



SIGNON

## **Sign Language Translation Mobile Application and Open Communications Framework**

**Deliverable 7.5: First Impact Review**



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**Overview:** This report provides an overview of the impact of the SignON project to date. It gives an outline of the impact that was described in the Grant Agreement and how this impact has been seen at the end of the first year of the project.

## Revision History

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### Approval Procedure

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## Acronyms

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

Acronym	Definition
API	Application Programming Interface
ASR	Automatic Speech Recognition
CLARIN	Common Language Resources and Technology Infrastructure
DHH	Deaf and Hard of Hearing
DoA	Description of Action
GA	Grant Agreement
InterL	Interlingua
IP	Intellectual Property
mBART	Multilingual Bidirectional and Auto-Regressive Transformer
MT	Machine Translation
NLU	Natural Language Understanding
SL	Sign Language/s
SLR	Sign Language Recognition
SLTAT	Sign Language Translation and Avatar Technology Workshop
SOTA	State-Of-The-Art
SUS Rating	System Usability Scale Rating
UI	User Interface
WP	Work Package

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## 1. Executive Summary

Our society is phonocentric - that is, built around the assumption that sound and speech are more primary than other forms of language use (writing; and languages expressed in a visual-gestural modality, sign languages). As a result of this auditory bias, people who are deaf or hard of hearing (DHH) are often excluded from accessing information in a society which is frequently communicated in an auditory modality (audio announcements, videos with no captions, etc.). Additionally, there is the presumption that captions solve the modality communication gap - but we must remember that the spoken and written languages of Europe are linguistically distinct from the signed languages of Europe. Thus, many signers experience the written languages of their home country as second languages, and literacy in these languages varies. We can also say that hearing people face challenges in trying to communicate with people in the DHH communities too, but while this may be an equivalent communicative challenge in the moment of communication, it is not at all the same challenge in terms of cumulative effort expected of deaf people to bridge communication gaps with hearing people - that burden is asymmetrical and impacts DHH people way more in their everyday lives, over the course of their lives. To try to address this challenge, the EU-funded SignON project aims to develop a mobile application that will translate between different European signed and spoken languages.

The application, which will take the form of lightweight software running on a modern mobile device with a camera, will interact with a cloud-based distributed framework dedicated to these computationally heavy tasks. The application and the framework will be designed through a co-creation approach where DHH and hearing users will work together with SignON researchers and engineers to build a solution that suits all user types. Furthermore, it will be built for easy adaptability to other languages (signed and spoken) and modalities. Ultimately, the application will promote equitable exchange of information among all European citizens.

This project will run over three years from January 2021 to December 2023, and at the time of writing this report, we are almost 12 months into the execution of the project. In this review, we present the impact of the project to date.

## 2. Introduction

One in a thousand persons in the EU (approximately half a million DHH persons) communicates in one of 31 national or regional sign languages (SL) as their first language. The SignON service will bridge the communication gap between the deaf communities, people who are hard of hearing (including people with implants), hearing people (including family members and friends of deaf people), industry partners and policy maker user groups and promote inclusion of deaf communities into society by providing an open source and scalable solution for real-time translation between SL, text and speech in the languages that will be addressed in the project (Flemish Sign Language (VGT), Sign Language of the Netherlands (NGT), Irish Sign Language (ISL), British Sign Language (BSL) and Spanish Sign Language (LSE), as well as English, Irish, Dutch & Spanish spoken languages). With the expected wide take-up of the technology, SignON will make a significant contribution to its users and the community.

Currently, the recognition of naturally performed SL is a challenging issue due to its multi-modal nature. Both manual and non-manual features are used in parallel to construct a signed utterance and their identification is crucial for real-time recognition. To build efficient data-driven Sign Language Recognition (SLR) models, large datasets are required and the lack of such resources results in poor applicability of currently available systems. SignON will also impact academic research, industry innovation and business progression through its SOTA advancements in real-time SL linguistics, SLR, Natural Language Understanding (NLU), Automatic Speech Recognition (ASR) (including atypical speech), Machine Translation (MT) and 3D avatar technology, and their underpinning fundamentals. Our platform and its constituent tools, will offer an alternative vision for the governance and values of SL translation and will be publicly available to end-users in the form of a mobile app for real-time translation. SignON is a fundamental step towards a new vision for SLR and translation between sign and spoken languages. It employs a user-centric approach to draw use-cases, to validate quality, to ensure acceptance based on continuous communication with the stakeholders. As such SignON aims to become a stepping stone to foster communication, information exchange, business creation, learning and knowledge acquisition with an inclusive and open society.

### 3. Expected Impacts as Defined in the Grant Agreement

In the Grant Agreement (GA), expected impacts were outlined. These address the expectations set by the programme call and were embedded in the original proposal (which was later turned into the GA). Additional impacts were also defined, including ones specific to each consortium partner. These expected impacts are described below and the impact of each to the end of the first year of the project is outlined.

#### 3.1 Expected impacts of the Project

SignON results will achieve impacts at multiple levels for the user communities, business, industry and research stakeholders as well as the consortium partners which we will discuss in sections 3.1.1 (Expected Impacts as per the Call), 3.1.2 (Additional Impacts) and 3.1.3 (Impacts for the Consortium).

##### 3.1.1 Expected Impacts as per the Call

###### *Improve multilingual speech processing on mobile devices:*

SignON will improve multilingual speech processing by:

1. Personalisable ASR for typical and atypical speech for English, Dutch, Spanish and Irish, accessible via the SignON application
2. Enhancement and processing of the ASR output through language-specific NLU pipelines for improved message understanding and
3. Exploiting the multilingual, multi-modal intermediate representation to capture the meaning of a message regardless of the source language and modality.
4. ASR tuned to DHH speakers (atypical speech), and to our knowledge will be the first to provide this. Recent evaluations of ASR for the DHH community could only report about performances for standard ASR engines<sup>1</sup>. Thus SignON makes a significant step forward in inclusiveness. The same holds for the ASR and NLU facility for an under-resourced language like Irish. The ASR models SignON will develop will be optimised for mobile devices and will be accessible online (communicating with a remote server hosting ASR models) or offline (models residing on the mobile device).

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<sup>1</sup> Glasser, A. (2019) [Automatic speech recognition services: Deaf and Hard-of-Hearing usability](#). C HI'19.

**Impact Progress Indicators from the Grant Agreement:**

1. Improved speech to text recognition assessed by automatic metrics over all SignON supported spoken languages;
2. Increased preference in using speech input to text reaching (at the end of the project) over all SignON supported languages - automatically assessed via the SignON app;
3. User satisfaction of translation based on speech input via voluntary user feedback based on a Likert 5-point scale.
4. User satisfaction of mobile services of at least 68.0<sup>2</sup> System Usability Score (SUS).

**Progress Indicators to Date:**

At the end of the first year, we now have good quality generic ASR engines for Netherlandic Dutch and Belgian Dutch. Generic ASR engines for English and Spanish are under development. We have worked and improved real time responses / latencies for the speech-to-text transcription framework at large.

In D1.4 the user community rated the initial SignON App speech to text (using Google Translate) to be easy to use and their overall SUS rating for the SignON Mobile App is well above the SUS threshold of acceptability of 68. Both SL users (77) and other users (84) rated it above 68, even though only the speech and text translations are functional, and there are no SL translation functions yet.

***Improve sign language recognition on mobile devices:***

SignON will deliver a mobile application with support for SLR based on single-camera video. While other technologies for SLR use excessive hardware (e.g. multiple cameras, wearables, etc.), SignON will fuse together state-of-the-art AI technologies - for face, hand and posture estimation - in a SLR component with improved performance. The SLR component will be based in the cloud, making the application available on any modern mobile device with a camera, without the need for specialised hardware or customised phones. Its distributed architecture will allow for parallel processing of computationally expensive tasks on high-end servers, leading to reduced latency alongside the high recognition accuracy. As SignON will support multiple SLs, and because it will not require expensive special equipment it will be a highly inclusive solution for SLR on mobile devices.

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<sup>2</sup> 68.0 is a widely accepted standard; <https://www.usability.gov/how-to-and-tools/methods/system-usability-scale.html>

**Impact Progress Indicators from the Grant Agreement:**

1. Improved SLR according to automatic metrics, e.g. accuracy, comparable to academic SOTA results under similar conditions;
2. Increased preference in using SL recognition to text input or speech recognition (for signers who can speak) for all supported SLs - automatically assessed via the SignON app;
3. User satisfaction of translation based on SL input via voluntary user feedback based on a Likert 5-point scale.
4. User satisfaction of mobile services of at least 68.0 System Usability Score (SUS).

**Progress Indicators to Date:**

An initial SLR component has been set up. This component can extract and post-process human poses using state-of-the-art techniques for body, face and hand pose estimation. These kinds of data have been evaluated for sign language translation (SLT) (on a dataset that is not part of the project, because dataset collection for SignON was still ongoing at the time), with promising initial results. However, additional work is required to improve the SLR component's robustness. Therefore, the SLR component was created to be modular. In the coming years of the project, it will be updated according to findings from experiments as well as linguistic analysis of sign languages.

***Deploy solutions allowing wide take up by people who are deaf or hard of hearing:***

Many past and current technologies and services for DHH people have been unsuccessful due to failure to meet users' requirements and/or expectations or due to the artificial setting of design and development, as well as due to the lack of available data sets. Through its co-creation workflow, SignON will positively impact user communities by responding to their self-selected needs for real-life communication. The users will drive this project and as a result, we will see the weight and importance of their decisions imprinted in the SignON service. Furthermore, our user-centric practices will set an example of how applications and services for accessibility and inclusiveness should be developed. In such a way, SignON will establish a standard for the development of user-centric technology through co-creation methodologies.

**Impact Progress Indicators from the Grant Agreement:**

1. Constant increase of the number of active users (of intermediate and final releases) and users who express interest in the final release based on demonstrations of and/or own experience with the intermediate releases and decrease of potential users with negative attitude towards

the proposed technology (measured through co-creation events, figures expressed in both absolute and relative values);

2. Constant increase of the number and demographic spread of social media followers from the DHH cohorts and increase in social media activity.

**Progress Indicators to Date:**

The SignON project, through its communication and dissemination as well as thorough co-creation activities has achieved significant social impact which we measure by the number of events held/invited, number of users and continuous user engagement. In terms of presentations and participations in various forums, SignON was presented at five such events, including CLIN31<sup>3</sup>, TaalStudio’s forum “Language and Technology: A successful combination”<sup>4</sup>, META-Forum 2021<sup>5</sup>, LEAD ME Winter Training School Madrid 2021, and on November 20, VGTC organised a presentation and workshop on "Language police or not?", attended by about a hundred Flemish signers. The SignON communications coordinator from VGTC took the opportunity to give a short presentation on SignON at the conclusion of the workshop.

At the time of writing on 30th November 2021 we noted the progress status of number of visitors and followers on SignON website and social media channels:

Channel	Measure	Project Target	First Year
Project website	# site visits	6,000 during the project lifecycle	1326 users
Total site visits at present:			1326
Facebook	# followers	10,000 during the project lifecycle	296 followers
Twitter			184 followers
LinkedIn			59 followers
Instagram			119 followers
Total social media followers at present:			658

<sup>3</sup> <https://www.clin31.ugent.be/>

<sup>4</sup>

[https://ec.europa.eu/info/events/translatingeurope-workshops/language-technology-winning-combination-2021-oc-01\\_en](https://ec.europa.eu/info/events/translatingeurope-workshops/language-technology-winning-combination-2021-oc-01_en)

<sup>5</sup> <https://www.european-language-grid.eu/meta-forum-2021/>

***Addressing under-resourced languages:***

SLs are under-resourced and are under-analysed relative to spoken languages. There is a need to develop resources and describe the languages of interest more fully as we go. The SignON project will strengthen the position of the supported SLs by contributing to the documentation of sign languages and by developing advanced technology that will allow different forms of translation between languages and modalities. The SignON framework will include automated mechanisms and methodologies for expanding, improving and verification of the service. It will facilitate the inclusion of new languages via the SignON technology for learning from user content which is intended for low-resource scenarios or, thanks to SignON's modular design, via new and upgraded tools and models. Through SignON's learning capability new resources can be collected and existing ones verified. The interactive 3D-puppeteering we will develop within this project will allow, through co-creation, to indefinitely expand the database of signs, validate and increase the quality of the automatic generation of Virtual Signers. In combination with the resources that can be collected through the SLR and ASR, SignON can create new parallel corpora. Extending the corpora pool will reduce a significant gap for data-driven methods for recognition of sign and speech. As such it will impact the advancement in this trend of research. In this way the SignON project will not only impact the users of the SignON service, but also the research and development communities and enable them to advance the SOTA in ASR, SLR, avatar technologies, SL translation and synthesis.

**Impact Progress Indicators from the Grant Agreement:**

1. Positive user assessment of the QoS for low-resource languages such as Irish;
2. Validation of the machine learning technology of SignON by the academic (citation number of SignON publications) and the user community;
3. Deploying new or extending existing corpora of speech-to-text, SL-to-text and SL-to-speech corpora as well as database of SL (monolingual data) for Virtual Signers research and development.

**Progress Indicators to Date:**

The initial SignON Mobile App's speech to text uses Google Translate and is available on both Android and Apple phones. While this is mainly to deliver a quick prototype to our stakeholders, it also shows that the distributed approach we undertake allows for updating, improving or replacing certain tools and models. In particular, the app can easily switch to the models we develop specifically for the needs of

SignON. Furthermore, SignON now supports Irish, as well as English, Dutch and Spanish spoken languages.

Our machine translation component, or the intermediate language representation, initially started with only handling spoken languages. We have now added other spoken languages and improved the translation quality for the existing ones. We are currently working on support for sign languages as well.

On the synthesis side, the 3D animated character is built via a platform which captures the human movements and learns from them. This is a great way to improve support for existing languages as well as integrating new languages.

Sign language corpora were commonly available only for online search. We have collected several of these corpora and made them available for download for all consortium partners. Depending on the licenses and the informed consents of the signers, we intend to make these data sets also available to a wider public.

#### ***Open Source Framework and Application Programming Interfaces (APIs):***

The SignON Framework, Application and cloud platform, which features its next-generation multilingual, multi-modal user-centred functionality, will be published free and open-source, to allow the inclusion of third party functionality and modules of existing and future applications, services and languages. Through standardised APIs to the SignON services as well as to its underlying components - the ASR, SLR, InterL, NLU, and SL Synthesis - other tools and frameworks can exploit the results of this project and benefit from their functionality independent from the usage domain, objectives and technology. For many, this would translate to compliance with ISO/IEC 40500:2012.4 9.<sup>6</sup> This will enable the SignON Framework to become a *de-facto* tool in industry and academia.

#### **Impact Progress Indicators from the Grant Agreement:**

1. Increasing community, traffic and contributions of the open-source code released on GitHub.
2. Use of APIs in other projects or products within the lifecycle of the project.
3. Number of citations/mentions of the SignON framework or APIs.

#### **Progress Indicators to Date:**

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<sup>6</sup> <https://www.iso.org/standard/58625.html>

So far, all the code we have been developing is hosted in repositories in GitLab<sup>7</sup>. We plan to release the code after each stable version.

The SignON platform is modular and operates through various connectivity interfaces (APIs) which allow the easy upgrade, or replacement of such components. Through dockerising<sup>8</sup> components and using external providers (e.g. acapela-group<sup>9</sup> for text to speech synthesis) the SignON platform is flexible, extendable and easy to test. Once released, it should be straightforward to adopt in research and industry.

### 3.1.2 Additional Impacts

#### ***Greater autonomy:***

Deaf signers can engage with hearing speakers immediately, without the delay (sometimes days/weeks) and administrative burden often associated with securing authorisations for providing a face to face interpreter. This also allows for more immediate engagement with the wider hearing community.

#### **Impact Progress Indicators:**

1. Indicated in co-creation surveys at the beginning and end of the project.

#### **Progress Indicators to Date:**

In the initial co-creation iteration using the first fast prototype SignON App reported in D1.4, the users gave the SignON Mobile App a System Usability Scale (SUS) rating of 80 overall, which is well above the SUS threshold of acceptability of 68. Both SL users (SUS=77) and other users (SUS=84) rated it above 68, which is to be expected as only the speech and text translations are functional using available proven products, and there are no SL translation functions yet. However, these SUS scores indicate that the SignON App has started on the right track of what users need and want. While the Cognitive Walkthrough indicates that a usable first prototype has been developed and is a good foundation for the future evolution of the App, the slightly lower score for SL users indicates that care will need to be taken that the needs of DHH people are well addressed in its co-development.

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<sup>7</sup> We decided to move from github to GitLab for consortium conveniences. GitLab is better for organising and maintaining large projects such as ours.

<sup>8</sup> A docker container is a standard unit of software that packages up code and all its dependencies so an application can run quickly and reliably from one computing environment to another (<https://www.docker.com/resources/what-container>). Dockerisation or dockerising refers to the process of converting software into docker containers.

<sup>9</sup> <https://www.acapela-group.com/>

***Potential to leverage SignON to supplement the work of face to face interpreters:***

In cases of incidental conversation, for informal conversation with a peer over a break in a meeting, for children in playground engagement (i.e. when human interpreters require a break, but a deaf participant in an event may wish to have a chat with another person/network). SignON is going to facilitate such communication.

**Impact Progress Indicators from the Grant Agreement:**

1. Endorsement of the SignON application by SL interpreter services, e.g. Irish Remote Interpreting Service (IRIS)<sup>10</sup>.

**Progress Indicators to Date:**

There have been none observed to date.

***Multiplier effect of SignON technology as a resource:***

Potential to leverage SignON by users, language learners (including parents of deaf children, teachers, friends), “hearing” environments (employers, colleagues, shopkeepers, pharmacy, etc.), interpreters, deaf people, as a point of reference. For example, hearing SL learners could use the SL recognition and translation to their spoken language to assess their progress. Deaf interpreters can also use the SignON application as a help tool to interpret from spoken language to sign language (currently they use a hearing “feed” interpreter as an intermediary, which means extra costs for the customers). The SignON application therefore interprets the spoken input into an intermediate form of sign language that subsequently serves as input for the deaf interpreters to interpret it into a more finished (more human) sign language.

**Impact Progress Indicators from the Grant Agreement:**

1. Indicated in co-creation surveys at the beginning and end of the project (users who are learners of SL);
2. Adoption of the SignON service in education, i.e. as a possible learning tool for sign language students.

**Progress Indicators to Date:**

There have been none observed to date.

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<sup>10</sup> <https://slis.ie/iris/>

**Machine Translation:**

The project will provide access to other SL corpora and the opportunity to produce valuable research into the linguistics of these under-resourced languages with a view to developing state-of-the-art machine translation tools that have the potential to facilitate better communication between DHH and hearing people.

**Impact Progress Indicators from the Grant Agreement:**

1. New corpora published to open-access repositories (e.g. <http://opus.nlpl.eu/>).
2. Improved MT performance measured by standard evaluation metrics such as BLEU and TER as well as judged by human evaluators (deaf and hearing).
3. Validation of the machine learning technology of SignON by the academic (citation number of SignON publications) and the user community

**Progress Indicators to Date:**

The CorpusVGT (<https://www.corpusvgt.be/>)<sup>11</sup> was previously only available as a web-based corpus, and not as a downloadable corpus. We have obtained the data and will make it available as a single-file downloadable corpus in the CLARIN infrastructure soon. This limitation is required by the permissions given by the signers that appear in the corpus, and which stipulates it can be used for non-commercial research only. It is currently already available to the SignON consortium members.

The Corpus NGT and the ECHO<sup>12</sup> corpus are available from the Language Archive at Max Planck Institute, but on a file by file basis. We have collected these files in order to make them available to the consortium. A similar issue occurred for the BSL corpus. We will investigate whether we are allowed to make these corpora available as single downloadable files.

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<sup>11</sup> Van Herreweghe, M., Vermeerbergen, M., Demey, E., De Durpel, H., and Verstraete, S. (2015). Het Corpus VGT. Een digitaal open access corpus van videos and annotaties van Vlaamse Gebarentaal, ontwikkeld aan de Universiteit Gent i.s.m. KU Leuven.

<sup>12</sup> Brugman, H., Crasborn, O., and Russel, A. (2004). Collaborative annotation of sign language data with peer-to-peer technology. In Proceedings of the Fourth International Conference on Language Resources and Evaluation (LREC'04),

Furthermore we are in the process of processing each of these datasets to make them suitable for use in a machine learning context. Either the processed data or the scripts to process the data, or both will be made publicly available.

We are continuously experimenting with text-to-text, SL-to-text and text-to-SL MT. We have trained effective bilingual and multilingual models based on mBART<sup>13</sup>. At this stage we have no stable models to be publicly released.

***Clear social justice and equality agenda that we help to achieve via SignON:***

The SignON project will promote fairness and equality through the inclusive approach of developing the SignON service that brings the DHH and hearing communities in an open dialogue mediated via the experts in our consortium. Through better understanding of communities' individual needs as well as the requirements to facilitate fair communication between them, SignON will deliver a communication service that will reduce social inequality and inclusion imbalance.

**Impact Progress Indicators from the Grant Agreement:**

1. Transparent reiterative cycles of discussion practicing active engagement with and between DHH and hearing communities across the life of SignON.

**Progress Indicators to Date:**

The users' feedback reported in both D1.3 "First user Requirements Report" and D1.4 "First technical requirements and user research (UX design) report" clearly indicate the open dialogue and inclusive involvement of the DHH users and Deaf community in developing the SignON App, Framework and Services that will reduce social inequality and inclusion imbalance.

**Education:**

The learning from the SignON project will offer a new resource to facilitate the instruction of life skills among vulnerable deaf people with limited literacy skills which DCU, as a third-level educational institute, would look to initiate. It will also allow further development of certain SL grammar books and will lead to a significant speed up in the annotation of SL corpora. In this way, strong points of two

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<sup>13</sup> Liu, Y., Gu, J., Goyal, N., Li, X., Edunov, S., Ghazvininejad, M., ... & Zettlemoyer, L. (2020). Multilingual denoising pre-training for neural machine translation. Transactions of the Association for Computational Linguistics, 8, 726-742.

independent groups can be joined to come up with something completely unprecedented, allowing easy access to syntactically annotated SL corpora which is something that KU Leuven wishes to exploit.

**Impact Progress Indicators from the Grant Agreement:**

1. Schools, universities and organisations representing and supporting deaf people present the platform as a way to engage with deaf people in a more human way reducing barriers to communication and promoting inclusion
2. Endorsement of the platform by the deaf communities, interpreters and hard-of-hearing people in the pilot sites

**Progress Indicators to Date:**

There have been none observed to date.

***Lowering gender bias:***

SignON will bring a service that lowers gender bias: (i) ASR, SLR and SL Synthesis will be adaptable to the user's preferences, including gender; (ii) the recognition, translation and synthesis tools will be developed following SOTA research on reducing gender bias, e.g. using gender-balanced data; (iii) participants in co-creation events will be selected in a gender-balanced way; (iv) with the 60/40 distribution of male to female institution leaders in our consortium the SignON project will be a positive example of unbiased synergy.

**Impact Progress Indicators from the Grant Agreement:**

1. Ethics guidelines are observed;
2. The co-creation approach and the measurements for reducing gender bias we develop within the SignON project are adopted by other European initiatives and projects.

**Progress Indicators to Date:**

The SignON research ethics committee (REC) was established at the beginning of the project. The SignON REC has compiled an ethical guidelines document and ensures these are observed across the life of the project. The committee supports the process towards securing ethical approvals for research relating to the project, and assists in responding to any ethical queries arising at project level.

***OpenSource tools for web-based interactive 3D graphics:***

UPF-GTI will be able to extend the capabilities of the OpenSource tools for web-based interactive 3D graphics it has been offering to the community through GitHub, improving the capability to edit, animate and render virtual characters with much higher quality.

**Impact Progress Indicators from the Grant Agreement:**

1. Increased traffic to the GitHub repository;
2. Endorsement of the 3D virtual signers and puppeteering system by other European projects, researchers and industry stakeholders.

**Progress Indicators to Date:**

There have been none observed to date, but it is too early in the project to expect this as the tools are still in progress.

**3.1.3 Impact to consortium partners**

The collaboration between the partners of the SignON consortium will expand their professional network and will create new avenues for knowledge transfer. It will have a common as well as an individual positive impact. Here is a rundown of the impact that our consortium partners have seen to date:

DCU: Dissemination of the Novel MT research will strengthen the position of DCU as a leader in MT. This project is contributing greatly to the many projects within DCU working towards educational equality for DHH students, including the ISL STEM Glossary project and the Bachelor of Education (ISL). This project will have practical use to the Deaf staff and students studying and working in the Faculty of Education in DCU.

FINC: The SignON project allows FINC to continue its effort and commitment in the development of accessibility services for current and prospective customers. In particular, the project so far helped to enhance FINC capabilities related to the development of apps with a strong focus on accessibility services for all citizens.

INT: As a CLARIN-B<sup>14</sup> technical centre, the portfolio of services of INT has been extended with the VGT corpus. The fact that INT now also covers sign language infrastructure had a positive impact on the external evaluation of the institute which was carried out in August 2021. It also allowed INT staff to gain experience with video corpora and with the specificities of cooperating with the deaf community. We expect to also add NGT resources and as such cover all the SLs of the Dutch speaking area. It will enable the (linguistic) research community in Europe to study these SLs and their annotated corpora and the machine learning community to train their models. The SignON project also allows INT to build up or strengthen its network with the deaf communities in Belgium and the Netherlands.

UPV/EHU: The current experience of UPV/EHU focuses on written language both in multilingual semantic representations and in machine translation. SignON allows UPV/EHU to extend this expertise to multimodal frameworks. The team is researching possibilities in which speech and SL can be incorporated into unified semantic representations and machine translation systems. Due to its inclusion in the SignON project, UPV/EHU is also collaborating with experts in these areas.

MAC: As a result of developing the initial fast prototype SignON mobile App and producing the D1.4 “First Technical Requirements & User Research (UX design) Report”, MAC staff are now more engaged and better aware of the requirements and wishes of DHH people and deaf communities. The MAC Team are also more experienced in the use of a user driven co-creation iterative technology design approach based on User Experience (UX) Design Thinking techniques. Working on WP2, MAC staff are now more aware of the technical options and potential of the open SignON App, Framework and services. Researching D6.6 “SignON Market Analysis” and D6.7 “First SignON Sustainable Exploitation, Innovation and IPR Plans”, the MAC Team have become much more aware of the SL/MT market situation, competitors and exploitation potential of SignON.

UPF: UPF-GTI will be able to extend the high-quality of their virtual characters currently being advanced in the H2020 PRESENT project in collaboration with film and games companies to support a much wider range of animations, and behaviours. The TALN natural language processing group at UPF is extending its current expertise to the area of data-driven text generation applying empirical research based on the use of deep learning methods such as sequence-to-sequence methods. Moreover, the team is currently exploring novel methods for simplification based on pre-trained language models which are fine-tuned

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<sup>14</sup> [www.clarin.eu](http://www.clarin.eu)

to the simplification task. This departs from previous research which was based on linguistically motivated approaches. Additionally, TALN had the opportunity of starting a new research line in the area of machine translation thanks to SignON.

TUDublin: Having developed an XML description of the Sign\_A framework in D5.4, TU Dublin have broadened the initial Sign\_A framework and added to this, while engaging and collaborating with international partners. D5.4 informs the development of an extended version of Behavioural Mark-up Language (BML), and TU Dublin continues to collaborate with international partners to achieve this goal. TU Dublin is currently extending computational models to take into account the other European sign languages associated with the project, other than ISL. This extension is informed by the linguistic analysis being applied to these languages, beginning with the analysis of VGT and BSL. The partnership enables TU Dublin to share their knowledge within the domain and also to expand as a research group within the domain of SL and Human Language Technology.

TCD: Trinity College Dublin's Centre for Deaf Studies works on linguistic and applied linguistics issues, taking a multi-disciplinary approach to understanding the situation of deaf people in society and using action research methods to influence positive societal change. SignON is facilitating further development of corpora in Irish Sign Language, establishing work on SL ontologies, investigation of ethical considerations and DHH, interpreter, and other stakeholder attitudes towards machine translation to/from SLs. This engagement with hard-of-hearing people is a new departure for us and offers new opportunities for thinking about the focus and scope of Deaf Studies in the 21st Century and potential for engagement with a broader range of communities than we have heretofore worked with. Work on the role of embodiment and depicting strategies as drivers of new lexicon in ISL is underway. Further, SignON has opened up avenues for multidisciplinary collaboration, including across the Irish universities engaged in SignON (e.g. with co-supervision of PhDs, through planned collaborative seminars, etc. which would not have happened without SignON); and broader engagement with the SFI ADAPT Centre.

VRT: The Vlaamse Radio- en Televisieomroep (VRT) is the public broadcaster of the Flemish Community in Belgium. Its mission is to inform, inspire and unite and so reinforce Flemish society. As a service providing organization, the VRT wants to take up a special position in society. It strives for a large audience, not so much to gain a high market share, but because it wants to be relevant to as many Flemish people as possible. This is the most important charter of the public broadcaster, i.e. reinforcing

democracy and society by contributing to a social and pluralistic debate, documenting society and stimulating culture and language and Flemish society in all its diversity. The SignON project will give the public broadcaster possibilities to try out the tooling inside a broadcast environment and to learn what other possibilities might be explored. The SignON project gives us the opportunity to better understand the specific needs from the Flemish deaf and hard of hearing community more clearly and to collaborate with them to co-create interesting experiments and use-cases. Currently we are in the legal process to provide data with signed and interpreted content to the consortium partners. This process alone is already interesting for our company regarding the necessities to the corpus creation at one hand and at the other hand the difficult legal process regarding the GDPR ruling (because of the use of personal identifiable information in the dataset).

The SignON project will make it possible to maintain a strong position in an inclusive society, especially to the deaf communities by offering more relevant signed content. With the European Accessibility Act (EAA) in foresight, VRT can be a frontrunner for the media and broadcast industry to share the SignON tooling and requirements.

UGent: Ghent University, in particular the IDLab-AIRO research group, researches SLR in cooperation with members of the Flemish deaf community and SL linguistics researchers. The partnership will allow researchers at IDLab-AIRO to share and gain knowledge from several domains and allow it to grow as a research group within the domain of SL processing; shifting research focus towards SL translation, a long-term goal of IDLab-AIRO. The SignON Project has given a boost to the SLT research in UGent. UGent has already collaborated with the Flemish Deaf and hard of hearing community but the extension to other such communities in Europe has definitely helped to widen their view. Also, the interaction with sign language linguists on the one side and industrial partners on the other allows them to use and increase their expertise while aiming for a much greater goal than they could achieve by themselves.

VGTC: The Flemish SL Centre is actively supporting applied research projects concerning Flemish Sign Language (VGT). The technologies developed in this project could assist other research projects, such as the (semi-)automated annotation of the corpus VGT, which in its turn will improve linguistic research into this language altogether.

In the SignON project, VGTC leads all communication and dissemination activities. Although there were already several similar projects in the past about automatic translations between spoken and signed

languages and the use of sign language avatars, these projects were not transparent enough for VGTC. The main reason was little or no extensive involvement of the deaf and sign language communities in these projects, and no structural cooperation from deaf and/or sign language experts. This created unreliability around this matter. Thanks to partnership in SignON as a sign language expertise center, we have a better insight into the intentions and operation behind the projects about automatic translations and sign language avatars. This helped VGTC to find optimal solutions for all parties in the project, where they feel that the deaf signers also have a voice (“nothing about us without us”). This improves the credibility of the project towards deaf communities. Also, communication and dissemination activities from VGTC help the SignON project to reach a wider audience of DHH people, as the result there is more insight into their concerns, needs and wishes. Internally, SignON provides new job opportunities for deaf people who want to work around their language and their community.

UCD: The SignON project has been a huge boost for UCD’s sign language/Deaf Research, both locally and regionally. First, while UCD have had discussions with TCD’s Centre for Deaf Studies, they have never collaborated directly. Now, one TCD academic (Prof. Lorraine Leeson) is on the doctoral panel of the UCD PhD student funded by SignON (Ruth Holmes) and discussions and academic outputs (e.g. publications) are ongoing or planned with TCD, TUD and DCU researchers involved in SignON. The potential for growth in the Deaf Research area, and also for the impact this has on the Deaf community, are bright. In addition, UCD researchers are involved with experts in the Machine Learning domain from UGent (WP4’s leaders) and we are exchanging ideas and directions regarding sign language recognition that are very beneficial for them.

The UCD community is reacting very positively to this increase in support for Deaf Research in UCD, and have been solicited by UCD Access & Lifelong Learning (the UCD service in charge of inclusion) to give talks (in June 2021), help them add sign language to some of UCD’s webpages (in progress) and support their initiatives towards Deaf students or potential students. Overall SignON is helping Deaf awareness in UCD and has the potential to increase Deaf inclusion and Deaf Research.

RU: Serious challenges for ASR are under-resourced languages (such as Irish) and ASR for special user groups (such as DHH people). Progress in these directions will crucially depend on the availability and quality of annotated (atypical) speech corpora. For RU the SignON project therefore offers a unique framework to develop its ASR technology into these directions directly in collaboration with the involved

user groups, which will deliver a boost to RU's mission to offer inclusive speech technology in an atypical communication context.

TaalUnie: The Union for the Dutch Language is not only concerned with Dutch, but also with the other languages that are used in the Dutch language area, which include NGT, the SL of the Netherlands and VGT, the sign language used in Flanders. The SignON project has begun to contribute to the three priorities NTU has identified for the coming years: a) Strengthening the digital language infrastructure: As the SignON framework, application and cloud platform will be made available free and open-source, this will stimulate future applications and services. b) Internationalization: The multilingual SignON components will enable communication between multiple languages. c) Accessibility and inclusion: SignON aims to facilitate communication between the deaf, hard of hearing and hearing communities in an open dialogue, while at the same time reducing gender bias, social inequality and inclusion disbalance. This contributes to further implementing the Convention on the Rights of Persons with Disabilities in the Dutch language area and beyond.

KU Leuven: KU Leuven is working on the accessibility of language - resources and tools: (i) For students and researchers (like GrETEL) and (ii) tools enabling users with specific needs to communicate with the world outside. SignON has allowed KU Leuven to extend its expertise on sign language processing, which has the potential to assist with a GrETEL for SLs, first just for VGT combined with Dutch, enabling easy access to signed corpora, for example for educational purposes. The project has equally contributed to the accelerated annotation of the Corpus Vlaamse Gebarentaal; has fostered fruitful cooperation between sign language researchers and computational linguists; and will benefit KU Leuven's initiatives with regard to the teaching of and research on Flemish Sign Language.

TiU: First, the Cognitive Science & Artificial Intelligence (CSAI) department of TiU has a strong NLP team that has recently been complemented with experienced MT researchers. This project is therefore providing the foundation for (i) further expanding this team in the area of MT and (ii) establishing a strong position among the MT and NLP communities. Second, the SignON project is offering a unique opportunity for TiU to expand its research in the social and behavioral aspects of AI. Working on WP4 has allowed the TiU SignON members to get a better insight into the properties of SL that need particular attention, and might constitute a challenge, when employing an MT model. These insights are the

starting point for the planning of the next steps of its contribution to WP4, and for the development of a more informed approach to the topic.

EUD: The EUD works for equality in the public and private life of deaf people. SLs play a key role in achieving this equality and in the accessibility of deaf persons and human rights in general. To this end, the SignON project is an excellent opportunity to get truly involved in SLs, on both a human and technical side. EUD took the opportunity to include users in a co-creation process and to represent users as best as possible while collaborating with technical partners on the tremendous possibilities that the technology can offer. The inclusion of end-users was achieved by organising focus group interviews in the scope of WP1. This way, valuable feedback could be gathered at the very start of the SignON project. The inclusion of user feedback from the focus groups and its analysis was necessary to address the needs of deaf people in line with the Convention on the Rights of Persons with Disabilities. The inclusion of EUD in an EU project of this scale, makes sure that the needs and priorities of the end-users of the SignON project are put to the forefront from the beginning. The importance of this must be underlined, as in the past very few projects included deaf users in the development from start to finish. This did not fit in with the “Nothing About Us Without Us” principle. EUD sincerely believes that the SignON project sets an example and has achieved transparency in its work process.

### **3.2 Measures to Maximise Impact**

At the beginning of the project SignON prepared a communication and dissemination plan (D6.1). This plan ensures proper visibility, accessibility and promotion of SignON and its results during the project lifecycle and after its completion. We target 5 groups of users: (i) deaf communities (signers), (ii) DHH people (non-signers), (iii) hearing people, (iv) SL interpreters, and (v) scientific community. To reach all these groups in a timely and appropriate manner, the consortium relies on the extensive network already established by SignON participants representing the community and industry partners as well as significant international reach of the External Advisory Board. We have already engaged and informed these groups through (i) scientific and popular publications; (ii) conference, workshop and seminar presentations; (iii) wide-ranging media coverage (newsletters, social media posts, press releases)). At the beginning of year 2 of the project we also plan to have the first public (iv) prototype presentations and demonstrations. The SignON website, [www.signon-project.eu](http://www.signon-project.eu), is the dissemination hub for our project. For the wider outreach, the content on our website is available in English and in International Sign (IS).

Furthermore, the website and its content are developed by deaf professionals who understand the communication needs of deaf communities.

All consortium partners are actively involved in the communication and dissemination activities, which are being led by VGTC (communication and dissemination) and MAC (exploitation). The ADAPT Centre/DCU as the managing body of this project provides legal and privacy advice and support.

The consortium tracks market trends to identify business strategies and roadmaps for the exploitation of Intellectual Property (IP) arising from the project's work. Deliverable D1.1 *Case studies and evidence analysis* presents our first analysis of use-cases, market and prior research; we continue to do so on a regular basis. In doing so, we will be able to discover new market trends and opportunities to incorporate new approaches while supporting efforts to demonstrate SignON's appeal and potential profitability to potential investors.

#### 4. Impact Progress to Date

The aim of the SignON service is to bridge the gap between deaf communities, people who are hard of hearing (including people with implants), hearing people (including family members and friends of deaf people), industry partners and policy makers, and to promote inclusion of deaf communities by providing an open source and scalable solution for real-time translation between SL, text and speech. With the expected wide uptake of the technology, SignON will make a significant contribution to its users and our target communities.

SignON also impacts academic research, industry innovation and business progression through its SOTA advancements in SL linguistics, SLR, NLU, ASR (including atypical speech), MT and 3D avatar technology, and their fundamentals. When openly released, our platform and its constituent tools will offer an alternative vision for the governance and values of SL translation and will be publicly available to end-users in the form of a mobile app for real-time translation. In the first year of the project, SignON is on a track to establish a new vision for SLR and translation to different EU languages and foster **communication, exchange of information, business creation, learning and knowledge acquisition with an inclusive and open society**, through a service co-created by the users.

As noted in Section 3.2., the target audiences will be engaged and informed via (i) co-creation events, (ii) scientific and popular publications, (iii) organisation of and participation in conference, workshop and seminars, (iv) wide-ranging media coverage and (v) prototype presentations and demonstrations.

- Co-creation events: WP1 (EUD and the Centre for Deaf Studies (CDS) in TCD) organised several interviews, either with multiple participants (a focus group), or with just one person. In total seven interviews were held in VGT or LSE, one focus group was held with ISL participants, and one with hard-of-hearing participants (Ireland). To ensure a diverse group of participants, people from different ages and genders were invited, which resulted in a heterogeneous group of ten participants. The impact is such that the potential (DHH) users felt listened to during these interviews, which resulted in a strong willingness to follow-up further stages of SignON development (e.g. to test each component of the SignON services if they have the opportunity). The impact is the positive view on the SignON project, thanks to being aware that deaf people are involved from the start this time and that we will actually listen to them. Currently other co-creation events are being arranged or are taking place.
- Scientific and popular publications: The list of work that spans from the SignON project and published in academic and non-academic venues is:
  - Mathieu De Coster, Mieke Van Herreweghe and Joni Dambre, Isolated Sign Recognition from RGB Video using Pose Flow and Self-Attention, Proceedings of the IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR) Workshops, 2021
  - Dimitar Shterionov, Vincent Vandeghinste, Horacio Saggion, Josep Blat, Mathieu De Coster, Joni Dambre, Henk van den Heuvel, Irene Murtagh, Lorraine Leeson, and Ineke Schuurman, The SignON project: a Sign Language Translation Framework, 31st Meeting of Computational Linguistics in the Netherlands (CLIN31). 2021
  - H. Saggion, D. Shterionov, G. Labaka, T. Van de Cruys, V. Vandeghinste and J. Blat, SignON: Bridging the gap between Sign and Spoken Languages, XXXVII Spanish Society for Natural Language Processing conference (SEPLN2021). 2021
  - Dimitar Shterionov, John O’Flaherty, Marcello Paolo Scipioni, Matteo Villa, Edward Keane and, Marco Giovanelli, Early-stage development of the SignON app and open framework - challenges and opportunities, Proceedings of the 18th Machine Translation Summit (MTSummit2021). 2021
  - Mirella De Sisto, Dimitar Shterionov, Irene Murtagh, Myriam Vermeerbergen and Lorraine Leeson, Defining meaningful units. Challenges in sign segmentation and segment-meaning mapping, Proceedings of the 1st International Workshop on Automatic Translation for Signed and Spoken Languages (AT4SSL). 2021.

- Mathieu De Coster, Karel D’Oosterlinck, Marija Pizurica, Paloma Rabaey, Severine Verlinden, Mieke Van Herreweghe and Joni Dambre, Frozen Pretrained Transformers for Neural Sign Language Translation, Proceedings of the 1st International Workshop on Automatic Translation for Signed and Spoken Languages (AT4SSL). 2021.
- Santiago Egea Gómez, Euan McGill and Horacio Saggion. Syntax-aware Transformers for Neural Machine Translation: The Case of Text to Sign Gloss Translation, Proceedings of the 14th Workshop on Building And Using Comparable Corpora. (RANLP 2021), 2021.
- Organisation of and participation in conferences, workshops, symposia and other forums. In 2021, the First International Workshop on Automated Translation of Sign and Spoken Languages was organised by members of the SignON consortium. SignON is also involved in organising the next edition of the Sign Language Translation and Avatar Technology Workshop (SLTAT) and a shared task on machine translation for sign and spoken languages within the WMT conference. Furthermore, SignON had booths at CLIN31 and at META-Forum 2021; SignON was invited to present at the “Language and Technology: A successful combination” forum organised by TaalStudio and Utrecht University. UPF-GTI was invited to present in the winter school *Media Accessibility Training: Sign Language and Subtitling for the Deaf and Hard-of-hearing* organised by the LEAD-ME COST action (<https://lead-me-cost.eu/>), which took the form of a 2 hour workshop about *Virtual Signers generation within SignON* on Monday November 15, with an attendance of around 25 people. CDS has presented at an industry conference with circa 200 participants (MIDAS, 18 November 2021) on invitation from Trinity College Dublin’s Director of Trinity Research and Innovation (TR&I).
- Wide-ranging media coverage: SignON content is disseminated via its channels in Facebook (SignONEU), LinkedIn (SignON (EU project)) and Twitter (@SignONEU). A great success is the SignON encyclopedia which presents videos containing information about sign language, avatars, deafness, machine translation and other interesting and related to the project topics. We also received a significant number of responses to our post on Facebook about sign language avatars for the Winter Olympics in China. When Sign Language avatars can be seen concretely (and are therefore no longer an abstract fact), it provokes reactions that stimulate our interaction with the potential users.
- The SignON website as a dissemination hub.

Since the major update of the website and its publication, and the launch of the social media channels of SignON, our target groups are aware of our project. Although they may still experience it as not necessarily relevant to them personally, the positioning of SignON is clearly present among the target groups, or in other words: they know that the SignON project exists and what its purpose is. The deaf people and sign language interpreters have started talking about it and are asking questions to the coordinator of WP6 in an informal way. These questions are good input for the planned FAQ-page on our website. Maartje De Meulder, a Deaf researcher with a high reputation within the academic field for deaf studies and sign languages, wrote an article about the ethical issues on sign language avatars and automated translation from spoken/written languages to sign languages and vice versa. She presented her article at the first iteration of the AT4SSL workshop and an interview with her is planned, to strengthen the involvement of the deaf academy in our project. A small resistance from the BSL community has begun with hashtag #notoavatars, that will be monitored by the coordinator of WP6. In this way we bring the target groups closer to us and this can improve our communication approach and address the communication and dissemination plan if necessary.

The dissemination activities that have taken place to date as part of the SignON project is further elaborated on in deliverable D6.2: First Annual Reports on Communication and Dissemination Activities which will be submitted to the EU Portal at the end of December 2021.

The plans for exploitation routes within and outside the SignON consortium will be outlined and discussed in deliverable D6.7: “First SignON Sustainable Exploitation, Innovation and IPR plans”, which is also due for submission at the end of December 2021.

## 4. Conclusions

This report presents the very significant impact achieved in the first year of the SignON project. It covers scientific, technical and societal impacts. It aligns the current impact with what was defined in the grant agreement. The report focuses on the communication and dissemination activities conducted in order to maximise the impact.

In 2022 we plan to deliver twenty deliverables and reach seven milestones. These will lead to the following impacts:

- to have the first (Beta) version of the app released for use which will impact the direct stakeholder communities. Reciprocally their feedback will provide new insights and impact the continuous development of the SignON application and service;
- the release of new research and development in the fields of SLR, ASR, MT, SLT and avatars which will impact both academic and industry landscapes;
- through continuous and open communication with the communities, we will expand the information exchange, the mutual understanding and acknowledgement of differences, while reducing biases and (potentially) inequality.