Long term memories: Trados and TM turn 20

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Abstract

During the nineties, translation memory (TM) technology revolutionised the way corporations and translators handled specialised text. Last year, 2004, the TM industry leader and *de facto* standard Trados turned 20. This article examines Trados' contribution to the development of TM and its current hold on the translation and globalisation markets as reflected by information gathered from the websites of Trados and its major competitors, plus expert opinion from professional publications and practitioner views from discussion lists. It then argues that, while Trados seems to have a firm grip on the lead, the push for Translation Memory eXchange (TMX) and new approaches for the reuse of text at the phrase level may tilt the balance. Finally, it ponders the capacity of freelance translators – the mainstay of the industry – to keep pace with the evolution of the new translation paradigm.

Keywords

translation memory, translation tools, computer assisted translation, global management systems, globalisation, workstation, language technologies

Twenty years on

Trados has celebrated its 20th anniversary year with yet another big promotional campaign: "20 Years of Great Memories." Even the humblest of the translators' newsletters will have carried the company's advertising.

The less translators seem to know about Trados, the more they seem to be in awe of it. What does a "job with Trados" mean, some will ask - while at the other end of the spectrum, TM-aware professionals will argue the right level of "Trados discount" to accept. Trados is certainly a search keyword that will return a lot of matches from a large cross-section of professional discussion lists. Although translators may not have learnt about Trados during their university training or via whichever mentor eased them into the profession, the name would be familiar to just about all. Indeed, unless working in the domain of literary translation (more concerned with comparative literature than the real world of legal, medical, pharmaceutical, technical, and other *specialised* texts) translators will have no choice but to familiarise themselves with TM in general and in particular with Trados as its *de facto* standard.

This article proposes to analyse the relevance of Trados' 20 year milestone – how this software has changed the way translation is performed and where it seems to be leading the profession. In order to do so, information was collected from several sources. To begin with, there is a wealth of data at the Trados website (www.trados.com), although this material may be understandably subjective. Similarly, we have the websites of Trados' competitors, which, although equally biased, give additional context and depth to the overall picture. Internet searches were also conducted for expert independent opinion contained in professional publications, and practitioner views through contributions to professional discussion lists.

As a starting point, it is logical to take a historical overview so as to put trends in perspective and find patterns that might help us foresee what lies ahead.

First, it pays to point out something that may be obvious to the initiated but is nonetheless important for all: the Trados *bogey* provoking anxiety and fear in many and confidence and superiority in computer *techies* is simply a software product - marketed mainly through the names of MultiTerm and Translator's Workbench. Trados is the actual software developer behind these brands, and is older than its best-known and eponymous product. Indeed, Trados the company began 20 years ago as a language service provider, and only later, from 1989 onwards, did it specialise in software development – with the first product in the Trados stable, MultiTerm, hitting the market in 1990.

From 1999 on, the line between Trados' delivery of products and its delivery of services begins to blur: special effort is being directed at trying to understand what this blurring of the lines is telling us about how specialised translation operates today.

Trados as service provider (1984-1989)

Trados (**TRA**nslation & **DO**cumentation **S**oftware) was established as a language service provider (LSP) firm in Stuttgart, in 1984, by Jochen Hummel and Iko Knyphausen in order to bid for some upcoming IBM translation work. They had developed keen interest in translation software just at the moment in which both microcomputer and TM technologies had come of age. They foresaw the future importance of computers in translation, and from the outset specialised in the sort of jobs that would require higher programming content.

The story of Hummel and Knyphausen, like other visionaries such as Bill Gates or Tim Berners-Lee, had to do mainly with being in the right place at the right time, and possessing the right mindset to make the most of opportunity. Hummel's and Knyphausen's time came in the mid eighties,

just when the mainframe was giving way to the microcomputer; their place was Germany, where state of the art European technology (including digital technology) intersected with the US milieu where translation and technology overlapped. It might not have been coincidence that two other major TM brands, Transit and Translation Manager 2, also started in Germany, the latter also in Stuttgart and also linked to IBM.

Computer assisted translation (CAT) encompasses, following Hutchings (1992), the concepts of both human-assisted machine translation (HAMT, under which the many MT tools will be generated) and machine-assisted human translation (MAHT) - the most relevant tool of which was to be known in the nineties as TM, and is the focus of this article. Interest in MAHT grew from the fifties when, fuelled by political and economic developments, the needs for translation expanded exponentially while the productivity of the individual translator remained constant; this created an expensive and time consuming bottleneck in the workflow of corporations that was waiting to be addressed with the help of computers.

At the terminological level, the seventies were the time in which Siemens produced its then gigantic 700,000 entry term bank, the European Commission commenced working on its Eurodicautom (which had its forerunner in the early sixties with the European Coal and Steel Community's Dicautom), and the Canadian Government constructed its Termium bank. At the sentence level, since the mid sixties there had been programming tests aimed at aligning parallel text and using this to retrieve information that would obviate any need to retranslate what had already been translated. In his seminal article "The origins of the translator workstation", Hutchings gives the best account yet on the genesis of these technologies, and states how, by the early eighties, all of TM's subsequent fundamental principles were already established. There was no founding figure, or a single point or moment of creation; in Hutchings words, "different people from different backgrounds came to similar and usually independent proposals at different times and at different stages of the development of computers" (Hutchins 1998: 3).

During the eighties, when large computer networks gave way to stand-alone machines with increasing processing and storage capabilities, the technologies to aid in translation tasks could finally break out of the in-house departments of big corporations where they had been hitherto confined.

The first commercial application is considered to be the Translation Support System (TSS) developed by ALPS (Automated Language Processing Systems) in Salt Lake City, Utah. TSS boasted a multilingual word-processor and terminology management system, with access to previously translated segments. Hummel, from Trados, will later call it the "grandfather of all translation memory systems" (Kingscott 1999: 7).

It was too early for the company to profit from its innovation, and by the late eighties TSS was taken off the market, although ALP continued to use it in its own translation agency venture ALPnet.

When Trados was established TSS was being tested at IBM in Germany. When its development was discontinued, the system was taken up by INK Netherlands, then re-engineered and relaunched as INK TextTools and TermTracer. Trados not only used INK TextTools in its translation work, but in 1987 also gained the rights to resell it in Germany. However, these translation aids were still too limited. In Hutchings words, in translation "everything was constrained by the computer technology then available" (1998: 5). It was too early and, as had happened before with ALPS, INK lost interest in pursuing further development.

This was not so in the case of the Trados people, who at time saw a window of opportunity and took the gamble of splitting their company, hiving off their translation services to INK so as to concentrate exclusively on software development (Brace 1994). This third time (after ALPS and INK) proved a charm for the technology, and Trados' gamble was to pay off: Windows was around the corner waiting to supersede DOS and the computer technology constraints to development were about to be significantly eased.

Trados as product provider (1989-1999)

The TM era was about to begin, and in Hutching's opinion the first to coin the "translation memory" expression were the Trados people themselves (Hutchins 1998: 15).

Already in 1988 Trados had developed TED, a plug-in for TextTools that was later to become, in expanded form, the first Translators Workbench editor (Brace 1992b). The first product they put on the market was MultiTerm, in 1990, while the first edition of Translator's Workbench was launched in 1992 (Wassmer 2003b).

Suddenly, competition was fierce. In 1992 IBM Deustchland decided to commercialise its in-house developed and well-tested Translation Manager 2. Also in 1992, GlobalWare released its XL8, if this one aimed at the software localisation market. Transit, which large language service provider STAR AG (also German) had begun developing in 1987, became also commercially available. From 1993, Telesoft in Spain and Transsoft in the US began marketing the budget-priced Déjà Vu (Brace 1994; Hutchins 1998; Roder 1994).

The big name at the time, however, was the Paris-based Eurolang Optimizer, launched in March 1994, following a one hundred million US dollar investment. The developers, Bernard Seite and Fernand Winkler,

were not aiming for the individual translator but rather for major clients, which already included Microsoft and Mendez Translations. It came on the back of many years of involvement in MT, cocooned under big projects like ESPRIT, GETA and Eurotra. For Optimiser, Trados competence was insignificant, its only fear being the possible appearance of Japanese cheaper clones! (Brace 1992a)

Take off for Trados, was slow but firm. They foresaw the importance the Windows platform would gain and swiftly moved to adopt it: first MultiTerm, in 1992, and then Translator's Workbench II in 1994 went for Windows, dropping their original proprietary interface and using the available word-processing packages instead. The first breakthrough had come soon after the initial release of MultiTerm, when the European Commission bought the first 200 licences, thus providing the capital to develop the Workbench and make the shift to Windows.

It was 1994, and in addition to its two founders Trados now included a computational linguist from the University of Stuttgart, Matthias Heyn, who was the architect of what was the first alignment tool on the market, T Align (later WinAlign) and was eventually to become the third partner (Brace 1992b). The company had sold another 200 licences to the European Commission, and a further 200 to Berlitz (Localization Ireland 1997).

The following year Trados opened an office in Brussels, manned by Heyn, to bid for another European Commission call for tenders for translation tools: in 1996 they won a new contract for MultiTerm and in 1997 for the Translator's Workbench. By then, Eurolang Optimiser had already proven to perform below expectations while Trados, with its European Commission leg-up, was ready to take on the big players. That same year, Knyphausen went on to open an office in US, in Alexandria, Virginia, and the second major breakthrough came in September, when Microsoft decided not only to use Trados for its internal localization needs, but to acquire a 20 percent share of the company as well. By year's end, they had offices in Ireland, Britain, France, Switzerland and Sweden, and were planning to send Heyn now to Tokyo (Localization Ireland 1997).

Trados' ambition, as stated by Hummel in an interview, was for "every translator in the world to have a piece of our software" (Kingscott 1999: 8). This was not an impractical notion: TM technology had been developed in the past by and for the big in-house translation sections of multinationals but, after the downsizing frenzy of the late eighties, most translation work was by then being done by contracted freelancers who had abandoned their typewriters for word-processors. Desktop capabilities for storage and handling of information had kept growing, and computers were more affordable. Successful CAT development in the mid nineties was geared towards freelance needs and Trados, for the

time being closed off from the big clients by Optimiser and Translation Manager 2, successfully targeted the freelancer section of the market.

Towards the end of the decade, Déjà Vu had emerged as Trados' major competitor in this freelance sector. Its developer released the first version, already Windows-based and working on a Word interface, in 1993. In 1996 Déjà Vu released a Windows 95 compliant version that dropped the Word interface in favour of a proprietary one, more flexible for coping with different source file formats. Déjà Vu's philosophy was to put every application into one neat package: sentences and terminology databases, filters, alignment, all integrated in a single product so as to cater for the most sophisticated of freelancing needs. This combined approach, along with service and support, was to be the main point of differentiation with Trados, which treated each component separately: MultiTerm, which by 1992 already came in Pro and Lite versions (Brace 1994), Workbench, WinAlign, and later the TagEditor and the many interfaces and filters needed to cope with formatting not readable by Word. In comparison with Déjà Vu, many freelance translators complained that Trados was technically inferior, more expensive, less user-friendly and came with sub-standard service. These opinions are best reflected in the Trados versus Déjà Vu *holy wars* whose strands may be followed in the *Lantra-L* discussion list (Garcia 2003). However, this did not overly concern Trados, as by then it was clearly seen as the choice of major clients which included by 2000 NATO, SAP, Crédit Suisse, Oracle, Siemens, Yahoo, plus large LSP such as ITP and Lionbridge (Trados 2000).

Trados as solutions provider (1999-…)

The nineties was the golden decade of TM. While progress in this area in the seventies was possible only from within large corporations, the nineties was a much more *democratic* playfield with relatively few resources being needed to put a program on the market. Multinationals and large LSPs certainly kept developing tools, some only for internal use (Mneme by Logos, ForeignDesk by Lionbridge etc) others also offering them commercially (IBM's already mentioned Translation Manager 2, Star's Transit, and SDL International's SDLX). But given the power and accessibility of computers, the necessary ingredients for successful TM software development were now a dedicated individual and a degree of support. The case of Emilio Benito and Déjà Vu is the best example, but mention can also be given of brothers Alain and Jos Bailleul's Trans Suite 2000, Környei Tibor's Wordfisher, and Yves Champollion's Wordfast, to name just a few.

The history of TM is still to be written and the advent of the digital age has brought bad news to historians. While an abundance of digital information is constantly being created, computer memory is much more

volatile than the hardcopy of yesteryear. In the end the only stories to remain will concern those whose talent, persistence and sheer good luck enabled them to succeed. That the opportunities for success may have arisen thanks to the talent, persistence and misfortune or mistiming of anonymous predecessors is unfortunate -but that is a recurring theme throughout history...

Later in the decade, the World Wide Web swept all before it and opened up a new era for translation technologies. On top of the productivity and consistency gained at desktop level, the new era offered the possibility of worldwide teams of translators collaborating on a single project, using computer servers to interact in real time with memory and terminology databases. The era of globalisation, *G11n*, and the integration of translation technologies into content-management, marketing, sales, and consumer support on a global scale, had begun.

Of the many software developers of the nineties, by 2004 only four had survived with a robust product that was adapted to the needs of the globalisation environment and offered strong databases, batch processing for disparate formats, server capabilities for web-based interactive database sharing etc. Of the four, two (Transit and SDLX) are in-house solutions backed by big LSP parent companies, with the other two being Trados and Déjà Vu. The other TM product which remains relevant without having made it to *global* standard is Wordfast; less sophisticated and expensive, it is more than adequate to the needs of individual translators working mainly in Word.

Trados swiftly positioned itself in this new web-enabled environment. In 1999, when the company turned 15, Hummel's vision appeared explained in an article appropriately titled "New strategic direction for Trados". The gist of Hummel's message is that Trados wants to move from being simply a tools provider to become a solutions provider – that is, a shift from pure software development toward a consultant role to ensure that Trados technologies fit the particular needs of each corporation. The new philosophy will now be "horses for courses": different solutions for different types of users. The company was at a crossroads: the software was getting too technical for freelance translators, while for big corporations it remained too simple. It was time to diversify (Kingscott 1999: 9).

The big era of Trados "solutions" began in earnest that same year, with major milestones in the freelance / small LSP end of the market including:
– Trados Translation Solution Freelance Edition 3, launched October, 1999;
– Trados 5, launched June 2001 (what happened to Trados 4?), with version 5.5 following about a year later;
– Trados 6, launched April 2003, with version 6.5 following in October.

Although Trados offered discounts for upgrades and made promotional offers, the retail price of US $995 for Trados 3, $795 for Trados 5, $895 for Trados 6, made the software seem expensive. These prices, as per standard Trados philosophy, tended not to include all the applications that freelancers might have wished for: WinAlign had to be bought separately when Trados 3 was released, as did MultiTerm iX, ExtraTerm, XTranslate and T-Window for Trados 5 (Raff 1999; 2002). Which components came packaged with the basic software also changed with different special promotions. However, over time the Trados package seems to be representing better value, given that each new issue was more robust that last and that more of the relevant components seemed to be bundled together in the later versions.

Trados would also occasionally include applications the freelancer did not really need - the best example being a kind of project management utility called WorkSpace, which was distributed to every freelance purchaser of Trados 5 versions and whose instructions for use occupied the entire *Getting started guide* shipped with the installation CD. It was advertised by Trados as bringing "integration, simplification" (Trados 2001), but although in some early independent reviews was praised for its "central intuitive interface" (Wassmer 2003b), it was soon seen as "more of a nuisance than a help" (Raff 2002) and an application which seemed designed to complicate what had been relatively simple in Trados 3. In the 2003 versions it had quietly disappeared.

If Freelance and small LSP communities seem subjected to a rather frenetic level of updating, the pace is no slower for corporations and large LSP. Trados clearly differentiates between both ends of the market, focusing on the needs of corporations and large LSP in its main www.trados.com site, leaving freelancers and small LSP in its ancillary www.translationzone.com.

The picture at the top end is fuzzier, however. For the freelancer we have file-strength *products*, purchasable software applications (Workbench, MultiTerm –the latest versions of these two offering server access, Tag Editor, T-Windows, filters etc. Products for the corporate market include the jargony MultiTerm Web Access (launched in October 2000), MultiTerm Client Server (October 2001), Trados GXT v.5.2 (August 2003), Trados TM Server (March 2003), and Trados TeamWorks (June 2004). What this sales-speak seems to indicate is server-strength TM and terminology *products* (i.e. databases, such as TM Server) plus utilities to connect databases to language vendors (agencies and freelancers) and company content management systems, plus services like consultancy and technical assistance. This makes the marketing angle correct in talking *solution* rather than just *product*, with TeamWorks being one example of a *solution*.

Oddly enough, such an angle brings Trados full circle and signals a return to the LSP field it came from. In its consulting and technical assistance role it is making incursions into the area of influence now occupied by Bowne, Lionbridge, SimulTrans and their fellow globalisation companies (most already Trados clients). Trados' headlong push in that direction was clearly flagged by its merger with globalisation company Uniscape in 2002. The fact that in September 2004 it appointed Joseph S Campbell, who came from the content management sector, as new CEO further corroborates the trend.

The *de facto* standard

If press releases at www.trados.com are to be believed, the future seems rosy:
- the number of licences sold jumps from 30,000 in February 2000, to 40,000 in December 2000, to 45,000 in September 2001, to 50,000 in October, to 55,000 in March 2002, to 65,000 in March 2003, to 67,000 in July, to 80,000 in September 2004, when the "super savings" campaign to celebrate its 20 anniversary was released;
- investment flows in, from First Union, Merril Lynch and HypoVereinsbank's AdAstra in 2000, Arthur Andersen and Deutsche Bank in 2001, Invision AG in 2002;
- large LSP such as Bowne, Berlitz, Lionbridge, SimulTrans, Weblocalise and many others get closer to Trados through the Client Partner Program, launched in 2000, or through other ventures, despite Trados moving into their services/solutions territory;
- integration with localisation (Passolo, Catalyst) and content management software (Documentum) seems to put Trados in a strategically better position than its competitors;
- 3,500 corporations rely on Trados in one way or another for their translation needs, a growing number taking on the TeamWorks solution launched in June 2004;
- the number of employees keeps growing: from 40 in September 1997, to 90 in September 2002 and 186 in 2003 (sources for data on number of employees to be found in Golan 2004; Line56 2002; Localization Ireland 1997).

In all, throughout 2004 Trados will affirm in its press releases that, "[m]ore translators, localization service providers, and companies use Trados products than all competing products combined".

However, unsubstantiated claims have to be taken with a grain of salt, especially in marketing which seems to rest easy regarding overstatement. Indeed, SDL also calls itself "the world's leading provider of translation services and technology solutions" (SDL 2004). Nevertheless it can be safely said that even if Trados is not necessarily every translator's tool of choice, it is the undisputed leader of the TM market. For proof of this it is

sufficient to note that while all other brands are making themselves Trados compatible, Trados itself, which in the past aimed for compatibility with Translation Manager 2 (Raff 1999), no longer sees any need for concessions.

This is a compelling position of leadership, and all the more remarkable considering it rests on a product that, as independent reviewers have often pointed out (Benis 1999; Nogueira 2002; Wassmer 2003a; Zetzsche 2003b) is more expensive than most others but not dramatically better in any aspect.

While Trados' leadership is uncontested at the translator desktop level, its hold may not be as strong in the global content management sphere. It has been remarked that the situation in this area, despite the large volume revenue it generates (estimated at 2.5 billion dollars annually) is still that of a *cottage* industry: the entry point is low cost, the market is fragmented, and the standards are not well defined (Rees-Evans 2003). If we also consider that the latest server technology - the same one in which Trados excels, by almost automatically connecting the client's content management system with the localisation vendor and project translators - is rendering most of the role of this globalisation industry obsolete, then the situation of the whole sector seems indeed volatile. Mark Homnack of SimulTrans, a long established, well regarded, mid-size globalisation company, painted a pessimistic picture at the 2000 Localization Industry Standards Association (LISA) conference; he reiterated his concerns in 2002 on the occasion of the Trados merger with Uniscape – a move which, like other mergers in the sector (Mendez and Berlitz with Bowne, ALPnet with SDL), he sees as fuelled more by investor insecurities than a melding of synergies (Homnack 2002a; 2002b).

Again, as has been the case all along, it is computing technology which holds the key: the available computer platforms, as the tectonic plate on which TM, globalisation and so many other technologies float, will continue to set the rhythm of change.

We have entered now the XML era, which will greatly affect the practice and management of translation:
– at the project level, by positioning translation as a by-product in the content management workflow of big and medium corporations and institutions; and at the authoring level, by the mainstreaming of authoring tools so that technical writers can ease into single sourcing (Schwartz 2003b: 4-7) - which, to parody the catchcry of TM, means never having to *write* the same sentence twice;
– at the programming level, and given the exponential growth of storage power and the acceleration of change in processing applications, the emphasis is on open, non-proprietary standards - which for translation and globalisation means a push for Translation Memory eXchange (TMX) and Term-Base eXchange (TBX) standards.

In this XML era, the playing field for TM developers is not as *democratic* as it was a decade ago. Too many small developers and some of the big ones have discontinued their products, and to create a competitive new one would require greater resources than in the nineties. Yet, while the technology for the reuse of translation at the term, sentence and paragraph level seems to have reached maturity, there is still room for advancement at the phrase level, which is said to be where repetition occurs the most. Traditional TM software has started paying attention to this. There is interest from Trados itself, as shown in Hummel (2003). Déjà Vu's "autoassemble" feature has been seen at *Lantra-L* as perhaps the most sophisticated tool thus far for dealing with text at this level (Garcia 2003) and is sometimes presented as an instance of example based machine translation (EBMT). However, new approaches such as those advanced by Multitrans and Logiterm are also being developed; while they do not seem to have much hold on the profession (if their presence –or lack of it- in discussion lists is a reliable indicator) they may yet help in opening up what in fact is the next frontier for translation technologies: the application of the principle of reusability to the translation of non-repetitive, non-Gricean, discursive text.

What lies ahead

Will Trados be in the same position it enjoys today in ten years time? It may well be. It has certainly succeeded in the past where others have failed. But again, with the semantic web around the corner, the environment by then may be totally different.

Irrespective of what happens at the top of the globalisation hierarchy, at the bottom of the localisation chain and for the foreseeable future there will always be a freelance translator who will need a TM interface to apply standard terminology and to reuse previous translations. At the moment, it need not be Trados, but it does need to be Trados compatible.

All the major TM brands possess some degree of compatibility with the market leader, although not all of them are compatible to the same extent. The ability to be accurately compatible with Trados has been a frequent topic in discussion lists – indeed, an iconic moment came in the course of the previously-mentioned Trados vs Déjà Vu *holy wars* on *Lantra-L*, when a leading Déjà Vu proponent claimed that Déjà Vu handled Trados files even better than Trados did (Garcia 2003). More recently, it has been interesting to note how SDLX, the second-most aggressively advertised TM brand in 2004 (after Trados, that is) used its Trados compatibility as an advertising weapon, with the accuracy of its compatibility with Trados backed by an impeccable source: Iwan Davies, administrator of the *TW_users* discussion list at Yahoogroups, and for years a most authoritative defender of Trados at *Lantra-L* (Davies 2004). Not that

Trados would condone the use of other software in Trados projects: "Don't let anyone convince you to use one form of TM at the server and a different at the desktop", is the advice given to global content managers (Schwartz 2003a: 10).

The other weapon in the SDLX arsenal, and equally well aimed, is TMX. While Trados pays occasional lip service to open standards and TMX, only SDLX has been officially certified by LISA as a TMX product (with Déjà Vu awaiting certification). SDL even offers a free application to allow Trados memories to be made TMX compliant! While TMX still has a way to go to establish itself as the standard (Zetzsche 2003a), the breeze appears to be blowing in that direction. Big corporations like to minimize exposure of all forms, which at the TM level may mean that the corporate sector could end up favouring open standards rather than risking being locked into a single application that may soon be superseded by another (Bois 2004).

For the freelancer at the bottom of the globalisation pyramid, for the small LSP vendor, indeed for the translation training departments at universities, the hour of TM has definitely arrived as the profession enters the post-industrial age. The artisan paradigm in which the profession was embedded just 20 years ago has been well and truly left behind. In the context of this latest evolutionary journey, propelled in the main by TM, the 20th anniversary of Trados, which has led for much of the way, marks an important milestone. TMX may be lurking around the corner, new technologies may be waiting further down the road, but in 2005 Trados and Trados-compatible products are the present and the immediate future.

As the 20th anniversary of Trados also reminds us, just how quickly the next innovations can be implemented when they do arrive is moot. While top-level professionals were early adopters of TM, and general awareness has long been high, actual uptake has only recently been identified by practitioners as a necessity. TM tools are becoming more powerful and more affordable, but translators are being called upon to employ them for increasingly complicated tasks. It is axiomatic that the most sophisticated technical aide is only as good as the person operating it: if the pace of innovation outstrips the capacity of the global freelance translator base to keep up, the near future might also hold a new productivity bottleneck – a lack of translators with adequate training and experience to exploit the technology.

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