Introduction

Four different working groups discussed which use cases of ASRU are the low hanging fruits.

- Working group 1 consists of 8 people. All attendance were in Braunschweig
- Working group 2 consists of 9 people. All attendance were in Braunschweig
- Working group 3 consists of 5 people. Some participated remotely some on-site.
- Working group 4 consists of 5 people; all of them except the moderator participated via Webex.

The application of Automatic Speech Recognition and Understanding (ASRU) can address applications

- in the operational environment,
- in the training environment
- In the ATC administration environment (post processing).

ASRU, i.e. Automatic Speech Recognition and Understanding, offers a wide range of potential applications in Air Traffic Management. However, technical feasibility alone does not justify implementation.

The objective was the working groups was to identify applications that combine measurable operational benefits without taking into consideration aspects like acceptable implementation costs, technical complexity and certification effort, these will be handled by other Working groups.

This working group should not only provide a list of possible applications. The crucial question is rather: Which ASRU applications should air traffic control organisations and industry primarily develop further, because, based on our assumption, those might be relatively easy to be implemented by offering measurable benefits.

For example, highlighting a call sign can help the air traffic controller without immediately altering a flight plan or clearance. In contrast, if an authorized flight level were to be automatically altered in the electronic flight plan, the potential consequences of misinterpretation would be far more serious; however, we shall not consider this here.

Does ASRU really have to carry out everything independently, or where can we combine ASRU results with ATCO support and with other assistant systems without losing the expected benefits?

Not every application necessarily has to take place at the air traffic controller's operational workstation. There could be particularly attractive opportunities, especially outside the immediate context of flight operations. Based on this some different levels could / should be considered:

- Level 1: only information, ASRU identifies and visualizes relevant information without altering operational data.
- Level 2: proposal, ASRU is preparing entry information for the ATCO in the operational system, however, before making this entry information ready for operational use, the ATCO has to confirm it.
- Level 3: automated action, ASRU modifies data or triggers functions without requiring separate confirmation.

Results of the Working Groups

Working Group 1

The first working group agreed on the following table as possible input for further discussions:

Application	Explanation	Benefits (low / medium / high)	Priority of implementation
Background transcribing	Gathering data for traffic count, incident investigation, analysis and optimization	high	1 = high
Training	Transricpt of training runs, debriefing searchable, autoc-oach	high	2 = medium
Readback Monitoring	Added safety layer	high	3 = high

Working Group 2

The second group agreed on the following table:

Application	Explanation	Benefits (low / medium / high)	Priority of implementation
Taxi routing recognition	Transform cleared taxi routings into systems	high	1 = high
Support safety investigation	Providing the transcripts by ASRU saves 85% time.	Medium to high	1 = high
Situational awareness in supervision	Monitoring sector & associated ATCO load for supervisors	High	1 = high

Working Group 3

The third Working Group agreed on the main take-away that for safety we need certification, so use cases that have a safety component are not low-hanging fruit use-cases. With this in mind the following low hanging fruits were suggested:

- Supporting simulation pilots or replacing them for ATCo training
- Keyword spotting/recognize special instructions (break-break / go-around) and show the result e.g. at the supervisor position
- Post analysis including transcription of ATCO-pilot communication
- Creating large ATC data basis for training AI-models. Currently the ATC data bases only indirectly consider the work of the ATCO, because they are restricted to radar tracks. Considering also the transcribed controller utterances would include the direct work of the controllers.

Independent of the implementation effort and whether the application is a low hanging fruit the working group considers the following ASRU applications:

For the ATCO the following use cases have been considered in an operational environment:

- Auto Callsign highlight of incoming calls from the pilots
- Auto input (e.g. simple inputs/ releases)

- Detect readback errors
- Detecting Conflicting input errors
- Detecting Conflicting clearances
- Stress indicators from prosodic features[1]

All above could touch safety and might require certification effort. Therefore, these applications are not really considered low-hanging fruits, but mentioned anyway.

In a training environment the following support for the simulation pilot was identified:

- Auto input for workload reduction of spoken ATCO instructions into the simulator
- Reducing required STO's means more training is possible with limited resources
- Professional simulation pilots are very efficient compared to non-professional simulation pilots and benefit less from automation (due to shortcuts, efficient keyboard use and pre-emptive behaviour etc.)

Note: Integration into the simulator environment may be easier than integration in an operational system, but still needs manufacturer (of sim system) involvement

ATC administration environment (post-operation/offline). Although the following use cases touch safety, they do not require a certification, because they are performed afterwards and not in the ops room:

For safety applications:

- Transcription support with KPI (indicators)
- Stress indicators from prosodic features
- Recognize special instructions (break-break / go-around)
- Stress indicators from prosodic features

Large datasets / data analytics:

- Do data analytics on months of transcribed RT data for different frequencies, to do statistics, finding anomalies of finding unknown correlations.
- Post-analysis for research/training

Working Group 4

The fourth Working Group agreed on the following seven use cases across HMI support, safety/monitoring and analytics were identified; civil and military as well as operational

[1] Which is not an application of ASRU, but can be derived from the voice signal.

and laboratory applications were considered. The results including ranking are shown in the following table.

Use Case	Implementation Effort	Integration Effort	Certification Effort	Total Effort (lower = better)
ATCO conformance to ICAO phraseology (offline)	2	2	2	6
Pilot transcription with probability and assessment of conformance to phraseology (live)	3	3	4	10
Readback error detection (live)	4	3	4.5	11.5
Measure workload of ATCO after transcription (after the fact statistics)	3	2	1	6
Display transcripts to ATCO to reduce workload	3	3	4	10
Automate inputs to the ATM system	4	4	5	13
Automatically send CPDLC messages	4	4	5	13

Each use case was rated from 1 (low) to 5 (high) for implementation, integration and certification effort; lower total effort ranks better.

The use cases ” ATCO conformance to ICAO phraseology” and “Measure workload of ATCO after transcription”.

The use cases “Automate inputs to the ATM system” and “Automatically send CPDLC messages“ have the highest effort, mainly due to integration and certification.

The different considered use cases mean:

- ATCO Conformance to ICAO Phraseology (offline): Checks recorded controller transmissions against ICAO phraseology.
- **Pilot Transcription and Phraseology Conformance (live):** Transcribes pilot transmissions live with confidence scores and phraseology assessment.
- **Readback Error Detection (live):** Detects readback errors in controller–pilot communication in real time.
- **ATCO Workload Measurement from Transcripts (after the fact):** Derives controller workload indicators from transcripts.
- **Transcript Display to Reduce ATCO Workload:** Shows live transcripts at the controller working position.
- **Automated Inputs to the ATM System:** Converts recognized voice instructions into structured ATM inputs.
- **Automatic CPDLC Messaging:** Generates and sends CPDLC messages from voice instructions.

The following challenges were identified for future work:

- Live applications require more integration and certification effort than offline analytics.
- Automated ATM inputs and CPDLC messaging have the highest certification burden.
- Benefits of live transcript display still need operational validation with controllers.