	8.35%
Speaker 5	2	0	21	1708	430	1.35%	5.12%
Speaker 6	2	17	40	1565	393	3.77%	5.60%
Speaker 7	6	1	19	1622	413	1.60%	3.15%
Speaker 8	7	0	10	1563	398	1.09%	3.02%
Speaker 9	8	15	16	1523	384	2.56%	4.43%
Speaker 10	2	0	1	1635	419	0.18%	0.72%
NA Totals	49	53	196	16356	4131	1.82%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	9	21	45	1549	395	4.84%	7.59%
Speaker 12	1	23	35	1705	429	3.46%	7.46%
Speaker 13	66	33	110	1558	394	13.41%	27.66%
Speaker 14	25	44	181	2153	532	11.61%	28.76%
Non NA Totals	101	121	371	6965	1750	8.51%	
Total Both	150	174	567	23321	5881	3.82%	

APPENDIX C (CONTINUED)

Beam Width 600, WordTransitionWeight -100							
N American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 1	5	4	29	1790	454	2.12%	5.51%
Speaker 2	3	10	18	1541	390	2.01%	4.87%
Speaker 3	3	6	13	1663	419	1.32%	3.58%
Speaker 4	6	2	30	1746	431	2.18%	7.66%
Speaker 5	0	0	19	1708	430	1.11%	4.42%
Speaker 6	0	22	37	1565	393	3.77%	5.60%
Speaker 7	4	10	14	1622	413	1.73%	3.39%
Speaker 8	4	0	9	1563	398	0.83%	2.26%
Speaker 9	6	17	15	1523	384	2.50%	4.17%
Speaker 10	3	0	2	1635	419	0.31%	0.95%
NA Totals	34	71	186	16356	4131	1.78%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	5	23	44	1549	395	4.65%	7.34%
Speaker 12	1	27	36	1705	429	3.75%	7.69%
Speaker 13	47	40	98	1558	394	11.87%	25.13%
Speaker 14	14	59	174	2153	532	11.47%	27.63%
Non NA Totals	67	149	352	6965	1750	8.16%	
Total Both	101	220	538	23321	5881	3.68%	

APPENDIX C (CONTINUED)

Beam Width 600, WordTransitionWeight -150							
N American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 1	4	6	30	1790	454	2.23%	5.51%
Speaker 2	3	10	21	1541	390	2.21%	5.38%
Speaker 3	3	4	15	1663	419	1.32%	3.58%
Speaker 4	4	3	30	1746	431	2.12%	7.66%
Speaker 5	0	1	19	1708	430	1.17%	4.65%
Speaker 6	0	23	37	1565	393	3.83%	5.85%
Speaker 7	3	10	12	1622	413	1.54%	3.15%
Speaker 8	4	1	10	1563	398	0.96%	2.76%
Speaker 9	4	17	15	1523	384	2.36%	3.91%
Speaker 10	1	0	2	1635	419	0.18%	0.48%
NA Totals	26	75	191	16356	4131	1.79%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	5	29	43	1549	395	4.97%	8.35%
Speaker 12	1	27	35	1705	429	3.70%	7.46%
Speaker 13	35	48	92	1558	394	11.23%	24.11%
Speaker 14	8	82	170	2153	532	12.08%	28.20%
Non NA Totals	49	186	340	6965	1750	8.26%	
Total Both	75	261	531	23321	5881	3.72%	

APPENDIX C (CONTINUED)

	Beam Width 800, WordTransitionWeight 0						
N American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 1	7	1	23	1790	454	1.73%	5.29%
Speaker 2	8	4	14	1541	390	1.69%	4.62%
Speaker 3	5	1	11	1663	419	1.02%	3.34%
Speaker 4	15	1	29	1746	431	2.58%	9.51%
Speaker 5	5	0	21	1708	430	1.52%	5.81%
Speaker 6	3	6	24	1565	393	2.11%	4.58%
Speaker 7	6	0	11	1622	413	1.05%	2.42%
Speaker 8	6	0	10	1563	398	1.02%	3.02%
Speaker 9	8	5	10	1523	384	1.51%	2.86%
Speaker 10	4	0	1	1635	419	0.31%	1.19%
NA Totals	67	18	154	16356	4131	1.46%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	9	7	40	1549	395	3.62%	7.34%
Speaker 12	4	3	24	1705	429	1.82%	5.59%
Speaker 13	93	10	102	1558	394	13.16%	28.68%
Speaker 14	35	10	161	2153	532	9.57%	26.88%
Non NA Totals	141	30	327	6965	1750	7.15%	
Total Both	208	48	481	23321	5881	3.16%	

APPENDIX C (CONTINUED)

Beam Width 800, WordTransitionWeight -50							
N American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 1	5	1	22	1790	454	1.56%	4.85%
Speaker 2	6	4	14	1541	390	1.56%	4.36%
Speaker 3	3	1	11	1663	419	0.90%	2.86%
Speaker 4	10	2	28	1746	431	2.29%	8.35%
Speaker 5	2	0	21	1708	430	1.35%	5.12%
Speaker 6	1	6	24	1565	393	1.98%	4.07%
Speaker 7	4	0	11	1622	413	0.92%	2.18%
Speaker 8	5	0	8	1563	398	0.83%	2.76%
Speaker 9	6	6	10	1523	384	1.44%	2.86%
Speaker 10	2	0	1	1635	419	0.18%	0.72%
NA Totals	44	20	150	16356	4131	1.31%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	5	7	39	1549	395	3.29%	6.58%
Speaker 12	1	11	18	1705	429	1.76%	5.59%
Speaker 13	71	17	94	1558	394	11.68%	26.14%
Speaker 14	24	16	155	2153	532	9.06%	25.56%
Non NA Totals	101	51	306	6965	1750	6.58%	
Total Both	145	71	456	23321	5881	2.88%	

APPENDIX C (CONTINUED)

Beam Width 800, WordTransitionWeight -100							
N American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 1	5	2	21	1790	454	1.56%	4.85%
Speaker 2	3	6	14	1541	390	1.49%	4.36%
Speaker 3	3	1	11	1663	419	0.90%	2.86%
Speaker 4	6	2	27	1746	431	2.00%	7.42%
Speaker 5	0	0	19	1708	430	1.11%	4.42%
Speaker 6	0	6	24	1565	393	1.92%	4.07%
Speaker 7	4	0	11	1622	413	0.92%	2.18%
Speaker 8	2	0	7	1563	398	0.58%	2.01%
Speaker 9	4	6	8	1523	384	1.18%	2.34%
Speaker 10	2	0	1	1635	419	0.18%	0.72%
NA Totals	29	23	143	16356	4131	1.19%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	4	7	41	1549	395	3.36%	6.84%
Speaker 12	1	12	21	1705	429	1.99%	6.06%
Speaker 13	45	20	89	1558	394	9.88%	22.84%
Speaker 14	15	16	153	2153	532	8.55%	24.44%
Non NA Totals	65	55	304	6965	1750	6.09%	
Total Both	94	78	447	23321	5881	2.65%	

APPENDIX C (CONTINUED)

	Beam Width 800, WordTransitionWeight -150						
N American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 1	4	2	24	1790	454	1.68%	4.85%
Speaker 2	3	6	14	1541	390	1.49%	4.36%
Speaker 3	3	1	11	1663	419	0.90%	2.86%
Speaker 4	4	3	27	1746	431	1.95%	7.42%
Speaker 5	0	0	19	1708	430	1.11%	4.42%
Speaker 6	0	7	24	1565	393	1.98%	4.33%
Speaker 7	4	0	11	1622	413	0.92%	2.18%
Speaker 8	2	1	8	1563	398	0.70%	2.51%
Speaker 9	2	6	8	1523	384	1.05%	2.08%
Speaker 10	0	0	1	1635	419	0.06%	0.24%
NA Totals	22	26	147	16356	4131	1.19%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	4	8	41	1549	395	3.42%	7.09%
Speaker 12	1	14	18	1705	429	1.94%	5.83%
Speaker 13	34	24	81	1558	394	8.92%	20.81%
Speaker 14	8	28	146	2153	532	8.45%	24.25%
Non NA Totals	47	74	286	6965	1750	5.84%	
Total Both	69	100	433	23321	5881	2.58%	

APPENDIX C (CONTINUED)

	Beam Width 1000, WordTransitionWeight 0						
N American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 1	7	1	23	1790	454	1.73%	5.29%
Speaker 2	8	4	14	1541	390	1.69%	4.62%
Speaker 3	5	1	11	1663	419	1.02%	3.34%
Speaker 4	16	1	29	1746	431	2.63%	9.74%
Speaker 5	5	0	21	1708	430	1.52%	5.81%
Speaker 6	3	3	18	1565	393	1.53%	4.07%
Speaker 7	6	0	11	1622	413	1.05%	2.42%
Speaker 8	6	0	10	1563	398	1.02%	3.02%
Speaker 9	6	0	3	1523	384	0.59%	1.82%
Speaker 10	4	0	1	1635	419	0.31%	1.19%
NA Totals	66	10	141	16356	4131	1.33%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	10	4	35	1549	395	3.16%	7.09%
Speaker 12	2	3	23	1705	429	1.64%	5.59%
Speaker 13	89	4	87	1558	394	11.55%	26.65%
Speaker 14	32	7	153	2153	532	8.92%	26.32%
Non NA Totals	133	18	298	6965	1750	6.45%	
Total Both	199	28	439	23321	5881	2.86%	

APPENDIX C (CONTINUED)

Beam Width 1000, WordTransitionWeight -50							
N American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 1	5	1	22	1790	454	1.56%	4.85%
Speaker 2	6	4	14	1541	390	1.56%	4.36%
Speaker 3	3	1	11	1663	419	0.90%	2.86%
Speaker 4	11	2	28	1746	431	2.35%	8.58%
Speaker 5	2	0	21	1708	430	1.35%	5.12%
Speaker 6	1	3	18	1565	393	1.41%	3.56%
Speaker 7	4	0	11	1622	413	0.92%	2.18%
Speaker 8	5	0	8	1563	398	0.83%	2.76%
Speaker 9	5	0	4	1523	384	0.59%	1.82%
Speaker 10	2	0	1	1635	419	0.18%	0.72%
NA Totals	44	11	138	16356	4131	1.18%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	5	5	34	1549	395	2.84%	6.33%
Speaker 12	0	7	20	1705	429	1.58%	5.59%
Speaker 13	64	4	85	1558	394	9.82%	24.87%
Speaker 14	23	12	153	2153	532	8.73%	25.56%
Non NA Totals	92	28	292	6965	1750	5.92%	
Total Both	136	39	430	23321	5881	2.59%	

APPENDIX C (CONTINUED)

Beam Width 1000, WordTransitionWeight -100							
N American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 1	5	2	21	1790	454	1.56%	4.85%
Speaker 2	4	4	15	1541	390	1.49%	4.36%
Speaker 3	3	1	11	1663	419	0.90%	2.86%
Speaker 4	6	2	28	1746	431	2.06%	7.66%
Speaker 5	0	0	19	1708	430	1.11%	4.42%
Speaker 6	0	3	18	1565	393	1.34%	3.56%
Speaker 7	4	0	11	1622	413	0.92%	2.18%
Speaker 8	2	0	7	1563	398	0.58%	2.01%
Speaker 9	4	0	4	1523	384	0.53%	1.56%
Speaker 10	2	0	1	1635	419	0.18%	0.72%
NA Totals	30	12	135	16356	4131	1.08%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	4	7	39	1549	395	3.23%	6.84%
Speaker 12	0	12	19	1705	429	1.82%	6.06%
Speaker 13	43	9	78	1558	394	8.34%	21.83%
Speaker 14	14	12	153	2153	532	8.31%	24.81%
Non NA Totals	61	40	289	6965	1750	5.60%	
Total Both	91	52	424	23321	5881	2.43%	

APPENDIX C (CONTINUED)

	Beam Width 1000, WordTransitionWeight -150						
N American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 1	4	2	21	1790	454	1.51%	4.63%
Speaker 2	4	4	15	1541	390	1.49%	4.36%
Speaker 3	3	1	11	1663	419	0.90%	2.86%
Speaker 4	4	3	27	1746	431	1.95%	7.42%
Speaker 5	0	0	19	1708	430	1.11%	4.42%
Speaker 6	0	7	15	1565	393	1.41%	3.82%
Speaker 7	4	0	11	1622	413	0.92%	2.18%
Speaker 8	2	1	8	1563	398	0.70%	2.51%
Speaker 9	2	0	4	1523	384	0.39%	1.30%
Speaker 10	0	0	1	1635	419	0.06%	0.24%
NA Totals	23	18	132	16356	4131	1.06%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	4	7	37	1549	395	3.10%	7.09%
Speaker 12	0	12	18	1705	429	1.76%	5.83%
Speaker 13	33	17	73	1558	394	7.89%	20.30%
Speaker 14	7	24	146	2153	532	8.22%	24.25%
Non NA Totals	44	60	274	6965	1750	5.43%	
Total Both	67	78	406	23321	5881	2.36%	

APPENDIX C (CONTINUED)

Beam Width 1200, WordTransitionWeight 0							
N American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 1	7	1	23	1790	454	1.73%	5.29%
Speaker 2	8	4	14	1541	390	1.69%	4.62%
Speaker 3	5	1	11	1663	419	1.02%	3.34%
Speaker 4	15	1	30	1746	431	2.63%	9.74%
Speaker 5	5	0	21	1708	430	1.52%	5.81%
Speaker 6	4	0	16	1565	393	1.28%	4.33%
Speaker 7	6	0	11	1622	413	1.05%	2.42%
Speaker 8	6	0	10	1563	398	1.02%	3.02%
Speaker 9	6	0	3	1523	384	0.59%	1.82%
Speaker 10	4	0	1	1635	419	0.31%	1.19%
NA Totals	66	7	140	16356	4131	1.30%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	9	4	33	1549	395	2.97%	6.84%
Speaker 12	2	3	23	1705	429	1.64%	5.59%
Speaker 13	86	4	90	1558	394	11.55%	26.90%
Speaker 14	32	7	156	2153	532	9.06%	26.50%
Non NA Totals	129	18	302	6965	1750	6.45%	
Total Both	195	25	442	23321	5881	2.84%	

APPENDIX C (CONTINUED)

Beam Width 1200, WordTransitionWeight -50							
N American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 1	5	1	22	1790	454	1.56%	4.85%
Speaker 2	6	4	14	1541	390	1.56%	4.36%
Speaker 3	3	1	11	1663	419	0.90%	2.86%
Speaker 4	10	2	29	1746	431	2.35%	8.58%
Speaker 5	2	0	21	1708	430	1.35%	5.12%
Speaker 6	1	0	16	1565	393	1.09%	3.56%
Speaker 7	4	0	11	1622	413	0.92%	2.18%
Speaker 8	5	0	8	1563	398	0.83%	2.76%
Speaker 9	5	0	4	1523	384	0.59%	1.82%
Speaker 10	2	0	1	1635	419	0.18%	0.72%
NA Totals	43	8	137	16356	4131	1.15%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	5	4	33	1549	395	2.71%	6.33%
Speaker 12	0	7	20	1705	429	1.58%	5.59%
Speaker 13	63	4	84	1558	394	9.69%	24.87%
Speaker 14	23	12	155	2153	532	8.82%	25.56%
Non NA Totals	91	27	292	6965	1750	5.89%	
Total Both	134	35	429	23321	5881	2.56%	

APPENDIX C (CONTINUED)

Beam Width 1200, WordTransitionWeight -100							
N American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 1	5	2	21	1790	454	1.56%	4.85%
Speaker 2	4	4	16	1541	390	1.56%	4.62%
Speaker 3	3	1	11	1663	419	0.90%	2.86%
Speaker 4	6	2	28	1746	431	2.06%	7.66%
Speaker 5	0	0	19	1708	430	1.11%	4.42%
Speaker 6	0	0	16	1565	393	1.02%	3.56%
Speaker 7	4	0	11	1622	413	0.92%	2.18%
Speaker 8	2	0	7	1563	398	0.58%	2.01%
Speaker 9	4	0	4	1523	384	0.53%	1.56%
Speaker 10	2	0	1	1635	419	0.18%	0.72%
NA Totals	30	9	134	16356	4131	1.06%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	4	4	34	1549	395	2.71%	6.33%
Speaker 12	0	12	19	1705	429	1.82%	6.06%
Speaker 13	43	7	78	1558	394	8.22%	21.83%
Speaker 14	15	12	153	2153	532	8.36%	24.81%
Non NA Totals	62	35	284	6965	1750	5.47%	
Total Both	92	44	418	23321	5881	2.38%	

APPENDIX C (CONTINUED)

	Beam Width 1200, WordTransitionWeight -150						
N American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 1	4	2	21	1790	454	1.51%	4.63%
Speaker 2	4	4	16	1541	390	1.56%	4.62%
Speaker 3	3	1	11	1663	419	0.90%	2.86%
Speaker 4	4	3	27	1746	431	1.95%	7.42%
Speaker 5	0	0	19	1708	430	1.11%	4.42%
Speaker 6	0	1	16	1565	393	1.09%	3.82%
Speaker 7	4	0	11	1622	413	0.92%	2.18%
Speaker 8	2	1	8	1563	398	0.70%	2.51%
Speaker 9	2	0	4	1523	384	0.39%	1.30%
Speaker 10	0	0	1	1635	419	0.06%	0.24%
NA Totals	23	12	134	16356	4131	1.03%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	4	7	37	1549	395	3.10%	6.84%
Speaker 12	0	12	18	1705	429	1.76%	5.83%
Speaker 13	32	15	70	1558	394	7.51%	20.05%
Speaker 14	7	24	145	2153	532	8.17%	24.25%
Non NA Totals	43	58	270	6965	1750	5.33%	
Total Both	66	70	404	23321	5881	2.32%	

APPENDIX D

**GROUND CONDITION WORD AND SENTENCE ERROR RATES
BY PARAMETER COMBINATION**

Beam Width 600, WordTransitionWeight 0							
North American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 2	3	13	30	1553	393	2.96%	7.38%
Speaker 6	5	16	40	1570	398	3.89%	8.54%
Speaker 8	3	1	7	1585	401	0.69%	1.75%
Speaker 9	5	5	29	1607	407	2.43%	7.86%
NA Totals	16	35	106	6315	1599	2.49%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	13	14	48	1573	398	4.77%	9.55%
Speaker 13	59	26	198	1580	405	17.91%	32.59%
Non NA Totals	72	40	246	3153	803	11.35%	
Total Both	88	75	352	9468	2402	5.44%	

Beam Width 600, WordTransitionWeight -50							
North American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 2	2	14	27	1553	393	2.77%	6.87%
Speaker 6	4	16	42	1570	398	3.95%	8.79%
Speaker 8	3	1	7	1585	401	0.69%	1.75%
Speaker 9	1	6	28	1607	407	2.18%	7.13%
NA Totals	10	37	104	6315	1599	2.39%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	9	24	43	1573	398	4.83%	8.54%
Speaker 13	43	35	174	1580	405	15.95%	31.36%
Non NA Totals	52	59	217	3153	803	10.40%	
Total Both	62	96	321	9468	2402	5.06%	

APPENDIX D (CONTINUED)

Beam Width 600, WordTransitionWeight -100							
North American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 2	1	16	25	1553	393	2.70%	6.87%
Speaker 6	1	16	41	1570	398	3.69%	8.29%
Speaker 8	3	1	7	1585	401	0.69%	1.75%
Speaker 9	0	8	26	1607	407	2.12%	7.13%
NA Totals	5	41	99	6315	1599	2.30%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	6	23	46	1573	398	4.77%	8.79%
Speaker 13	32	60	159	1580	405	15.89%	30.62%
Non NA Totals	38	83	205	3153	803	10.34%	
Total Both	43	124	304	9468	2402	4.97%	

Beam Width 600, WordTransitionWeight -150							
North American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 2	1	20	26	1553	393	3.03%	7.89%
Speaker 6	1	19	40	1570	398	3.82%	8.54%
Speaker 8	3	2	7	1585	401	0.76%	2.00%
Speaker 9	0	8	27	1607	407	2.18%	7.37%
NA Totals	5	49	100	6315	1599	2.44%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	5	35	45	1573	398	5.40%	9.05%
Speaker 13	22	78	144	1580	405	15.44%	30.12%
Non NA Totals	27	113	189	3153	803	10.43%	
Total Both	32	162	289	9468	2402	5.10%	

APPENDIX D (CONTINUED)

Beam Width 800, WordTransitionWeight 0							
North American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 2	3	7	21	1553	393	2.00%	5.85%
Speaker 6	5	1	32	1570	398	2.42%	8.04%
Speaker 8	3	1	6	1585	401	0.63%	1.50%
Speaker 9	5	5	29	1607	407	2.43%	7.86%
NA Totals	16	14	88	6315	1599	1.87%	3.88%
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	10	6	28	1573	398	2.80%	6.78%
Speaker 13	51	15	176	1580	405	15.32%	31.60%
Non NA Totals	61	21	204	3153	803	9.07%	
Total Both	77	35	292	9468	2402	4.27%	

Beam Width 800, WordTransitionWeight -50							
North American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 2	2	10	21	1553	393	2.12%	6.11%
Speaker 6	4	1	32	1570	398	2.36%	8.04%
Speaker 8	3	1	6	1585	401	0.63%	1.50%
Speaker 9	1	6	28	1607	407	2.18%	7.13%
NA Totals	10	18	87	6315	1599	1.82%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	6	4	29	1573	398	2.48%	6.53%
Speaker 13	43	22	166	1580	405	14.62%	30.37%
Non NA Totals	49	26	195	3153	803	8.56%	
Total Both	59	44	282	9468	2402	4.07%	

APPENDIX D (CONTINUED)

Beam Width 800, WordTransitionWeight -100							
North American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 2	1	10	21	1553	393	2.06%	6.11%
Speaker 6	1	1	31	1570	398	2.10%	7.54%
Speaker 8	3	1	6	1585	401	0.63%	1.50%
Speaker 9	0	8	26	1607	407	2.12%	7.13%
NA Totals	5	20	84	6315	1599	1.73%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	4	6	27	1573	398	2.35%	6.03%
Speaker 13	28	38	151	1580	405	13.73%	29.14%
Non NA Totals	32	44	178	3153	803	8.06%	
Total Both	37	64	262	9468	2402	3.83%	

Beam Width 800, WordTransitionWeight -150							
North American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 2	1	12	21	1553	393	2.19%	6.62%
Speaker 6	1	1	30	1570	398	2.04%	7.29%
Speaker 8	3	2	6	1585	401	0.69%	1.75%
Speaker 9	0	8	27	1607	407	2.18%	7.37%
NA Totals	5	23	84	6315	1599	1.77%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	2	6	29	1573	398	2.35%	6.28%
Speaker 13	20	45	141	1580	405	13.04%	28.15%
Non NA Totals	22	51	170	3153	803	7.71%	
Total Both	27	74	254	9468	2402	3.75%	

APPENDIX D (CONTINUED)

Beam Width 1000, WordTransitionWeight 0							
North American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 2	3	1	22	1553	393	1.67%	5.85%
Speaker 6	5	3	30	1570	398	2.42%	8.04%
Speaker 8	0	1	5	1585	401	0.38%	1.25%
Speaker 9	5	5	29	1607	407	2.43%	7.86%
NA Totals	13	10	86	6315	1599	1.73%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	9	2	26	1573	398	2.35%	6.28%
Speaker 13	51	15	177	1580	405	15.38%	31.60%
Non NA Totals	60	17	203	3153	803	8.88%	
Total Both	73	27	289	9468	2402	4.11%	

Beam Width 1000, WordTransitionWeight -50							
North American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 2	2	2	21	1553	393	1.61%	5.60%
Speaker 6	4	1	32	1570	398	2.36%	8.04%
Speaker 8	0	1	5	1585	401	0.38%	1.25%
Speaker 9	1	6	28	1607	407	2.18%	7.13%
NA Totals	7	10	86	6315	1599	1.63%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	5	4	22	1573	398	1.97%	5.53%
Speaker 13	44	16	167	1580	405	14.37%	30.37%
Non NA Totals	49	20	189	3153	803	8.18%	
Total Both	56	30	275	9468	2402	3.81%	

APPENDIX D (CONTINUED)

Beam Width 1000, WordTransitionWeight -100							
North American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 2	1	2	21	1553	393	1.55%	5.60%
Speaker 6	1	1	31	1570	398	2.10%	7.54%
Speaker 8	0	1	5	1585	401	0.38%	1.25%
Speaker 9	0	8	26	1607	407	2.12%	7.13%
NA Totals	2	12	83	6315	1599	1.54%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	3	4	21	1573	398	1.78%	5.03%
Speaker 13	29	32	147	1580	405	13.16%	28.89%
Non NA Totals	32	36	168	3153	803	7.48%	
Total Both	34	48	251	9468	2402	3.52%	

Beam Width 1000, WordTransitionWeight -150							
North American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 2	1	4	21	1553	393	1.67%	6.11%
Speaker 6	1	1	30	1570	398	2.04%	7.29%
Speaker 8	0	2	5	1585	401	0.44%	1.50%
Speaker 9	0	8	27	1607	407	2.18%	7.37%
NA Totals	2	15	83	6315	1599	1.58%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	1	5	23	1573	398	1.84%	5.53%
Speaker 13	23	38	146	1580	405	13.10%	28.40%
Non NA Totals	24	43	169	3153	803	7.48%	
Total Both	26	58	252	9468	2402	3.55%	

APPENDIX D (CONTINUED)

Beam Width 1200, WordTransitionWeight 0							
North American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 2	3	1	21	1553	393	1.61%	5.60%
Speaker 6	6	1	32	1570	398	2.48%	8.04%
Speaker 8	0	1	5	1585	401	0.38%	1.25%
Speaker 9	5	5	29	1607	407	2.43%	7.86%
NA Totals	14	8	87	6315	1599	1.73%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	8	0	25	1573	398	2.10%	6.03%
Speaker 13	50	15	181	1580	405	15.57%	31.85%
Non NA Totals	58	15	206	3153	803	8.85%	
Total Both	72	23	293	9468	2402	4.10%	

Beam Width 1200, WordTransitionWeight -50							
North American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 2	2	2	21	1553	393	1.61%	5.60%
Speaker 6	5	1	32	1570	398	2.42%	8.04%
Speaker 8	0	1	5	1585	401	0.38%	1.25%
Speaker 9	1	6	28	1607	407	2.18%	7.13%
NA Totals	8	10	86	6315	1599	1.65%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	5	2	24	1573	398	1.97%	5.53%
Speaker 13	45	17	165	1580	405	14.37%	30.62%
Non NA Totals	50	19	189	3153	803	8.18%	
Total Both	58	29	275	9468	2402	3.82%	

APPENDIX D (CONTINUED)

	Beam Width 1200, WordTransitionWeight -100						
North American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 2	1	2	21	1553	393	1.55%	5.60%
Speaker 6	2	1	31	1570	398	2.17%	7.54%
Speaker 8	0	1	5	1585	401	0.38%	1.25%
Speaker 9	0	8	26	1607	407	2.12%	7.13%
NA Totals	3	12	83	6315	1599	1.55%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	3	4	21	1573	398	1.78%	5.03%
Speaker 13	28	29	152	1580	405	13.23%	28.89%
Non NA Totals	31	33	173	3153	803	7.52%	
Total Both	34	45	256	9468	2402	3.54%	

	Beam Width 1200, WordTransitionWeight -150						
North American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 2	1	4	21	1553	393	1.67%	6.11%
Speaker 6	1	1	30	1570	398	2.04%	7.29%
Speaker 8	0	2	5	1585	401	0.44%	1.50%
Speaker 9	0	8	27	1607	407	2.18%	7.37%
NA Totals	2	15	83	6315	1599	1.58%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	1	4	23	1573	398	1.78%	5.28%
Speaker 13	22	38	149	1580	405	13.23%	28.40%
Non NA Totals	23	42	172	3153	803	7.52%	
Total Both	25	57	255	9468	2402	3.56%	

APPENDIX E

**FLIGHT CONDITION WORD AND SENTENCE ERROR RATES
BY PARAMETER COMBINATION**

Beam Width 600, WordTransitionWeight 0							
N American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 2	1	3	23	534	176	5.06%	14.77%
Speaker 6	5	18	27	584	179	8.56%	16.76%
Speaker 8a	0	0	4	305	104	1.31%	3.85%
Speaker 8b	2	2	11	560	182	2.68%	6.59%
Speaker 9	2	9	9	395	139	5.06%	7.91%
NA Totals	10	32	74	2378	780	4.88%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	2	4	13	191	86	9.95%	12.79%
Speaker 13	4	7	16	191	84	14.14%	21.43%
Non NA Totals	6	11	29	382	170	12.04%	
Total Both	16	43	103	2760	950	5.87%	

Beam Width 600, WordTransitionWeight -50							
N American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 2	0	5	24	534	176	5.43%	14.77%
Speaker 6	3	19	26	584	179	8.22%	16.76%
Speaker 8a	0	0	4	305	104	1.31%	3.85%
Speaker 8b	0	3	10	560	182	2.32%	6.59%
Speaker 9	0	12	7	395	139	4.81%	7.19%
NA Totals	3	39	71	2378	780	4.75%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	0	7	10	191	86	8.90%	12.79%
Speaker 13	0	8	18	191	84	13.61%	22.62%
Non NA Totals	0	15	28	382	170	11.26%	
Total Both	3	54	99	2760	950	5.65%	

APPENDIX E (CONTINUED)

B Width 600, WordTransitionWeight -100							
N American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 2	0	5	24	534	176	5.43%	14.20%
Speaker 6	1	20	27	584	179	8.22%	16.20%
Speaker 8a	0	0	4	305	104	1.31%	3.85%
Speaker 8b	0	3	9	560	182	2.14%	6.04%
Speaker 9	0	12	7	395	139	4.81%	7.19%
NA Totals	1	40	71	2378	780	4.71%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	0	7	10	191	86	8.90%	12.79%
Speaker 13	0	11	18	191	84	15.18%	23.81%
Non NA Totals	0	18	28	382	170	12.04%	
Total Both	1	58	99	2760	950	5.72%	

B Width 600, WordTransitionWeight -150							
N American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 2	0	12	24	534	176	6.74%	15.91%
Speaker 6	0	31	25	584	179	9.59%	18.99%
Speaker 8a	0	0	4	305	104	1.31%	3.85%
Speaker 8b	0	3	9	560	182	2.14%	6.04%
Speaker 9	0	12	7	395	139	4.81%	7.19%
NA Totals	0	58	69	2378	780	5.34%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	0	10	8	191	86	9.42%	13.95%
Speaker 13	0	17	17	191	84	17.80%	25.00%
Non NA Totals	0	27	25	382	170	13.61%	
Total Both	0	85	94	2760	950	6.49%	

APPENDIX E (CONTINUED)

Beam Width 800, WordTransitionWeight 0							
N American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 2	1	3	23	534	176	5.06%	14.77%
Speaker 6	6	8	25	584	179	6.68%	15.64%
Speaker 8a	0	0	4	305	104	1.31%	3.85%
Speaker 8b	2	2	11	560	182	2.68%	6.59%
Speaker 9	4	3	8	395	139	3.80%	7.19%
NA Totals	13	16	71	2378	780	4.21%	8.01%
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	0	4	8	191	86	6.28%	11.63%
Speaker 13	0	5	13	191	84	9.42%	19.05%
Non NA Totals	0	9	21	382	170	7.85%	
Total Both	13	25	92	2760	950	4.71%	

Beam Width 800, WordTransitionWeight -50							
N American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 2	0	5	24	534	176	5.43%	14.77%
Speaker 6	4	9	23	584	179	6.16%	15.08%
Speaker 8a	0	0	4	305	104	1.31%	3.85%
Speaker 8b	0	3	10	560	182	2.32%	6.59%
Speaker 9	2	6	6	395	139	3.54%	6.47%
NA Totals	6	23	67	2378	780	4.04%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	0	4	8	191	86	6.28%	11.63%
Speaker 13	0	5	13	191	84	9.42%	19.05%
Non NA Totals	0	9	21	382	170	7.85%	
Total Both	6	32	88	2760	950	4.57%	

APPENDIX E (CONTINUED)

Beam Width 800, WordTransitionWeight -100							
N American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 2	0	5	24	534	176	5.43%	14.20%
Speaker 6	2	10	25	584	179	6.34%	15.08%
Speaker 8a	0	0	4	305	104	1.31%	3.85%
Speaker 8b	0	3	9	560	182	2.14%	6.04%
Speaker 9	1	9	6	395	139	4.05%	6.47%
NA Totals	3	27	68	2378	780	4.12%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	0	4	8	191	86	6.28%	11.63%
Speaker 13	0	10	13	191	84	12.04%	21.43%
Non NA Totals	0	14	21	382	170	9.16%	
Total Both	3	41	89	2760	950	4.82%	

Beam Width 800, WordTransitionWeight -150							
N American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 2	0	9	24	534	176	6.18%	15.34%
Speaker 6	0	14	23	584	179	6.34%	15.64%
Speaker 8a	0	0	4	305	104	1.31%	3.85%
Speaker 8b	0	3	9	560	182	2.14%	6.04%
Speaker 9	1	11	4	395	139	4.05%	6.47%
NA Totals	1	37	64	2378	780	4.29%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	0	4	9	191	86	6.81%	12.79%
Speaker 13	0	13	12	191	84	13.09%	21.43%
Non NA Totals	0	17	21	382	170	9.95%	
Total Both	1	54	85	2760	950	5.07%	

APPENDIX E (CONTINUED)

Beam Width 1000, WordTransitionWeight 0							
N American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 2	1	3	23	534	176	5.06%	14.77%
Speaker 6	6	8	25	584	179	6.68%	15.64%
Speaker 8a	0	0	4	305	104	1.31%	3.85%
Speaker 8b	2	2	11	560	182	2.68%	6.59%
Speaker 9	3	3	9	395	139	3.80%	7.19%
NA Totals	12	16	72	2378	780	4.21%	8.01%
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	0	4	8	191	86	6.28%	11.63%
Speaker 13	0	5	13	191	84	9.42%	19.05%
Non NA Totals	0	9	21	382	170	7.85%	
Total Both	12	25	93	2760	950	4.71%	

Beam Width 1000, WordTransitionWeight -50							
N American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 2	0	5	24	534	176	5.43%	14.77%
Speaker 6	4	9	23	584	179	6.16%	15.08%
Speaker 8a	0	0	4	305	104	1.31%	3.85%
Speaker 8b	0	3	10	560	182	2.32%	6.59%
Speaker 9	1	3	9	395	139	3.29%	6.47%
NA Totals	5	20	70	2378	780	3.99%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	0	4	8	191	86	6.28%	11.63%
Speaker 13	0	5	13	191	84	9.42%	19.05%
Non NA Totals	0	9	21	382	170	7.85%	
Total Both	5	29	91	2760	950	4.53%	

APPENDIX E (CONTINUED)

Beam Width 1000, WordTransitionWeight -100							
N American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 2	0	5	24	534	176	5.43%	14.20%
Speaker 6	2	10	25	584	179	6.34%	15.08%
Speaker 8a	0	0	4	305	104	1.31%	3.85%
Speaker 8b	0	3	9	560	182	2.14%	6.04%
Speaker 9	1	3	9	395	139	3.29%	6.47%
NA Totals	3	21	71	2378	780	3.99%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	0	4	8	191	86	6.28%	11.63%
Speaker 13	0	10	13	191	84	12.04%	21.43%
Non NA Totals	0	14	21	382	170	9.16%	
Total Both	3	35	92	2760	950	4.71%	

Beam Width 1000, WordTransitionWeight -150							
N American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 2	0	9	24	534	176	6.18%	15.34%
Speaker 6	0	14	23	584	179	6.34%	15.64%
Speaker 8a	0	0	4	305	104	1.31%	3.85%
Speaker 8b	0	3	9	560	182	2.14%	6.04%
Speaker 9	1	5	7	395	139	3.29%	6.47%
NA Totals	1	31	67	2378	780	4.16%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	0	4	9	191	86	6.81%	12.79%
Speaker 13	0	13	12	191	84	13.09%	21.43%
Non NA Totals	0	17	21	382	170	9.95%	
Total Both	1	48	88	2760	950	4.96%	

APPENDIX E (CONTINUED)

Beam Width 1200, WordTransitionWeight 0							
N American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 2	1	3	23	534	176	5.06%	14.77%
Speaker 6	6	8	25	584	179	6.68%	15.64%
Speaker 8a	0	0	4	305	104	1.31%	3.85%
Speaker 8b	2	2	11	560	182	2.68%	6.59%
Speaker 9	3	3	8	395	139	3.54%	7.19%
NA Totals	12	16	71	2378	780	4.16%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	0	4	8	191	86	6.28%	11.63%
Speaker 13	0	5	12	191	84	8.90%	17.86%
Non NA Totals	0	9	20	382	170	7.59%	
Total Both	12	25	91	2760	950	4.64%	

Beam Width 1200, WordTransitionWeight -50							
N American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 2	0	5	24	534	176	5.43%	14.77%
Speaker 6	3	9	25	584	179	6.34%	15.08%
Speaker 8a	0	0	4	305	104	1.31%	3.85%
Speaker 8b	0	3	10	560	182	2.32%	6.59%
Speaker 9	2	3	8	395	139	3.29%	6.47%
NA Totals	5	20	71	2378	780	4.04%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	0	4	8	191	86	6.28%	11.63%
Speaker 13	0	5	13	191	84	9.42%	19.05%
Non NA Totals	0	9	21	382	170	7.85%	
Total Both	5	29	92	2760	950	4.57%	

APPENDIX E (CONTINUED)

Beam Width 1200, WordTransitionWeight -100							
N American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 2	0	5	24	534	176	5.43%	14.20%
Speaker 6	2	10	25	584	179	6.34%	15.08%
Speaker 8a	0	0	4	305	104	1.31%	3.85%
Speaker 8b	0	3	9	560	182	2.14%	6.04%
Speaker 9	1	4	9	395	139	3.54%	6.47%
NA Totals	3	22	71	2378	780	4.04%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	0	4	8	191	86	6.28%	11.63%
Speaker 13	0	10	13	191	84	12.04%	21.43%
Non NA Totals	0	14	21	382	170	9.16%	
Total Both	3	36	92	2760	950	4.75%	

Beam Width 1200, WordTransitionWeight -150							
N American	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 2	0	9	24	534	176	6.18%	15.34%
Speaker 6	0	14	23	584	179	6.34%	15.64%
Speaker 8a	0	0	4	305	104	1.31%	3.85%
Speaker 8b	0	3	9	560	182	2.14%	6.04%
Speaker 9	1	6	7	395	139	3.54%	6.47%
NA Totals	1	32	67	2378	780	4.21%	
Non-NA	Ins	Del	Sub	Words	Sent	Wer	Ser
Speaker 11	0	4	9	191	86	6.81%	12.79%
Speaker 13	0	13	12	191	84	13.09%	21.43%
Non NA Totals	0	17	21	382	170	9.95%	
Total Both	1	49	88	2760	950	5.00%	