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# Automatic Speech Semantic Recognition and Verification in Air Traffic Control



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Corporation, Inc.

Presented to: 32<sup>nd</sup> Digital Avionics Systems Conference

By: Daniel R Johnson, Dr. Val Nenov

Date: October 9, 2013

# Introduction

- **FAA Human Factors Branch**
  - Optimize human-system performance
  - Measure human performance
    - human-in-the-loop simulation
    - field data
- **Brainventions Corporation, Inc**
  - Based in Los Angeles, California since 1992
  - Software and electronics research, development and commercialization
  - Research in clinical information systems, clinical trials, imaging (PET, MR), and ANN, AI, NLP, ASR



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# Introduction

- **Cooperative Research and Development Agreement (12-CRDA-0287)**
  - Investigate the current state of the art in ASSR
  - Measure its accuracy
  - Explore the potential applications in Air Traffic Control



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# Overview

- **Common uses of ASR in ATC**
  - Simulator training and pseudo pilots
  - Offline transcription for research and forensics
  - Voice entry of waypoints in FlightDeck by VoiceFlight
  - Controller workload estimations
- **ASR approaches in ATC**
  - Using and training Commercial Off The Shelf engines
  - Building dedicated recognizers from scratch and domain specific acoustic and language models



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# Brainventions System

- **ValsVox**
  - Web-based Software as a Service (SaaS) application for real-time speech recognition and semantic parsing of ATC voice communications
- **Cloud-based client/server architecture**
  - Microsoft Speech Server
  - ValsVox Application (.Net)
- **Grammars**
  - ICAO Standard Phraseology, FAA 7110.65
  - Conversational plus FAA sample sets



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# DEMO



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# Data Collection

- **Facility**
  - Research and Development Human Factors Laboratory (RDHFL)
  - Designed to conduct real-time, human-in-the-loop simulations and Human Factors research
- **Simulated ATC Environment**
  - The Distributed Environment for Simulation, Rapid Engineering and Experimentation (DESIREE)
- **Aircraft dynamics and pseudo-pilot stations**
  - The Target Generation Facility (TGF)



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# Data Collection

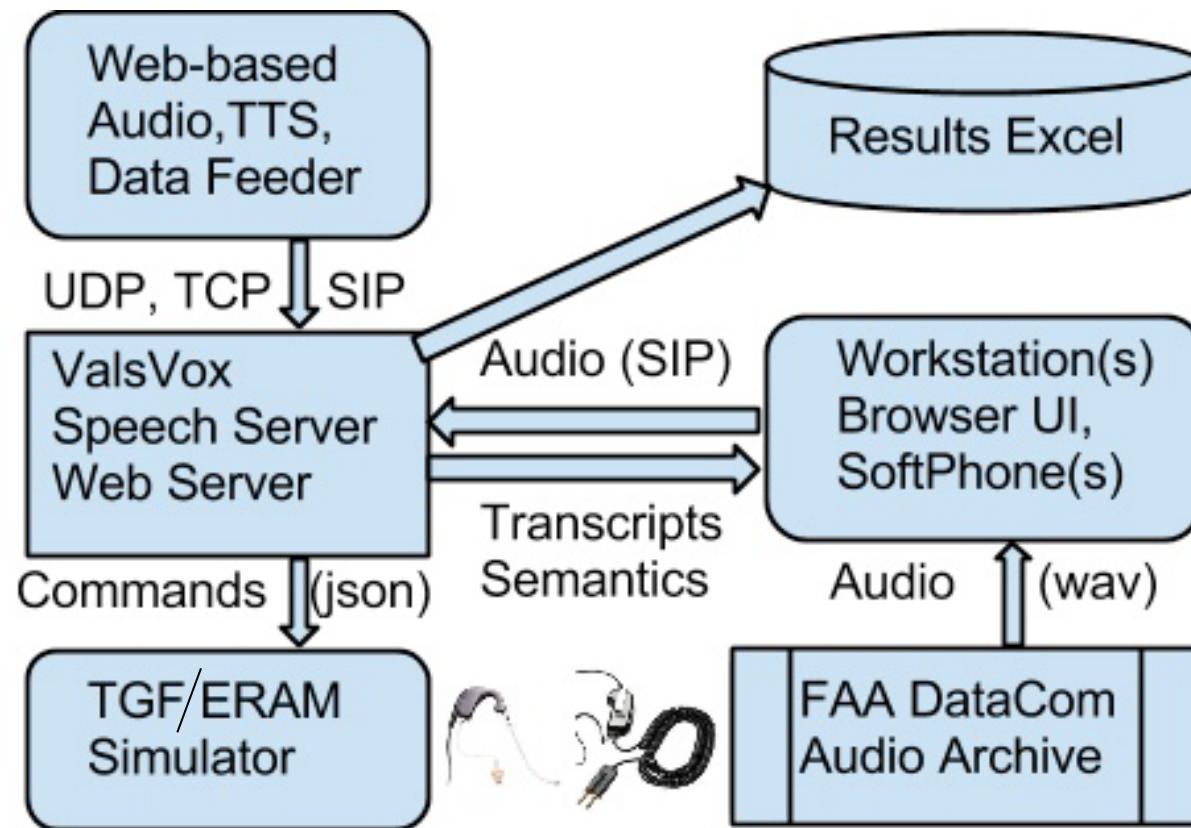
- **Audio source**
  - Previously recorded study with available transcripts
  - DataComm HITL (2009)
  - Genera Center fictional airspace
  - 10 runs selected
    - each approximate 50 mins (500 total mins)
- **Ptt Player**
  - Used to replay scenario with speaker position identification



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# System Architecture



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# Metrics

<b>False Positive Rate (FPR)</b>	Ratio of false positives to the total number of real events
<b>Event Detection Rate (EDR)</b>	Ratio of correctly detected events to the sum of total real events and false positives
<b>Event Detection Rate without call sign (EDRnc)</b>	EDR with the exception that the call sign need not be correct
<b>Event Correct Rate (ECR)</b>	Ratio of correctly detected events with all details correct and the sum of total real events and false positives
<b>Event Correct Rate without call sign (ECRnc)</b>	EDR with the exception that the call sign need not be correct



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# Results

## Semantic Metrics

	FPR	EDR	EDRnc	ECR	ECRnc
Avg (%)	5.99	40.62	83.34	35.61	74.47
StdDev	2.20	11.74	3.79	11.35	5.64

	Altitude	Heading	Speed	Fix	Freq
Proportion	25	3	6	33	33
Avg EDRnc (%)	85.31	78.33	62.06	72.20	96.44
StdDev	13.07	31.48	17.40	12.40	3.08

## Word Error Rate

	Corr	Sub	Del	Ins	Err
Avg	68.8	16.2	15.1	2.9	34.2
StdDev	4.2	2.8	2.2	.8	4.2



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# Discussion

- **Recognition of call signs**
  - First concept controller utterances
  - Phonetic distortion, PTT truncation
  - Weighted towards training
- **Loose numbers disambiguation**
  - Cross-utterance pattern matching
- **ASSR in Simulation**
  - Simulation Pilot VUI



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# Conclusion

- **ValsVox vs other ATC ASR Systems**
  - Small training set (hours of audio, hundreds transcriptions)
  - Generic acoustic model
- **Future Work**
  - Develop ATC specific acoustic model
  - Perform grammar enhancements
  - Decrease non-recognitions
  - Investigate statistical variation in semantic metrics



# Authors



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