SignON

Sign Language Translation Mobile Application and Open Communications Framework

Deliverable D2.7 -

Final Release of the SignON Communication Mobile Application

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1.0	MAC	27/09/2023	Review, inputs and approval from all Partners
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0.1	MAC	06/07/2023	Initial draft based on D1.10, D2.4 & D2.6 and further research.

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Approval Procedure

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V1.0	D2.7	Ed Keane	MAC	01/09/2023
V1.0	D2.7	Josep Blat	UPF	05/09/2023
V1.0	D2.7	Anthony Ventresque	TCD	25/09/2023
V1.0	D2.7	Karim Dahdah	VRT	06/09/2023
V1.0	D2.7	Mathieu De Coster	UGent	20/09/2023
V1.0	D2.7	Jorn Rijckaert	VGTC	01/09/2023
V1.0	D2.7	Henk van den Heuvel	RU	01/09/2023
V1.0	D2.7	Catia Cucchiarini	TaalUnie (NTU)	25/09/2023
V1.0	D2.7	Bram Vanroy	KU Leuven	01/09/2023
V1.0	D2.7	Davy Van Landuyt	EUD	04/09/2023
V1.0	D2.7	Mirella De Sisto Dimitar Shterionov	TiU	13/09/2023 14/09/2023

Acronyms

The following table provides definitions for acronyms and terms relevant to this document.

Acronym	Definition
API	Application Programme Interface
App	SignON Communication and Translation Mobile Application
ASL	American Sign Language
ASR	Automated Speech Recognition
BSL	British Sign Language
DevOps	A set of practices that combines software development and IT operations[1]
DHH	Deaf and Hard of hearing
DoA	Description of the Action
GA	Grant Agreement
HTML	Hypertext Markup Language
HTTP	HyperText Transfer Protocol
HTTPS	HyperText Transfer Protocol Secure
ICT	Information and Communication Technologies
InterL	Interlingua
IS	International Sign
ISL	Irish Sign Language
LSE	Spanish Sign Language (Lengua de Signos Española)
MT	Machine Translation
NGT	Sign Language of the Netherlands (Nederlandse Gebarentaal)
NLP	Natural Language Processing
RIA	Research and Innovations Action, SignON project type.
SignON	Both the service and this project (GA 101017255)
SL	Sign Language
SLMT	Sign Language Machine Translation

[1] What is DevOps? - Amazon Web Services (AWS)

SLR	Sign Language Recognition
SLTT	Sign-Language-To-Text
STT	Speech-To-Text
TTS	Text-to-Speech
TTSL	Text-to-Sign-Language
UI	User Interface
URL	Uniform Resource Locator
UX	User Experience
VGT	Flemish Sign Language (Vlaamse Gebarentaal)
WP	Work Package
WWW	World Wide Web

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Executive Summary

This deliverable is the SignON project's final major release of the SignON Sign Language Machine Translation (SLMT) Mobile Application pre-commercial prototype, and concluding formal output of task T2.3 "Design and Development of the SignON Communication Mobile Application". Task T2.3 developed the prototype app using an iterative user-driven agile DevOps approach and industry-standard components in the SignON open Framework, as described in D2.3. The SignON SLMT App aims to be an intuitive, easy-to-use user input and output, interfacing with the cloud-based SignON Service platform (T2.1 and T2.2) where the computationally intensive tasks (of WP3, 4 & 5) are executed. This V3.0 release of the app will now enable WP1 summative evaluation to be undertaken and reported in D1.6 "Quality Assessment Report". The evolution to the App V3.0 builds on the formative evaluation pilot trials that took place, as reported in D1.10 "Final Technical requirements and user research (UX design) report". This co-creation approach widened the uptake, improved sign language detection and multilingual speech processing on mobile devices for everyone. The SignON SLMT App V3.0 is available for both Android and Apple mobile devices on the Google Play Store and Apple App Store as "SignONMobile".

1. Introduction

SignON researched and developed the SignON transmodal Sign Language Machine Translation (SLMT) prototype mobile application communication service that uses machine translation (MT) to translate between sign languages (SL) and spoken languages (SpL). The SignON project's pre-commercial prototype service aims to facilitate the exchange of information among deaf and hard of hearing (DHH), and hearing individuals. In this user-centric and community-driven project we tightly collaborated with European DHH communities to (re)define use-cases, co-design and co-develop the SignON service and application, assess the quality and validate their acceptance. Our ultimate objective is the fair, unbiased and inclusive spread of information and digital content in European society.

SignON is a free, open-source prototype application and framework for capturing and processing signed, spoken or written utterances (in video, audio or text formats) and translation between signed and spoken languages. To facilitate these tasks, SignON uses a common representation for mapping of video, audio and text into a unified space that is used for translating into the target modality and language. To ensure wide uptake, improved SL detection and synthesis, as well as multilingual speech processing on mobile devices for everyone, the SignON service is deployed as a smartphone application running on standard modern devices, i.e. the SignON Mobile App available for Android and iOS devices.

The SignON App has a lightweight interface. The SignON Framework of services, however, is distributed on a cloud platform where the computationally intensive services are executed. The project has been driven by a focused set of use-cases tailored towards the SL communities. We targeted signed and spoken languages from Ireland (Irish Sign Language, Irish and English), Britain (British Sign Language and English), the Netherlands (Sign Language of the Netherlands/Nederlandse Gebarentaal and Dutch), the Flemish Community of Belgium (Flemish Sign Language, Dutch) and Spain (Spanish Sign Language and Spanish). Nevertheless, SignON has also provided its SignON Machine Learning (ML) training App, which as described in D2.9 "Second Machine Learning interface" incorporates an audio/video (+ transcription/translation) capturing system that will possibly allow ML models to learn (i) new sign and spoken languages; (ii) style-, domain- and user-adaptation and (iii) automatic error correction, based on user feedback.

The technical requirements of the SignON SLMT App were derived by iteratively mapping the end-user requirements (Task 1.3) onto the technical implementation of the App. The App must communicate primarily with DHH citizens (end-user requirements).

Task 2.3 “Design & Development of the SignOn Communication Mobile Application” is interlinked with task 1.4 “Technical user Requirements, Iterative design process (UX)”. During the different development cycles, the execution of T1.4 was the principal intermediary to moderate each cycle from design process to user testing, to generate and constantly improve the SignON Mobile App to better meet users’ wishes and requirements.

1.1 SignON User-Centred Co-Creation Phased Development Process

This deliverable is the Research and Innovations Action (RIA)[2] project’s final major baseline release of the SignON SLMT Mobile Application TRL6[3] pre-commercial prototype, and last formal output of task T2.3 “Design and Development of the SignON Communication Mobile Application”. Task 2.3 developed the app using an iterative user-driven Agile DevOps approach and industry-standard components in the SignON open Framework as described in D2.5 “Final release of the Open SignON Framework”. The SignON SLMT Communication App provides an intuitive, easy-to-use user input and output that interfaces with the cloud based SignON Service platform (T2.1 and T2.2) where the computationally intensive tasks (of WP3, 4 & 5) are executed. This V3.0[4] release of the App now enables a WP1 summative evaluation to be undertaken and reported in D1.6 “Quality Assessment Report”. The app has evolved to V3.0 building on the formative evaluation pilot trials that took place, as reported in D1.10 “Final Technical requirements and user research (UX design) report”. This co-creation approach facilitated uptake, improved sign language detection and multilingual speech processing on mobile devices for everyone.

The phased development of the SignON platform (including the SignON mobile application, service, framework, and components) was according to iterative R&D cycles and released in phases at the completion of each cycle. This was coordinated through a phase-release schedule that included major, minor and patch releases, as defined in D2.1 “SignON Development Repository”. This enabled co-creation workflow cycles to take place, evolving it to its V3.0 release near the end of the project.

The prototype components are as follows:

- **SignON open Framework** has been developed as a collection of scripts, tools, services, specifications, and APIs that provide the communication between the different components and the user (via the SignON SLMT Mobile App) in a distributed microservice architecture.

[2] RIA’s are expected to have an outcome with TRL 2 to 6, while an IA (Innovation Action) project is intended for higher TRLs between 6 and 8. See h2020-wp1820-annex-ga_en.pdf (europa.eu)

[3] TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) h2020-wp1820-annex-g-trl_en.pdf (europa.eu)

[4] Formally version 3.0.0 as per the versioning defined in 2.1 “SignON Development Repository”, Mar 2021.

This follows a bottom-up design methodology, assuming the existence of the separate components.

- **SignON communication and translation mobile application**, as each user's interface to the overall cloud platform and SignON Framework, was developed using industry-standard components and open frameworks to run on standard modern smartphone and tablet devices without the need for special equipment. Following the initial co-creation events and a preliminary analysis, a fast prototype was developed and released in May 2021 to enable users to become familiar with the intended features and user interface (UI) of the SignON Mobile App service. It facilitated active involvement of users in the co-creation cycles from early in the project leading to defining functional specification and its co-development (through formative evaluation in WP1), resulting in the App's second formal operational V2.0 release at mid project, and subsequently to this V3.0 release.

1.2 Updates from V2.0

Based on user feedback in a structured evaluation of the SignON SLMT App V2.0 during May 2023[5], the following updates were implemented to create the current V3.0 of the App:

1. Multilingual 
    a. The App's UI language automatically switches to match the user's phone language (Dutch, English, Irish, Spanish), with English as default if their phone is something else.
2. Preferences Screen 
    a. A high contrast "Dark Contrast" display option – to give strong colours and contrast using a dark background with light letters.
    b. The user also has the option to use all of their phone's system display and sound settings.
3. Information Screen 
    a. Uses the user's chosen UI language, (as in 1.a)
        i. Includes links to the User Guide on how to use the app, and to the SignON Project - Sign Language Translation Mobile Application (signon-project.eu) allowing the user to read all of the background to the app.
4. Home / Translation screen 

[5] Reported in D1.10 "Final Technical Requirements & User Research (UX design) Report", June 2023.

a. Shows the user's currently selected input and output languages (Text & SL)

b. The send arrow (>) glows and is highlighted when it's required to be clicked

c. The Text Input Field has been made more obvious that it is the place to type text into, and larger allowing the user to better see their message and identify any mistakes made. It also now includes text auto-correction and predictive type-ahead for the text typing.

d. When speech is the selected output option a sound play symbol is provided to indicate that the app is speaking.

5. Technical Updates
   a. Some minor internal technical updates to the code and Framework API based on operational experience, as reported in the SignON code repository[6].

[6] https://github.com/signon-project

2. Final release of the SignON Mobile App

As described in the Description of Action (DoA), the SignON SLMT Communication App aims to be intuitive, easy-to-use user input and output interfacing with the cloud based SignON platform where the computationally intensive tasks of the SignON Framework (from WP3, 4 & 5) are executed. This is to address the clear need for an open multilingual transmodal SLMT services framework, API and mobile App that can readily accommodate new SLs, particularly less resourced SLs.

The SignON transmodal SLMT mobile App runs on a standard modern smartphone and tablet devices and OS, using their existing cameras, other input sensors and User Interfaces (UI).

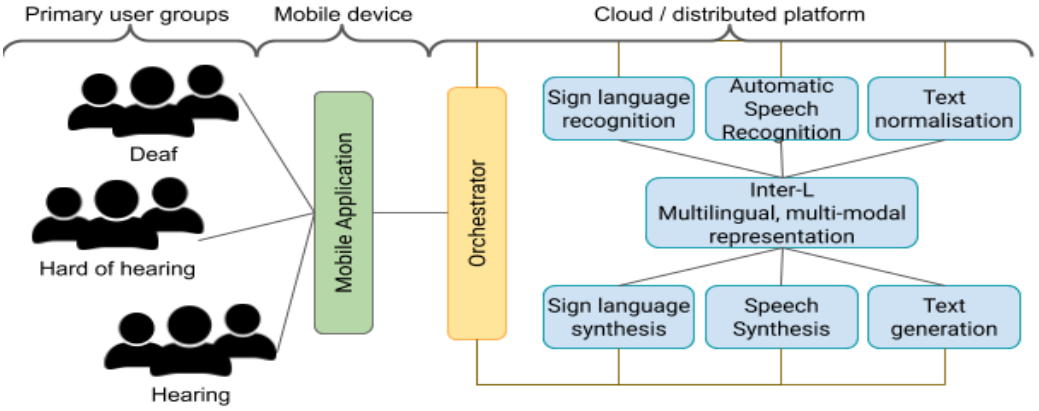


Figure 1 SignON Concept

In line with User Experience (UX) Design and Design Thinking[7], the project used an Agile DevOps approach[8], with iterative fast prototypes that enabled users to become actively involved in the co-creation process of its functional specification and its co-development (through formative evaluation in Work Package (WP) 1) from early in the project. The co-creation approach now facilitates uptake, improved SL detection and multilingual speech processing on mobile devices for everyone.

Version V3.0 of the SignON Mobile App for Android and iOS based phones, includes Sign Language Recognition (SLR), Automatic Speech Recognition (ASR), Sign Language Translation (SLT), Spoken Language Machine Translation and Sign Language Synthesis (SLS) functionality, as described in D3.2 "Sign language recognition component and models", D4.8 "Final Routines for transformation of text from and to InterL", D4.10 "Final Routines for transformation of SL representations from and to

[7] See D1.4 "First Technical Requirements & User Research (UX design) Report", June 2021
[8] https://devops.com/how-to-combine-devops-and-agile/

the InterL", and D5.1 "First version of virtual character". The App includes the Acapela TTS[9] for natural speech synthesis and SignON ASR[10] "atypical speech" recognition, as described in the DoA.

The App is simple to use, but powerful.

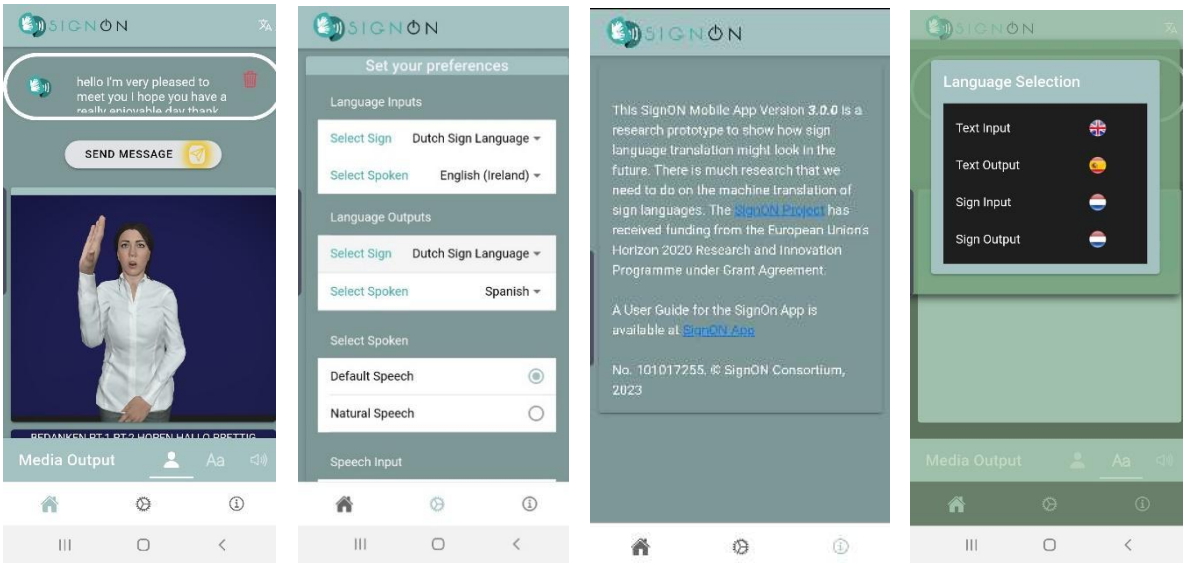


Figure 2 SignON Mobile App V3.0 Translation, Preferences & Information Screens

This third major release of the prototype mobile app demonstrates the SignON SLMT features, so that users can see, hold, and feel something tangible and provide realistic inputs on what they want, and for the developers to get an appreciation of the realities of the mobile app platform and cloud requirements.

This RIA project's final major release of the SignON Mobile App V3.0 prototype is available for both Android and iOS mobile devices on the Google Play Store and Apple App Store, as "SignONMobile".

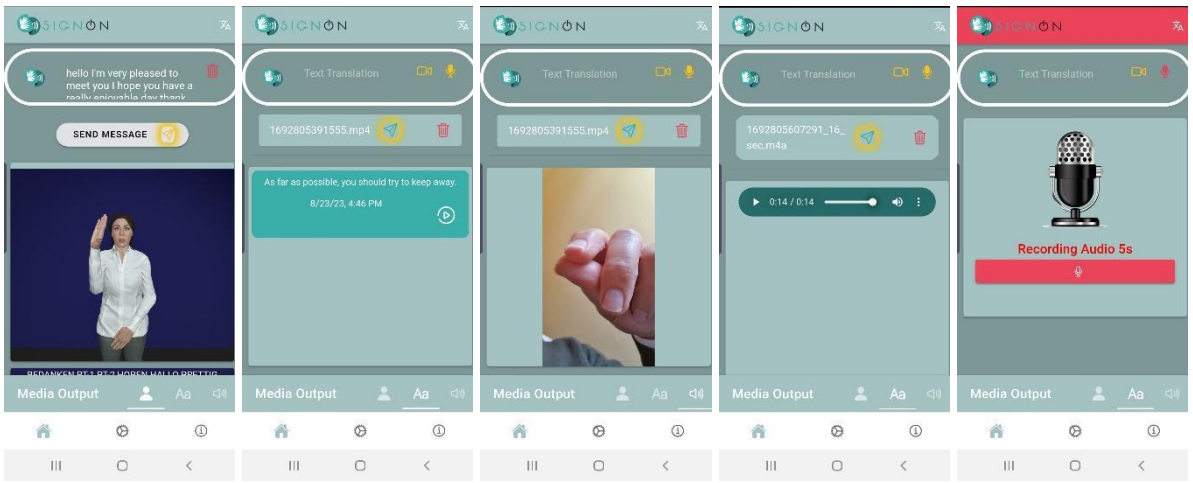
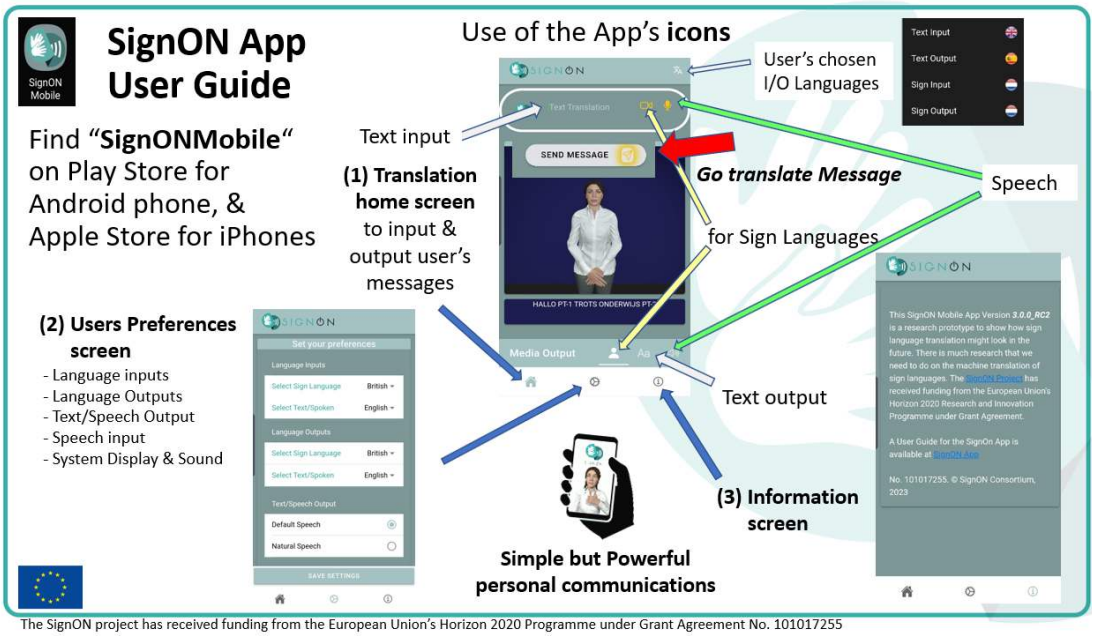


Figure 3 SignON Mobile App V3.0 screens

[9] Acapela Group: Text To Speech (TTS) solutions, personalized voices based on neural technology. (acapela-group.com)

[10] As described in D3.4 "Automatic speech recognition component and models".

The App user interface (UI), which has been iteratively developed based on users' recommendations for simple and intuitive use, is explained in the "User Guide" shown in figure 4:



The SignON project has received funding from the European Union's Horizon 2020 Programme under Grant Agreement No. 101017255

Figure 4 SignON SLMT App V3.0 User Guide

3. Status of the SignON SLMT V3.0 App

The SignON SLMT App's users' requirements were derived by mapping the end users' requirements (Task T1.3) and interlinking to this task (T2.3 "Design & Development of the SignON Communication Mobile Application") on the technical implementation of the SignON application. During the different development cycles, the execution of task T1.4 "Technical user Requirements, Iterative design process (UX)" consisted of being the principal intermediary to moderate each cycle from design process to user testing and to provide definitions on the UX design of the SLMT Mobile App.

Based on the users' formative evaluation feedback, discussion of the user requirements and the project objectives given in the DoA, the final definition of the user technical requirements of the SignON Mobile App are described in D1.10 "Final Technical Requirements & User Research (UX design) Report".

As a technology product, SignON is conceptualised around multiple components orchestrated within the SignON Framework and delivered through the cloud using a distributed microservice architecture. The components operate in a network of remote machines and are accessible through APIs, as shown in Figure 5.

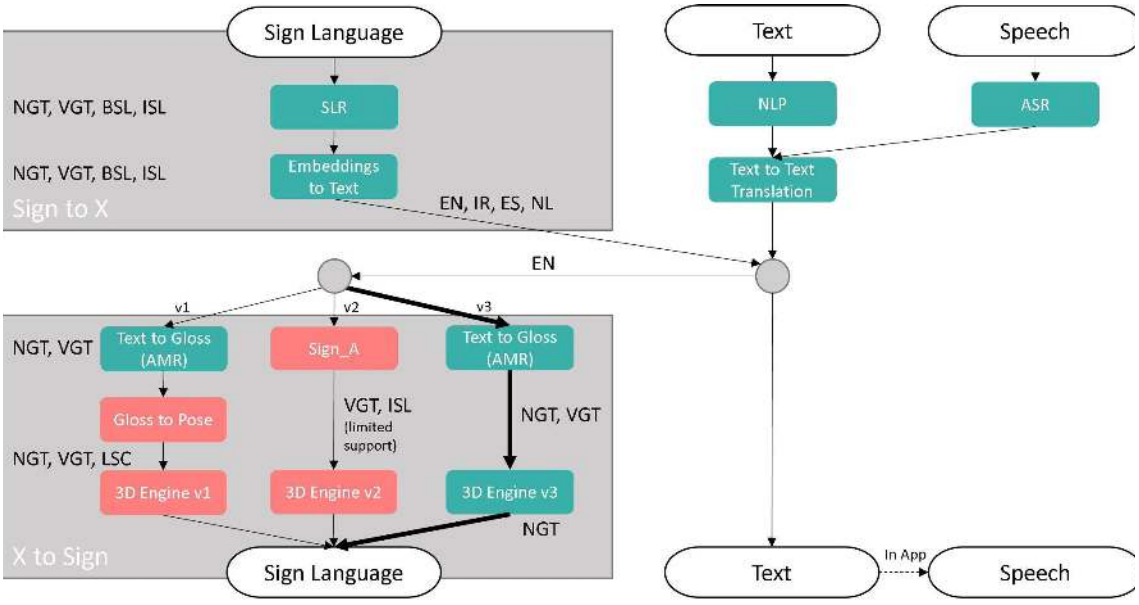


Figure 5 SignON Framework Services Architecture

In practice, the SignON Framework encompasses pipelines for translation between different languages and modalities, e.g. one such pipeline is for translating from Irish Sign Language (ISL) to spoken Dutch (sign-to-speech translation). This type of distributed architecture has proven effective for large and scalable cloud-based software ecosystems. The distributed and modular architecture of the software facilitates the uptake and growth of the SignON service beyond the life of the project.

Its modularity allows for improved and additional components to be seamlessly integrated into the SignON Framework.

The SignON SLMT App V3.0 is an evolution of the app's previous versions, as explained in D2.6 "First release of the SignON Communication Mobile App". This SignON RIA project's final major baseline release of the SignON SLMT App prototype provides the SignON SL, ASR and MT Framework Services, that are now available from the ongoing WP2, WP3, WP4 and WP5 R&D work,[11] as summarised in Figure 6.

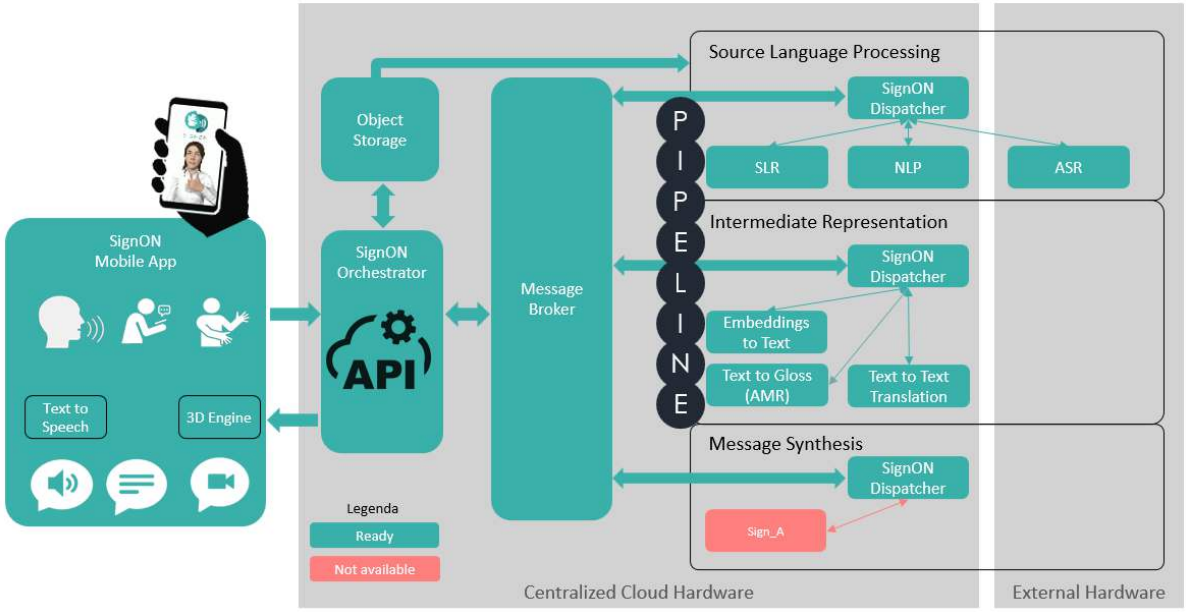


Figure 6 SignON SLMT App V3.0 Framework Functionality

As the SignON project is a Research and Innovations Action (RIA)[12], it has successfully produced the SignON SLMT mobile Apps and Framework services as a TRL6[13] pre-commercial prototype that will be validated before the end of the project and "demonstrated in relevant environment" in the evaluation to be undertaken and reported in the D1.6 "Quality Assessment Report".

The SignON SLMT App aims to be an innovative prototype that uses AI and computer vision to recognize and translate sign language. It aims to bridge the communication gap between all individuals enabling seamless communication using an open architecture and powerful user-centred framework as a user-centred solid foundation for future enhancements in

[11] As described in the most recent deliverables of each of the WPs.
[12] RIA's are expected to have an outcome with TRL 2 to 6, while an IA (Innovation Action) project is intended for higher TRLs between 6 and 8. See h2020-wp1820-annex-ga_en.pdf (europa.eu)
[13] TRL 6 – technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies) h2020-wp1820-annex-g-trl_en.pdf (europa.eu)

SLMT across the EU and beyond.

The SignON SLMT App's strengths include:

a. It provides a validated open multilingual transmodal SLMT services Framework, API & mobile App that can readily accommodate new SLs, particularly less-resourced SLs.
b. It is based on leading R&D expertise, cutting-edge technologies and innovations in SL recognition and translation[14]. This expertise enables SignON to be at the forefront of the industry and deliver state-of-the-art next-generation solutions.
c. User-Centred Interface and Features: The SignON SLMT app is designed with a strong user-centred focus, prioritising the needs and preferences of DHH users. The interface and features have been developed and validated to be intuitive, accessible, and user-friendly, enabling a seamless and enjoyable user experience.
d. Engaging Users' Community: The SignON SLMT App and Framework services aim to provide the deaf community with a platform to co-create a reliable and accessible communication tool. By starting to bridge the gap between sign language and spoken/written languages, the app aims to enable DHH and hearing individuals to engage more effectively in various aspects of life, including education, employment, and social interactions.
e. Continuous Improvement based on User Feedback: the SignON devops process actively collects user feedback and incorporates it into the development process. This iterative approach ensures that the app continuously evolves and improves to address user needs, resulting in an app that is constantly improving its user satisfaction.

However, the SignON SLMT App and Framework Services are still a TRL6 prototype system with a number of weaknesses for normal everyday SLMT operational use. These weaknesses include:

a. SL functionality, and the speed and accuracy of its SLR, SLT and SLS need to be improved and made more robust, reliable and address more SL. Due to training data limitations, the current V3.0 functionality is limited to the Sign Language of the Netherlands (NGT).
b. Building a large and diverse SignON user base will take time and effort and a robust commercial SignON SLMT service, requiring expensive development and productization, SLMT training data collection, marketing strategies and user acquisition campaigns, after this current RIA project ends.
c. Established ASL-focused SLMT products, such as SignAll[15] and Hand Talk[16] have stronger user awareness and adoption due to their earlier market entry and promotional efforts,

[14] SignON's technologies are state of the art as defined for ASL at Sign Language Processing
[15] https://www.signall.us/
[16] Hand Talk: your website accessible in ASL

potentially affecting the initial traction and sustainable commercial operation of the SignON SLMT services.

The SignON Framework encapsulates all internal components, e.g. ASR, SLR, 3D virtual signer synthesis, interlingua, NLU, and so on. Each component resides on a remote machine and operates independently from the rest in a distributed microservice architecture, providing Function as a Service (FaaS)[17] enabling the SignON SLMT services with the potential to scale in real time in response to demand.

The SignON services will be made openly and freely available to third parties, so they can integrate their services and components into the complete SignON Framework. This ensures wide and coherent development of new services for all users, enabling the SignON Framework to become the industry standard and platform for fair, unbiased, and inclusive sharing of information and digital content in European society.

3.1 App V3.0 implementation of the SignON User Requirements

Within the constraints described above, this RIA project's final major release of the SignON Mobile App implements most of the user technical requirements documented in D1.10 "Final technical requirements and user research (UX design) report", as follows:

SignON App V3.0 Features	User Technical Requirements from D1.10	Current status
A. User's Mobile Device	1. The SignON App must be easy and intuitive to use. Simple but powerful. To run on standard modern phones and tablets. 2. The SignON Mobile App will be free and easily downloadable by users from the Google Play Store for Android phones and tablets, and from the Apple App Store for iPhones and iPads. 3. All the SignON Mobile App's user's inputs and outputs will be on a single mobile user device to communicate in-person with people nearby. 4. Future work may interwork with a messaging app (such as WhatsApp) on the same user device, to remote people. 5. The User's mobile device must have broadband data Internet access for the App to operate using the SignON Framework cloud-based services. a. Future work may provide limited off-line operation, such as an user selectable vocabulary of Signing GIFs, if requested by users.	1. Done. 2. Done. 3. Done. 4. To be done 5. Done a. To be done.
B. System Performance	1 Translation/conversion will be unidirectional operation with users taking turns to input their messages of up to 30 seconds duration. a. Users may choose to store messages on their own device, but messages will not be retained by the Framework cloud system. Data privacy and protection will be explicitly stated to the user.	1. Done. 2. Done for speech & text. Not yet for SL. 3. Not yet achieved

[17] https://en.wikipedia.org/wiki/Function_as_a_service

SignON App V3.0 Features	User Technical Requirements from D1.10	Current status
	b. Video, audio, or text streaming will not be provided. 2 Translation/conversions should: a. Respond within 2 seconds – with a maximum of 5 seconds for SL-to-SL translations, to enable effective user communications. b. Provide user-acceptable accuracy for 75% of users. 3 Users should have at least 75% average satisfaction rating with the overall operation of the SignON service.	
C. User Preferences	1. The SignON App supports video, audio, and text User Interface (UI) modalities of communication[18], and provides one-tap user-selectable translation and conversion between any combination of: a. Flemish Sign Language (VGT), Sign Language of the Netherlands (NGT), Irish Sign Language (ISL), British Sign Language (BSL) and Spanish Sign Language (LSE)[19] b. English, Irish, Dutch and Spanish speech and texts[20]. 2. The App will provide, and retain, user-selectable: a. default personalised options for the User Interface, App text languages and favourite settings. b. UI display, audio, and text options, including contrast and SL avatar customisation.	1. Done. 2a.Done. 2b. Part done – no avatar options yet.
D. SL Translation	1. User SL Input a. No additional special attachments or special lighting will be required for capturing SL input. The App will automatically adapt to input ambient light conditions, within the limits of the user's device. b. User-selectable use of either selfie/forward-facing device video camera live, or a pre-recorded video.	1a. Done. 1b. Done. 1c.Not yet, In progress 1d. Part done 1e. In progress 2a. In progress

[18] SignON supports deafblind signers who have some sight as key users, as explained in D1.7. However, it does not support other UI modalities or tactile SLs (see for instance "DeafBlind Communities May Be Creating a New Language of Touch", May 2022, DeafBlind Communities May Be Creating a New Language of Touch | The New Yorker, and Protactile - Wikipedia). The European DeafBlind Network (EDBN) defines "deafblindness" as a "*condition that combines in varying degrees of both hearing and visual impairment... Two sensory impairments multiply and intensify the impact of each other creating a severe disability which is different and unique … their specific needs vary enormously according to age, onset and type of deafblindness. Deafblind people are unable to use one sense to fully compensate for the impairment of the other… Thus they will require services which are different from those designed exclusively for either blind people or deaf people*". Deafblindness - Edbn

[19] The ISO 639-3 codes for these 5 languages are: VGT (Flemish Sign Language), SSP (Spanish Sign Language), BFI (British Sign Language), ISG (Irish Sign Language) and DSE (-the Sign Language of the Netherlands), https://iso639-3.sil.org/code_tables/639/data?title=&field_iso639_cd_st_mmbrshp_639_1_tid=All&name_3=&field_iso639_element_scope_tid=All&field_iso639_language_type_tid=All&items_per_page=200, It must be noted that even though it is technically correct and appropriate to use this standardized nomenclature to classify languages, the deaf communities don't use these ISO acronyms at all, and feel that it is something "hearing researchers" are forcing on deaf communities!

[20] The ISO 639-3 codes for these 4 languages are: ENG (English), GLE (Irish), NLD (Dutch / Flemish) and SPA (Castillan, Spanish), https://iso639-3.sil.org/code_tables/639/data?title=&field_iso639_cd_st_mmbrshp_639_1_tid=All&name_3=&field_iso639_element_scope_tid=All&field_iso639_language_type_tid=All&items_per_page=200

SignON App V3.0 Features	User Technical Requirements from D1.10	Current status
	c. SLR lexical accuracy[21] and operation acceptable to 75% of users: I. Accommodating both formal and informal styles. II. Covering regional signs, age variation & fingerspelling[22]. III. Recognising emotion (through facial expression and signing style). IV. Recognising and translating classifiers and using an appropriate lexicon. V. Attending to specific features of SL grammar. d. Future work may include a user option to add new signs, or have SignON learn them through repeated use of certain signs[23]. e. Performance comparable to the best available automatic SL recognition and translators for SignON's supported multiple SLs. 2. User SL output a. A user acceptable and customisable 3D virtual signer, which focuses on linguistic lexical accuracy[24]. This means accurate hand forms, hand and finger movements, body movement, posture, gestures[25], the right speed, and facial features such as showing the right emotion, lip movement, eyebrows, and eye gaze[26].	2b. In progress 2c. In progress 2d. Meets 80% 2e. Not yet – in progress.

[21] At the level of SL lexical items accuracy similar to text/speech translation Apps such as Google Translate, thus not addressing the wider inter-personal communications and richness of body language and SL's multimodal communications richness, the "megablend" as discussed in "Visuo-spatial construals that aid in understanding activity in visual-centred narrative", Donna Jo Napoli and Lorraine Leeson, Language, Cognition and Neuroscience, Volume 35, 2020 - Issue 4, https://doi.org/10.1080/23273798.2020.1744672, see also https://www.redhenlab.org, https://markturner.org and Body language - Wikipedia

[22] But no SL gloves ! see https://www.theatlantic.com/technology/archive/2017/11/why-sign-language-gloves-dont-help-deaf-people/545441/

[23] Currently provided using the SignON ML Training App as described in D2.9 "Second Machine Learning interface".

[24] At the level of SL lexical items accuracy similar to text/speech translation Apps such as Google Translate, thus not addressing the wider inter-personal communications and richness of body language (How to Understand Body Language and Facial Expressions (verywellmind.com)) and SL's multimodal communications richness, the "megablend" as discussed in "Visuo-spatial construals that aid in understanding activity in visual-centred narrative", Donna Jo Napoli and Lorraine Leeson, Language, Cognition and Neuroscience, Volume 35, 2020 - Issue 4, https://doi.org/10.1080/23273798.2020.1744672, see also https://www.redhenlab.org and https://markturner.org

[25] Frontiers | Gesture's Neural Language | Psychology (frontiersin.org) and Co-Speech Gesture in Communication and Cognition (uoregon.edu). See for instance Sign Language Avatars | Kara Technologies

[26] Similar to that provided by the Alter open source cross-platform SDK that includes a real-time 3D avatar system, facial motion capture, and multi-platform components for creating avatars (Avatar Designer). The SDK is built from scratch for web3 interoperability and the open metaverse. It enables avatars to be programmed into games, apps, and websites (such as SignON). See GitHub - facemoji/alter-sdk: Alter SDK lets you easily pipe avatars with motion capture into your game, app, or website. It just works. However it was bought by Google so the future direction of the open source SDK is not clear, and according to GitHub it is now discontinued. Initial investments of the order of US$10M and Google purchase estimated in US$100M. M$:https://www.siliconrepublic.com/business/google-alter-acquisition-ai-avatar-metaverse-tiktok?mc_cid=8e7960c711&mc_eid=63acabb0b4

SignON App V3.0 Features	User Technical Requirements from D1.10	Current status
	b. The avatar must be user customisable concerning gender, skin colour, and contrasting colours in clothing and background. c. Have a user option to include message text to confirm and correct the accuracy of the avatar's signing. d. Adhere fully to the "Best Practice Protocol on Sign Language Avatars" from the University of Vienna[27]. e. Overall performance better than best available avatars	
E. Speech & Text Translation	1. For normal and atypical, formal and informal, speech. 2. User preselection, and an option for automatic detection of the user's input text and speech languages. 3. Indicate visually that speech is being recorded and played back (for DHH users). 4. User option to store conversation message texts on the user's device. 5. Future work may translate/answer phone calls, interpret emotions and ambient background noise, and use symbols or simple text. 6. Overall performance better than a modern phone's standard ASR.	1. Done for normal speech. 2. Done. 3. Done. 4. Done 5. To be done. 6. Done.

Table 1 Status of current SignON SLMT App V3.0 Functionality

Overall, while the prototype SignON SLMT App V3.0 addresses most of its spoken language and text MT requirements, it only partially addresses the users' SLMT requirements.

3.2 Adherence to the Vienna Best Practice Protocol on Use of SL Avatars

Despite only partially addressing users' SLMT requirements, the SignON SLMT V3.0 App's avatar meets 80% of the Vienna Best Practice Protocol[28] recommendations for the use of SL Avatars (and the remainder are partially addressed), as follows:

Vienna Best Practice Recommendations		Met by SignON V3.0 Avatar
Linguistic Aspects	1. Avatars' torso, pelvis, shoulders (individually & together), all parts of the face, including eyes (direction of gaze), & entire head must be moved completely & appropriately. 2. Offer diversity in style & register, as well as linguistic variants within a text. 3. Provide precise (frame exact), harmonious interplay of manual & non-manual components of a sign.	1.Yes[29] 2.Partially 3.Partially 4.No 5.Yes 6.Partially

[27] https://avatar-bestpractice.univie.ac.at/en/english/

[28] "Best Practice Protocol on the Use of Sign Language Avatars", Verena Krausneker, Sandra Schügerl, University of Vienna, 2021, University of Vienna (univie.ac.at)

[29] With the current limitations in the SignON SLR and SL avatar (as discussed in D2.6 "First Release of the SignON Communication Mobile Application") the more precise term should perhaps be "intending to get a YES" rather than "YES" as used in this table. However, the latter is used for clarity and brevity.

Vienna Best Practice Recommendations		Met by SignON V3.0 Avatar
	4. Recorded avatar videos should feature pictograms & images where appropriate. 5. Signing avatars must be intelligible for all deaf SL users who depend on the conveyed information with appropriate linguistic quality of the animation. 6. Captions should be included.	
Aspects of Translation Competence	7. Texts presented by avatars must undergo quality control before being published/released. 8. Use deaf-led quality control to certify avatars or texts presented by avatars. 9. For computer-generated translation, quality control is by trained & qualified interpreters. 10. Use appropriate quality management criteria for movability, fine motor skills of the animation, ease of perception & translation quality, etc. that exceed the DIN EN ISO 17100:2015 Requirements for translation services[30].	7.Partially 8.Yes 9.Partially 10.Yes
Ethical Aspects	11. SLs originate from deaf communities & must be treated with respect. 12. Avatars are not a substitute for human interpreters, they may be an addition. 13. Deaf people must guide where avatars can be appropriately deployed. 14. Deaf people must lead in the creation of SL avatars, translation process, & quality control. 15. Avatar developers need to cooperate with each other & with the self-advocacy associations of deaf communities. 16. Avatars should be developed & researched in interdisciplinary teams. 17. “Nothing about us without us” must apply in the field of SL avatars. 18. Must adhere to the UN Convention on the Rights of Persons with Disabilities including "professional sign language interpreters, to facilitate accessibility to buildings & other facilities open to the public", ensure right to freedom of expression & opinion, including the freedom to seek, receive & impart information by "recognizing & promoting the use of SLs". 19. Human/citizens' rights & true accessibility must be prioritized over cost savings. 20. All publicly funded signing avatars must adhere to this Best Practice Protocol.	11.Yes 12.Yes 13.Yes 14.Yes 15.Yes 16.Yes 17.Yes 18.Yes 19.Yes 20.Yes
Situational Appropriateness	21. Deaf people should make the informed decision when & where avatars can be deployed. 22. Avatars are not yet able to relate complex topics & not every length of text can be adequately represented. 23. Best use of avatars is where the content allows it & SL recognition is demonstrably of the highest quality. 24. Deployment crucially depends on the sensitivity of the topic & potential for danger. 25. In all cases where hearing people are informed by human voices or real speakers, deaf people should also be informed by human interpreters. 26. For more confidence in the avatars, those responsible for them are identified, e.g., on the website of the avatar provider.	21.Yes 22.Yes 23.Yes 24.Yes 25.When available 26.Yes 27.Yes 28.Partially 29.Yes

[30] ISO - ISO 17100:2015 - Translation services — Requirements for translation services

Vienna Best Practice Recommendations		Met by SignON V3.0 Avatar
	27. Avatar SL content must aim at gaining the trust & convince all deaf viewers, including those with multilingual & high levels of linguistic competencies. 28. There should be emotion & charisma in avatars, including e.g. irony & nuances. 29. Interdisciplinary research on avatars & their ramifications should be conducted continuously.	
Social Aspects	30. Avatars should only be deployed when they are a useful & appropriate addition to human interpreters. 31. Avatars must not contribute to the social isolation of deaf people. 32. Deaf people should not be "obliged" to spend even more time in front of a screen instead of having real, live interactions,	30.Yes 31.Yes 32.Yes
Aesthetic Aspects	33. In all situations, it must be evaluated if an avatar (a character that is perceived to be highly artificial) is appropriate. 34. Depending on the situation & video, the avatar sizing must ensure ease of intelligibility, & if the animated avatar should be free-standing or better placed in picture-in-picture. 35. Consider when it is desirable for a SL to be represented by a human & when it makes no real difference if an animated, artificial avatar does so	33.Partially 34.Yes 35.Yes

Table 2 SignON Avatar & Vienna Best Practice Recommendations

The Best Practice Protocol concludes that if deployed adequately, SL avatars can be a purposeful supplement to human sign language interpreters and thus offer freedom of choice. However, avatars should never be presented, seen, or marketed as a "solution" to the "communication problems" of deaf SL users. Deploying SL avatars must not create disadvantages for deaf people. SL avatars should be deployed responsibly in the interests of deaf SL users.

The Vienna report[31] concluded that it “would be desirable that SL avatar technology was freely available to everyone as an application (such as Google Translate or other free computer assisted translation tools). Hence, deaf people could use avatars independently and self-determinedly in those situations they find appropriate (and would even supply the app with information that is relevant for future users)”. This is exactly what SignON is doing!

[31] “Best Practice Protocol on the Use of Sign Language Avatars”, Verena Krausneker, Sandra Schügerl, University of Vienna, 2021, University of Vienna (univie.ac.at)

4. Conclusions and Recommendations

This deliverable is the SignON RIA project's final major baseline release of the SignON SLMT prototype App[32], which is available on the Google Play Store and Apple App Store as "SignONMobile" for both Android and IOS mobile devices. It is also the project's formal output of task T2.3 "Design and Development of the SignON Communication Mobile Application", which developed the app using an iterative user-driven agile DevOps approach and industry-standard components in the SignON open Framework, as described in D2.4. Even though the SignON Communication App is a pre-commercial RIA project prototype, it provides an intuitive, easy-to-use user input and output interface to the cloud based SignON Service platform (T2.1 and T2.2) where the computationally intensive tasks (of WP3, 4 & 5) are executed. The extent to which it achieved this is discussed in the formative evaluation pilot trials that took place, as reported in D1.10, and it has now evolved to its final major RIA release, as described here near the end of the project. This user-driven iterative co-creation approach aims to facilitate uptake, improved SL detection and multilingual speech processing on mobile devices for everyone. This will now feed into the summative evaluation of D1.6 "Quality Assessment Report" just before the end of the project.

Once the project ends, the SignON SLMT prototype App will be free and open to download it from SignON code repository[33]. As discussed in D1.10, this will enable a community of users to evolve through social media to collect data, ideas, and opinions from a broad audience and thus enable open-ended and less structured crowdsourcing research based on the collective intelligence and diverse perspectives of a large group of people, to lead to wider awareness, take-up, and impact. This "wisdom of the crowd" will enable SignON's further evolution as a strong and validated foundation for a "standard" EU-recommended open multilingual transmodal SLMT services Framework, API and mobile Apps that can readily accommodate new SLs, particularly less-resourced SLs. It will thus improve cooperation among EU and associated countries to strengthen the European Research Area including, standardisation, dissemination, awareness-raising, communication and networking activities, policy dialogues, mutual learning, and studies, after the SignON RIA project ends.

[32] Formally defined as version 3.0.0 as per the versioning defined in D2.1 "SignON Development Repository", Mar 2021.
[33] https://github.com/signon-project