Spanish-Swedish Neural Machine Translation for the Civil Engineering Domain

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Laburpena

Proiektu honetan punta-puntako itzulpen automatiko neuronalaren domeinu egokitzapena aztertu da. Horretarako, suediera-gaztelera bikoterako lau itzultzaile automatiko garatu ditugu: domeinu orokorreko bi sistema (bat itzulpen norabide bakoitzerako) eta domeinura egokitutako beste bi sistema (bat itzulpen norabide bakoitzerako). Gure domeinura egokitutako sistemak Ingeniaritza Zibilerako egokitu ditugu. Domeinu barruko sistemak sortzeko, domeinuz kanpoko datu paraleloez gain, domeinu barruko datu elebakarrak bildu eta erabili ditugu. Testu elebakar horiek automatikoki itzuliz, domeinuko bi corpus paralelo sintetiko sortu ditugu. Guk sortutako lau sistemak neurri automatikoak erabiliz ebaluatu eta Google Translatek sortzen dituen itzulpenekin konparatu ditugu. Gazteleratik suedierara itzultzen duten bi sistemak, gainera, eskuz ebaluatu ditugu post-edizio ataza bat erabiliz, sistemaren produktibitatea neurtuz. Emaitza automatikoek gure lau sistemek antzeko emaitzak sortzen dituztela erakusten dute, guztiak Google Translate nabarmen gainditzen dutelarik. Produktibitate testak, ordea, domeinu-testu zehatzak post-editatzerakoan domeinura egokitutako itzulpen sistemak onuragarriak direla erakusten du.

Hitz gakoak: itzulpen automatikoa, domeinu egokitzapena, atzerakako-itzulpena, produktibitatearen ebaluazioa

Abstract

This project explores domain adaptation of state-of-the-art neural machine translation. We develop a total of four self-attention-based NMT systems for Swedish-Spanish: two general out-domain systems (one in each translation direction) and two in-domain systems (also one in each translation direction). We adapt our in-domain systems for the Civil Engineering domain. Apart from out-domain parallel data, we collect and use in-domain monolingual data that we translate creating two synthetic parallel in-domain corpora with the original sentences as target language. All four systems are tested and compared with automatic evaluation metrics. The Spanish-to-Swedish systems are also evaluated manually by a post-editing task measuring the systems productivity. Results show that our four systems perform similarly, all of them outperforming significantly Google Translate. The productivity test indicates, however, that post-editing domain-specific text benefits from domain-adapted MT.

Keywords: machine translation, domain adaptation, back-translation, productivity evaluation

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1 Introduction

As the final thesis of the master HAP/LAP (Hizkuntzaren Azterketa eta Prozesamendua/Language Analysis and Processing) of the University of the Basque Country, we explored data-driven domain-specific machine translation. More specifically, we developed neural machine translation systems for the Civil Engineering domain in Spanish and Swedish, which we trained with Spanish and Swedish monolingual texts on road and railway projects that we collected and translated automatically as to obtain (although synthetic) bilingual in-domain corpora.

These systems are motivated by the growing need of translation services in the Civil Engineering sector. As this sector, like many other sectors, is extremely supply and demand driven, clients, consulting firms, contractors and subcontractors are sometimes obliged to cooperate beyond national borders (in order to make profit, or even survive). English is of course the mostly used language in this kind of situations, but there are cases in which English is not sufficient, and a country's public information needs to be available in the language spoken by its citizens.

Sweden, unlike Spain, is experiencing a construction boom at the moment, and is an attractive subject for Spanish consulting firms and contractors. The Swedish Transport Administration, however, not only demands excellent technical solutions for their road and railway projects, but also high-quality documentation in Swedish.

The aim of this project is to develop Civil Engineering-adapted machine translation systems for Spanish firms that have to understand and create technical documentation in Swedish. Testing the usefulness of the systems in a real-world scenario is therefore an important part of this project. To this end, we carried out a post-editing task to measure and compare the productivity of our Spanish-to-Swedish systems. All systems, nonetheless, were evaluated automatically and compared to Google Translate.

The report is organized as follows. In section 2 we first describe the fundamentals of different machine translation approaches, and some proposed domain adaptation techniques. We also have a look at the most common evaluation methods, both automatic and human, where we focus on post-editing as an evaluation metric. In section 3 we discuss related work. In sections 4 and 5 we present our project in detail: our baseline system, the data we collected, created and used for training and testing, as

well as how we evaluated our systems. The results are presented in section 6, followed by some conclusions and suggestions for future work in section 7.

2 Theoretical Background

This chapter is divided into three parts. In section 2.1, we review machine translation in general, its different approaches, evolution and the state-of-the-art. In section 2.2, we have a closer look at the domain adaptation of machine translation, and different techniques proposed to increase the quality of translations in specific domains. Section 2.3 is devoted to the evaluation of machine translation systems, both automatic and human methods.

2.1 Machine Translation

Machine translation (henceforth MT) is the process of automatically translating texts from one language (source language) to another (target language). From its emergence in the 1960's, MT makes a crucial part in our now vastly globalized world.

There are two main approaches to MT differentiated by the type of engine (Somers, 1999). The first approach, rule-based machine translation, is based on linguistic knowledge, whereas the second approach, corpus-based machine translation, also called data-driven machine translation, makes use of corpora. Example-based machine translation, statistical machine translation and neural machine translation are three types of corpus-based machine translation techniques. There are also translation methods that combine different kinds of MT systems. This approach is called hybrid machine translation (Sawaf et al., 2017). In this paper, however, we do not cover this approach.

2.1.1 Rule-Based Machine Translation

The idea behind rule-based machine translation (henceforth RBMT) is that Language is composed of different linguistic features and rules that behave differently among languages. All languages have, for instance, plural in their repertoire, but can be expressed in a lot of ways. English uses the suffix *-s* (*-es*) in its regular form whereas Swedish uses the suffixes *-ar*, *-or*, *-er*, or none, depending on the gender of the noun. These features are considered in RBMT and mapped between the source and target language by a set of rules.

In order to do these mappings, RBMT systems are provided with several components: a source language morphological analyzer, a source language parser, a bilingual translator, a target language morphological generator, a target language parser, and

dictionaries (one bilingual dictionary, one for the source language, and one for the target language). The translation process of RBMT is illustrated in Figure 1.

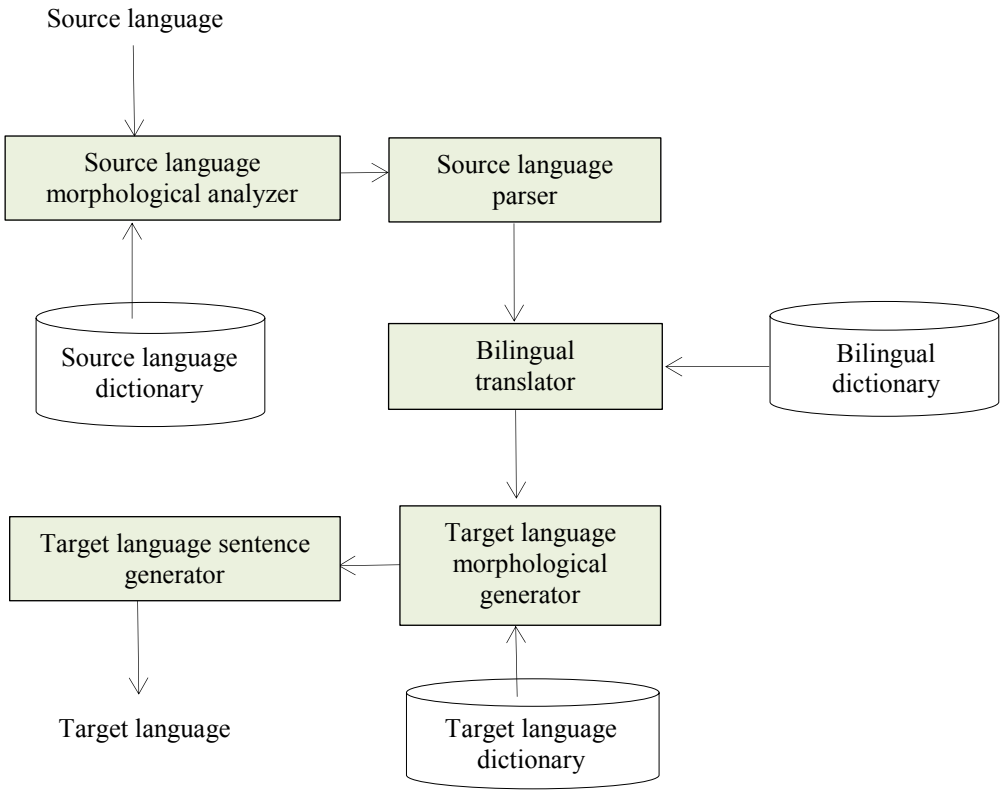

Figure 1: Architecture of a rule-based MT system

With these components, the RBMT translation process consists in 1) analyzing the source language, 2) transferring linguistic knowledge extracted from the input, and 3) generating the output following the rules of the target language. Depending on the analysis depth, RBMT systems can be divided into three kinds. These are direct systems, transfer-based systems, and interlingual systems, the first being the shallowest, and the latter the deepest.

In this approach no bilingual corpora are required, which is an advantage in low-resource scenarios. Furthermore, since they are provided with fixed sets of terms, RBMT systems give a terminological consistency, which can be advantageous in specific translation situations, like in the case of domain adaptation. On the other hand, the one-to-one mappings are troublesome when dealing with big systems, ambiguity and idiomatic expressions. In comparison to other MT approaches, RBMT output also tends to be more mechanical and repetitive (Forcada et al., 2011).

RBMT systems are still used and developed today (cf. Shachi et al., 2001; Hurskainen & Tiedeman, 2017), although not as extensively as other, newer corpus-based systems.

2.1.2 Corpus-Based Machine Translation

In contrast to RBMT, corpus-based machine translation (henceforth CBMT) makes use of corpora. Corpora are (huge) collections of texts and have a crucial role in this approach. Before explaining the different MT methods in CBMT, it comes thus naturally to describe the different types of corpora used in this approach.

2.1.2.1 Corpora

According to *The Oxford Companion to The English* (McArthur, 1992, pp. 265–266), a corpus is, "[i]n linguistics and lexicography, a body of texts, utterances, or other specimens considered more or less representative of a language, and usually stored as an electronic database […] whose features can be analyzed by means of tagging (the addition of identifying and classifying tags to words and other formations) and the use of concordancing programs."

Corpora are the essence of corpus linguistics and widely used in other fields such as natural language processing (NLP). Whereas in most NLP applications monolingual corpora, usually annotated, are used, the primary recourses in CBMT are bilingual or multilingual corpora. Most of them are generic, out-domain corpora, such as multilingual Europarl (Koehn, 2005) and bidirectional ESPC; the English-Swedish Parallel Corpus (Altenberg & Aijmer, 2000), but there are also several more content-specific corpora, in-domain corpora, like the English-Spanish biomedical and clinical corpus in MeSpEN (Villegas et al., 2018).

2.1.2.1.1 Parallel Corpora

In this paper we follow McEnery and Xiao (2007) and refer to parallel corpora as bilingual or multilingual corpora that contain source texts and their translations.[1] These can be, as quickly mentioned above, unidirectional, bidirectional, or multidirectional. This directionality depends on which language is the translation of the other. Also corpora including texts that are produced simultaneously in different languages (e.g. Europarl) are parallel corpora.

[1] The term *translation corpus* is sometimes used to refer to this type of corpora, differentiating them from "pure" parallel corpora including original texts in different languages. In this paper we do not distinguish between these types.

Parallel corpora are aligned in order to provide MT systems with information about how a word or sequence of words in one language is expressed in another language. The alignment of these two corpora is fundamental in order to transmit this cross-linguistic information mapping properly. To assure the quality of corpora, the optimal way to map correctly information between two languages would be to align this information manually, unit by unit. This is, however, as most manual work, very expensive and time-consuming since corpora usually contain million of words. Consequently, several automatic alignment techniques have been proposed and developed during the CBMT history (cf. Och & Hermann, 2004; Varga et al., 2005).

Apart from the actual alignment process, the level at which the corpora are aligned is also important. Nowadays, most corpora are aligned at sentence level, but they can also be aligned at word or phrase level.

2.1.2.1.2 Comparable Corpora

Comparable corpora, on the other hand, are not translations of texts, but rather texts containing components of the same sampling frame and similar balance and representativeness (McEnery & Xiao, 2007). The most famous comparable corpus is, perhaps, the Wikipedia. The Wikipedia contains annotated article alignments and has been and still is used widely in MT in order to extract and compile customized corpora (Tomás et al., 2008; Adafre & de Rijke, 2006; Smith et al., 2010). MT can thus benefit from comparable corpora. Rapp et al. (2016) review some recent work on MT based on this type of corpora, which includes compilation of parallel segments, extraction of bilingual lexicons, and end-to-end MT, i.e. neural machine translation (see section 2.1.2.4).

2.1.2.1.3 Monolingual Corpora

Also monolingual corpora are used in CBMT. Their main purpose is to provide language-specific data to the systems, but have also gained importance in other MT areas when parallel corpora are scarce or nonexistent, like in the area of domain adaptation (see section 2.2.1.2).

2.1.2.2 Example-Based Machine Translation

Example-base machine translation (henceforth EBMT) is the origin of CBMT and appeared in the 1980's (Nagao, 1984). EBMT is restricted to high-quality parallel data, since it extracts and combines already existing words and sentence pairs – examples.

The first step in EBMT is to choose the best match for the input among these examples in the source language. The second step is to manipulate the chosen example. This manipulation works as follows: firstly, the input and the examples are aligned in order to find the segments of the examples that correspond to the input; secondly, the system searches for and identify the corresponding segments in the target language examples that are associated with the matches; and lastly, it creates the output with the identified segments in the target language (Somers, 1999). The procedure is illustrated in Figure 2.

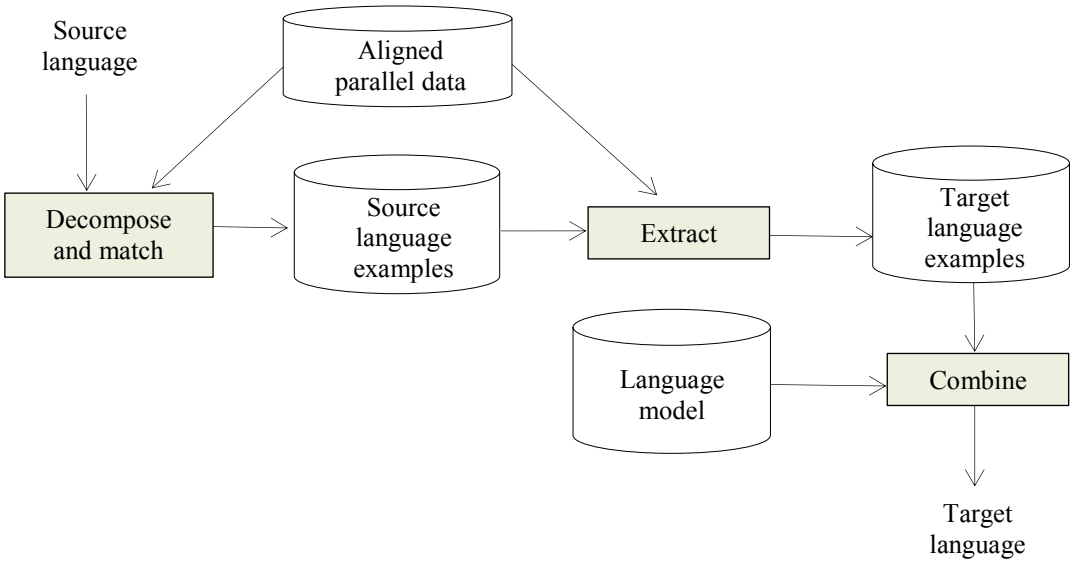

Figure 2: Translation process in example-based MT

The great disadvantage with this method is that it relies entirely on the quality of the corpus used. As discussed above, not only should the alignment accuracy be outstanding, but the level at which the texts are aligned also determines the output.

As the corpus-based approach has developed, EBMT is no longer used in isolation, but rather combined with other MT models.

2.1.2.3 Statistical Machine Translation

As can be deduced from its name, statistical machine translation (henceforth SMT) seeks the most probable translation of a word or sequence of words. SMT systems are composed of a translation model, a language model and a decoder (algorithms). The translation model infers the relations of words in the source and target languages in bilingual corpus, whereas the language model measures the probability of sequences of words in the target language in a monolingual corpus. Consequently, the statistical

information of both models is given to the decoder that performs the output translation, selecting the most probable output based on the information extracted from the corpus. The translation process of an SMT system is illustrated in Figure 3.

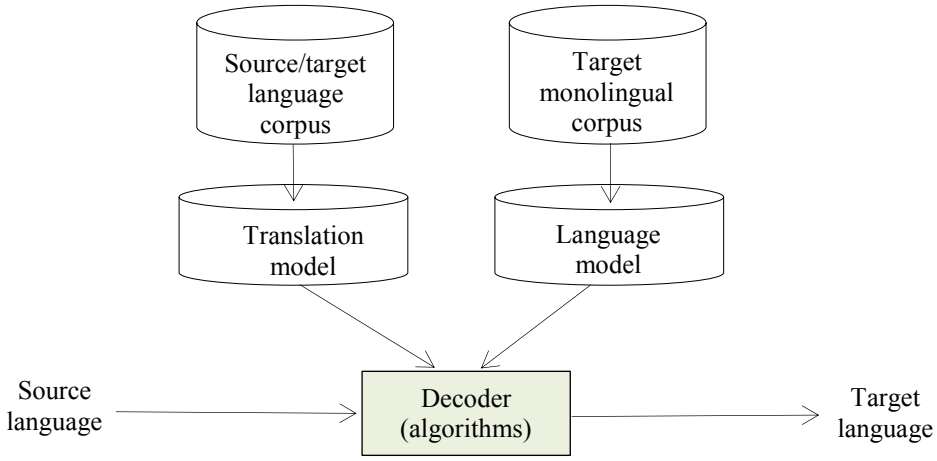

Figure 3: Translation process of an SMT system

The first SMT systems appeared in the 1990's and used words as basic units for translation (Brown et al., 1993). More recent systems, however, are based on phrases (Koehn et al., 2003), and show high performance especially when working with languages of similar structure in word order and morphology (Koehn, 2010). This performance relies, however, entirely on the statistical information provided by bilingual corpora. When parallel resources are scarce, SMT faces great challenges since it is unable to translate words that do not appear in the training data.

2.1.2.4 Neural Machine Translation

Neural machine translation (from now on NMT) is the new breed of CBMT. Like SMT, it is trained on corpora, but, unlike SMT, it applies the theory of neural networks (NNs). The idea of using NNs in MT emerged already in the late 1990's (Forcada & Ñeco, 1997; Castaño & Casacuberta, 1997), but the computational effort was too high at the time. It was not until the works by Kalchbrenner and Blunson (2013) and Sutskever et al. (2014) that NNs were first implemented in MT.

The term *neural network* is given to the computational approach inspired by the complex functions of the neurons in the human brain. An artificial NN (ANN) is a set of connected units that resemble neurons in that their activation depends on the stimuli they receive from other units. The activation of a unit is multiplied with a weight

representing the strength and nature of its connection with other units. This weight can be positive or negative. If positive, a unit tends to activate another unit it is connected to. On the contrary, when negative, no such activation occurs and the connection between units is inhibited (Forcada, 2017).

Analyzed separately, these activations provide little information, and must therefore be analyzed as bigger units (hence the term neural *networks*). When grouped together, units form layers (vectors), which are numerical representations of the activation states of each unit in a specific group. Input units form the input layer of an NN, providing the hidden units of the hidden layer with information. The hidden units perform computations and transfer information from the input layer to the output layer. The output units are responsible for computations and converting information from the NN into readable data. Figure 4 shows a simplified representation of an NN.

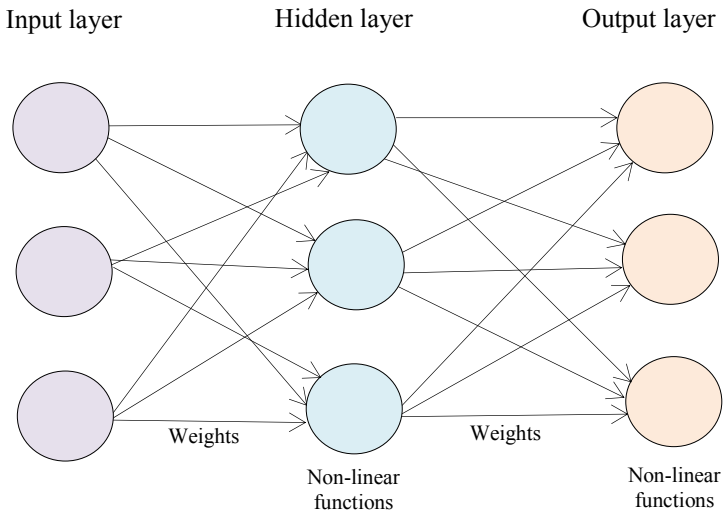

Figure 4: A simplified neural network

The computations in both the hidden and the output layer of an NN are non-linear functions, or so-called activation functions, which have the purpose to introduce non-linearity into the unit output. Non-linearity is the key concept in NNs in general, and in NMT in particular. Language is, as most real-world data, non-linear, and NMT systems seek to learn these non-linear representations of words and sentences in the corpora. In doing so, NMT systems use an encoder-decoder configuration, with one NN for the encoder and one NN for the decoder.

During the training of an NMT system, the weights associated to the connections between units are modified according to a specific loss function in order to measure the distance between reference and output, and subsequently make this distance as small as possible. The weights are repeatedly updated by applying small corrections until the loss function is minimum or small enough. During the translation process, the decoder predicts the most probable of the representations built by the encoder, and converts the chosen representation, still as a numerical value, into output text in the target language.

In such way, NMT systems, as opposed to other MT systems, do not make use of any linguistic or statistical data. Instead, they observe and imitate the translation process. In fact, NMT has been proven to work without parallel corpora, relying the training process entirely on monolingual data (Artetxe et al., 2017).

For an NMT system, then, translating means decoding the source text and encoding the target text. How this encoding-decoding process proceeds depends on the architecture of the systems. Below we explain the main architectures used in NMT today.

2.1.2.4.1 Recurrent Neural Networks

Recurrent neural networks (RNNs) are the beginning of NMT. The encoding-decoding process with RNNs proceeds in a recursive manner. Here, the representation of a sentence is recursively formed by the representations of the words it contains. The encoder first combines the pre-learned encoding for the empty sentence with the representation of the first word of the sentence. Then the encoder combines the representation of the first word and the representation of the second word in the sentence. In this manner, it successively continues combining preceding words until the representation of the whole sentence is obtained.

Similarly, the decoder starts the decoding process from the encoded sentence provided by the encoder, and produces two vectors: an initial decoder state, containing the representation of the source sentence and the representation of an empty sequence in the target language; and a vector, containing probabilities for all possible words in the first position of the target sentence. The most probable word is then chosen as output by the decoder. After the first word is obtained, the decoder produces another two vectors: the second decoder state, containing the representation of the source sentence and the representation of the first word in the target sentence previously chosen; and a vector, containing probabilities for all possible words in the second position of the target

sentence. The decoding process, then, continues in this same recursive way until the whole target sentence is obtained. To finish the sentence, the decoder decides when there is no further word to be added and generates an end-of-sentence token.

2.1.2.4.2 Attention-Based Recurrent Neural Networks

Attention-mechanisms are widely used in NNs. In RNNs used for MT, an attention-mechanism can be added to the system in order to improve the translation performance. Bahdanau et al. (2015) use an attention-mechanism in the decoder to focus on specific parts of the source sentence. In this way, unlike RNNs without attention, the representations of all tokens in a sentence are saved, and not only the representation of each sentence. Given the saved hidden states of previously generated words and the representations of the input words, it is possible to predict an alignment probability to each input word. By weighting the input words according to this probability, the most relevant context of the input is obtained, which is used to predict the next hidden state and output word. The attention-mechanism is computed as an intermediate part of the model and is trained together with the rest of the model, requiring no pre-computed alignments. Connecting the encoder and the decoder through this attention component, this model has been proven to outperform previous RNN models.

2.1.2.4.3 The Transformer

The Transformer in Vaswani et al. (2017) is a sequence transduction model based entirely on attention in order to draw global dependencies between input and output. The model replaces the RNN layers with multi-headed self-attention. Self-attention, or intra-attention, relates different positions of a single sequence in order to compute a representation of the same sequence. Relying exclusively on attention, both the decoder and the encoder use this mechanism to choose the most adequate representation of words. Being multi-headed, the Transformer takes into account all token representations in a given sentence simultaneously, and not in a linear manner as in attention-based RNN systems.

The Transformer has been proven to outperform attention-based RNN systems and achieves state-of-the-art results in some language pairs, such as English-to-German and English-to-French (Vaswani et al., 2017).

2.2 Domain Adaptation for Machine Translation

Improving MT for a specific domain is known as MT domain adaptation. Paradoxically, high-quality domain-specific MT systems are highly demanded whereas general out-domain systems usually perform poorly when tested on specific domains (Koehn & Knowles, 2017). A way of dealing with domains with low resources is to use a third language (usually English) as pivot, translating the source language into the pivot language and thereafter the pivot's translations into the target language (Tiedemann, 2012a). This is useful, but not optimal. Consequently, several domain adaptation techniques –both data centric and model centric– that make use of already existing out-domain parallel corpora as well as in-domain monolingual corpora have been proposed both for SMT and for NMT (Wang et al., 2016; Chu et al., 2018).

In comparison to SMT, domain adaptation for NMT is rather new, and, although it yields the state-of-the-art performance in scenarios where large-scale (parallel) corpora are available, it performs poorly in low resource scenarios (Chu & Wang, 2018). Thus, domain adaptation is a general issue in MT. Here, however, we focus on domain adaptation for NMT. Many of the domain adaptation techniques for NMT are based on previous SMT techniques, whereas some are unique methods for NMT (Chu & Wang, 2018). The techniques we cover in this section are specified in Figure 5.

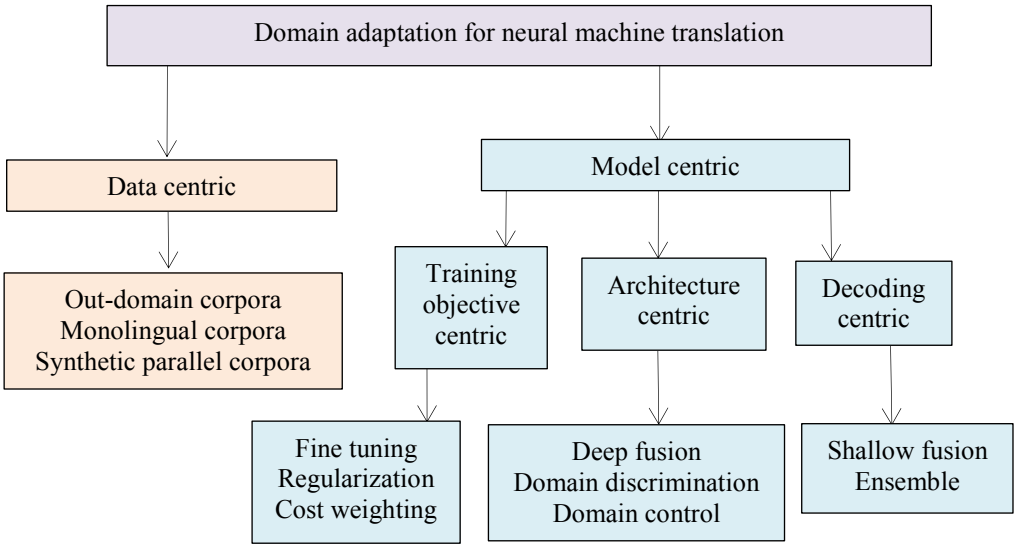

Figure 5: Domain adaptation for NMT (adapted from Chu and Wang, 2018)

2.2.1 Data Centric Domain Adaptation for NMT

Data centric domain adaptation focuses on selecting and generating data for a given domain. The ideal, of course, in such scenario, would be to manually write and translate millions of texts for the specific domain. Since this is very expensive, the next methods that use existing corpora have been proposed.

2.2.1.1 Using Out-Domain Corpora

Chu and Wang (2018) refer to using a combination of out-domain and in-domain corpora to train a mixed MT system as multi-domain methods. For instance, the multi-domain method in Sennrich et al. (2016a) uses tags to control the politeness in sentences translated by NMT. In this method, corpora of multiple domains are concatenated with two small modifications: domain tags and oversampling. The domain tags prime the NMT decoder to generate sentences for the specific domain. If the corpus with domain-specific sentences is too small, oversampling can be done in order to increase the amount of in-domain data, so the system pays equal attention to each domain in the training process. Sajjad et al. (2017) explore different methods to train this kind of multi-domain systems. Apart from concatenation, they also test stacking, selection, and ensemble. The first method trains the NMT system and each domain corpus iteratively; the second one selects parts of the out-domain data that is similar to the in-domain data; and the latter ensembles the multiple NMT models trained independently. The authors find that fine tuning (a training technique explained in section 2.2.2.1) the concatenation system with in-domain data obtains best results.

Data selection, one of the techniques in Sajjad et al. (2017), is widely used in SMT (cf. More & Lewis, 2010; Axelrod et al., 2011; Duh et al., 2013), and consists of scoring the out-domain data using models trained on both in-domain and out-domain data. The training data are then selected from the out-domain data on the basis of the scores previously obtained. Wang et al. (2017) show that SMT data selection techniques improve NMT performance, although modestly. Consequently, proper NMT selection methods have been proposed (cf. Wang et al., 2017; van der Wees et al., 2017).

2.2.1.2 Using Monolingual Corpora

There are different studies that use monolingual data for domain adaptation in NMT. Some of them use monolingual data in combination with a language model (cf. Gülçehre et al., 2015; Domhan & Hieber, 2017), but there are more system-independent

techniques that use monolingual texts. Currey et al. (2017), for example, merely copy the monolingual target text into the source side.

Another system-independent way of using monolingual data is to create artificial data from it. Sennrich et al. (2016b) use a target monolingual corpus to strengthen the decoder after translating it automatically to generate a synthetic parallel corpus, with the automated translations as source. This method is also referred to as back-translation and is represented in Figure 6.

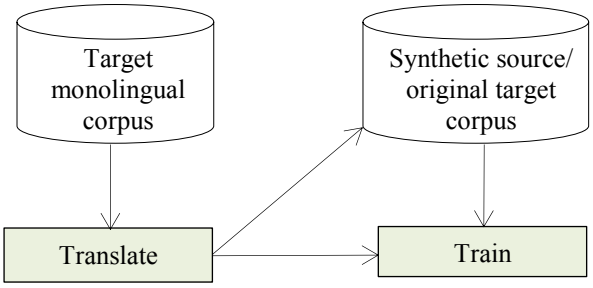

Figure 6: Synthetic data generation for NMT in Sennrich et al. (2016b)

Soto (2018) carried out some experiments on Basque-to-Spanish NMT on the health domain and found that adding monolingual data together with their automatic translations improved the performance with 5.6 BLEU points. Both Sennrich et al. (2016b) and Soto (2018) back-translate target monolingual data. Other studies use source side monolingual data (Zhang & Zong, 2016) or both (Park et al., 2017).

2.2.2 Model Centric Domain Adaptation for NMT

Another way of adapting an NMT system to a specific domain is to change the proper model in one way or another. These modifications can be done at different levels: in the training state, in the architecture of the system, or in the manner the systems decode the data.

2.2.2.1 Training Objective Centric

Training objective methods change the training functions or procedures to obtain optimal in-domain training. There are different ways to optimize the training depending on the objective. The conventional method for domain adaptation is fine tuning (cf. Loung & Manning, 2015; Servan et al., 2016; Freitag & Al-Onaizan, 2016). Fine tuning is referred to as the process in which an NMT system, after being trained until

convergence with out-domain data (i.e. when the system has reached a good as possible result), fine tunes its parameters on less rich in-domain data. Csaba Varga (2017) applies fine tuning on parallel sentences extracted from comparable corpora. With fine tuning, however, there is a risk of overfitting[2] due to the small size of in-domain data.

To overcome this problem, another variety of fine tuning, so called mixed fine tuning, can be applied. Mixed fine tuning combines conventional fine tuning with the multi-domain method discussed above. Chu et al. (2018) show that mixed fine tuning performs better than the multi-domain method or fine tuning separately. The regularization technique in Barone et al. (2017) also addresses the overfitting problem during fine tuning. They introduce tune-out, based on the dropout technique in Srivastava et al. (2014). Instead of dropping randomly chosen units in the training process, tune-out selects and uses out-domain weights.

Another training objective centric technique is cost weighting. This technique adjusts the weight values of the different domains in order for the sentences of the same domain to have similar weight. Chen et al. (2017) modify the NMT cost function with a domain classifier. In their work, the output probability of the domain classifier is transferred into the domain weight.

2.2.2.2 Architecture Centric

Architecture centric methods make modifications in the NMT architecture. Together with in-domain monolingual data, deep fusion can be applied. Deep fusion combines a recurrent neural network language model (RRNNLM)[3] trained with in-domain monolingual data with an NMT model for the decoder (Gülçehre et al., 2015). The hidden states of the RRNNLM and the decoder are then concatenated. When computing the output probabilities, the NMT model is fine tuned in order to use the hidden states of both models, and not only that one of the decoder.

Britz et al. (2017) propose a discriminative technique to leverage the diversity in multi-domain corpora. They add a feed-forward neural network (FFNN)[4] that serves as

[2] Overfitting is the machine learning term referred to when a system is too adapted to the data used in the training process.

[3] The RRNNLM by Mikolov et al. (2010) is the state-of the-art language model in NMT. As in SMT, the language model seeks to model the target language, but in a sequential manner.

[4] An FFNN is an NN in which the flow of information only goes in one direction (forward), with no recurrent connections as in RNNs.

discriminator in the encoder. The encoder uses attention to predict the domain of the source sentence.

Another way of predicting the domain of the source sentence is proposed in Kobus et al. (2016). They append domain-specific features to the word representations. Specifically, they propose a term frequency-inverse document frequency (tf-idf) to predict the domain tags.

2.2.2.3 Decoding Centric

Decoding centric techniques focus on the algorithms used in the decoder and can be used together with other model centric methods. Gülçehre et al. (2015) use shallow fusion decoding together with their deep fusion architecture explained above. Shallow fusion decoding means that the probability of the next word obtained by the NMT model is combined with the probabilities generated by the RNNLM and the decoder. Freitag and Al-Onaizan (2016) ensemble out-domain models and fine tuned in-domain models in order to prevent degradation of the out-domain data after fine tuning the in-domain data.

2.3 Evaluation of Machine Translation Systems

Appropriate and reliable evaluation techniques make up an important part in the field of MT. Assessing MT performance properly requires well-established methods and metrics that permit comparing different systems. Nowadays there are several customary evaluation methods available to use for anyone who wants to test their MT system. These can be divided into two main groups: automatic and human (or manual) evaluation methods.

2.3.1 Automatic Evaluation

Automatic evaluation metrics are the most commonly used methods for MT. This is partly because they require less effort and work than human evaluation methods, but also because they are more objectively justified. These metrics typically compare the output of the MT systems against human translations, offering one single reference or multiple references for a single source sentence (Lin & Och, 2004). The most common automatic metrics measure the lexical similarity between MT output and reference(s). These include the overlap in words and word sequences, as well as word order and edit distance. The idea behind these metrics is that the quality of MT outputs increases the

more they resemble their reference(s). There are also automatic metrics that measure MT performance in terms of linguistic features, such as part-of-speech (POS), sentence structure, textual entailment, synonyms and semantic roles. Below we have a brief look at three different types of automatic metrics relevant to our project.

2.3.1.1 BLEU

The star of automatic metrics is BLEU (Papineni et al., 2002). BLEU stands for bilingual evaluation understudy and calculates the score of translations at corpora level by measuring the number of word *n*-grams of the MT output that correlates with the reference(s). The *n*-grams measured are of varying length, usually from 1 to 4, as illustrated in Figure 7.

REF	**This**	**is**	**just**	**an**	**example**	**of**	**BLEU**	(7)
1-gram	**This**	**is**	just	an	**example**	of	**BLEU**	7
2-gram	**This is**	is just	just an	an example	example of	of BLEU		6
3-gram	This is just	is just an	just an example	an example of	example of BLEU			5
4-gram	This is just an	is just an example	just an example of	an example of BLEU				4
MT	**This**	**is**	**merely**	**a**	**BLEU**	**example**		(6)
1-gram	**This**	**is**	merely	a	**BLEU**	**example**		**4/6**
2-gram	**This is**	is merely	merely a	a BLEU	BLEU example			**1/5**
3-gram	This is merely	is merely a	merely a BLEU	a BLEU example				0/4
4-gram	This is merely a	is merely a BLEU	merely a BLEU example					0/3

Figure 7: *n*-gram matches (in red) between reference and MT output in BLEU

The reference sentence in Figure 7 has a length of seven words. This means that there are seven possible unigrams, six bigrams, five 3-grams, and four 4-gram in total. In an identical MT output, all these would have a match. This is not the case in Figure 7, where the MT output has a length of six words, which means that it has six unigrams, five bigrams, four 3-grams, and three 4-grams. To obtain the BLEU score of the MT output, the *n*-gram matches, marked in red, are divided by the total of *n*-grams in the MT output. If an MT output is shorter than the reference, a brevity penalty is applied, which is the difference between the total of words in both corpora, like 6/7 in our example in Figure 7. If the output is longer than the reference no penalty is applied, and

the result is multiplied by 1. All matched *n*-grams divided by all possible *n*-grams in the output are multiplied together with the brevity penalty. The example in Figure 7 obtains a BLEU of 0.1142 (4/6 x 1/5 x 6/7) x 100 = 11.42.

2.3.1.2 TER

TER (translation edit rate) in Snover et al. (2006) is another common metric. TER measures the number of edits it takes for an MT output to become identical to its reference. The score is obtained by dividing the number of edits by the average number of reference words. In this way, TER is the minimum number of edits required in MT outputs. In this metric, edits count as substitutions, insertions and deletions of single words, as well as shifts of word sequences. An example of TER is illustrated in Figure 8.

REF	**This**	**is**	**just**	**an**	**example**	**of**	**TER**	(7)
MT	**This**	**is**	**merely**	**a**	**TER**		**example**	(6)
Shift	This	is	merely	a	**example**		**TER**	**1**
Substitution	This	is	**just**	a	example		TER	**1**
Substitution	This	is	just	**an**	example		TER	**1**
Insertion	This	is	just	an	example	**of**	TER	**1**

Figure 8: An example of TER

In Figure 8, the number of total edits is 4 (one shift, two substitutions, and one insertion). To obtain the TER, the number of edits (4) is divided by the number of words in the reference sentence (7). In the case of an identical MT output, that is 0 edits divided by the number of reference words, the score is 0. Our example in Figure 8 obtains 4/7, which sums around 0.57.

2.3.1.3 WER and Character-Based Levenshtein Distance

WER (word edit rate) is the measurement of the minimum number of edits between two sentences operated by the Levenshtein algorithm (Levenshtein, 1965). Like in TER, WER edits are insertions, deletions and substitutions. Unlike TER, however, in this metric the shift is done by two operations; deletion and insertion.

REF	**This**	**is**	**just**	**an**	**example**	**of**	**WER**	(7)
MT	**This**	**is**	**merely**	**a**	**WER**		**example**	(6)
Substitution	This	is	**just**	a	WER		example	**1**
Substitution	This	is	just	**an**	WER		example	**1**
Deletion	This	is	just	an	**WER**		example	**1**
Insertion	This	is	just	an	example		**WER**	**1**
Insertion	This	is	just	an	example	**of**	WER	**1**

Figure 9: An example of WER

In the example in Figure 9, the number of total edits is 5 (two substitutions, one deletion, and two insertions). Like in TER, this number (5) is divided by the number of words in the reference sentence (7). In the case of an identical MT output, that is 0 edits divided by the number of reference words, the score obtained is 0. Our example in Figure 9 obtains 5/7, which sums around 0.71.

The Levenshtein distance is also used to measure single-character edit distance, calculating the total of edits in one sequence (i.e. in one word). Single-character level distance can be useful in MT, since it is able to indicate different types of errors in an MT output (see Table 2 in section 2.3.2.1).

2.3.2 Human Evaluation

As Koehn and Monz (2006, p. 106) put it: "while automatic evaluation measures are an invaluable tool for the day-to-day development of [MT] systems, they are only a imperfect substitute for human assessment of translation quality." A fully valid translation may, therefore, be unfairly penalized if it has been phrased differently. Although several reference translations are used, it is impossible to cover all possible translations, since the number of possible translations, in theory, is infinite. Therefore, human evaluation of MT is always motivated, providing a deeper insight to MT performance.

There are numerous proposed and developed human evaluation methods. These methods can be divided into two groups. Although there is no real consensus on this division (cf. Han, 2018) these groups are usually referred to as traditional methods and task-oriented methods. Traditional methods consist of more subjective "opinion-giving"

methods, whereas the second group includes more practical tasks, as illustrated in Figure 10.

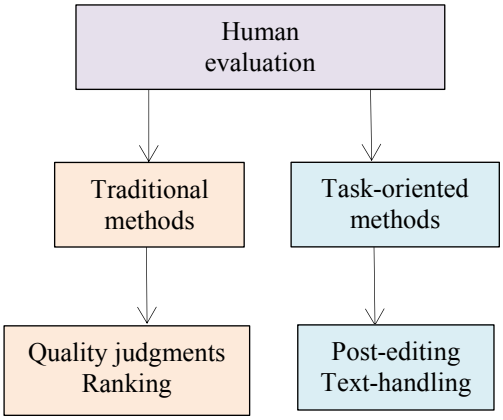

Figure 10: Human evaluations methods

2.3.2.1 Traditional Methods

The earliest human assessment methods for MT, dating from around 1966, are traditional methods, which are the average subjective ratings of the automated output among evaluators in a given aspect. They include intelligibility and fidelity evaluation in that the translations should be well edited and understandable in the same ways as if composed by humans (Carroll, 1966). Some years later, Church and Hovy (1993) created a methodology to evaluate the fluency, adequacy and comprehension of MT outputs, in which evaluators were asked to judge these aspects on a scale 1-to-5. This type of judgment scales has been and still is very popular in manual evaluation of MT systems, not only as to normalize the actual assessment of a specific system's quality but also to estimate this quality and its usefulness in a specific task, such as post-editing (Koponen, 2010). Also ranking methods have been proposed (cf. Callison-Burch et al., 2012; Bojar et al., 2013) which seek to order several MT outputs by its quality.

Lacruz et al. (2014) propose a user rating scale based on the amount of errors in the automated translation. This scale, presented in Table 1, is often used together with a task-oriented method (see section 2.3.2.2.1).

User rating of MT quality	
Rating	**Criterion**
1	Gibberish – The translation is totally incomprehensible
2	Non-usable – The translation has so many errors that it would clearly be faster to translate from scratch
3	Neutral – The translation has enough errors that it is unclear if it would be faster to edit or translate from scratch
4	Usable – The translation has some errors but is still useful for editing
5	Very good – The translation is correct or almost correct

Table 1: Rating and criteria for user ratings of MT quality in Lacruz et al. (2014)

Defining errors, however, is not as straightforward as it may seem. Errors are of different kinds, and the grade of impact they have on a given sentence depends on their type. For this, ratings of errors based on linguistic aspects have been proposed, as Temnikova's (2010) rating in Table 2.

User rating of MT quality	
Rating	**Error**
1	Correct word, incorrect form
2	Incorrect style synonym
3	Incorrect word
4	Extra word
5	Missing word
6	Idiomatic expression
7	Wrong punctuation
8	Missing punctuation
9	Word order at word level
10	Word order at phrase level

Table 2: User rating in Temnikova (2010)

Temnikova's (2010) user rating in Table 2 aims at evaluating an MT system's quality, not only on the basis of total errors in an output sentence, but on the type of errors. For

instance, a sentence with an incorrect word (3) would according to this rating resemble higher quality than a sentence with a missing word (5).

2.3.2.2 Task-Oriented Methods

Task-oriented evaluation methods seek to evaluate how much the systems actually help in a given translation or analysis task. There are many types of tasks that can be carried out in order to evaluate MT systems. Text-handling tasks, for example, may consist of discarding irrelevant documents for a given domain, or extracting key information (White & Taylor, 1998). In this paper, however, we focus on post-editing tasks, which are vastly used in MT evaluation.

2.3.2.2.1 Post-Editing

Post-editing (henceforth PE) is the activity of manually correcting an automatically produced text and is one of the oldest forms of human-machine cooperation for translation. As the implementation of MT in translation services is gaining more importance (Joscelyne et al., 2017), there is a motivation of testing the quality of MT systems via PE tasks. PE can help measuring how well MT systems assist translators in a given task. This can be tested in different ways, such as by measuring the edit distance between the original MT output and the post-edited final sentence, or by comparing the time needed for post-editing MT output from different systems and/or with translating from scratch, often called processing speed. The processing speed is the average number of processed words in a fixed amount of time (second, minute, or hour) and is often used to measure the productivity of a translation and/or PE task. For instance, Arenas (2008), Plitt and Masselot (2010) and Federico et al. (2012) show that the translation productivity increases when translators are provided with MT output to post-edit.

Measuring the PE effort, however, is not a straightforward task. Krings (2001) divides the PE effort into temporal, technical and cognitive effort. In this paper we focus on the temporal and the technical efforts. The temporal effort in a PE task is usually measured by processing speed, and the technical effort is usually measured by edit distance. However, a small technical effort does not necessarily imply a high number of words translated in a short amount of time. Green et al. (2013) show that the category of word and syntactic complexity affect the translation (or PE) time. Not surprisingly, they find that nouns and adjectives, that is, content words, have a significant effect on the temporal effort. This finding can easily criticize Temnikova's (2010) user rating in

Table 2, which simply considers words as a whole, and punctuation. A missing word (5) may require different amount of effort to add, depending on its type. Thus, a missing content word should not be rated equally to a missing grammatical word, neither in a quality evaluation of a system, nor in measuring its productivity. This fact raises questions about the development of MT systems aimed for PE, in that the overall edit distance may become irrelevant if the MT system fails at providing the translator with adequate content words.

2.3.2.2.2 HTER

PE tasks are often furthered with the HTER metric (Snover et al., 2006). HTER is the human-targeted version of the TER metric explained above. Using post-edited sentences, HTER is motivated by the fact that it includes notions of semantic equivalence that entirely automatic evaluation metrics tend to ignore.[5]

HTER involves the comparison between what they call targeted references (post-edited references) and hypotheses (MT outputs) as to find the closest match of all possible fluent references that have the same meaning as the original references. The closest targeted reference is then used as the only human reference in a conventional TER test. In HTER, the number of edits in this closest targeted reference is divided by the number of words in the hypothesis.

[5] This is due to the fact that reference sentences used in BLEU, TER, etc., usually are few.

3 Related Work

Whereas numerous MT studies include the Spanish language, Swedish appears relatively little in the MT literature. This has, of course, its logical explanation, considering the number of speakers each of these languages has. Some MT studies involving Swedish are summarized below.

Stymne and Holmqvist (2008) investigate the effects of processing Swedish compounds for phrase-based SMT between Swedish and English. Tyers and Nordfalk (2009) develop a shallow-transfer MT system from Swedish to Danish in the Apertium platform. Volk et al. (2010) use GAZA++ to develop SMT systems for translating film subtitles for English and the Scandinavian languages. Ullman and Nirve (2014) paraphrase noun-noun compounds in Swedish to improve Swedish-English SMT using Moses (Koehn et al., 2007). More recently, Swedish was one of the languages in Tang et al. (2018), who evaluated different NMT models on historical spelling normalization, comparing the results with those from a similar study, but with SMT (Pettersson et al., 2014). All the aforementioned studies, although their foci differ, handle Swedish in general MT contexts. Sigurd et al. (2005), on the other hand, present two domain-specific interlingual RBMT systems between Swedish and English. Both systems include domain-specific lexicons (single words, multi-word phrases, discontinuous phrases and grammatical phrases) and offer simple and shallow syntactic sentences in marine forecasts and recipes.

To our knowledge, there is no similar work that has been carried out between Swedish and Spanish, neither in domain-adapted MT nor in general MT.

Although their work does not include our language pair, Etchegoyhen et al. (2018) carried out a study similar to the one we present in this paper. They tested and evaluated two MT systems (SMT and NMT) adapted for three different domains with varying degrees of specificity and amount of in-domain data, together with outputs from Google Translate. The domains (and language pairs) in this study were industrial documentation of machine tool components and processes (for Spanish-German), installation and maintenance documentation of elevators (for Spanish-French), and reports and press releases of international non-profit organisms (for English-Spanish), the latter considered to be the least specific. The in-domain training data for all domains were provided by translations memories (plus additional Spanish elevator manuals previously

translated into French) consisting of 25,256, 106,521, and 23,138 parallel segments, respectively.

The three systems were evaluated both automatically, by the three metrics BLEU, METEOR and TER, and manually with quality assessment (fluency and adequacy) attitude evaluation, and PE measurements (edit time and edit effort).

Results showed high correlation between BLEU scores, fluency and PE time: the higher the fluency and shorter the PE time, the higher the BLEU score. Also, the automatic and manual evaluation in all three domains showed homogenous results by ranking the systems in the same order. The ranking in the international reports and press releases domain was 1) Google Translate, 2) NMT, and 3) SMT, whereas in the other two domains NMT was ranked highest followed by SMT and Google Translate. Etchegoyhen et al. (2018) conclude that domain adaptation has a positive impact on MT in general, but more significantly on domains with higher degree of specificity. Also, they show that domain-adapted NMT is effective, "confirming that the paradigm shift that has taken place in the field towards neural machine translation can be considered adequate as well for the highly-specific scenarios that are common in the translation industry" (Etchegoyhen et al., 2018, p. 13).

4 Our Approach

As seen in section 2.2, NMT can be adapted for specific domains by a wide range of techniques, and the method for a given system should be implemented according the real-life scenario it will be used in (Chu & Wang, 2018).

One of the biggest challenges in this project has been to obtain sufficient training data to train our domain-specific systems with, since there is no public Spanish-Swedish corpus in the domain of Civil Engineering (neither parallel nor monolingual). We adopt a data-driven solution to tackle this problem. Parallel out-domain corpora available in Spanish-Swedish may contain some specific segments useful for our in-domain systems. These segments are, however, not gathered and grouped in an in-domain sub-corpus but rather randomly distributed in the corpora, which hinder the use of multi-domain methods. Instead, we collect and make use of monolingual data, which provides us with in-domain synthetic parallel corpora.

Focusing on the training data and their influence on the translation performance, in this project we use the same baseline system for all of our systems. We use state-of-the-art NMT as this approach has been proven to benefit from back-translation. The implementation of this MT approach is also motivated by the scarce studies including Swedish. It is thus of great interest to test NMT between Swedish and Spanish also in a general setting, in order to see how this language pair is handled by advanced NMT. To this end we evaluate all systems automatically. We also translate the test data with Google Translate to better interpret the results.

As our project aims to develop NMT systems for the Civil Engineering domain that help Spanish engineers to understand and produce Swedish technical texts in real-life scenarios, we highlight the importance of task-based human evaluation. In line with Etchegoyhen et al. (2018), we set up a PE task to measure the productivity of our Spanish-to-Swedish systems. Combining automatic evaluation with human evaluation is motivated for many reasons, some of them discussed previously in this paper.

5 Methodology

In this chapter we present our baseline system and the resources we used for training and testing our four systems. Also, we describe the evaluation methods, both automatic and manual, that we employ to assess and compare their performance.

5.1 The System

Our baseline system is the NMT framework Marian[6]. Marian is written in pure C++ with minimal dependencies and can implement different architectures. In this project we use the self-attention-based model Transformer (Vaswani et al., 2017). Table 3 summarizes our baseline system's parameter configuration. This configuration is also the recommended configuration in Vaswani et al. (2017).

Parameter configuration	
Parameter	**Value**
Vocabulary	32 000
Embedding size	512
Encoder depth	6
Decoder depth	6
Transformer heads	8
Optimization	adam
Learning-rate	0.0003
Drop-out	0.1
Maxi batch size	1000
Mini batch size	64
Beam-width	6
Length normalization	yes
Coverage penalty	no

Table 3: Configuration of our baseline system

[6] https://marian-nmt.github.io/features/

5.2 Resources

The resources we used in our project, both for training and testing, are presented below.

5.2.1 Training Data

5.2.1.1 Out-Domain Parallel Corpora

There exist a number of Spanish-Swedish parallel corpora. The corpora used in our project are summarized in Table 4. All corpora are sentence aligned and part of the OPUS collection (Tiedemann, 2012b)[7].

Spanish-Swedish out-domain corpora			
TheCorpus	**Sentences**	**Spanish tokens**	**Swedish tokens**
Europarl	1.8M	57.5M	50.7M
GlobalVoices	8.4K	0.2M	0.2M
DGT	3.0M	66.8M	56.0M
EMEA	1.2M	13.8M	13.9M
Eurobookshop	1.8M	85.5M	68.4M
EUconst	10.3K	87.3K	0.1M
JRC-Acquis	1.6M	66.1M	52.9M
Total	**9.4M**	**289.9M**	**242.2M**

Table 4: Spanish-Swedish parallel corpora

5.2.1.2 Dictionary

Together with the parallel corpora mentioned above, we incorporated an in-domain dictionary to our systems. This dictionary contains 811 parallel entries (words, phrases and some whole sentences), with a total of 1606 and 2383 Swedish and Spanish tokens, respectively.[8]

[7] http://opus.nlpl.eu/

[8] We are aware of the limited size of this dictionary, and that its contribution to our systems will be very little, if any. We decided to include it, however, as it is the only parallel in-domain data we have, and it would be a waste not to use it. For our research purpose, that is, adapt NMT with monolingual data, we trained both out-domain systems with the dictionary as to focus the results on the effect of our in-domain corpora.

The dictionary was incorporated to the system in the same way as the out-domain corpora.[9]

5.2.1.3 Monolingual In-Domain Corpora

We collected 760 Swedish texts and 792 Spanish texts on or related to Civil Engineering projects in order to compile these into two corpora of approximately 6M (460,283 lines) and 8.7M tokens (454,242 lines), respectively. In doing so, we first converted the original file formats (mostly PDF) to plain text and then sentence split (one sentence per line) the corpora automatically. In lines with more than one sentence, we separated each segment by punctuation (., *!* and *?*) followed by space. Then we cleaned the corpus by the premise that each line/sentence would contain more alphabetical characters than numbers and be longer than 5 characters. The cleaning process reduced the Swedish corpus to approximately 5.3M tokens and the Spanish corpus to approximately 7.5M tokens. This "simple" cleaning, however, inevitably implies that there may be copies of the same word/sentence and incomplete sentences, as well as instances of out-domain general text (e.g. "document title" and "introduction") that affect the translations negatively. Table 5 and 6 show 15 representative example sentences of the Swedish and the Spanish monolingual corpus, respectively.

[9] Arthur et al. (2016) and Zhang and Zong (2016) propose special methods for incorporating bilingual dictionaries in MT in order to optimize its influence on the probability distribution.

Example sentences from the Swedish monolingual corpus for the Civil Engineering domain
Sträckan mellan Rautas – Rensjön går utan undantag i fjällandskap nedanför trädgränsen.
I fastmarkspartierna bedöms grundvattenytan normalt vara belägen på 1–3 m djup under markytan.
Geotekniska förhållanden 4.1.
Dokumenttitel
Inledning Av 2 kap 14 § Vägmärkesförordning (2007:90), VMF framgår att märke F5 vägvisare och märke F6 tabellvägvisare ska ha vit botten med svart versal och gemen text och svarta symboler då de används för vägvisning till inrättningar eller anläggningar.
gäller dock 11 kap.
Den fasta marken inom undersökningsområdet är till stor del bevuxen med fjällbjörkskog och i mer låglänta partier förekommer mer öppna myrmarker.
Urgrävning av torv och lösa sediment, 0,2 – 1,0 m
Tabell 4–1: Sammanställning av föreslagna förstärkningsåtgärder
Antingen så lägger man underkant grundsula/platta på frostfritt djup alternativt så utförs urgrävning till frostfritt djup varefter återfyllning ske med material tillhörande tjälfarlighetsklass 1.
Materialtyp (AMA)
(ritningar tillhör MUR geoteknik och är bilagd till detta Teknisk PM Geoteknik) Spårlägen mm Järnvägen går på 1,5 – 3,0 m bank längs hela delsträckan i något kuperad terräng som stiger svagt mot nordväst.
Fastställt av
Geotekniska förhållanden Mellan km 1435+450 och km 1435+625 utgörs jorden av 0,5 till 1,3 m torv som underlagras av grusig sand med hög till mycket hög relativ fasthet.
Jb-sonderingar vid föreslaget läge för ekodukten visar att berg återfinns ca 1,8 – 3,1 m under befintlig markyta på vänster sida om befintlig och planerad järnväg och ca 2,7 m under befintlig markyta på högra sidan om väg E10.

Table 5: 15 examples of the Swedish monolingual corpus for the CE domain

Example sentences from the Spanish monolingual corpus for the Civil Engineering domain
Mantenimiento de Infraestructura Dirección Técnica
El enlace y la formación de las piezas que componen una estructura metálica suponen un problema, cuya resolución forma parte del proceso constructivo en una parte muy importante y fundamental del mismo, tanto en su proyecto como en su ejecución.
Anexo 1.- Resumen de la EA-95 Anexo 11.- Simbolización material de aportación (Normas UNE) Anexo 111.- Recomendaciones prácticas BIBLIOGRAFíA
Consiste en extraer y retirar de las zonas designadas todos los árboles, tocones, plantas, maleza, broza, maderas caídas, escombros, basura o cualquier otro material indeseable según el Proyecto o a juicio del Director de las Obras.
Las medidas de protección de la vegetación y bienes y servicios considerados como permanentes, no serán objeto de abono independiente.
INTRODUCCiÓN 1.1.
Demolición con máquina excavadora.
En los rellenos tipo terraplén se distinguirán las cuatro zonas siguientes, cuya geometría se definirá en el Proyecto: −
Núcleo: Es la parte del relleno tipo terraplén comprendida entre el cimiento y la coronación.
Incluye las siguientes operaciones: − − −
Su espesor será como mínimo de un metro (1 m).
Consiste en el derribo de todas las construcciones o elementos constructivos, tales como aceras, firmes, edificios, fábricas de hormigón u otros, que sea necesario eliminar para la adecuada ejecución de la obra.
En el caso particular de existir conducciones o servicios enterrados fuera de uso deberán ser excavados y eliminados hasta una profundidad no inferior a metro y medio (1,5 m) bajo el terreno natural o nivel final de excavación, cubriendo una banda de al menos metro y medio (1,5 m) alrededor de la obra, salvo especificación en contra del Proyecto o del Director de las Obras.
Serán aplicables las prescripciones del artículo 320, "Excavación de la explanación y préstamos" de este Pliego.
322 EXCAVACIÓN ESPECIAL EN TALUDES EN ROCA

Table 6: 15 examples of the Spanish monolingual corpus for the CE domain

Following the work of Sennrich et al. (2016b), we translated the corpora with our own systems in order to obtain two synthetic parallel in-domain corpora. The configuration of our baseline system was slightly different from when we translated the test data. The monolingual data were translated with sampling (for the other translations we used beam with). This makes generally poorer translations but has been proven to boost the back-translation method (Edunov et al., 2018).

5.2.2 Test Data

Automatic metrics, such as BLEU and TER, need parallel data (i.e. references) to compute the MT performance. Since the only in-domain data we had were synthetic[10], we created a test data set with parallel sentences manually. Parts of these sentences were translated, whereas the majority were manually and carefully selected from the EUR-Lex data[11], trying to cover as much domain-specific content in the training data as possible. The test data consist of 1000 parallel sentences with a total of 23,850 Spanish and 17,745 Swedish tokens. 5 sentence pairs from the test data used for automatic evaluation are presented in Table 7.

Automatic evaluation test data	
Spanish	**Swedish**
En el tramo al norte de la ciudad se construirá un puente integral.	På sträckan norr om staden ska en plattrambro byggas.
En caso de que las aguas subterráneas no correspondan plenamente a ninguna cuenca hidrográfica en particular, se especificarán e incluirán en la demarcación hidrográfica más próxima o más apropiada.	I de fall grundvatten inte helt följer ett visst avrinningsområde, skall de identifieras och hänföras till det närmaste eller det lämpligaste avrinningsdistriktet.
La red ferroviaria de alta velocidad que utilice tecnologías actuales o nuevas se compondrá de líneas especialmente construidas para la alta velocidad, equipadas para velocidades generalmente de 250 kilómetros por hora o superiores.	Höghastighetsnätet som utnyttjar befintlig eller ny teknik skall bestå av banor särskilt konstruerade för höghastighetståg och utrustade för hastigheter på i allmänhet 250 km/h eller däröver.
Velocidad después de fallo de baliza.	Hastighet efter balisfel.
El diseño de las carreteras se funda en el volumen de tráfico esperado y una carga por eje máxima de 13 toneladas.	Vid utformningen av vägarna utgår man från den förväntade trafikvolymen och ett maximalt axeltryck på 13 ton.

Table 7: 5 sentence pairs from the test data used for automatic evaluation

5.3 Training Process

We trained our systems successively. We started the process with training the Spanish-to-Swedish out-domain system and used that system to translate our Spanish in-domain

[10] We had of course our in-domain dictionary. Testing MT performance on single words and phrases is, however, not recommended.

[11] © European Union, https://eur-lex.europa.eu, 1998-2019

corpus, creating in this way the Swedish-Spanish in-domain pseudo corpus. This corpus, together with the out-domain corpora, was used to train the Swedish-to-Spanish in-domain system. With this system we translated the Swedish in-domain corpus as to obtain the Spanish-to-Swedish in-domain pseudo corpus, with which, together with the out-domain corpora, we trained our Spanish-to-Swedish in-domain system. Having these three systems, the Spanish-to-Swedish out-domain and in-domain systems, and the Swedish-to-Spanish in-domain system, we simply trained the Swedish-to-Spanish out-domain system to obtain the four systems. Figure 11 visualizes this training and translating process.

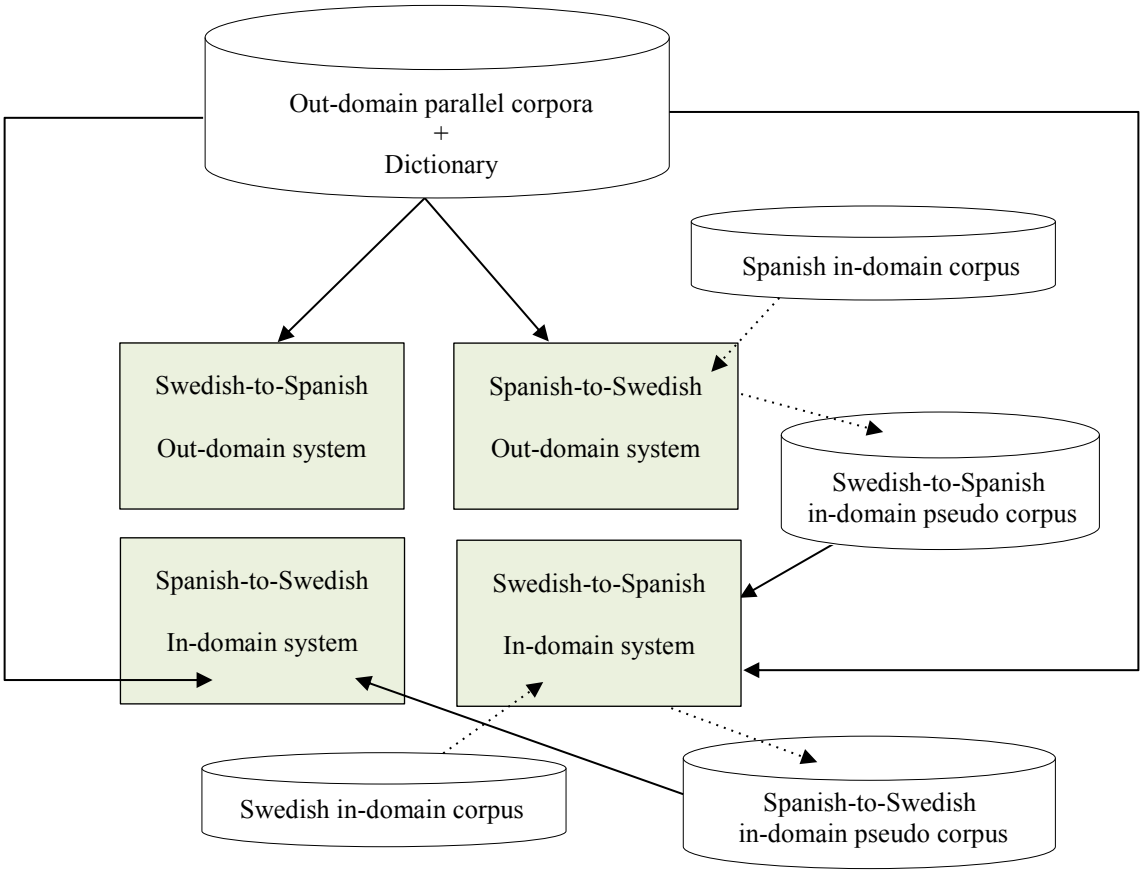

Figure 11: Systematic training (continuous arrows) and translating (dotted arrows) process of our systems

Notice that our in-domain corpora were translated differently. Whereas the Spanish in-domain corpus was translated with an out-domain system, the Swedish in-domain corpus was translated with an in-domain system.

The training process, thus, resulted in four different systems. Table 8 provides a summary of the systems and the data with which they were trained.

Systems and training data				
Direction	**Spanish-to-Swedish**		**Swedish-to-Spanish**	
Type	**Out-domain**	**In-domain**	**Out-domain**	**In-domain**
Corpora	Out-domain + Dictionary	Out-domain + Dictionary + Swedish in-domain	Out-domain + Dictionary	Out-domain + Dictionary + Spanish in-domain

Table 8: Systems and training data

5.4 Evaluation

We evaluated our systems both automatically and manually. The automatic evaluation aims to see if there is any improvement in the performance after adding the in-domain corpora. Since this is merely an indication of the systems' quality, we also tested the systems in terms of productivity via a task-oriented method. Whereas the automatic evaluation was implemented on all four systems, i.e. both translation directions, the productivity test was only carried out on the Spanish-to-Swedish systems, due to the lack of human resources.

5.4.1 Automatic Evaluation

After training both out-domain and in-domain systems for both language directions, we evaluated all four systems with the BLEU metric as well as the TER metric. We also translated the test sentences with Google Translate in order to compare our systems with other Spanish-Swedish MT systems.

5.4.2 Productivity Test

We conducted a productivity test in order to see if our Spanish-to-Swedish in-domain system helps increasing the productivity in a PE task in comparison to our out-domain system, as well as with no automatic translation provided. Thus, the productivity test does not only aim at comparing our two systems. It also explores their usability in general, from the point of view of the translator.

We contacted three Swedish native civil engineers with high level of Spanish. None of them are professional translators, but all have experience in translating Spanish technical text into Swedish at the Engineering firm they currently work.

The task was carried out with the TAUS DQF tool.[12] The tool offers different project types. In this test we only used the project Productivity Testing. During the PE task, the tool automatically calculates the edit time in words per hour (WPH), i.e. the average number of words processed in an hour, and the PE effort, which is the number of character changes made on the MT output (Levenshtein edit distance).

The task consisted of three subtasks. In one of them the participants had to translate from scratch thirty Spanish sentences into Swedish. In each of the other two subtasks they had to post-edit thirty automatically translated sentences in Swedish. One text group was translated by our in-domain system, and the other text group was translated by our out-domain system. The whole task consisted of ninety sentences in total.

Importantly, the participants were told to do as little changes as possible, following the TAUS guidelines for "good enough" quality. "Good enough" quality is achieved by making as little changes as possible, or until the edited or translated sentence is acceptable, albeit structurally unnatural, in that it conveys the same meaning as its source. For the complete translation and PE guidelines for the test, see Appendix A.

The Spanish sentences to be translated and post-edited were grouped by content[13] and complexity criteria, aiming at three equally structurally complex groups. The thirty sentences in each group had an average between 31.2 and 31.8 words per sentence and 5.9 characters per word. The total number of words and characters of each group is presented in Table 9.

[12] https://dqf.taus.net/

[13] Dividing the groups by content complexity, however, is somewhat difficult, since it depends largely on the knowledge of the participant performing the task. We discuss this issue in section 6.2.1 when presenting the results.

	PE task text groups		
	Group 1	**Group 2**	**Group 3**
Sentences	30	30	30
Words	955	936	944
Characters	5,662	5,531	5,571

Table 9: Structural complexity of the Spanish sentences to translate and post-edit by groups

In order to avoid translating and post-editing the same sentence, each participant was given a unique test. In this way, all groups were translated from scratch and post-edited starting from the output of both systems. The tasks of each participant are presented in Table 10.

Participants and test sets			
Participant	**Group 1**	**Group 2**	**Group 3**
P1	No MT	Out-domain	In-domain
P2	In-domain	No MT	Out-domain
P3	Out-domain	In-domain	No MT

Table 10: Participants and test sets

The text groups with the Spanish original sentences and the Swedish automated translations are presented in Appendix B.

We evaluated and compared the task performance with the measures provided by the tool: translation and PE time, the amount of words processed per hour, and single-character edit distance (here called PE effort). The difference between the participants' post-edited sentences and our systems output sentences was also calculated with the HTER metric afterwards.

6 Results

In this chapter we present the results of our systems. In section 6.1 we compare our systems' automatic evaluation results with Google Translate, and in section 6.2 we present the results of the productivity test on our Spanish-to-Swedish systems. In section 6.3 we discuss the overall results.

6.1 Automatic Evaluation

6.1.1 BLEU

The BLEU scores obtained for our four systems, as well as for Google Translate, are presented in Table 11 and Table 12.

Spanish-to-Swedish	
System	**BLEU**
Out-domain	30.9
In-domain	**31.0**
Google Translate	24.7

Table 11: BLEU scores of Spanish-to-Swedish systems

Swedish-to-Spanish	
System	**BLEU**
Out-domain	**35.9**
In-domain	35.8
Google Translate	27.2

Table 12: BLEU scores of Swedish-to-Spanish systems

The results show that there is no significant difference between our systems. In the Spanish-to-Swedish translation direction, the in-domain system obtains 0.1 BLEU higher than the out-domain, whereas in the Swedish-to-Spanish direction the out-domain systems obtain 0.1 BLEU more than the in-domain system.

More significantly, both directions outperform Google Translate with 6.2 and 8.7 points (out-domain), and 6.3 and 8.6 points (in-domain).

6.1.2 TER

The TER scores obtained for our four systems, as well as for Google Translate, are presented in Table 13 and 14.

Spanish-to-Swedish	
System	**TER**
Out-domain	51.4
In-domain	**51.0**
Google Translate	56.0

Table 13: TER scores Spanish-to-Swedish

Swedish-to-Spanish	
System	**TER**
Out-domain	47.9
In-domain	**47.4**
Google Translate	50.9

Table 14: TER scores Swedish-to-Spanish

The TER scores are slightly different from the BLEU scores in that the in-domain system obtains the best result in both translation directions (0.4 for Spanish-to-Swedish and 0.5 for Swedish-to-Spanish). The most significant result here, once again, is that all four of our systems outperform Google Translate. These results indicate that our systems are of high quality. For instance, Toral et al. (2011) compared their system with several online MT systems where Google Translate obtained best results.

6.2 Human Evaluation

6.2.1 Productivity Test

The results of the PE tasks with the Spanish-to-Swedish systems provided by the TAUS DQF tool are presented in the following tables.

Productivity test: translation and PE time (seconds)			
Participant	**No MT**	**Out-domain**	**In-domain**
P1	3463	2168	**1582**
P2	2717	1912	**1838**
P3	3889	**2471**	3205

Table 15: Productivity test: translation and PE time (seconds)

As seen in Table 15, both our systems increase the productivity according to the time spent on each task, compared to translating from scratch. Our in-domain system outperforms our out-domain system two times out of three. The time difference, however, varies between the participants. Whereas participant 1 showed a significant time difference between the tasks (586 seconds), participant 2 performed similarly in both tasks.

The time spent on the tasks may depend on the number of words in the texts. It is therefore necessary to measure the time in relation to the number of words (processing time). In Table 16 we present the total number of words processed per hour (WPH) in each task.

Productivity test: WPH			
Participant	**No MT**	**Out-domain**	**In-domain**
P1	990	1555	**2147**
P2	1241	1776	**1866**
P3	873	**1387**	1052

Table 16: Productivity test: WPH

The WPHs in Table 16 correlates with the amount of time in Table 15. Given both the time and the WPHs, it can be concluded that our systems had a positive influence on the participants' performance.

At first, it also seems that our in-domain system is the most advantageous. In Table 17 we present the average PE effort required by both systems.

Productivity test: average PE effort		
Participant	**Out-domain**	**In-domain**
P1	21.7	**17**
P2	23.2	**11**
P3	**19.6**	25.5

Table 17: Productivity test: average PE effort

The average PE effort in Table 17 is the average sentence PE effort of the thirty MT sentences in each text group, providing in this way a more general picture of the PE effort of the whole text. The PE tool provides the edit distance of each post-edited sentence in the task, based on the single-character Levenshtein edit distance (see section 2.3.1.3). These varied from 0 to 80. It is important to mention that the PE tool counts edits that later may be "re-edited" to its origin. Scores range from 0 to 100, where 0 means no edits were required and 100 means that all/most of the text was modified. The overall results in Table 17 are therefore promising, the most edited text obtaining 25,5 points. Like in the results of PE time and WPHs above, our in-domain system obtains best results in two of our three participants.

The graphs in Figures 12–17 give an overview of the PE effort by sentence. The x-axis (*segment edit distance*) represents the level of effort. The y-axis (*percentage of total segments*) shows the percentage of the segments falling in each effort category from 0 to 10.

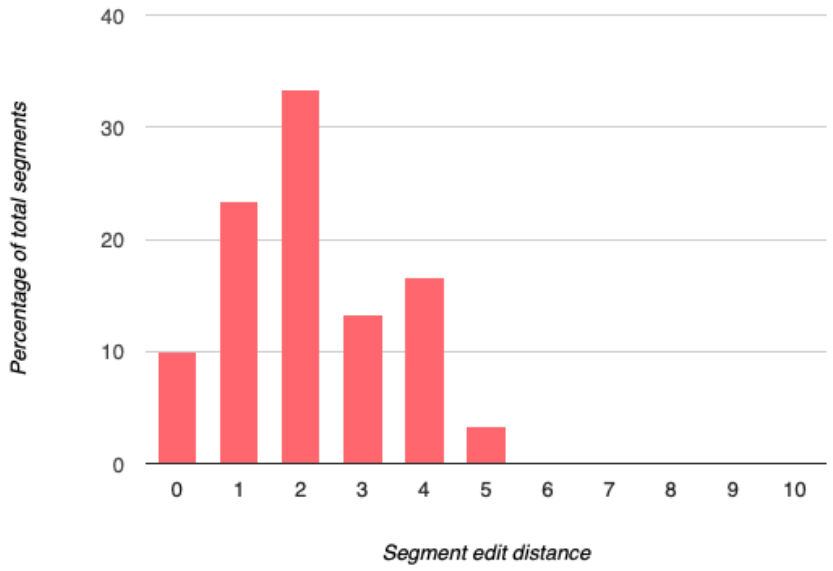

Figure 12: Edit distance P1 out-domain

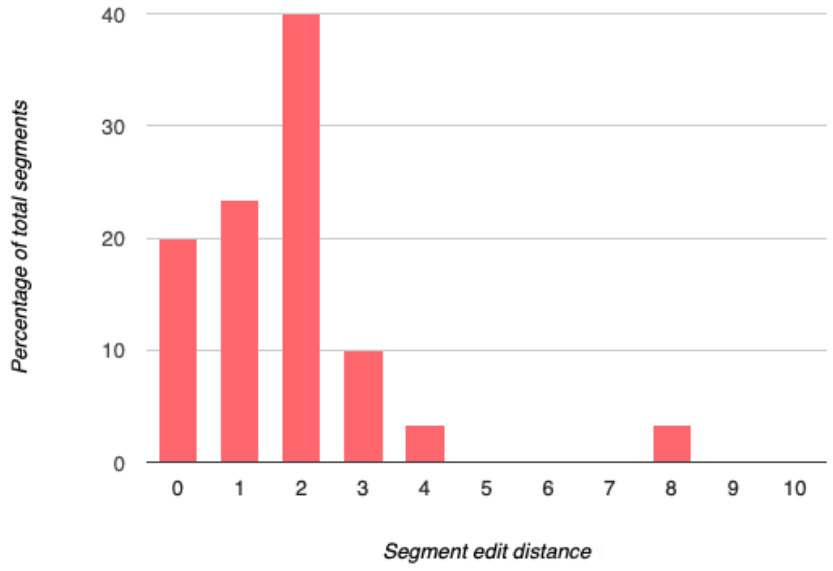

Figure 13: Edit distance P1 in-domain

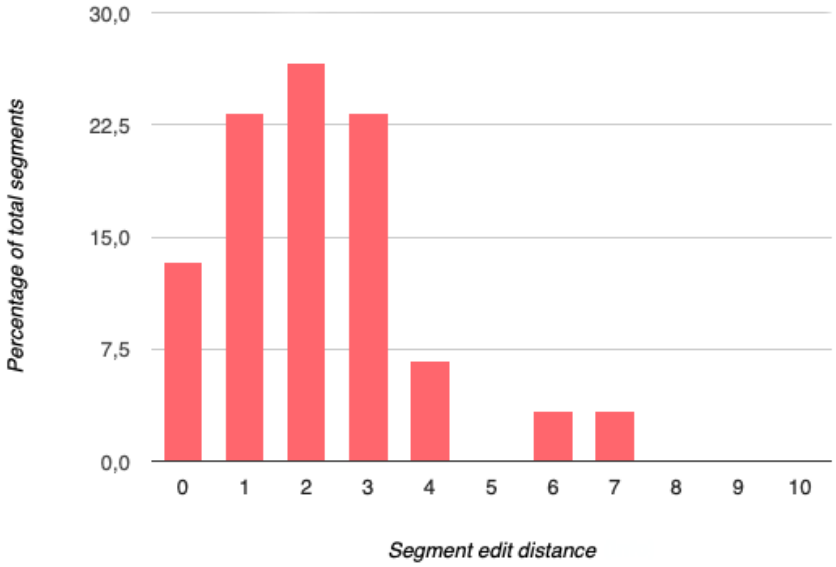

Figure 14: Edit distance P2 out-domain

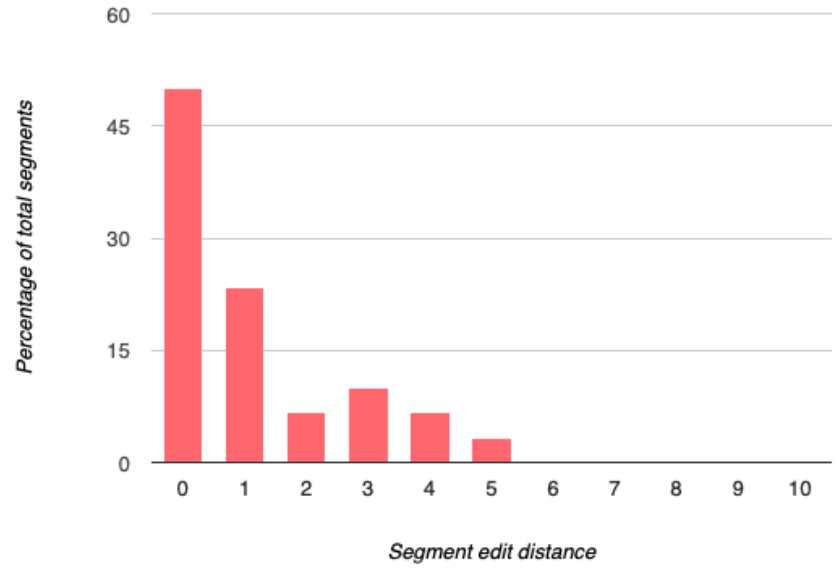

Figure 15: Edit distance P2 in-domain

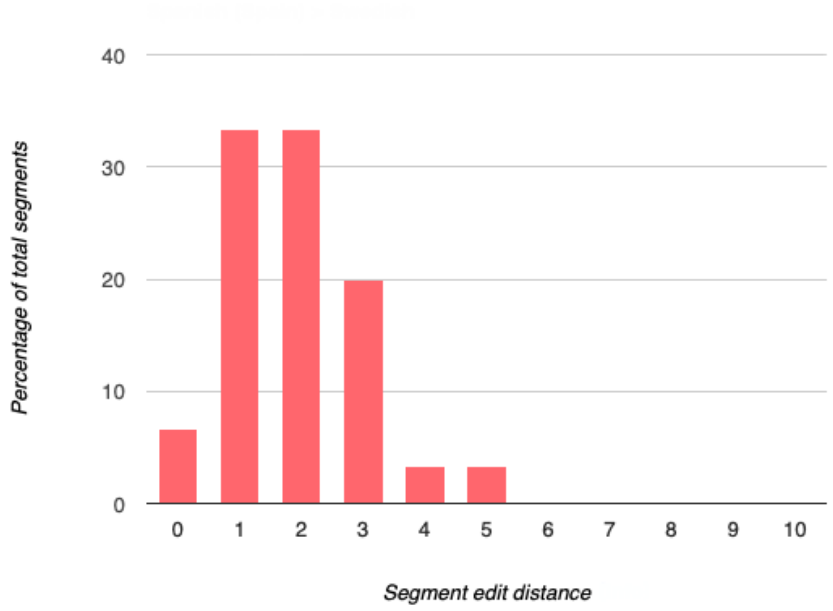

Figure 16: Edit distance P3 out-domain

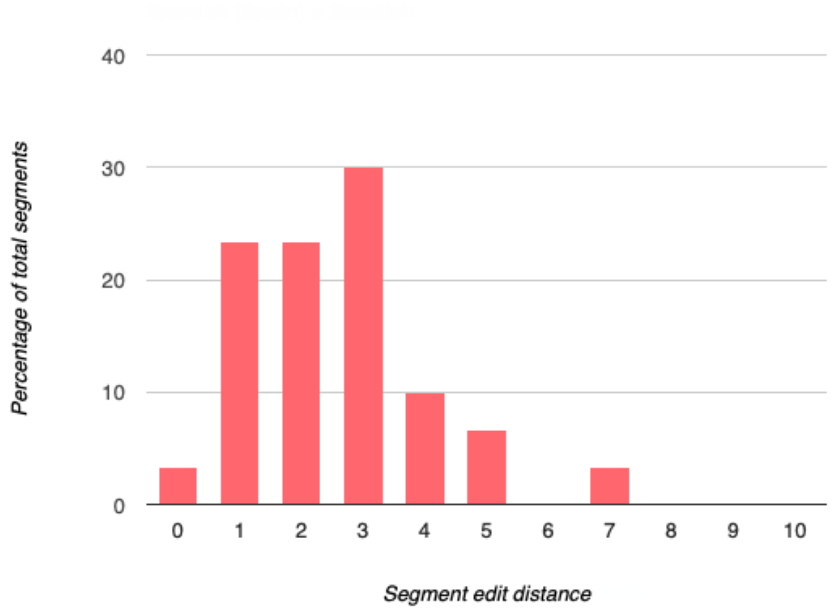

Figure 17: Edit distance P3 in-domain

As seen in the figures above, the in-domain system obtains more segment edit distances in the 0 category than the out-domain system. The out-domain system, however, tends to cause a PE effort falling in the categories 1 to 5, being in this way more consistent.

Furthermore, the in-domain system also causes more sentences falling in the category 7 as well as the only PE effort in category 8 among the participants.

A summary of the productivity test by system is presented in Table 18.

Productivity test: results by system			
System	**Time**	**WPH**	**PE effort**
No MT	10069	716	-
Out-domain	**6551**	**1290**	21.5
In-domain	6625	1224	**17.8**

Table 18: Productivity test: results by system

Table 18 shows the sum of the time spent for each task, and the average WPH (the total words processed divided by the total time) by system. When put together, the out-domain system outperforms the in-domain system, albeit not significantly. The average PE effort, that is, the sum of all character edits divided by the total of characters in the MT output is, however, lower in the in-domain system.

6.2.1.1 HTER

Apart from the results provided by the PE tool, we also evaluated the differences between MT output and post-edited sentences with HTER. Table 19 shows the overall results obtained by both systems, including all post-edited sentences in the productivity test.

Spanish-to-Swedish	
System	**HTER**
Out-domain	21.4
In-domain	**18.4**

Table 19: HTER scores Spanish-to-Swedish

In HTER, the results show a clear advantage for the in-domain system. Both the character-based and the word-based edit distance indicates, thus, that our in-domain system performs slightly better than our out-domain system.

6.3 Overall Results

Overall results show that both our systems increase the productivity of the translation task significantly in comparison to translating from scratch. The difference between the MT systems is small, although some advantage may be given to our in-domain system, especially if we focus on the number of edits (both single-characters and words) required to modify its output to "good enough" sentences.

However, and although we tried to set up three equal groups of text, differences between participants and text groups may have influenced the results. Particularly, participant 3 post-edited text group 2 from the in-domain output and processed more WPHs (335) in comparison to when post-editing the out-domain output. Participant 1, on the other hand, post-edited group 2 with the out-domain output, and obtained a bigger difference between the tasks (592 WPHs). Furthermore, the difference between in-domain and out-domain in participant 2, who did not post-edit text group 2, is considerably smaller (90 WPHs). Thus, both content, technical knowledge and/or acceptance of participants have a great impact on the performance in a PE task. More tasks with more participants are therefore needed to be able to draw reliable conclusions. In this test we focused on the systems' performance on the same texts. Ideally, the participants also should have translated the same texts provided the same automated output.

Still, it is possible to state that post-editing Civil Engineering texts benefits from our systems, and that both perform well achieving significantly higher results than Google Translate.

7 Conclusions and Future Work

In this project we explored data-driven domain-specific NMT in the Civil Engineering domain for Spanish and Swedish. We used state-of-the-art NMT and in-domain synthetic parallel corpora that we obtained with back-translation.

Results are promising in one way, as they show our baseline system is of high quality and outperforms Google Translate significantly. Our in-domain systems, on the other hand, do not perform significantly better than our out-domain systems. Although the productivity test results only can –and should– be used as an indication, it seems that our in-domain systems require less post-edits, but more time. Overall results, both automatic and human, show thus no difference between our systems.

One of the reasons to this is that our out-domain systems perform very well. As mentioned before, our general training data may contain segments that are useful for the Civil Engineering domain, which increase the results. Civil Engineering is a wide-ranging domain, including several specialized sub-disciplines, such as structures, topography, geology, hydrology, environment and mechanics. This argument is supported by Etchegoyhen et al. (2018) that show that more specific domains obtain better scores (both automatic and human) when compared to a general system, independently of the model and architecture used. Hence, the small difference in the systems performance does most likely not originate from the amount of in-domain data (cf. Etchegoyhen et al., 2018), nor the type of system, but from the fact that the out-domain data, which we trained all our systems with, cover, in fact, a great deal of what we consider in-domain data.

To prove our hypothesis it is necessary, however, to train and test the systems further, with additional data that are more domain-specific. Considering the interdisciplinary nature of Civil Engineering, future work will have to focus on compiling and creating data for the several sub-domains to obtain clearer differences between our systems. This may be done either by a multi-domain system (Sajjad et al., 2017) or different systems for each sub-domain. Also, and importantly, future test data should be designed in a similar way, as to be able to test the systems in a more coherent way, corresponding to the obtained technical content and level in the training data.

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9 Appendices

A. Productivity Test: Instructions and Guidelines

B. Productivity Test: Source Sentences and MT Outputs

A. Productivity Test: Instructions and Guidelines

Dear participant,

Thank you for helping me carrying out this translation and post-editing task, which is an important part of my thesis. The aim of this task is to evaluate the productivity of our Spanish-to-Swedish Machine Translation system adapted for the Civil Engineering domain. Below you have a brief task description, and some instructions and guidelines for the task.

Task description

This productivity task will measure the amount of time you need to translate or post-editing a Spanish text into Swedish, as well as the effort it requires. The task consists of three (3) subtask. In one (1) of them you will have to translate from scratch thirty (30) Spanish sentences into Swedish. In each of the other two (2) subtasks you will have to post-edit thirty (30) automatically translated sentences in Swedish, parting from the original Spanish sentences. The task consists of ninety (90) sentences in total.

You can do the subtasks in the order you prefer, but it is recommended to follow the numerical order (1.1., 1.2, 1.3 if you do test 1; 2.1, 2.2, 2.3 if you do test 2; and 3.1, 3.2, 3.3 if you do test 3) since the sentences constitutes a fluent text. You are free to use resources (the Internet, dictionaries, etc.) in all three subtasks.

To perform the task, you will be given three (3) links sent to you in three (3) separate e-mails (one of each task). In this task we use TAUS Dynamic Quality Framework (DQF) online tool (https://dqf.taus.net/). Please read the instructions provided in the e-mails carefully, to make sure you fully understand how the tool works.

As you will see in the instructions, the tool displays “previous”, “current”, and “next” Spanish sentences to translate/post-edit in the upper part of the window. Below, you type your texts, either your translations from scratch (with no automatic translation provided) or your post-editions, modifying the automatic translations displayed. You are not restricted to make a one-to-one match. If needed, one Spanish sentence can be translated/post-edited into two (or more) Swedish sentences.

You can pause the tasks, by clicking on “pause”, how many times you like, but please note that your changes will not be saved until you press the button “next”. Make sure you are satisfied with your sentences before clicking on “next”: you will not be able to go back and modify them. Please note that the tool will measure the time you are working on each task, so do not leave the task open if you are not working at the time, since that will affect the results.

Next you will find some guidelines and tips we want you to have in mind while carrying out the task.

Translation guidelines

You will translate freely according to your personal preferences in terms of vocabulary, grammar and sentence structure. You will try to translate as fast as possible, while

making sure your translation contains the same message and communicates the same meaning as the Spanish source text.

Tips for translating

- Write what first comes to mind.
- Do not overthink.
- Stop when you reached a what you consider acceptable translation.

Post-editing guidelines

In the two post-edit subtasks you will aim to achieve a "good enough" quality.

"Good enough" is defined as comprehensible (i.e. you can understand the main content of the message), accurate (i.e. it communicates the same meaning as the source text), but as not being stylistically compelling. A "good enough" text may sound like it was generated by a computer, syntax might be somewhat unusual, grammar may not be perfect, but its message is accurate.

Tips for post-editing:

- Edit the text to make it more fluent and clearer only if necessary.
- Correct phrasal ordering and spelling if they make the text hard or impossible to understand.
- Use words, phrases or punctuation as they are, if acceptable.
- Make sure that no information has been changed, added or deleted.

Once again, thank you for your collaboration.

Kind regards,

Linda Emilia Hedberg

B. Productivity Test: Source Text and MT Outputs

Source	Out-domain	In-domain
Group 1		
El presente Proyecto de Ampliación y Mejora de la carretera de La Mata al límite de la provincia tiene como objeto describir, definir, justificar y valorar las obras necesarias para acondicionar la carretera CV-120 en el tramo comprendido entre la población de La Mata y el cruce con la CV-121.	Syftet med detta förslag till utvidgning och förbättring av vägen från avlivning till provinsgränsen är att beskriva, definiera, motivera och utvärdera de arbeten som krävs för att konditionera väg CV-120 på sträckan mellan avlivning och korsning med CV-121.	Syftet med detta projekt är att utsträcka och förbättra gång- och cykelvägen till länsgränsen för att beskriva, definiera, motivera och bedöma de byggnadsverk som behövs för att anpassa väg CV-120 på sträckan mellan Björkstugan och korsningen med CV-121.
La carretera CV-120 forma parte de la Red Local de la Diputación de Castellón.	Väg CV-120 är en del av det lokala nätet i Castellón.	Väg CV-120 ingår i Trafikverkets lokalnät i Castellon.
Discurre al noroeste de la provincia de Castellón a través de la comarca de Els Ports, atravesando a su paso los términos municipales de La Mata y Olocau del Rey.	Åker till nordväst om provinsen Castellón genom Els Ports kommun och korsar de kommunala termerna i kungen och Olocau.	Går nordväst om provinsen Castellon genom Els Ports comarca och passerar genom de kommunala termerna "mata" och "Olocau del rey".
Dicha carretera supone la principal vía de conexión entre las propias localidades de Olocau y La Mata, así como también entre éstas y el resto de infraestructuras viarias.	Denna väg är den främsta förbindelsevägen mellan Olocau: S egna städer och massakern, och även mellan dessa och den övriga väginfrastrukturen.	Denna väg är den viktigaste förbindelsevägen mellan Olocau och Luleå samt mellan dessa och övrig väginfrastruktur.
Por este motivo la Diputación Provincial de Castellón, en su dinámica de mejorar las comunicaciones entre los pueblos de la provincia, se ha planteado la actuación en la carretera CV-120 en el tramo comprendido entre el PK 8+160 y el PK 12+600 (según kilometraje actual de la misma).	Därför har provinsen Castellón, i sin dynamik att förbättra kommunikationen mellan provinserna i provinsen, tagit upp åtgärder på väg CV-120 mellan PK 8 + 160 och PK 12 + 600 (beroende på hur långt denna sträcka är).	Därför har länsstyrelsen i Castellon i sin strävan att förbättra kommunikationen mellan byarna i provinsen tagit upp åtgärder på väg CV-120 på sträckan mellan PK 8 + 160 och PK 12 + 600 (enligt aktuell sträckning).

El tramo de carretera objeto de mejora, tiene una longitud aproximada de 4,50 km, y sirve de vía de comunicación entre la población de La Mata y las distintas poblaciones y vías principales de la provincia.	Den uppgraderade vägsträckan är ungefär 4,50 km lång och fungerar som en kommunikationsväg mellan massans befolkning och olika populationer och huvudvägar i provinsen.	Den uppgraderade vägsträckan är ca 4,50 km lång och fungerar som en kommunikationsväg mellan malmbangården och de olika större populationerna och vägarna i området.
La carretera CV-120 soporta en la actualidad un tráfico reducido, siendo también reducido el porcentaje de vehículos pesados.	Vägen CV-120 har för närvarande en begränsad trafik, och andelen tunga fordon minskar också.	Väg CV-120 medför idag liten trafik och andelen tunga fordon är också liten.
La plataforma existente tiene aproximadamente una anchura de 5,00 m de calzada, con un carril por sentido de circulación y ausencia de arcenes, lo que impide el cruce de vehículos con comodidad.	Den befintliga plattformen har en bredd på cirka 5,00 m, med en räls per körriktning och utan bågar, vilket förhindrar att fordonen korsar sig med bekvämlighet.	Den befintliga plattformen har en bredd av ca 5,00 m, med körfält per körfält och vägren, vilket gör att det inte går att korsa trafikerade fordon.
El firme que cuenta con un espesor aproximado de 5 cm de aglomerado asfáltico sobre zahorras, se encuentra envejecido y deteriorado por el uso y las marcas viales han desaparecido.	Det fasta material som har en tjocklek på ca 5 cm av asfaltagglomeratet på zahorrer är åldrat och försämrat av användningen och vägmarkeringarna har försvunnit.	Den asfaltmastix som har en tjocklek av ca 5 cm på slitlager är åldrad och skadad av användning och vägmarkeringar har försvunnit.
Reviste especial importancia el cruce existente al final del tramo de estudio, el cual une la carretera CV-120 con el puente situado justo en el límite de la provincia.	Det är särskilt viktigt med korsningen vid slutet av studietiden, som förbinder väg CV-120 med bron precis vid provinsgränsen.	Den befintliga korsningen i slutet av utredningskorridoren, som förbinder väg CV-120 med bron strax norr om utredningskorridoren, är särskilt viktig.
Dicho cruce resulta deficiente desde el punto de vista de la seguridad y la comodidad, por lo que en el proyecto también se propone un nuevo diseño para este enlace.	Detta korståg är dåligt ur säkerhets- och bekvämlighetssynpunkt, så i projektet föreslås också en ny utformning för denna länk.	En sådan korsning är dålig ur säkerhets- och bekvämlighetssynpunkt, och därför föreslås i projektet en ny utformning av denna länk.
Por todo lo expuesto es por lo que se redacta el presente proyecto de mejora, donde se describen las obras necesarias, en todos sus aspectos, en los distintos documentos que lo integran.	Det är därför som det här förbättringsprojektet utarbetas, där de nödvändiga arbetena i alla avseenden beskrivs i de olika dokument som ingår.	Mot bakgrund av ovanstående har detta förslag till förbättring utarbetats, där de nödvändiga arbetena i alla avseenden beskrivs i de olika dokument som ingår i det.

Como se ha mencionado, las obras se concentran en el último tramo de la CV-120, comprendido en su totalidad dentro de los Términos Municipales de La Mata de Morella y Olocau del Rey.	Som redan nämnts är arbetena koncentrerade till den sista delen av CV-120, som i sin helhet omfattas av de kommunala termerna Morella och Olocau del kung.	Som nämnts är byggnaderna koncentrerade till den sista delen av CV-120, som helt och hållet ingår i kommunens massor i Morella och Olocau i kungen.
Fundamentalmente se pretende ampliar la plataforma existente y mejorar el firme, manteniendo el trazado actual en la mayor parte, con rectificaciones puntuales de curvas y proyectando una variante por el camino existente que conecta la CV-120 con la población de La Cuba.	Syftet är i huvudsak att utvidga den befintliga plattformen och förbättra den fasthet som finns genom att hålla fast vid den nuvarande linjen i de flesta fall, med punktliga justeringar av kurvorna och genom att planera en variant på den befintliga vägen som kopplar samman CV-120 med den kubanska befolkningen.	Syftet är i huvudsak att bredda den befintliga plattformen och förbättra den befintliga vägen genom att behålla det nuvarande spåret i stort sett, med punktvisa kurvändringar och genom att planera en variant på den befintliga vägen som förbinder CV-120 med Kubas befolkning.
También se proyecta actuar sobre el drenaje, señalización, ejecución de firme y seguridad.	Åtgärder planeras också för dränering, signalering, fastgöring och säkerhet.	Åtgärder planeras även för dränering, signalering, utförande och säkerhet.
Derivada de la ejecución de las obras se han de reponer los cruces y algunos tramos longitudinales de vías pecuarias, intentando minimizar en lo posible los tramos en los que se compartan usos entre éstas y la calzada de la CV-120, lo cual indudablemente redundará en una mejora de la seguridad vial.	Som ett resultat av arbetets utförande måste korsningar och vissa längsgående sträckor av vägbanor återställas, och man bör försöka minimera de sträckor där vägsträckorna mellan vägsträckorna och vägbanan CV-120 delas så mycket som möjligt, vilket utan tvekan kommer att leda till en förbättring av trafiksäkerheten.	I samband med arbetena bör korsningar och vissa längsgående sträckor av gång- och cykelvägen återställas så att de så långt som möjligt minimeras för de sträckor där gång- och cykelvägen går mellan väg 120, vilket otvivelaktigt kommer att leda till ökad trafiksäkerhet.
En los planos se ha utilizado como base la cartografía resultante a escala 1:1.000 con equidistancias entre curvas de nivel de 1m.	I ritningarna har den resulterande vridmomentkurvan i skala 1:1000 med kurvavstånd på nivå 1 m använts som bas.	På plankartorna har den resulterande kartografi i skala 1:1 000 med kurvradier på 1 m använts.
Se ha realizado un estudio Geológico-Geotécnico para caracterizar los terrenos por los que discurre el trazado de la CV-120 a su paso por los Términos Municipales de La Mata de Morella y Olocau del Rey.	En geologisk-geologisk studie har genomförts för att karakterisera de markområden som ligger bakom morella och Olocau i kungen.	En geoteknisk/geoteknisk utredning har genomförts för att karakterisera terrängen längs sträckan mellan Krokvik - Rautas.

La finalidad del estudio es la caracterización geológica y geotécnica de la zona objeto de proyecto, analizando aquellos aspectos que inciden en la construcción de las obras.	Syftet med studien är en geologisk och geologisk karakterisering av det område som är föremål för projektet och en analys av de aspekter som påverkar bygg- och anläggningsarbetet.	Syftet med studien är geoteknisk och geoteknisk karakterisering av det område som ska projekteras, med analys av de aspekter som påverkar byggskedet.
Los trabajos de campo desarrollados han consistido en:	Arbetet på fältet har bestått i följande:	Arbetet på fältet har omfattats av följande:
1. Realización de 2 sondeos: la profundidad de investigación, ha sido de 5 m. en cada uno de ellos.	1. Bedömning av två undersökningar: forskningsdjupet har varit 5 km för var och en av dem.	1. Utbildning av två undersökningar: forskningsdjupet har varit 5 km för var och en av dem.
2. Observación y estudio de los cortes y afloramientos existentes a lo largo del trazado y las proximidades del mismo.	2. Upptagning och undersökning av befintliga styckningsdelar och fläckar längs och i närheten av rälsförhöjningen.	2. Välj och studera befintliga skärningar och skärningar längs med och i närheten av sträckan.
Con las muestras obtenidas en los sondeos realizados para la investigación del subsuelo en el entorno del puente antes comentado, se han llevado a cabo los ensayos habituales de identificación y clasificación, cuyas actas se incluyen en el Apéndice 5 del Anejo nº 4: Estudio geológico-geotécnico.	Rutintester för identifiering och klassificering har utförts på prover som tagits vid undersökningar av underjord i den ovan nämnda bromiljön. Rapporterna finns i tillägg 5 till bilaga 4: Geologisk geologisk undersökning.	Med hjälp av de prover som tagits från undersökningar av undergrunden i bromiljö har rutinundersökningar för identifiering och klassificering utförts, se bilaga 4, tillägg 5: Geoteknisk och geoteknisk undersökning.
A partir de la información obtenida de los cortes y afloramientos se deduce que para aquellos casos en los que haya que ampliar el ancho actual de calzada, a costa de retranquear el talud actual, pueden adoptarse taludes similares a los actuales, adaptándolos en su caso, por cuestiones de uniformidad y estética global, a taludes comprendidos entre 1H/2V y 1H/4V.	På grundval av de uppgifter som erhållits från styckningsdelar och florationer framgår det att i de fall där den nuvarande vägbredden måste förlängas till priset av att den nuvarande talud flyttas över, kan liknande väggar antas och i förekommande fall anpassas till väggar mellan 1H/2v och 1H/4V i fråga om enhetlighet och estetik.	På grundval av de uppgifter som erhållits från skärningar och diken framgår det att i de fall då befintlig vägbredd behöver breddas på bekostnad av den befintliga vägen kan dikesmassor antas som i dagsläget, eventuellt med hänsyn till homogenitet och övergripande estetik, vid diken mellan 1H/2v och 1H/4V.
En los mapas de tráfico correspondientes, consta una IMD1998= 375 veh/día, y IMD2001= 413 veh/día.	På motsvarande trafikkartor finns en IMD1998 = 375 VEH/dag och IMD2001 = 413 VEH/dag.	På motsvarande trafikkartor finns en IMD1998 = 375 VEH/dygn och IMD2001 = 413 VEH/dygn.

Si se toma como año horizonte el 2030, estimando como vida útil para el firme un periodo de 20 años, y se prevé un aumento de tráfico de un 3% anual como situación más desfavorable, se obtiene una IMD2030 = 724 veh/día.	Om man utgår från att år 2030 är det år då man beräknar en 20-årig livslängd för fasta fordon och räknar med en ökning av trafiken med 3% per år som den mest ogynnsamma situationen, får man en IMD2030 = 724 VEH per dag.	Om man tar 2030 som ett år med en livslängd på 20 år och en trafikökning på 3% per år som mest ogynnsam situation, erhålls en IMD2030 = 724 VEH/dag.
El cálculo del tráfico pesado se ha efectuado a partir de las memorias de tráfico de la Generalitat Valenciana, obteniendo así un porcentaje medio de vehículos pesados del 6,4%.	Beräkningen av tung trafik har gjorts på grundval av trafikminnen från Generalitat Valenciana, vilket ger en genomsnittlig andel tunga fordon på 6,4%.	Beräkningen av tung trafik har gjorts utifrån Trafikverkets trafikminnen, vilket ger en genomsnittlig andel tunga fordon på 6,4%.
Con ello, se obtiene un tráfico de vehículos pesados en la carretera de 47 vehículos pesados al día, que ha servido de base para el diseño del firme de la carretera.	På så sätt uppnås en trafik med tunga fordon på vägen med 47 tunga fordon per dag, vilket har legat till grund för utformningen av väghållaren.	Detta leder till en trafik med tunga fordon på vägen med 47 tunga fordon per dygn, vilket har legat till grund för utformningen av vägen.
Como se ha explicado anteriormente, a partir del dato calculado de porcentaje medio de vehículos pesados (6,4%) se ha calculado para el año estudiado (2030), la previsión de intensidad media diaria de pesados, obteniéndose en el tramo es igual a 47 vehículos pesados/día.	På grundval av den beräknade genomsnittliga procentandelen tunga fordon (6,4%) för det år som undersöks (2030) beräknas den genomsnittliga dygnsmedelintensiteten för tunga tunga som ligger på sträckan till 47 tunga fordon/dag.	Som förklaras ovan beräknas den beräknade genomsnittliga andelen tunga fordon (6,4%) för det aktuella året (2030) och beräknas för sträckan uppgå till 47 tunga fordon/dygn.
Con los datos obtenidos, y teniendo en cuenta la Tabla 1A de la Norma, se ha tomado para la carretera una categoría de tráfico T41 (señalar que según la normativa de firmes de la Comunidad Valenciana, correspondería a la misma categoría).	På grundval av de uppgifter som erhållits, och med beaktande av tabell 1a i standarden, har en trafikkategori T41 tagits för vägtrafiken (ange att den enligt Valencia-gemenskapens bindande bestämmelser skulle motsvara samma kategori).	Med de insamlade uppgifterna och med hänsyn till tabell 1a i standarden har en trafikkategori T41 tagits för väg (observera att enligt Vägverkets föreskrifter för vägtrafik gäller samma kategori).
Group 2		
Según indicaciones del Anejo 3. Estudio Geológico y Geotécnico, a lo largo de la traza el terreno que se encuentra consiste fundamentalmente en suelos adecuados (gravas, arenas, areniscas y limos).	Enligt uppgifterna i bilaga 3, geologisk och geologisk undersökning, består marken längs tratten huvudsakligen av lämpliga jordar (grus, sand, sandsten och lime).	Enligt bilaga 3, geoteknisk undersökning och geoteknisk undersökning, består jorden huvudsakligen av lämplig jord (grus, sand, sand och berg).

Sin embargo en los casos de ampliación de calzada en zonas de terraplén el suelo existente posee una capa importante de tierra vegetal.	När det gäller utbyggnaden av vägbanor i terrapleringsområden har dock den befintliga marken ett stort lager av vegetabilisk mark.	Vid utbyggnad av väg i terrassyta har dock befintlig markyta ett stort växtskikt.
La explanada E1 se conseguirá en estos casos ejecutando una capa de 50 cm de espesor mínimo de suelo adecuado y 35 cm de suelo seleccionado.	Plockningen E1 ska i dessa fall uppnås genom att ett skikt på minst 50 cm med lämplig golvtjocklek och 35 cm utvalt golv anbringas.	I dessa fall ska E1-sondering utföras genom att ett 50 cm tjockt lager utförs med lämplig minsta tjocklek av jord och 35 cm av vald jord.
La retirada de suelo inadecuado se realiza hasta la cota inferior de la explanada o hasta que aparezca suelo adecuado.	Olämplig markuttag görs till den nedre delen av plockningen eller till dess att lämplig jord syns.	Olämpliga jordar tas bort till undergrunden eller till lämplig jord.
En la ejecución del firme del nuevo trazado se distinguen dos casos.	Två fall skiljer sig åt i genomförandet av den nya sträckningen.	Vid genomförandet av den nya sträckningen görs en åtskillnad mellan två fall.
El que se realiza sobre el firme ya existente y el que se realiza sobre el terreno natural.	Det är det som sker på den befintliga fasta punkten och det som sker på naturlig mark.	Det som görs på befintlig bebyggelse och det som görs på naturmark.
La sección sobre el terreno natural y en la zona de la variante, previa eliminación de la capa superficial, es la siguiente:	Avsnittet på naturlig mark och i varianten, efter borttagning av ytskiktet, är följande:	Efter avlägsnande av ytskiktet är den del av naturområdet och området där varianten är belägen följande:
10 cm de mezcla bituminosa en caliente, constituida por: 5 cm capa de rodadura y 5 cm capa de base.	10 cm värmeblandad bituminös blandning, bestående av 5 cm slitskikt och 5 cm basskikt.	10 cm varmblandad bitumenblandning, bestående av: 5 cm slitlager och 5 cm ballast.
La sección tipo dispuesta para la mejora, consiste en una plataforma de 7,5 metros de ancho (siete de calzada y una berma de 0,25 metros a ambos lados).	Standardsektionen för förbättring består av en plattform med en bredd på 7,5 meter (sju vägbanor och en våg på 0,25 meter på båda sidor).	Typsektion för förbättring består av en plattform med en bredd av 7,5 meter (7 meter och 0,25 meter på båda sidor).
Los valores de los taludes aplicados tanto en desmonte como en terraplén surgen del propio estudio geotécnico llevado a cabo en la zona.	Värden för taluder som applicerats både på avrymning och terraplen härrör från själva geosfären i området.	De värden på borrkärnor som tillämpas i både schakt och terrass härrör från den geotekniska undersökning som genomförts i området.
A partir de éste se ha optado por aplicar un talud de 1H:2V para desmontes y de 3H:2V para terraplenes.	På grundval av detta har man valt att tillämpa en talud på 1H: 2v för avrymning och 3H: 2v för terraplener.	Utifrån detta har man valt att tillämpa en tjälfarlighetsklass på 1H: 2v för avvattning och 3H: 2v för terrass.

El nuevo trazado de la carretera se ha realizado bajo la premisa de aprovechar siempre que sea posible la traza actual de la misma.	Den nya vägsträckan har genomförts under förutsättning att man så långt det är möjligt utnyttjar den nuvarande vägsträckan.	Den nya vägens sträckning har genomförts under förutsättning att befintlig väg så långt det är möjligt kan nyttjas.
Dentro de este aspecto, en los tramos que ha sido factible superponer trazados, se ha preferido por motivos constructivos ampliar la plataforma por un único margen, ya que ampliar por ambos lados implica ejecutar estrechas cuñas (realizando en las mismas: relleno, compactación, extendido de firme…) lo cual resulta demasiado costoso técnica y económicamente.	Inom detta område har man av konstruktiva skäl föredragit att utvidga plattformen med en enda marginal på de sträckor som har kunnat överskridas, eftersom en utvidgning på båda sidor innebär att man genomför smala skrapor (på dessa sträckor: Fyllning, kompaktering, utsträckt av fast form...), vilket är alltför tekniskt och ekonomiskt kostsamt.	I detta avseende har det av konstruktiva skäl varit bättre att utvidga plattformen med en enda marginal på de sträckor som har kunnat övervinnas, eftersom en utvidgning på båda sidor innebär att man genomför smala kugghjul (fyllning, kompaktering, utläggning av fast mark...), vilket är för tekniskt och ekonomiskt kostsamt.
Con ese fin, se ha buscado la coincidencia de una de las dos aristas exteriores de la plataforma proyectada con la homóloga de la plataforma actual.	I detta syfte har en av de två externa karisterna på den planerade plattformen med motsvarigheten till den nuvarande plattformen strävat efter att sammanfalla.	I detta syfte har man försökt förena en av de två ytterkanten av den planerade plattformen med den befintliga plattformens motsvarighet.
Sin embargo, existen tramos en los que ésta no ha sido la principal premisa.	Det finns dock avsnitt där detta inte har varit den viktigaste förutsättningen.	Det finns dock sträckor där detta inte har varit den viktigaste förutsättningen.
Entre estos se encuentran los tramos que la traza discurre sobre obras de paso y obviamente el tramo de la variante.	Till dessa hör de sträckor som trappas av från övergångsarbeten och naturligtvis från varianten.	Till dessa hör de sträckor som ligger i anslutning till passagemöjligheter och naturligtvis även den del av sträckan som går i skärning.
En el primer caso, para la ampliación de las estructuras de paso (en todos los casos excepto en la estructura nº1) se ha optado por ejecutar los correspondientes ensanchamientos mediante losas voladas a ambos lados del tablero actual.	I det första fallet har man för att utvidga övergångsstrukturerna (i samtliga fall med undantag för struktur nr 1) valt att genomföra motsvarande utökningar med hjälp av rutor som flyter på båda sidor av den nuvarande skivan.	I det första fallet har man för utbyggnaden av passagemöjligheter (i samtliga fall med undantag för konstruktionen 1) valt att genomföra motsvarande breddning med rörbroar på båda sidor om den befintliga bron.

En estos casos se ha buscado centrar el trazado actual con el existente, procurando disponer una alineación recta en planta dentro del espacio asociado a la estructura de paso, puesto que el cálculo estructural de la ampliación en curva resultaría sensiblemente más complejo.	I dessa fall har man strävat efter att koncentrera den nuvarande sträckan till den befintliga, genom att se till att det finns en kortvarig linje inom det utrymme som är förknippat med korsningsstrukturen, eftersom den strukturella beräkningen av kurvutvidgningen skulle bli betydligt mer komplicerad.	I dessa fall har man strävat efter att koncentrera det befintliga spåret till det befintliga, genom att sträva efter en linjedragning inom det område som är förknippat med övergångskonstruktionen, eftersom den strukturella beräkningen av en utbyggnad i kurva skulle bli betydligt mer komplicerad.
En cuanto a la variante, tal y como se ha dicho se aprovecha el camino existente que discurre inferior al trazado actual y que bordeando el río Cantavieja conecta con el puente hacia La Cuba.	När det gäller varianten utnyttjas, som redan har sagts, den befintliga vägen som är mindre än den nuvarande, och som genom att ta bort floden Cantavieja ansluts till bron till Kuba.	När det gäller varianten utnyttjas, som redan har sagts, den befintliga vägen som ligger under den nuvarande sträckningen och som går genom floden Cantavières ansluter sig till bron till Kuba.
La inclusión de la variante en el trazado, se sustenta por una parte en la voluntad de mejorar la conexión con las poblaciones situadas al otro lado del río, las cuales únicamente cuentan con el camino de tierra existente, y por otra en la mejor solución técnica que ofrece la variante inferior.	Införandet av varianten i ritningen bygger dels på viljan att förbättra förbindelserna med befolkningarna på andra sidan floden, som bara har den befintliga markvägen, dels på den bästa tekniska lösning som erbjuds av den lägre varianten.	Att ta med varianten på sträckan bygger dels på en vilja att förbättra förbindelsen med befolkningarna på andra sidan floden, som bara har den befintliga landvägen, dels på den bästa tekniska lösning som den lägre varianten erbjuder.
En efecto, la traza actual que discurre arriba de la variante está cruzada por tres arroyos cuyas estructuras son de entidad considerable y se encuentran salvando un talud muy pronunciado en el margen izquierdo (en sentido Olocau), detal forma que la ampliación de la plataforma se traduciría en una compleja actuación de ensanchamiento para dichas estructuras.	Den nuvarande språngbräda som finns i varianten korsas nämligen av tre skuggor vars strukturer är av betydande karaktär och som räddar en mycket uttalad talud på vänster sida (i Olocau-riktningen), så att en utvidgning av plattformen skulle leda till en komplicerad utsträckt verksamhet för dessa strukturer.	Den nuvarande trumman ovan bron korsas av tre vattendrag vars strukturer är av stor betydelse och som utgör en stor barriär i den vänstra änden (Olocau), vilket innebär att utbyggnaden av plattformen skulle leda till en komplicerad utbredning av dessa strukturer.
Sin embargo, puesto que el camino existente hacia La Cuba no presenta esta problemática, se concluye que el trazado más ventajoso en este tramo es el correspondiente a la variante.	Men eftersom den väg som finns till Kuba inte har denna problematik, dras slutsatsen att den mest fördelaktiga sträckan i denna del är den som motsvarar varianten.	Eftersom den befintliga vägen till Kuba inte har denna problematik, dras slutsatsen att den mest fördelaktiga sträckningen på denna sträcka är den som är mest fördelaktig för varianten.

El trazado dispuesto en el proyecto también prevé la adecuación de todos los cruces entre los caminos rurales existentes y la carretera.	I projektets utformning föreskrivs också att alla korsningar mellan befintliga vägar på landsbygden och vägarna skall vara lämpliga.	I planförslaget anges också att samtliga korsningar mellan befintlig väg och väg ska anpassas.
Éstos quedan completamente acondicionados geométricamente, en planta mediante la aplicación de unos radios de cruce con el eje de la carretera y en alzado mediante la compatibilización de rasantes.	De är helt geometriska uppgraderade, i en anläggning med hjälp av korsningsradier med vägaxeln och i fast form genom att skära ihop raderna.	Dessa är helt och hållet geometriska, i form av korsningsradier med vägens centrumlinje och i form av korrosion.
Se concluye dicha adecuación la ejecución de una capa de firme en la zona de intersección.	En sådan överensstämmelse uppnås genom att ett lager vägs in i skärningsområdet.	Detta görs genom att ett tätskikt utförs i skärningsområdet.
Por último señalar que al no tratarse de un proyecto de nuevo trazado de carretera (a excepción de la nueva variante) no son de obligado cumplimiento las prescripciones establecidas en la norma 3.1-I.C., no obstante se ha tomado el criterio de intentar adecuar en la medida de lo posible, el trazado a la normativa mencionada para garantizar unos parámetros aceptables de seguridad y confort para los conductores.	Slutligen bör det påpekas att eftersom det inte rör sig om ett nytt vägprojekt (med undantag för den nya varianten) är kraven i standard 3.1-I.C inte uppfyllda, har man dock valt att försöka att så långt det är möjligt anpassa definitionen till ovannämnda bestämmelser för att garantera godtagbara säkerhetsparametrar och bekvämlighet för förare.	Slutligen bör det påpekas att eftersom det inte rör sig om ett nytt vägprojekt (med undantag för den nya varianten), är kraven i standard 3.1-I.C., har dock kriteriet att så långt det är möjligt försöka anpassa utformningen till ovan nämnda regler för att säkerställa acceptabla säkerhets- och bekvämlighetsparametrar för förare tagits fram.
Evidentemente, en el caso del tramo de la variante, el nuevo trazado sí se ha ajustado a las prescripciones de la norma 3.1-I.C.	När det gäller varianten har den nya spårningen uppenbarligen anpassats till standarden 3.1-I.C.	För delsträckan har det nya spåret naturligtvis anpassats till kraven i standard 3.1-I.C.
Mediante la realización del estudio hidrológico incluido en este proyecto, se ha pretendido establecer un conocimiento lo más fiel posible de la realidad de los regímenes hídricos de la zona objeto de estudio.	Syftet med att genomföra den hydrologiska studie som ingår i projektet är att göra det möjligt att få största möjliga kännedom om de faktiska förhållandena i vattensystemen i det område som undersöks.	Genom att genomföra den hydrologiska undersökning som ingår i detta projekt har man försökt skapa så god kunskap som möjligt om vattendragens verklighet i det studerade området.

En concreto, las cuencas de aportación a la traza de la carretera en proyecto son diez, de las cuales se ha calculado su superficie, puntos alto y bajo y longitud del cauce principal, como se muestra en el plano de cuencas que se adjunta en el anejo nº 9.	Närmare bestämt är de avrinningsområden som planeras för att bidra till vägen tio, av vilka ytan, höjd- och bottenpunkterna och huvudlängden har beräknats, vilket framgår av det områdesplan som anges i bilaga 9.	I synnerhet är avrinningsområdena för den planerade vägen tio, varav dess yta, höjd- och lågpunkter samt längd har beräknats, vilket framgår av den karta över avrinningsområden som återfinns i bilaga 9.
Para todos los cálculos realizados se ha utilizado la metodología recogida por la Instrucción 5.2-I.C “Drenaje Superficial”, la cual basándose en la IMD que soporta la vía objeto de estudio, indica un periodo de retorno de 10 años para el cálculo del caudal de drenaje y de 100 años para el correspondiente al caudal de los cauces salvados por obras de drenaje transversal.	Alla beräkningar har gjorts med hjälp av den metod som anges i instruktion 5.2-I.C "ytdränering", som på grundval av den IMD som bär den undersökta vägen anger en återvändandeperiod på 10 år för beräkning av dräneringsflödet och 100 år för beräkning av flödet av de kanaler som räddas genom tvärgående dräneringsarbeten.	För samtliga utförda beräkningar har den metod som beskrivs i avsnitt 5.2-I.C "ytdränering" använts, vilken på grundval av den IMD som ligger till grund för den studerade vägen visar en återkomstperiod på 10 år för beräkning av dräneringsflöde och 100 år för flöde av dräneringsledningar som är täckta av dräneringsarbeten i tvärled.
Group 3		
A continuación se dispone el valor de los caudales asociados a 10, 25 y 100 años de periodo de retorno, calculados para las cuencas incluidas en la zona de estudio.	Värdet av flödena för 10, 25 och 100 år av returperiod, beräknade för de avrinningsområden som ingår i studieområdet, anges nedan:	De flöden som är kopplade till 10, 25 och 100 års återkomsttid, beräknade för de avrinningsområden som ingår i undersökningsområdet, anges nedan:
Una vez obtenidos dichos caudales se puede proceder a diseñar las obras necesarias para garantizar el drenaje de las obras de este Proyecto.	När dessa flöden har uppnåtts kan de nödvändiga arbetena utformas för att se till att arbetet med detta projekt dräneras.	När dessa flöden har uppnåtts kan de arbeten som är nödvändiga för att säkerställa dräneringen av arbetena i detta projekt utföras.
A partir de los valores de los caudales asociados al periodo de retorno de 100 años y las definiciones geométricas de las obras de drenaje, se ha realizado la comprobación de la capacidad hidráulica de las mismas bajo la acción de dichos caudales de diseño.	På grundval av värdena för flödena i samband med den 100-åriga återvändandeperioden och de geometriska definitionerna av dräneringsarbetet följts, och dessa flödenas hydrauliska kapacitet har kontrollerats med hjälp av dessa konstruktionsflöden.	Vid beräkning och utformning av dränering har de riktlinjer som anges i "krav brobyggande" (Trafikverket) i "krav brobyggande" (Trafikverket) och "krav brobyggande" (Trafikverket) följts.

Debido a la ampliación de la plataforma es necesaria la ampliación de algunas obras de drenaje, mientras que para otras se ha optado por su derribo y sustitución por una obra de drenaje nueva.	På grund av utvidgningen av plattformen är det nödvändigt att utvidga vissa dräneringsarbeten, medan andra har valt att riva upp och ersätta dem med nya dräneringsarbeten.	På grund av utbyggnaden av plattformen är det nödvändigt att utvidga vissa dräneringsarbeten, medan man för andra har valt att riva upp och ersätta dem med ett nytt dräneringsarbete.
Tanto para las ampliaciones como para las nuevas obras de drenaje transversal se ha dispuesto tubería de hormigón armado de 800 mm de diámetro para las cuales se ha comprobado su capacidad, como queda reflejado dentro del Anejo de drenaje.	För både utvidgningar och nya tvärgående dräneringsarbeten finns 800 mm armerad betongrör med en diameter som har kontrollerats med avseende på deras kapacitet, vilket återspeglas i dräneringsbilagan.	För såväl breddning som nybyggnad av dränering i tvärled har en 800 mm tjock armerad betongtrumma för vilken dess kapacitet har kontrollerats, vilket framgår av dräneringsbilagan.
Algunas de las consideraciones anteriores, referentes a la estricta necesidad de capacidad hidráulica de las obras transversales, se amplía para tener en cuenta los requerimientos que de tipo ambiental ha puesto de manifiesto la Administración competente a través de la Estimación de Impacto Ambiental.	Vissa av de ovan nämnda överväganden, som avser det strikta behovet av hydraulisk kapacitet för tvärgående verk, har utvidgats för att ta hänsyn till de miljökrav som har fastställts av den behöriga myndigheten genom en miljökonsekvensbedömning.	En del av ovanstående överväganden, som gäller det strikta behovet av hydraulisk kapacitet för tvärgående arbeten, har utvidgats för att ta hänsyn till de miljörelaterade krav som den behöriga myndigheten har visat genom miljökonsekvensbeskrivningen.
En este sentido se ha aumentado la capacidad de determinadas obras de drenaje transversal con tal de compatibilizar su función hidráulica con la función de mantener el paso de determinadas especies de la fauna autóctona habilitando así algunos corredores para la fauna.	I detta avseende har kapaciteten hos vissa tvärsnittsdräneringsarbeten ökat så att deras hydrauliska funktion kan förenas med funktionen att bibehålla passagen för vissa arter av den inhemska faunan och på så sätt göra vissa korridorer tillgängliga för den inhemska faunan.	I detta avseende har kapaciteten för vissa tvärgående dräneringsarbeten ökat för att göra det möjligt att förena deras hydrauliska funktion med funktionen att bibehålla passagemöjligheter för vissa arter av den inhemska faunan och därmed skapa vissa korridorer för faunan.
Por tanto, y en concreto las obras de drenaje nº4 y 7 se conformarán mediante marcos de sección libre interior de 2x2 m.	Därför, och i synnerhet dräneringsarbetena 4 och 7, kommer att sammanställas med en ram med ett fritt inre tvärsnitt på 2x2 m.	Därför, och i synnerhet dräneringsarbeten nr 4 och 7, ska utformas med en fri inre sektion på 2x2 m.
En la siguiente tabla se muestran las obras de drenaje asociadas a las cuencas consideradas para el cálculo:	Följande tabell visar dräneringsarbeten i samband med de avrinningsområden som beaktas vid beräkningen:	I tabellen nedan visas de dräneringsarbeten som är kopplade till de avrinningsområden som ingår i beräkningen:

Las obras de drenaje 15 y 16 únicamente se amplían en el tramo final de desembocadura, para considerar la ampliación de la plataforma hacia el este.	Dräneringsarbetena 15 och 16 utökades endast till den slutliga glidsträckan för att man skulle kunna överväga en utvidgning av plattformen österut.	Dräneringsarbeten 15 och 16 breddas endast på slutsträckan för att ta hänsyn till utbyggnaden av plattformen österut.
Dicha ampliación se ejecutará “in situ” mediante la confección de obra de hormigón armado.	Denna utvidgning skall genomföras "på plats" genom tillverkning av armerad betong.	En sådan förlängning ska utföras "på plats" genom att en armerad betongkonstruktion anläggs.
Las obras de drenaje 5, 9, 11, 13, 18 y 19 que no aparecen en la tabla anterior son una serie de obras de drenaje nuevas, formadas por arquetas y colectores de 800 mm de diámetro, cuya función será transportar el agua procedente de las cunetas, de uno a otro margen, bien por interrupción de las mismas, bien para desaguar.	Dräneringsarbeten 5, 9, 11, 13, 18 och 19 som inte anges i ovanstående tabell är en serie nya dräneringsarbeten som består av skrapredskap och uppsamlare med en diameter på 800 mm, vars syfte är att transportera vatten från sängar antingen från den ena till den andra marginalen, antingen genom avbrott i dräneringsarbetet eller genom att riva upp dem.	Dräneringsarbeten 5, 9, 11, 13, 18 och 19 som inte framgår av tabellen ovan är en rad nya dräneringsarbeten som består av trummor och trummor med diametern 800 mm och vars funktion kommer att vara att transportera vatten från trummorna, från ena sidan till den andra, antingen genom avbrott i dräneringen eller för att riva upp vattnet.
La evacuación del agua recogida en la plataforma y sus márgenes queda cubierta mediante cunetas y bajantes, dispuestas en el drenaje longitudinal, y los colectores dispuestos a lo largo de la traza incluidos en el drenaje transversal.	Utrymningen av det vatten som uppsamlas på plattformen och dess marginaler täcks av kungar och sänkor som är placerade i längsgående dränering och de uppsamlare som är placerade längs rälsförhöjningen som ingår i tvärsnittsdräneringen.	Avvattning av vatten som samlas in på plattan och dess slänter täcks av diken och diken i längsled och trummor längs trumman som ingår i den tvärgående dräneringen.
Dentro de la tipología longitudinal, se ha dispuesto en las zonas de desmonte una cuneta de tipo triangular, con talud exterior vertical y talud interior de 6H:1V, un calado máximo de 30 cm y revestimiento de hormigón en los tramos con pendiente longitudinal superior a 3%.	Inom den längsgående typologin har en kunett av triangeltyp med vertikal yttre talud och 6H: 1V-talud, en största djupgående på 30 cm och betongbeläggning på sträckor med en längsgående lutning på mer än 3%.	Inom längsgående typologi har en triangelformad kantbalk med vertikal ytterslänt och innerslänt av 6H: 1V, en största spännvidd av 30 cm och betongbeläggning på sträckor med en längsgående lutning av mer än 3% installerats.
Además, en las obras de drenaje 3, 4, 6 y 7 que encontramos en el tramo de la variante para el desagüe de las cuencas existentes, se realizará un encauzamiento revestido con 10 cm de hormigón HM-20/B/20/IIa.	I dräneringsarbetena 3, 4, 6 och 7 på varianten för avlopp från befintliga avrinningsområden skall dessutom en avskärmning med 10 cm betong HM-20/b/20/IIa genomföras.	Vid dräneringsarbeten 3, 4, 6 och 7 på delsträckan för avvattning av befintliga avrinningsområden ska dessutom en tätning med 10 cm betong av HM-20/b/20/IIa utföras.

En el caso de los terraplenes, aquellos cuya altura sea mayor de 2 metros estarán dotados de bajantes que permitirán desaguar hacia el exterior sin erosionar el propio material del terraplén.	När det gäller terraplener ska de med en höjd av mer än 2 meter vara utrustade med sänkor som gör det möjligt att lossa ut materialet utan att urholka själva materialet från terraplen.	För termitsvetsar som är längre än 2 meter ska de förses med slitlager som gör det möjligt att riva ut utsidan utan att erodera själva jordmaterialet.
También se han dispuesto bajantes en aquellos puntos en los que se ha previsto realizar un desagüe hacia alguno de los cauces naturales o hacia alguna de las acequias existentes.	Det har också gjorts nedskärningar när det gäller de punkter där man planerar att göra en urholkning mot någon av de naturliga kanalerna eller mot någon av de befintliga kejsarerna.	I de fall där en avvattning planeras till något av de naturliga trummorna eller till något av de befintliga trummorna har även grundvattensänkningar gjorts.
La justificación de la capacidad hidráulica de todos los elementos de drenaje adoptados (tanto los drenaje longitudinal como transversal) se incluye dentro de los cálculos realizados en el propio anejo de drenaje.	Motivering för hydraulisk kapacitet för alla antagna dräneringsdelar (både längsgående och tvärgående dränering) ingår i beräkningarna i själva dräneringsbilagan.	Redovisning av hydraulisk kapacitet för samtliga antagna dräneringselement (både längs- och tvärfall) ingår i beräkningarna i själva dräneringsbilagan.
El trazado del presente proyecto de mejora implica la ampliación de tres estructuras existentes.	Det aktuella förbättringsprojektets utformning innebär en utvidgning av tre befintliga strukturer.	Utformningen av detta förbättringsprojekt innebär en utbyggnad av tre befintliga konstruktioner.
Al tratarse de una ligera ampliación se ha optado por disponer una solución sencilla para la ampliación de las estructuras, de forma que se mantenga en la medida de lo posible la solución formal existente, con el fin de causar el menor impacto estético posible.	Eftersom det rör sig om en liten utvidgning har man valt att ha en enkel lösning för en utvidgning av strukturerna, så att den befintliga formella lösningen så långt som möjligt kan bibehållas, för att få minsta möjliga estetiska effekt.	Eftersom det rör sig om en liten utvidgning har man valt att ha en enkel lösning för en utvidgning av strukturerna, så att den befintliga formella lösningen så långt det är möjligt kan bibehållas för att ge minsta möjliga estetiska effekt.
Esta estructura, situada entre los P.K. 1 + 520.000 y 1 + 550.500 del nuevo eje, coincide exactamente con la conexión final del tramo en variante con la carretera existente.	Denna struktur, som ligger mellan P.K. 1 + 520.000 och 1 + 550.500 på den nya axeln, sammanfaller exakt med den slutliga förbindelsen mellan den varianta sträckan och den befintliga vägen.	Denna struktur, som ligger mellan punkterna 1 + 520 000 och 1 + 550.500 i den nya axeln, sammanfaller exakt med den slutliga förbindelsen mellan delsträckan och befintlig väg.
Precisamente por este hecho ha sido muy difícil centrar el eje de la ampliación con el eje existente, y por ello la ampliación presenta una esviación importante con respecto a la obra existente.	Just på grund av detta har det varit mycket svårt att koncentrera utvidgningen på den nuvarande axeln, och därför är utvidgningen ett viktigt steg i riktning mot det befintliga arbetet.	Just därför har det varit mycket svårt att koncentrera utvidgningens axel till den befintliga axeln, och därför är utvidgningen ett viktigt steg i riktning mot det befintliga arbetet.

La estructura existente es un pontón constituido por dos muros exteriores de unos 10 metros de longitud y un arco intermedio de 5.10 m de altura libre y 3.20 m de luz.	Den befintliga konstruktionen är en ponton som består av två ytterväggar på cirka 10 meter och en mellanbåge på 5 10 m fri höjd och 3 20 m ljus.	Den befintliga konstruktionen består av två ytterväggar med en längd av ca 10 meter och en mellanbåge med en fri höjd av 5, 10 m och 3, 20 m ljus.
El arco que corona este vano tiene un radio de 1.60 m.	Det finns en radie på 1 60 m i den här kupongen.	Rensjön har en radie på 1 60 m.
El paso inferior está esviado con respecto a la perpendicular del eje de la vía.	Det nedre steget är inställt i förhållande till spårets vinkelräta axel.	Den nedre passagen är avskärmad i förhållande till spårets mittlinje.
Se ha optado por una estructura lo más parecida posible la ya existente, por lo que se ha proyectado un muro exterior para contención de tierras y la prolongación del arco existente hasta la cara exterior del nuevo muro.	Man har valt en så liknande struktur som möjligt som den som redan finns, och därför har man planerat en yttre mur för att hejda marken och en förlängning av den befintliga bågen till utsidan av den nya muren.	En så liknande struktur som möjligt har valts, vilket innebär att en yttermur för markanspråk och förlängning av befintlig trumma till utsidan av den nya muren planeras.
El espacio creado entre el nuevo muro y el existente será rellenado con material adecuado, y se dispondrá una losa de hormigón armado que servirá como tablero y como base del pavimento bituminoso.	Det utrymme som skapas mellan den nya muren och den befintliga muren ska fyllas med lämpligt material och en armerad betong ska finnas tillgänglig som skiva och som underlag för oljeskiktet.	Det utrymme som skapas mellan den nya och den befintliga bron kommer att fyllas med lämpligt material och en armerad betongplatta som kommer att fungera som brobaneplatta och som underlag för bitumenbundna lager.
El pretil actual que será demolido durante las obras será sustituido por un nuevo pretil de acero, normalizado PMC2/10b.	Den aktuella pretil som ska rivas under arbetena ska ersättas med en ny pretil av stål, standard PMC2/10b.	Den befintliga trumma som kommer att rivas under byggtiden kommer att ersättas av en ny stålpåle, standard PMC2/10b.
Esta estructura, situada entre los P.K. 1 + 863.100 y 1 + 886.500 tendrá un ancho total de 8,52 metros.	Denna struktur, som ligger mellan P.K. 1 + 863.100 och 1 + 886.500, ska ha en total bredd av 8,52 meter.	Denna konstruktion, som är belägen mellan P.K. 1 + 863.100 och 1 + 886.500, ska ha en total bredd av 8,52 meter.

La estructura existente es idéntica a la anterior en cuanto a su tipología, variando algunas de sus dimensiones: longitud total muros exteriores: 23.52 m, luz vano: 4.00 m, altura libre vano: 6.10, radio arco: 2.00, altura máxima pavimento-terreno: 7.12 m.	Den befintliga strukturen är identisk med den tidigare i fråga om typologi, och vissa dimensioner varierar: total längd yttre murar: 23.52 m, vano ljus: 4.00 m, fri höjd vano: 6.10, radioburen radie: 2.00, maximal markhöjd under jord: 7.12 m.	Den befintliga strukturen är identisk med den tidigare med avseende på dess typologi, med några av dess mått: Total längd yttre murar: 23.52 m, mörkt ljus: 4.00 m, fri höjd vano: 6.10, radie båge: 2.00, maximal höjd på golvet/marken: 7.12 m.