HAAWAII
Highly Advanced Air Traffic Controller Workstation with Artificial Intelligence Integration

Overview of the HAAWAII-Project

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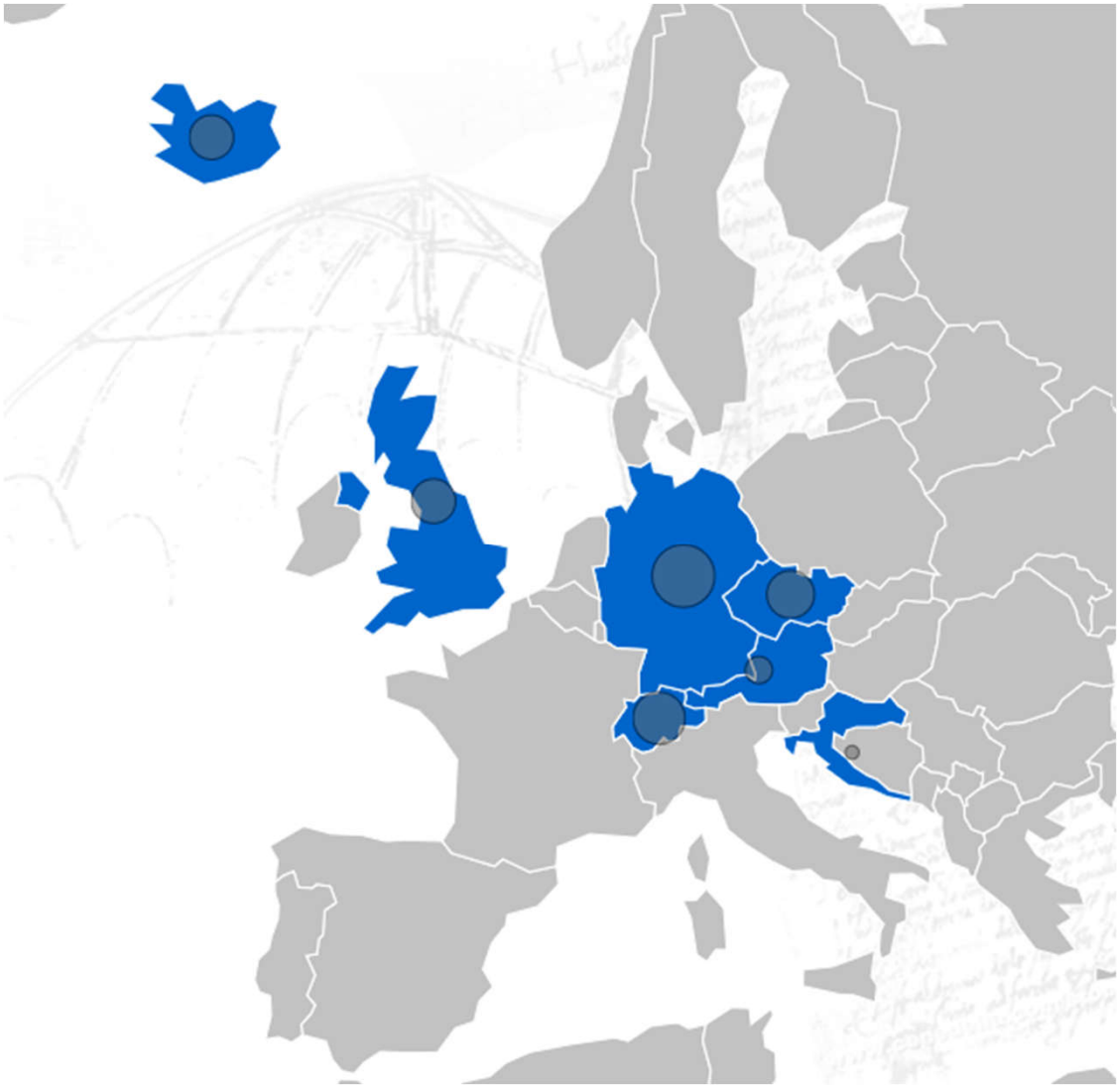
SESAR JOINT UNDERTAKING

Founding Members
EUROPEAN UNION EUROCONTROL

The Partners



- DLR (Germany)
- BUT (Czech Republic)
- Idiap (Switzerland)
- Austro Control
- Isavia ANS (Iceland)
- NATS (UK)
- Croatia Control

Highly Advanced Air Traffic Controller Workstation with Artificial Intelligence Integration

Objectives of HAAWAII

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Objectives

- **Obj1:** Exploiting massive amounts of unlabelled voice data through new **unsupervised learning algorithms**
- **Obj2:** Automatic recognition of the controller and **pilot** communication for London TMA and Isavia enroute airspace
- **Obj3:** Automatic detection of pilot readback errors
- **Obj4:** Pre-filling of radar labels and CPDLC messaging
- **Obj5:** Improve ATCo staffing, rostering and flow management planning and reaction for the London TMA by measuring and anticipating the workload from voice communication
- **Obj6:** Data privacy issues are sufficiently considered, i.e. minimum amount of anonymized data stored

Objectives and KPIs resp. target values

- **Obj1:** Exploiting massive amounts of unlabelled voice data through new **unsupervised learning algorithms**

Key performance indicators (KPI)	Baseline from MALORCA	Target
KPI 1.1: Amount of voice and surveillance data exploited	150 hours	Approx. 10'000 hours
KPI 1.2: Improvement of automatic speech recognition models through the deployment of unlabelled data	Only labelled data was used	10% absolute; 25% relative
Deliverables // Associated anticipated risks	D2.2, D2.3, D3.4, D3.5 // RI2.2 to RI2.5	
Status:	**> 1000 hours**	

Objectives and KPIs resp. target values

- **Obj2:** Automatic recognition of the controller and **pilot** communication for London TMA and Isavia enroute airspace

Key performance indicators	Baseline from MALORCA	Target
KPI 2.1: average command recognition rate, see [Kleinert18]	92% / 85%	> 85% for ATCos; > 75% for pilots
KPI 2.2: average command recognition error rate, see [Kleinert18]	0.6% / 3.2%	<3% for ATCos; <5% for pilots
KPI 2.3: average callsign recognition rate	98.5 / 95%	> 95% for ATCos; > 90% for pilots
Deliverables // Associated anticipated risks	D3.4, D3.5, D5.3 // RI2.2 to RI2.5	
Status: NATS	84.5% ATCOs; 78.8% for pilots (command recognition rate) 10.1% ATCOs, 13.3% for pilots (command recognition **error** rate) 91.2% ATCOs, 92.1% for pilots (callsign recognition rate)	

Objectives and KPIs resp. target values

- **Obj3:** Automatic detection of pilot readback errors

Key performance indicators	Baseline	Target
KPI 3.1: Read-back error detection rate	not established	at least 50%
KPI 3.2: False alarm rate for readback error detection	not established	below 10%
Deliverables // Associated anticipated risks	D5.1, D5.2 // RI2.1, RI2.8	
Status:	**Just started**	

Objectives and KPIs resp. target values

- **Obj4:** Pre-filling of radar labels and CPDLC messaging

Key performance indicators	Baseline	Target
KPI 4.1: Accuracy on pre-filled radar label contents (with command type and command value) and CPDLC messages ready to be sent to on board systems	70% for Prague in PJ.16-04 and 55% for Vienna in PJ.16-04	90%
KPI 4.2: Requirements for system integration	not available	defined
Deliverables // Associated anticipated risks	D1.1, D1.2, D6.2, D6.3 // RI2.5 to RI2.7	
Status:	**Just started**	

Challenges of HAAWAII

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8:30 min

Challenges

From Proposal

- „Real“ Airspace: London TMA
- Brexit
- Recognition of ATCo’s and pilot’s voice
- Readback Error Detection
- Realtime performance
- Data Privacy Issues, Legal Issues from EU and from Iceland and from UK and Switzerland
- Recognition in the ops room and not in lab environment

New Challenges

- COVID-19
  - Virtual Working together, no team building “at a beer”
  - Traffic in real airspace is less than in Vienna for MALORCA project
- Splitting of continuous wave stream
- Pilot/ATCo classification

From an utterance to the HMI

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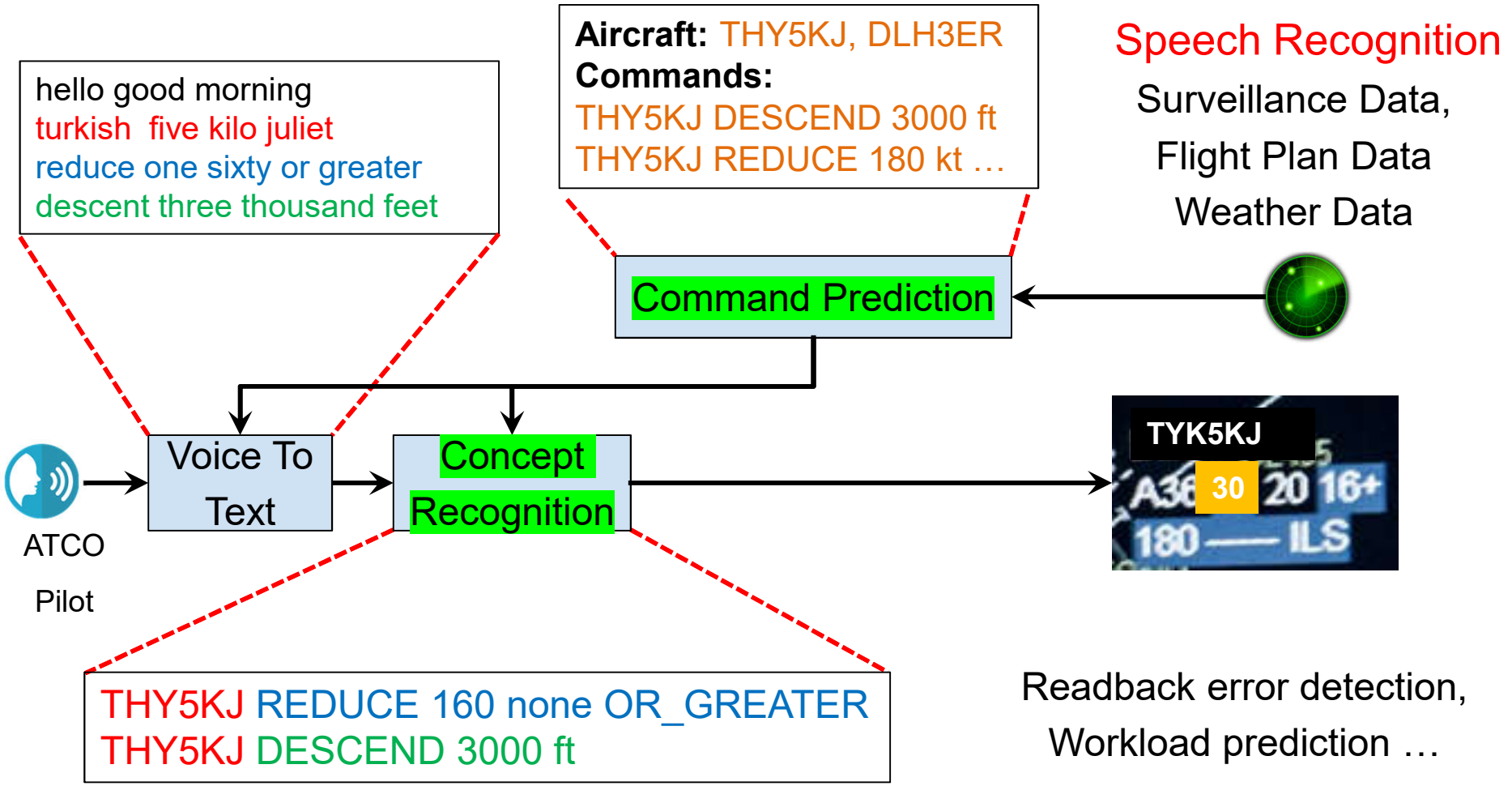
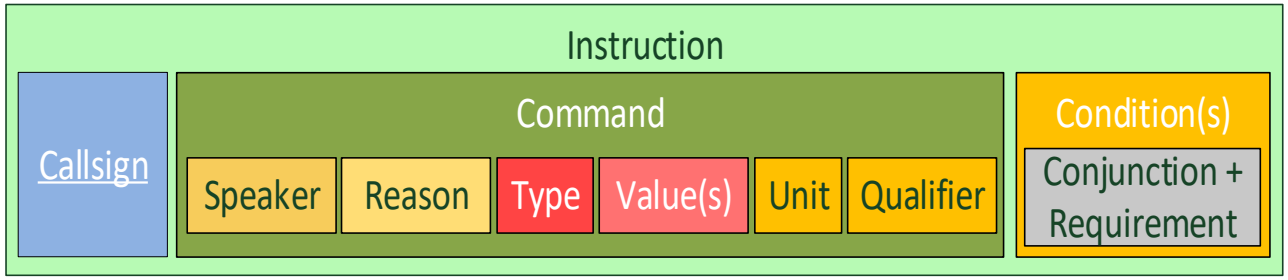
HAAWAII Applications

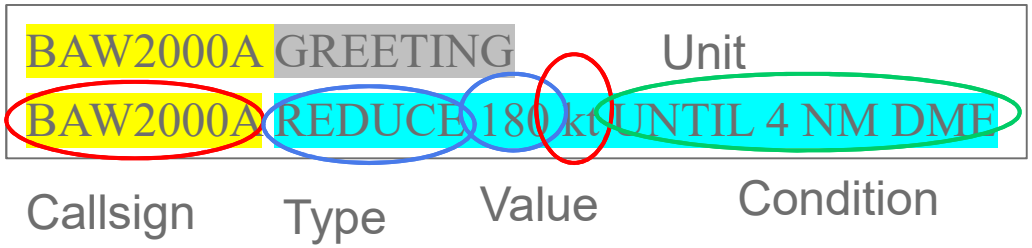


From Words to ATC Concepts



good morning speed bird two zero zero zero alfa
reduce one eight zero knots until DME four miles

Speed Recognition is NOT Speech Understanding
-Alan Turing 1952



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From Words to ATC Concepts

BAW2000A REDUCE 180 kt UNTIL 4 NM DME

A command is correctly recognized, IFF both

- the callsign,
- the type,
- the second type
- the value,
- the unit,
- the qualifier,
- the condition,
- the speaker, (pilot, ATCO) and
- the reason (command, readback, request, reporting)

are correct!!!

Otherwise it is a command recognition error or a rejection.

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Command Recognition Errors

BAW2000A REDUCE 180 kt UNTIL 4 NM DME

BAW2000A REDUCE 170 kt UNTIL 4 NM DME (error)

NO_CALLSIGN REDUCE 170 kt UNTIL 4 NM DME (rejection)

BAW2000A NO_CONCEPT (rejection)

BAW2000A REDUCE 170 kt UNTIL 5 NM DME (one error)

BAW2000A REDUCE 180 kt UNTIL 5 NM DME (error)

BAW2000A REDUCE 180 kt OR_ABOVE UNTIL 4 NM DME (one error)

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Command Recognition Errors

Said:

BAW2000A REDUCE 180 kt UNTIL 4 NM DME

Recognized:

BAW2000A REDUCE 180 kt UNTIL 4 NM DME

BAW2000A GREETING

-	one recognition	Cmd Recognition Rate:	100%
-	one error	Cmd Recogn. Error Rate:	100%

→ Recognition rate plus Error Rate plus Rejection Rate >= 100%

HAAWAII Applications

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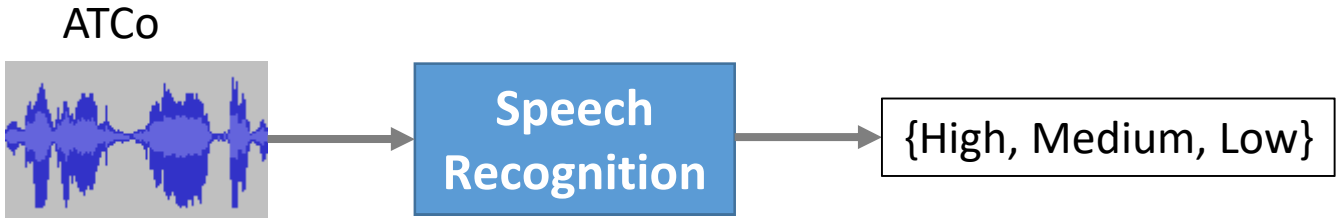
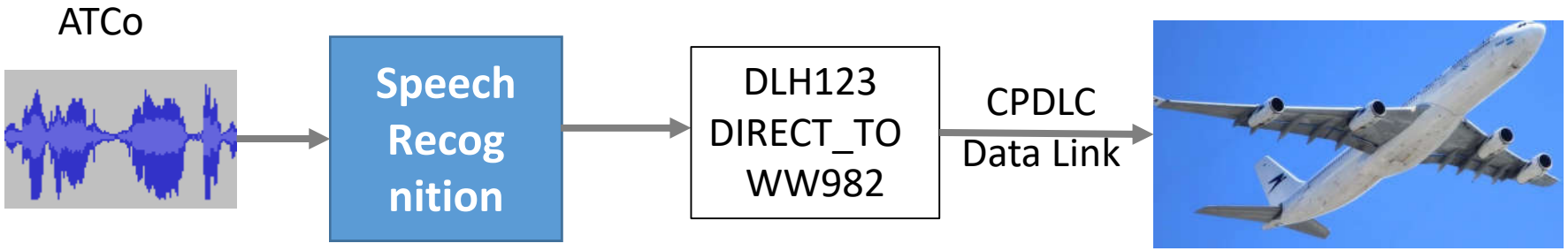
HAAWAII Applications

- Workload Estimation / Prediction
- Integration of ASR with CPDLC
- Callsign Highlighting
- Pre-Filling Radar Labels / Command Extraction
- Readback Error Detection

Objective ATCo Workload Estimation



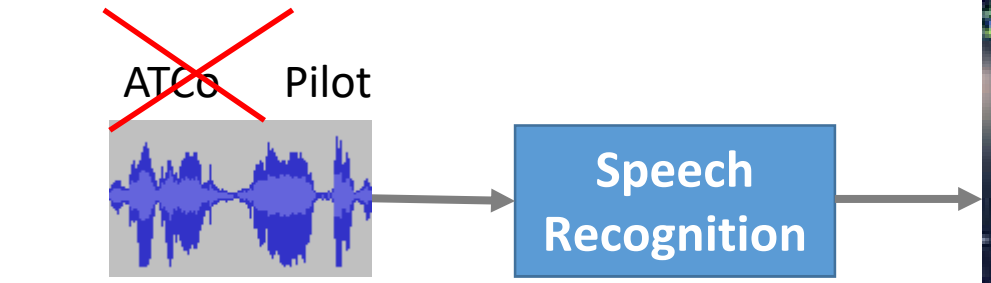
Integration of ASR and CPDLC



lufthansa one two three proceed to whiskey whiskey nine eight two

CPDLC: Controller –Pilot Data Link Communication

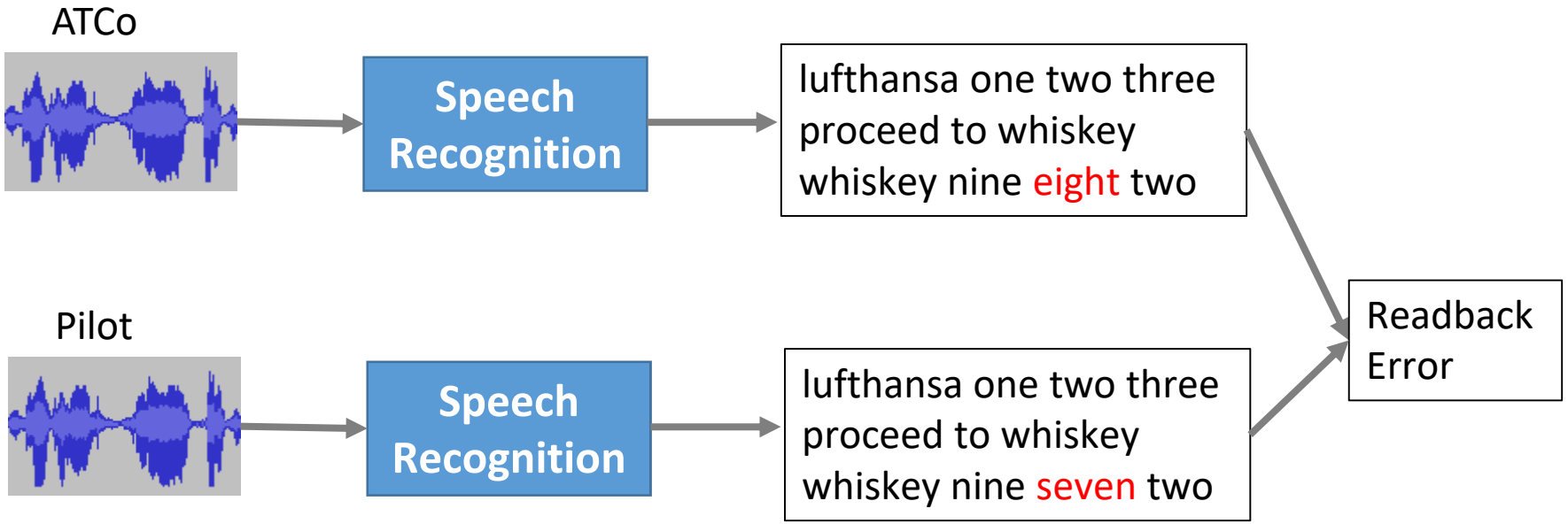
Callsign Highlighting & Pre-Filling Radar Labels



lufthansa one two three
proceed to whiskey
whiskey nine eight two

ATCo Callsign Highlighting is “easy”.
The challenge and benefits is for pilot’s voice.

Readback Error Detection (simple)



The challenge is, however, much bigger
as the next presentations and the two workshops will address.

Readback Error Detection (Real)

Speed Recognition is NOT
Speech Understanding
Alan Turing 1952

ATCo

good morning speed bird two zero zero zero alfa
reduce one eight zero knots until DME four miles
contact tower
on frequency one one eight decimal seven zero zero

Readback Error?

Pilot

one eighty to DME four
tower one eighteen seven
speed bird two thousand alfa

- Word sequences are different
- Not each command needs a readback
- Sequence of command can be different
- “nineteen” and “one one nine” are the same
- “thousand” and “zero zero zero” are the same

Requirements

R_{both} / E_{both}	0.1%	0.2%	0.3%	0.4%	0.5%	0.6%
98%	4.8%	9.1%	13.0%	16.7%	20.0%	23.1%
95%	4.9%	9.4%	13.4%	17.1%	20.5%	23.6%
90%	5.2%	9.8%	14.0%	17.9%	21.4%	24.6%
85%	5.5%	10.3%	14.7%	18.7%	22.4%	25.7%
80%	5.8%	10.9%	15.5%	19.7%	23.4%	26.9%
75%	6.1%	11.6%	16.4%	20.7%	24.6%	28.2%
70%	6.5%	12.3%	17.4%	21.9%	25.9%	29.6%
60%	7.6%	14.0%	19.7%	24.6%	29.0%	32.9%
50%	8.9%	16.4%	22.7%	28.2%	32.9%	37.0%
40%	10.9%	19.7%	26.9%	32.9%	38.0%	42.4%
20%	19.7%	32.9%	42.4%	49.5%	55.1%	59.5%
10%	32.9%	49.5%	59.5%	66.2%	71.0%	74.6%

- Detection Rate > 50%
- False Alarm Rate < 10%

- 2% of Commands contain Readback errors (seldom events)

→ Recognition Rates >50% on Command Level

→ Recognition Error Rates < 0.2% on Command Level

Overview of the following two days
The Presentations

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The presentations

Jules Harfmann Teo Simiganoschi: Speech Recognition in the ATC environment for Human Performance Evaluation, Radar Label Maintenance, Readback Error Detection

- Details the main applications and motivates some workshops

Petr Motlicek: Looking behind the scenes of machine learning and AI - technical details of automatic speech recognition applied in ATC and first results

- Helicopter view on training on acoustic, language and pronunciation models

Claudia Cevenini (Uni Bologna) Legal challenges of Using Speech Data

Legal challenges when dealing with speech data. New directives/regulations from EC will also be mentioned.

Olivia Nunez: SJU expectations on ASR research

Conclusions

- You need to adapt ASR to your local environment, but this can be done automatically, provided you have training data.
- Pilot recognition is possible.
- Readback error detection has just started.

- Voice communications is the most efficient way for human-human communication.
- How to integrate Automatic Speech Recognition and Understanding into the ATC environment?

- The questions is not any more, if ASR performance is good enough.
- The question is, how to benefit already now from available performance.
- The glass is half full, and not half empty. (It is even fuller than 50%)!

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Thank you very much for staying in this virtual conference

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