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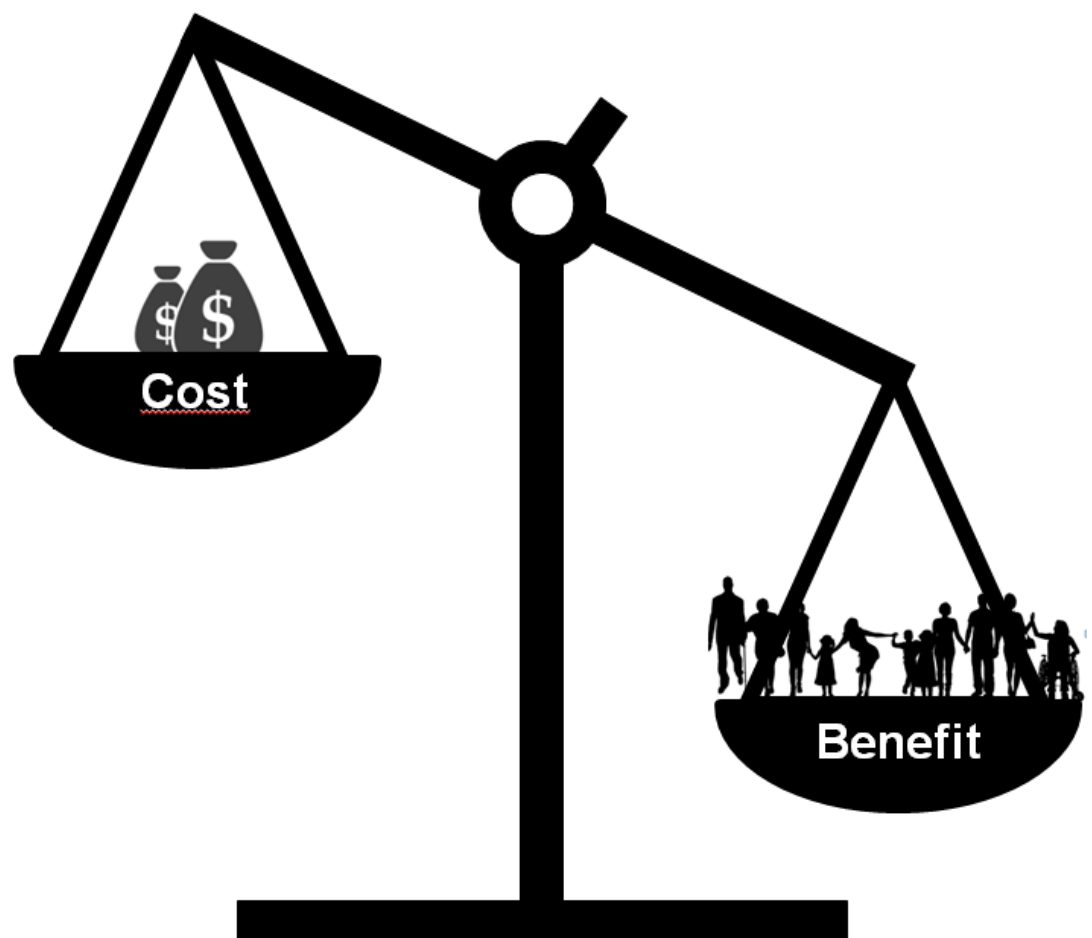
Cost-benefit analysis of universal design

Literature review and suggestions for future work

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Stein Erik Skotkjerra and **Technology for all**, a department of Norges Blindeforbund – The Norwegian Association for the Blind and Partially Sighted (NABP).
Technology for all provides services and education within the field of universal design of ICT. The main objective of NABP is to achieve equal opportunities and status in society for people with visual impairment - and other groups of disabled people. NABP also participates in various research and development activities.

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Abstract

This report presents results from a literature study of good practices of universal design (UD), cost-benefit analyses, and measurements of outcomes and effects of UD. Further, the reviewed literature is structured and analysed. Based on this a framework for planning and performing case-studies with the purpose of measuring cost-benefits of Universal Design is proposed.

Sammendrag

Denne rapporten gir en oversikt over litteratur og dokumentasjon av de kommersielle og forretningsmessige effektene av å arbeide med universell utforming i en virksomhet. Resultater fra tidligere forskning og case-studier blir strukturert og analysert. På bakgrunn av dette foreslås et rammeverk for planlegging og gjennomføring av case-studier med det for mål å måle kost-nytteeffekter av universell utforming.

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Content

NR🌊 **Cost-benefit analysis of universal design**

1 Introduction

In 2009, the Council of Europe recommended to its member states that "cost-benefit analyses of the application of Universal Design and the communication of the results should be carried out to provide for greater visibility of the effects of Universal Design" (CM/Rec 2009). According to the Council of Europe, Universal design should be measured according to pre-defined criteria and procedures, and both social aspects and technical aspects should be measured.

However, performing cost–benefit analyses or measuring the effects or outcomes of applying universal design principles is not trivial. It is necessary with thorough planning based on a sound methodology.

Therefore, in the project uu-effekter (Eng: UD Effects), the Norwegian Association for the Blind and partially sighted (NABP) and the Norwegian Computing Center wanted to review previous work in this field, and to investigate aspects affecting choice of methodology for measuring effects of UD.

In this note we present results from a literature study of good practices of universal design, measurements of outcomes and effects of universal design, and cost-benefit analyses. Further, we structure and analyse the reviewed literature, and propose a framework and a procedure for future studies.

1.1 Target audience

There are several target audiences for this report. The most obvious audiences are professionals and educators in universal design and accessibility. We also hope that the report can be useful for software development managers, directors or executives who want to better understand the potential effects of universal design. Finally, we hope that usability and software professionals in general will be interested.

1.2 Use of terms

Terms such as universal design, accessible design, accessibility, Design for All (DfA), inclusive design, and universal access have very similar goals, and are often used interchangeable. (Other and similar terms are ability-based design, barrier-free design and transgenerational design).

In this report we use the term universal design (UD), but we include results from research and publications that use any of the above mentioned terms, particularly accessibility, DfA, and inclusive design.

We emphasize the following aspects:

Universal design is about both the design process and the design goals:

- The goal is to arrive at products or services that are accessible and usable to the widest range of users giving every citizen equal opportunities to take part in the society.
- The process emphasises a holistic view, is based on user-centred design and the involvement of end users from the beginning of the development process and throughout.

2 Universal design as a goal and a process

Despite increased focus on accessibility through politics and legislation, people with disabilities continue to meet significant barriers when trying to use web products and services (Cooper et al. 2012).

There is a broad consensus among researchers and users that compliance with the WCAG guidelines is an important prerequisite for achieving universal design, but it is by no means sufficient (Brajnik 2008; Rømen & Svanæs 2011; Cooper et al. 2012; Kelly et al. 2009; Arrue et al. 2007; Petrie & Kheir 2007; Power et al. 2012). For example, empirical studies indicate that WCAG compliance can remedy between 35-50% of user problems among people with disabilities (Rømen & Svanæs 2011; Power et al. 2012). A web solution may be WCAG compliant but too difficult to use for particular user groups. Therefore, a user-centred development process involving users with disabilities is recommended (Arrue, Vigo & Abascal 2007; Power et al. 2012; Kelly et al. 2009; Kelly et al. 2005). Thus, while legislation has focussed on conformance to website accessibility guidelines and metrics to measure such conformance, Cooper al. (2012) argue that more emphasis must now be given on enhancing practices which support the development of inclusive design of web solutions.

The Norwegian report "Universal design - a conceptual clarification» (MD 2007), which is based on input from a wide variety of stakeholders, points out that universal design is more than just to fulfill a set of established requirements. The design process should be interdisciplinary, take the whole usage context into consideration and involve a wide array of users.

The benefits of user involvement to software design have been shown in several studies, and lack of user involvement has repeatedly been associated with failed software projects (Kujala 2008). During the last decade several inclusive design challenges have been conducted to encourage industry to engage in inclusive design. The basic idea of these inclusive design challenges is to let designers work with disabled people to solve a real-world design problem.

Examples of such events include the European Business Conference (EBC); The Vodafone Smart Accessibility award for mobile apps (Dredge 2012) and the SS12 Code for a Cause competition (*SS12: CODE FOR A CAUSE* 2013). Such events have resulted in creative solutions and praised designs and have also resulted in new business opportunities (Dong et al. 2003; Dredge 2012; Pullin et al. 2011). Companies involved in such events have stated that inclusive design can be especially valuable as a source of innovation and differentiation (Dong, Cassim & Coleman 2007).

Designers who have participated in an inclusive design challenge found that the opportunity to interact with disabled people as particularly useful and valuable. For instance, they stated that they became aware of latent problems that they would not have predicted otherwise (Dong et al. 2003).

In other words, with a one-sided focus on compliance with the WCAG, guidelines one does not only risk to create web solutions that are not fully accessible and usable to many users, but one may also miss out on many of the benefits and opportunities that can result from a more holistic and user-centred approach (Fuglerud & Sloan 2013).

To summarise, universal design denotes both a design goal and a design process. The design goal is to develop solutions that are accessible and usable to as many people as possible. Researchers and practitioners generally agree that universal design as a process should be based on user-centred design and include users with disabilities.

To contribute to the political and legal intention of developing ICT solutions that ensure equal opportunities and rights to social participation for all, regardless of disability, it is important to bring forth knowledge and evidence about the relationship between universal design as a process and its outcomes and potential benefits for users, society, industry and businesses.

3   Related work

In this section we review previous work in terms of research on attitudes to UD in Industry, as well as case studies, business cases and outcomes of universal design.

In the following we take a look at various sources of UD (and similar approaches). The material is organized into several sub sections.

The first sub section includes studies of attitudes to, assumptions and knowledge about universal design. This is included because attitudes, assumptions and claims about UD are potential aspects that may be worth investigating. There might be studies that confirm hypotheses about UD, but also studies that do not confirm these hypotheses.

In the nest section we include studies that have attempted to measure outcomes of universal design or performed some form of cost-benefit analysis.

Various case studies and good practice examples can be found in the literature. While many of these good practice examples do not include quantifiable information, or information about return of investment (ROI), they often include other relevant information, such as a description of the goals, strategies, the organization, the design process and what was done and the features of the resulting ICT solutions. These aspects are of relevance for a cost-benefit analysis and we therefor include such examples.

To be better able to get an overview, information from several case studies are structure and presented in section 4.

3.1 Knowledge about and attitudes to UD

A prerequisite for UD is that organizations and their developers know what it is and the main aspects in how to achieve it. This is not necessarily the case. For example, a recent survey among 1150 public and private organizations in Norway found that there is relatively little knowledge about the Norwegian regulation about UD of ICT which came into effect July 1st 2013. The survey showed that among the enterprises that have web pages, and therefore are affected by this legislation, only 14% could mention at least one of the elements of the relevant web accessibility standard, namely the "Web Content Accessibility Guidelines (WCAG) 2.0" (DIFI 2014, pp. 7-8).

Further, attitudes and negative conceptions may constitute a barrier towards UD. Eikhaug et. al. (2010) mention ten common prejudices about UD, i.e. it is perceived to be

1. expensive
2. boring
3. only about physical objects
4. only about accessibility and disability
5. only a bout assistive technology
6. not relevant for me
7. not concerned with aesthetics
8. for niche markets such as older people
9. just another buzzword
10. only about public services

A survey among the ICT industry in the UK (Dong, Keates & Clarkson 2004) found that the main barriers to UD were:

- lack of a business case
- think you have to sacrifice aesthetics
- believe that UD is costly
- a perception that UD is too difficult or too complex

Another perceived difficulty is that there may be conflicting user needs between different user groups (Gregor, Newell & Zajicek 2002), and that accommodating

everybody may result in products and services that are complex and hard to use because of many options and alternatives (Pullin 2009).

3.2 Cost-benefit analyses

A first impact analysis of the consequences of new legislation on the area universal design in Norway is given in (Halvorsen & Andersen 2007). The report looks at a number of activities with impact for an overall cost increase:

- analysis of existing content,
- acquirement of (external) technical expertise,
- acquirement of new tools for content generation and management,
- modification of existing tools, and
- testing and quality assurance.

While those factors are likely to be one-time expenses, operation and maintenance are claimed to outperform them in terms of much higher costs. It is also argued that costs must be seen in relation to how many people work with the development of UD inside a company. Another aspect that is in how far assistive technology (AT) can be applied to reach over the inaccessibility gap. The use of AT is said to save a lot of money as compared to an entire redesign of the solution, which is estimated to be very costly (Halvorsen & Andersen 2007). Further, the report summarizes some earlier international cost estimates. The numbers here are partly based on interviews with IT engineers and advisors, partly with buyers, sellers, and manufacturers of web solutions, and partly with representatives for companies which help other companies to increase the inclusiveness of their web site, such as Deque (Brodkin 2007). Halvorsen also sheds some light on the socio-economic analysis of the benefits of accessibility, but concentrates on listing the benefits and referring to (Boardman et al. 2006) for the proper methodology within cost-benefit analyses. (See section 6 for a list of effects from UD and accessibility referred to in the literature review).

A thorough analysis has estimated the one-time expenses of requiring WCAG 2.0 for public organizations' web portals and the continuous yearly costs for multimedia production (DIFI 2009). The calculations differ between costs related to existing solutions vs. new equipment/tools, costs which must be seen in relation with a one-time upgrade of content vs. the continuous preparation of multimedia, and costs linked to training. With other words, there are expenses for the CMS provider and expenses for the content publisher. The report also differentiates between internal costs and expenses for buying external services. The calculation model recognizes that the web sites from discerned organizations, such as companies, schools, small and big municipality, and other public authorities, vary in size and complexity by means of a simple multiplication factor. The uncertainty in the estimates is quantified by means of Monte Carlo simulations, resulting in range of costs where the estimate will lie with a probability of for instance 90%. Regarding possible benefits, the report restricts itself to listing of a number of non-measurable qualitative advantages.

In the analysis of the impact of implementation of UD into web solutions, the estimation of expenses in (Brynn 2010) follows the derivation of costs in (DIFI 2009) closely, while mentioning that the starting point for any improvement is important, too: Does the solution fulfil WCAG 1 yet, or does it have to be built from scratch? The authors don't fail to consider costs related to buying of new tools such as for publication, testing, and content management. However, the main value of this report is to extend the scope to include private entities, to try to quantify the savings or benefits and to consider the three guidelines WCAG 2 (all three levels), ATAG 1, and ISO 8241-20. The report also fills in some of the estimated parameters in Difi's models with actual measurements, by means of a process dubbed Unified Web Evaluation Methodology (UWEM), while properly discussing the uncertainty of the approach. Two cases are mentioned as examples for the quick and positive return on investment that follows increased accessibility, one from the public and one from the private sector.

In a report similar to the aforementioned analysis from DIFI (2009), the analysis is extended to include companies and other private organizations (DIFI 2010b). The authors use roughly the same methods and models, and follow otherwise the considerations of the last report's authors, replacing some estimated parameters with more accurate, measured values, where known. However, this work goes a bit more into detail and discusses matters like what is the definition of the main solution, how much content is going to be produced in the future, and what are the costs of buying a new CMS vs. the costs for a major upgrade. It is also mentioned that the expenses for user testing need to be part of the equation. Taking all these aspects into account, they argue that a sensitivity analysis as in DIFI (2009) is not meaningful since many relevant parameters cannot be quantified, or may even be hidden. This report is a bit more detailed than the previous one by diversifying benefits for users, service providers, and society. But also here, the authors claim that quantifying the benefits of UD is not reliable enough to provide useful results.

An impact study of the consequences for self-serve machines is given in (Aslaksen, Kalhagen & Bakken 2010). This work employs a welfare economics analysis as specified in (Longva & Tverstøl 2014). The analysis utilizes the findings from a survey among people with visual impairment (MMI 2004) and applies these findings to visually impaired, dyslectics, and elderly. The authors calculate costs and benefits for the machine types ATM and ticket, while for queue, and goods there was not enough user behaviour data to give a proper estimate. Where given, the benefits always outweigh the costs. The calculation of costs is based on a comparison of a universally designed alternative and an alternative without particular UD measures, accounting for a natural progression towards more universally designed solutions. The estimation of benefits considers advantages for users with and without impairments, and for the machine owning organization as well. However, both costs and benefits estimations are bound to many uncertainties and assumptions, and this is honoured in sensitivity calculation.

Another impact study considers the implementation of a guideline for the design of electronic forms on the public sector (DIFI 2010a). Here, it is argued that a quantitative analysis would not lead to meaningful results, and therefore the work concentrates on

the qualitative effects. However, the study lacks a real cost-benefit analysis, and important organizations like the Norwegian Labour and Welfare Administration are omitted from the expert panel. Other shortcomings are that the study has neither referred to relevant work nor taken into account previous impact analyses reviewed here.

The topic cost estimations of software projects appears to be a very active research field. Though being rather generic, fruitful conclusions can be drawn from here and applied to projects dealing with universally designed software solutions. Jørgensen (2008) discusses different approaches to computing good and sustainable cost estimates, such as the use of estimation models vs. expert assessment. Another aspect is the difference between an analytical approach and plain intuition.

Related to this is the question of proper estimation of ROI in IT projects, for instance addressed in (Jørgensen 2011). The author lists a number of factors influencing ROI estimations, direct vs. indirect effects, quantifiable vs. non-quantifiable effects, short-term vs. long-term impact, high-risk vs. low-risk, and others. It is also discussed how ROI is measured, and among others the impact for internal processes complicates the picture considerably. Moreover, the author points at the combination of skills, knowledge, and IT investments for getting the most out of IT projects. It is furthermore relevant to know that IT projects faced with a high degree of uncertainty and measurement problems, as often the case in UD projects, typically overestimate the ROI. According to the author there is no well-established way for the calculation of the ROI, but it is advisable to combine several methods and compute a number of ROI values with associated confidence intervals. For good examples, it is referred to (SSØ 2009).

As the term universal design comes from the world of architecture and the design of physical environments, it seems natural to turn to this area to see how researchers here are measuring the effects of UD.

One case study considers a building claimed to be universally designed (Danford 2003). Four populations are employed under the evaluation, three with various impairments, and one control group without impairments. The participants' activities are quantified in terms of their (subjective) perception and (objective) performance by means of different measures/metrics. The former is called Environmental Utility Measure (EUM), and the latter is dubbed Functional Performance Measure (FPM). The study compares the collected data regarding the building of concern to the metrics related to "most other buildings".

Another work considers four artificial buildings with different degrees of universal design (Grimble, Danford & Schoell 2010). The work involves users with temporary and permanent conditions and impairments, and a control group without impairments. Subjective and objective metrics for all buildings are then compared to each other.

A rather extensive analysis of the economic effects of UD for buildings is given in (Medby et al. 2006). This work concentrates on a thorough discussion of the topic and establishing the proper methodology. A number of important questions are formulated and answered, like what is a universally designed solution, which parameters to acknowledge in the calculations, and how to deal with risk, among others. The authors also argue that the given constraints, such as whether a reference point for measurements exists, may be dominant in the proper choice of methodology, be it cost-benefit, cost-efficiency, or cost-effect. Finally, the work gives two interesting case studies; one for the upgrading of an existing environment, and one for the acknowledgement of UD in a project from scratch.

A study conducted by the National Council of Disability in the United States found that while existing civil rights laws take costs into account in determining whether particular accessibility accommodations or strategies are too costly, they do so in ways that often place too much emphasis on the direct costs of inclusive design, while failing to highlight the costs of inaccessible design (NCD 2001).

It can also be argued that the recognition of universal design in the requirement specification and its subsequent implementation on the ICT sector often can be seen as a simple IT investment. This is especially true for software-only projects but depends when it comes to self-service machines and other products which involve hardware. However, if this is a valid assumption, the findings by Brynjolfsson and Hitt (1996) apply (Brynjolfsson & Hitt, 1996), who found that the gross marginal product for computer capital is 81%, and that the return on IT investment exceeds that of non-IT capital investment. While this basically means that the investment of IT capital is low as compared to the revenue generated by IT, the study must be interpreted with care. First, measuring a company's productivity has changed considerably since this study were conducted, with the arrival of the Web, Internet points of sale, online customer support, and so on. Second, the marked has changed a lot too, with the arrival of many services (as compared to previous products). Also, the study considers only companies and does not include the public sector. The consequences for society are neither of concern.

3.3   Case studies and good practice examples

The two most famous cases on the effects of working with accessibility within the web design area are probably the TESCO and D&G cases. These cases are described on the W3C WAI web pages (W3C WAI L&G 2009; W3C WAI Tesco 2009). In both of these cases both technical accessibility assessment and usability testing with people with disabilities were performed. In both cases several positive outcomes of these efforts were reported. However, it is difficult to perform an analysis of these cases in order to draw concrete lessons from them. The cases are quite different. They came up with different solutions and have measured different types of outcomes. For example, in the Tesco case, a special solution for the visually impaired was developed. Although it increased accessibility for visually impaired, it cannot be described as universal design, because here one common solution for everybody is encouraged. The measured parameters also differ. In the Tesco case shorter time to purchase among the end-

users were reported, while in the L&G case, the number of visitors who received offers doubled within 3 months. In D&G the maintenance costs decreased by two thirds, while this is not commented upon in the Tesco case.

In the report "Design for All and ICT business practice", prepared by a study team under contract to the European Commission, several examples including DfA approaches in business practice are described. While these examples do not include information about measurable costs or benefits, the report clearly demonstrates that there these organisations have worked with accessibility at an organisational level. The successes are perceived to be interlinked with the level of management commitment, the accessibility strategy, organisational structures and processes.

The Accessibility Maturity Model (AMM), developed by the Business Taskforce on Accessible Technology as a standard for best practice, can be used to assess the accessibility performance of a business. It can also be used to guide and plan accessibility work in businesses (Ashington 2010).

It seems to be more documented examples of the effects of UD within the area of products design than in web design, see e.g. (Waller et al. 2013). In the book "Innovating with people", published by the Norwegian Design Council, examples of methods tools and UD cases are given (Eikhaug et al. 2010). The exhibition "Design That Makes a Difference" which was shown at Oslo on the Norwegian Centre for Design and Architecture in January 2014 showed several design cases. The cases were mainly from product design, but with regjeringen.no and yr.no as good examples within web design. One can also find many different cases in the British Onevoice report (Ashington 2010). Here the website of the BBC and the British government are cited as good examples. This report uses a strategic performance framework to incorporate the most critical success factors of businesses, and they suggest to quantify measurements using key performance indicators (KPIs), and point to future work to develop such KPIs (Ashington 2010).

Some studies have investigated the relationship between usability and accessibility, and found a close relationship. This is not surprising since and UD requires accessibility and usability for everybody. Huber and Vitouch (2008) wanted to analyze the relationship between usability and accessibility. They designed an online test environment with three test portals with different accessibility levels; 1) No accessibility considerations, 2) WCAG 1.0 A and 3) WCAG 1.0 AA. The portals were tested with 131 test users whereby 22 had disabilities. They found that the perceived usability increased with increasing degree of accessibility. The perceived usability increased almost equally for people with and without disabilities. This study supports the contention that increased accessibility improves usability for everyone.

Another study investigated the relationship between accessibility, visual quality and aesthetics (Mbipom & Harper 2011). 50 websites evaluated by 30 sighted users and 16 of the 50 websites were evaluated by 11 experts with Barrier Walkthrough (BW) with a focus on accessibility for the visually impaired. They found that websites with classic design is generally easier to use

than webpages with creative or expressive design. They also found that complex visual design need not affect accessibility adversely. The study concludes that the cleaner a web page is experienced to be, the better visual accessibility, and that this is positive for both sighted and visually impaired users.

There are a number of well-documented examples of cost savings with usability engineering (Marcus 2005). For example, it is showed that it is extremely important to start usability engineering at the beginning of the development process, since it costs 10-100 times as much to fix a problem after a system has been released as in the design phase. It is also found that 80% of software life cycle costs occur during the maintenance phase and were associate with "unmet and unforeseen" user requirements and other usability problems(Nielsen 1993; Marcus 2005). These findings are relevant to UD.

A few examples of negative consequences of non-compliance to accessibility requirements, in terms of reputation damage and lawsuits can be found in Kline (2011).

Although many of the above mentioned examples are good and inspiring, they are quite high level and often lack details about exactly what was done and how the success was measured. There is therefore a need for more detailed and structured information about the relationship between concrete UD efforts and outcomes.

I the Annexes A and B, several of the ICT-related examples and case studies mentioned above are further described and categorized. The case studies are presented in two ways, as sequential hierarchical bullet list in Annex A and in a table format in Annex B. (The information in the table is a slightly more compressed version of the sequential list in Annex A).

4 Case studies analysis

While reviewing the various case studies we have tried to systematizes and categorize the important elements. We have structured the information into categories. This can be regarded as a framework for documenting and evaluating effects of UD.

4.1 UD – effects: a framework

Case study (reference): Giving the study a short name and a reference

Business strategy: These are the overall goals for working with universal design in each case, and we have also included some overall strategic choices. Examples include:
- commitment to UD at board and top management level
- collaboration with specialized consultancies or experts in UD and accessibility
- collaboration with NGO's and user organizations representing various user groups
- participating in research or standardization work

Organization structure & processes: Here specific steps that have been taken at an organizational level are described. Examples include
- organizational unit(s) that is dedicated to UD
- position(s) that is dedicated to UD, such as an accessibility champion
- processes and decision lines across departments
- interdisciplinary work, including people with UD competence in the development
- activities to develop and share UD awareness, competence and knowledge
- infrastructure (accessibility lab)

UD methods and approaches: Here, specific design and development methods or activities related to the process of creating universally designed web pages are described. Such as
- User Centered Design activities (focus groups, filed observation, interviews, customer panels)
- Development using accessibility standards and guidelines
- Accessibility and usability evaluation
    - Technical accessibility testing (WCAG compliance)
    - AT compatibility testing
    - Expert evaluation
    - Usability testing including people with impairments

Outcomes and effects: These are the effects or success criteria's mentioned in the case study descriptions (The categories below are further detailed in section 5.2):
- Improved products and services
- Market and customers
- Community relations and reputation
- Internal processes and employees
- Financial
- Legal

Because the various aspects are interconnected it is sometimes a bit difficult to separate them and some aspect may fit into several of the categories. However this illustrates the breadth and the complexity in studying effects of universal design.

4.2 Potential outcomes of UD

From the previous sections we see that it is not difficult to find arguments and claims for various positive outcomes of UD. First of all, it is argued that it is the right thing to do because of social, ethical and humanitarian reasons. Below we give a key-word based summary of the various business related outcomes mentioned in the reviewed literature, and organize them into some main categories:

Improved products and services

- More accessible mainstream products
  - Improved product with accessibility features, such as better displays, synthetic voice option, more accessible keyboards, tactile mark on keyboard no 5, wheelchair access, insert coins without force (only gravity), large keyboard, allow plug in of ear phones, have voice-over (audio instructions when moving finger over screen) , street phones has features to increase volume for the hearing impaired (or in noisy environments), light on landline phones indicating ringing (for deaf people or in quiet environments) (BT, NCR, Telefónica)
- Potential spin-offs
- New access technologies, e.g.
  - alternative versions of information material: Braille, large print, audio (BT)
  - picture telephone and a home assistant (Siemens)
- Improved quality of service
  - Increased speed of service - all customers can now self-serve through channels open 24 hours a day, seven days a week (HMRC)
  - improved quality of service - the same quality of service for anyone who needs or prefers to customize their computing devices, use assistive technologies (ATs), or requires clear, easy to follow content (HMRC)

Market and customer satisfaction

- Increased marketability - by increasing functionality for all users
- Increase international marketability: More and more countries introduce UD and accessibility into their legislation, and thus, to be able to sell across international markets, it is necessary to consider these aspects.
- Improved customer satisfaction, best scores in usability ratings (VP)
- The website is future proofed for new technologies (VP)
- Increased the customer growth rate with between 100 and 200 percent (Telefónica)
- Reach new markets and attract more customers (Marcus 2005)
- Retain customers (Marcus 2005)
- Support for people with temporary difficulties: Including features that make products and services usable for persons with disabilities will also make them easy to use for people with temporary difficulties, such as a broken arm, lost glasses, walking with at pram or luggage etc.
- Increase market share (Marcus 2005)
- Reduce user errors and time to complete tasks (Marcus 2005; Mayhew & Tremaine 2005)
- Increase success rate and increase user satisfaction (Marcus 2005)
- Increase ease of use, ease of learning and trust (Marcus 2005)
- Increased number of visits, return visits, and length of visits (Mayhew & Tremaine 2005)

Community relations and reputation

- build a reputation of an exemplar public body - engaging and consulting all our customers as to the way we do things, and building trust that we are a responsible organisation (HMRC)
- increased the number of people that they reach through awareness campaigns and external presentations (BT)
- grow reputation - credibility from the social responsibility stance(VP)
- Raised brand awareness - a market leading website according to BBC radio and TV review, judged to be easier to access and use compared to other sites.
- Great feedback from the web community (BBC)
- Great recognition from winning the Jodi Award, judges stated: "a high profile international museum, setting new standards in what should be in place in our online sectoral provision" (BM)
- contributed to wider inclusion objectives by promoting cultural identity on the web and raising awareness of the ICT barriers to the experience of culture, to help overcome digital exclusion (BM)
- Responding to an increasingly socially minded and demanding audience (BM)

Internal processes and employees

- Maximize employee engagement and productivity
- Improve supply chain management
- promote and deliver products and services through online channels using a strict website practice incorporating international and in-house accessibility standards, and regular user consultancy (HMRC)
- Developed innovation and skills - making customisable web pages that are usable and accessible by all, with an expert accessibility team (BBC)
- Improved service provision and delivery - with solutions captured as practice guidelines for other customisable developments (BBC)
- Advance research - surveying UK disabled communities to gain a better understanding of assistive technologies (BBC)
- Stimulation to design, develop, communicate and interpret the service of accessible online experiences. (BM)
- Pursue new customers - a clear practice for reaching new users, using expert partners and working to high international standards (VP)

Financial effect

- Increased revenue
    - the take up of some financial products via the website increased by 300% (L&G)
    - a 90% increase in online life insurance sales (L&G)
    - a £13 million increase in annual revenue from a £35,000 investment to develop an accessible website (Tesco)
    - 68% uplift in revenue to £62 million after a redesign to incorporate accessibility standards. (Virgin)

- o new channels to market/higher website traffic (VP)
- Improved ROI
  - o the DfA approach also resulted in content that was more accessible and usable across a wide array of networks and devices (BBC)
  - o a 95% increase in online life quote requests (L&G)
  - o a 100% return on investment in five to six months. (L&G)
  - o by advertising quick wins from innovative, accessible websites to other stakeholders in the museum (BM)
- Reduced costs
  - o decrease support costs (Marcus 2005)
  - o support costs were cut as there were zero complaints from people using handheld devices (L&G)
  - o web transactions cost approximately £0.27 each, compared with £3.22 for the phone and £6.56 for face to face (HMRC)
  - o an estimated saving of 66% a year on website maintenance as speed/effort required to manage content was reduced from an average of five days to half a day per job (L&G)
  - o lower website maintenance and server load costs, (VP)
  - o Reduce maintenance costs and save redesign costs (Marcus 2005)
  - o a decrease in demand for alternative format materials e.g. printed materials in large print/embossed Braille as the website user is able to enlarge the font or use a screen reader (HMRC)
  - o by winning over key influencers, hence reaching whole communities at a relatively low expense (BM)
  - o A 40% reduction in bandwidth costs after introducing an accessible solution (IBM)
  - o Reduce training and documentation costs (Marcus 2005)
- Increased cost efficiency
  - o utilising previous experience and guidelines ensured well targeted test and development costs (L&G)
  - o involving the accessibility team with prior experience of the broad range of users' needs throughout the development was crucial in keeping down cost of the number of user tests (L&G)
- improved cash flow - easier for customers to pay the tax and duty they owe and receive the credits and payments due to them (HMRC)

Legislation

- Avoid legal action/cost/damage by conforming to accessibility legislation

5 A procedure for cost-benefit analysis of UD

Inspiration in how to perform a cost-benefit analysis of UD can be drawn from the above case studies and from other fields, such as the software process improvement field and the usability field.

A procedure for a cost-benefit analysis may include the following steps (Mayhew 2005):

1. **Start with planning the UD process.**
   As discussed in section two, universal design should be based on a user centred design (UCD) process and involve people with impairments. Therefore, a first step of doing an effect study of universal design should be to plan the UD activities for the particular project in question. Such a plan can be based on the widely recognized standard for UCD; Human-centred design for interactive systems (ISO 9241-210 2010). Moreover, procedures for involving people with impairments are laid out in the Norwegian standard for universal design and user participation (NS 11040 2013). This standard is based on the UCD process described in (ISO 9241-210 2010).

2. **Establish analysis parameters**
   Most of the planned costs and estimated benefits will be specific for the particular case in question. The selected parameters should be selected and documented before the UD process starts.

3. **Calculate the costs of implementing the UD plan**
   Once the plan is made, the costs connected to the plan can be estimated. One should also make sure also that the actual costs are recorded so that the actual costs can be compared to estimates.

4. **Select relevant benefit categories**
   The benefit categories will depend on the type of web solution in question. Examples can be found in section 5.

5. **Quantify and estimate benefits**
   This involves to finding appropriate units, tools and techniques that can be used to measure the potential outcomes.

6. **Compare costs to benefits.**

6 Summary and conclusion

This review shows that there are many factors that may influence the efficiency and effects resulting from efforts to achieve universally designed web solutions.

It should be noted that many of the case studies referred to in this report have been taken from major corporations with a long design tradition. They have large budgets, the means to involve multi-disciplinary teams, and opportunities for extensive testing and to systematically review user feedback. However, because the ICT design business is highly competitive, design processes and activities can also be spread out over networks of smaller companies (TNO STB 1998). While each company can only influence a very small proportion of the total development of products and services, the processes and practices of smaller companies are at least as important as that of the larger companies.

From cases discussed in this report, we can see that the main reasons for doing Universal Design is to reach broader audiences and to comply with legislation. Many of the case organisations consult experts in Universal Design (or similar approaches) or they consult user groups and end user organisations, such as disability organisations and organisations that represent the needs of older people etc. Some companies have also selected to participate in research activities, standardisation activities or they run projects with a focus on older people.

Management commitment towards UD is mentioned as important in several of the cases. Particularly, the large companies have established organisational units or positions that have special competence and knowledge about Universal Design. In most of the cases, special thought have been given to sharing of knowledge about UD within the organisation. Examples include having people from the UD unit participating in development projects. Interdisciplinary work is mentioned as important and various forms of awareness activities are also mentioned.

User-centred design activities are frequently mentioned among the UD approaches used, such as focus groups, field observation, interviews with customers, and customer panels etc.). The most common evaluation techniques are testing for compliance with relevant guidelines, expert evaluation and usability testing.

We have collected a long list of outcomes from the case studies. These have been organised into six main categories. The first category, products and services, covers both improved mainstream products and new or improved access technology (e.g. special purpose assistive technology). The second category, market and customers, is about the effects that UD may have on market shares, customer satisfaction or customer efficiency. The third category is about reputations and relations with partners and community. The fourth category is about effects on internal processes and employees, such as improved or more efficient development routines and

increased competence and engagement among the employees. The fifth category is about financial effects, such as increased revenue, improved ROI and a decrease in support costs. The sixth and final category is to avoid legal action cost or damage by conforming to legislation.

A conclusion can be drawn from this overview, that it is far from trivial to study effects or to perform cost –benefit analyses of universal design. Real world cases are always affected by a number of uncertainties. To be able to say something about the effects, it is necessary to get details on the company in question, its products and market, its organizational characteristics, the specific UD process and techniques that are applied, as well as surrounding and contextual factors that might influenced the outcomes. Outcomes should not only be measured in terms of business parameters, but also in terms of the accessibility and usability of the resulting ICT solution. In this report we have presented a preliminary framework for planning and performing case-studies with the purpose of measuring cost-benefits of Universal Design.

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Annex A. **Case studies sequential summary**

British Telecom (TNO STB 1998), p. 76

- Business strategy
  - Both special products and mainstream products
  - If the option of offering facilities that are of particular help to disabled or elderly customers requires some extra costs, then it is sometimes best to amortise these within mass market products rather than develop expensive variations specifically for these users.
  - Community programme
  - Dialogue with various advocacy groups
- Organisation structure
  - Ageing and Disability unit
  - Accessibility champion
  - Board level support for DfA work
- Organisational processes
  - HF meets an engineer during lunchtime
  - DfA awareness: newsletter
  - Involving HF department at an early stage
  - Presentations to public about their DfA work
- DfA methods and approaches
  - Focus groups
  - Ethnographic field observations
  - Interviews
  - Visiting homes
  - Consumer panels
  - Included elderly in testing processes
- Outcomes /effects
  - Improved product with accessibility features
    - Better displays
    - Synthetic voice option
    - Tactile mark on 5
    - Wheelchair access
    - Insert coins without force (only gravity)
    - Large keyboard
  - Off-the-shelf, rather than special purpose
  - Alternative versions of information material
    - Braille
    - Large print
    - Audio
- Partner and community relations/reputation
  - Increasing the number of people that they reach through awareness campaigns
  - Increasing the number of people they reach through external presentations

Telefónica (TNO STB 1998), p. 78

- Business strategy
  - Consult user groups, such as
    - Visually impaired
    - Colour blind
    - Illiterate
    - Once
    - Spanish organisation for the deaf
  - involved in international accessibility standards development
  - involved in research and innovation
- Organisation structure
  - Usability department
  - Has a usability lab
- Organisation processes
  - Usability journal
  - The usability department approves all new products before they can enter the market
  - The usability department can veto product that do not meet their usability standards
- UD methods and approaches
  - User-centred product development, which is based on thorough testing
  - Testing/evaluating guideline conformance
  - Testing in usability lab
  - Questionnaires
- Outcomes /effects
  - More accessible mainstream products:
    - volume control in street phones (hearing impaired can increase volume)
    - light on landline phones indicating ringing (for deaf people)
    - big button phones
    - phones allow one handed operation
    - plugs to connect to text telephone or portable computer
  - Market and customers
    - Increased the customer growth rate with between 100 and 200 percent.

NCR (TNO STB 1998), p. 80, owned by AT&T. Produces ATM's, software and web design for bank applications

- Business strategy
  - To meet customer requirements
  - Contact with a wide range of advocacy groups for disabled people both in North America and in the UK
- Organisation structure
  - Established a design team

- Organisation processes
    - Design team are involved early in development processes
    - Design team are involved in defining user requirements and formulating and testing product concepts
- UD methods and approaches
    - Market research
    - Undertakes market research in the beginning of projects: discuss people's experiences when using previous NCR products and ask them what they would like to see integrated into new products
    - Has a focus on usability specification
    - Conducts focus groups
    - including people with disabilities
- Outcomes
    - Improved products:
        - larger ATM screens
        - wheelchair accessible
        - allow plug in of ear phones
        - voice-over (audio instructions when moving finger over screen)
        - more accessible keyboards

Siemens (TNO STB 1998)

- Business strategy
    - The goal is to develop new input techniques and display technologies
    - 25% of staff engage in new products development
    - Screen the market for new impulses
    - Participate in HF networks
    - Participate in HF/CHI/HCI conferences
    - Consult specialists about challenges for disabled
    - Special activities to study needs of the elderly and Silver market projects
    - Elderly do not want to be addressed as persons with special needs, therefore a design-for-all approach is chosen
- Organisation structure
    - Business strategies internal group
    - User interface department (UID)
    - The UID is part of the "Technology and Innovation" (TI) general unit.
- Organisation process
    - Ensure that there is someone who is engaged in interface design in all development departments
    - The UID supervises the whole product development process
        - The UID supervises conceptual design, technology and product development and testing before release
        - The UID is involved in standardization,
        - The UID has a strong position and can impede further product development if it is does not fit into their guidelines
- DfA methods and approaches

- o Usability tests (performed by external company)
- o Study input from customers
    - study letters from unsatisfied customers
- o Focus groups based market studies
    - design
    - features
    - price margins
- o Field trials with 20-40 people
    - test the phone and fill out a 20 page questionnaire
- o Field observations
    - Interview 100 -150 persons
- o In depth discussions with users
- o User tests with elderly
- Outcomes
    - o Access technology
        - Picture telephone and a home assistant

Philips Design (TNO STB 1998)

- Strategy
    - o Human-focused, research-based and multidisciplinary design approach, which is seamlessly integrated in the business and product creation process.
    - o High design
        - Design is perceived as an "ethical" act, a force for good, and a key instrument for improvement in the quality of people's lives.
        - Interdisciplinary
        - integrates expertise from non-design related disciplines such as anthropology, sociology, psychology, trends analysis etc., as well as design disciplines such as product design, graphic design, and ergonomics
    - o Participating in large scale research projects
    - o Special project on design for elderly and welfare products
- Organisation
    - o Strategic Design Group
    - o Human behaviour research group
    - o Multidisciplinary teams and co-operation
- Design process
    - o Designers is included in all phases of the development process
    - o Has a people focus throughout the whole development process
    - o Follow a formalised development process to address all issues at hand

Landmark (TNO STB 1998), an independent design company with 8 employees.

- Strategy
  - DfA is basis in all development
  - Design for users with no choice
    - artificial hips
  - Smart solutions that are both clever and attractive
  - Addition of simple elements
  - Removing frustration
  - Consider both physical and social-cultural limitations
  - Design for the world (not only the Western world)
- Design process
  - Creates abstract and non-functional conceptual models
  - A simulation model is developed and tested on all user groups

Visual Position Ltd (OneVoice 2010)

- Strategy
  - To reach audiences that competitors with less accessible web sites could not reach.
  - Worked with partners with DfA expertise
    - Expertise in accessible design/development
    - Expertise in Assistive Technology
    - Expertise in the challenges that particular user groups have
- DfA methods and approaches
  - Redeveloped website from the ground in a period of 18 months with five key VP employees and six hired experts
  - Used the W3C's web content accessibility guidelines (WCAG), seeking the highest AAA (triple-A) compliance
  - Audited the website for accessibility and usability using everyday scenarios for each of the new customer groups
- Outcomes /effects
  - Market/customers
    - Increased "findability", KPI: improved the website's natural search engine rankings due to the accessibility techniques used
    - Improve customer satisfaction,- in a BBC radio and TV review, the website came out ahead of competitor websites in usability ratings
    - grow reputation - credibility from our social responsibility stance(VP)
  - Internal processes and employees
    - Pursue new customers - a clear practice for reaching new users, using expert partners and working to high international standards
  - Financial
    - Increased revenue - new channels to market/higher website traffic
    - Reduced costs - lower website maintenance and server load costs,
    - Avoid legal fees/damaged - conforming to UK accessibility legislation.

- Raised brand awareness - a market leading website following the BBC radio and TV review, promoting the website as: " easier to access and use than confused.com, simplyswitch.com, compareandgo.co.uk, moneysupermarket.com and uswitch.com"
- The website is future proofed for new technologies

HM REVENUE & CUSTOMS (HMRC) (OneVoice 2010)

- Strategy
  - To provide a high quality and efficient online public service that all customers could access, use and understand
  - Established a proactive and long-term strategy for new and existing content and a strict web accessibility policy
  - all content should meet the requirements of the DDA and adhere to the W3C's web content accessibility guidelines (WCAG) AA, in line with accessibility regulations for UK government websites.
  - Used a consultancy with DfA expertise
  - Reducing costs by moving customers in direction from face to face or phone support, to more self service on the web
  - Complying with legislation.
- Organisation structure
  - Specialist in-house content writers ensure new web content is accessible, clearly presented and easy to understand and follow
- DfA methods and approaches
  - Has developed a kit of accessible components which is used for each new transactional service, to ensure consistency
  - Formal accessibility testing for new and existing content involves
    - Perform regular testing by internal online services employees, external users with varying impairments and independent expert testers
    - Use sitemorse software to test against wcag aa, with an accessible alternative provided if aa development is not feasible.
  - Reviewing all existing web content:
    - Identifying need for accessibility improvements on a priority basis, balancing factors such as level of usage, adherence to aa and, most importantly, feedback from users
    - Content is rewritten to make it easier to read
    - Redesigned page layouts to aid navigation
    - Improved search functions
- Outcomes /effects
  - Market/customers
    - improved quality of service - the same quality of service for anyone who needs (or prefers) to customise their computing devices, use assistive technologies (ATs), or requires clear, easy to follow content
    - increased speed of service - all customers can now self-serve through channels open 24 hours a day, seven days a week.

- o Internal processes and employees
  - promote and deliver products and services through online channels - a strict website practice incorporating international and in-house accessibility standards, and regular user consultancy
- o Partner and community relations/reputation
  - build a reputation of an exemplar public body - engaging and consulting all our customers as to the way we do things, and building trust that we are a responsible organisation
- o Financial
  - reduce costs - KPI: web transactions cost approximately £0.27 each, compared with £3.22 for the phone and £6.56 for face to face
  - reduce costs - KPI: a decrease in demand for alternative format materials e.g. printed materials in large print/embossed Braille as the website user is able to enlarge the font or use a screen reader
  - improve cash flow - easier for customers to pay the tax and duty they owe and receive the credits and payments due to them
- o Avoid legal action/fees - complying with UK government legislation

Legal & General (L&G) OneVoice (2010)

- Strategy
  - o A moral obligation to be inclusive
  - o Accessibility gives potential extra business from people previously unable to access and use the website
  - o Offering accessible services online give an advantage over competitors
  - o Compliance with legal requirements
  - o Worked with partners with DfA expertise
    - Accessible design/development
    - Expertise on challenges of visually impaired (RNIB)
- DfA methods and approaches
  - o Redesigned, restructured and redeveloped the website
  - o Tailored the website to work for people with different browsers, devices and disabilities
  - o User testing throughout the development phase, including those with varying impairments using a variety of assistive hardware and software.
  - o Testing using technical tools - to assess the website against WCAG, different platforms and devices
  - o Customers were consulted and customer feedback was analysed from both the website and help desk.
- Outcomes/effects
  - o Market/customers
    - Increased "findability" - a rise in natural search engine traffic of 30%
    - Increased market - 13,000 extra visitors a month from improved browser compatibility (including users with handheld devices)
    - Improved satisfaction - zero complaints from people using handheld devices such as PDAs, mobiles and Blackberrys

- Increased speed of service - a 75% reduction in time to load a page .
  o Financial
    - Increased revenue - the take up of some financial products via the website increased by 300%
    - Increased revenue - a 90% increase in online life insurance sales
    - Reduced costs - support costs were cut as there were zero complaints from people using handheld devices
    - Reduced costs - an estimated saving of £200,000 (66%) a year on website maintenance as speed/effort required to manage content was reduced from an average of five days to half a day per job
    - Improved ROI - a 95% increase in online life quote requests
    - Improved ROI - a 100% return on investment in five to six months.

BBC (OneVoice 2010)

- Business strategy
  o To enrich people's lives with programmes that inform, educate and entertain (BBC)
- Organisation structure
  o Accessibility team
- Organisation process
  o The accessibility team worked across all design, editorial and technical aspects with a design team and developers, aiming to ensure a usable, not just a technically accessible experience.
- DfA methods and approaches
  o User centred design (UCD) approach in conjunction with BBC accessibility standards.
  o Ensured font sizes and use of colour met standards and that links were not too spaced out (for screen magnifier users) and not too close together or too small (for users with cognitive/motor impairments).
  o User testing included users with visual, cognitive and motor impairments.
    - To cater for a screen reader user's unique experience of dynamic web content, testing was split two ways: testing by a blind screen reader expert from AbilityNet to gauge the technical accessibility of the page against popular screen readers; and general testing by a range of blind users to assess the usability of the page.
    - User testing highlighted the need to make the semantic mark up of the page a priority, ensuring that each panel of the homepage design could be treated and navigated consistently by all users.
  o Technical accessibility testing
    - AT compatibility testing: after experimentation with the JAWS screen reader and JavaScript, the developers found a solution that worked both visually and ensured that first users of JAWS, and then users of other screen readers could successfully use the customised content areas.

- Outcomes/effects
    - o Market and customers
        - Reach a wider audience - ensuring access to the public service for all
        - Added value for all users - all users get a better user experience
        - Improved user satisfaction - Well established feedback mechanisms showed that there was no negative feedback from users with impairments (a rarity for a new website launch)
    - o Financial
        - Reduced costs - involving the accessibility team with prior experience of the broad range of users' needs throughout the development was crucial in keeping down cost of the number of user tests
        - Increased cost efficiency - utilising previous experience and guidelines ensure well targeted test and development costs
        - Improved ROI - the DfA approach also resulted in content that was more accessible and usable across a wide array of networks and devices.
    - o Internal processes and employees
        - Developed innovation and skills - making customisable web pages that are usable and accessible by all, with an expert accessibility team
        - Improved service provision and delivery - with solutions captured as practice guidelines for other customisable developments
        - Advance research - surveying UK disabled communities to gain a better understanding of assistive technologies
    - o Partner and community relations / reputation
        - Great feedback from the web community:
            - · "to see such a highly trafficked and well respected site with an accessible home page shows everyone it can be done"
            - · " awesome ... the Beeb website has included display options so users can choose from a wide range of viewing formats".

The British Museum (BM) (OneVoice 2010)

- Business strategy
    - o A moral obligation to be inclusive
    - o Potential extra business from people previously unable to access and use the website
    - o Offering accessible services online give an advantage over competitors
    - o Compliance with legal requirements
- DfA methods and approaches
    - o Focused in depth on the needs of specific audiences, including those of different language, age and with varying impairments.
    - o In order to engage the global community, website content were translated into many languages.
    - o Producing extra-value content, taking into account the younger generation's preferences

- o The website was developed using the W3C's web content accessibility guidelines (WCAG)
  - o The website was tested by expert reviewers
  - o The website was tested by users with varying impairments to ensure it was both accessible and usable
  - o Engaged with particular user groups, such as older people, deaf children and people with learning difficulties to enable a better understanding of their needs
  - o Produced British Sign Language (BSL) videos for the website
  - o Plan to produce audio description of the museum's famous objects
- Outcomes/effects
  - o Market and customers
    - - encouraged social participation and integration
      - · through engaging features to support social involvement and quality of life
  - o Partner and community relations/reputation
    - - The museum received great recognition from winning the Jodi Award, judges stated: "a high profile international museum, setting new standards in what should be in place in our online sectorial provision"
    - - Contributed to wider inclusion objectives
      - · by promoting cultural identity on the web and raising awareness of the ICT barriers to the experience of culture, to help overcome digital exclusion
  - o Added value
    - - Through educational, social and entertaining content which responds to an increasingly socially minded and demanding audience?
  - o Internal Processes
    - - Stimulation to design, develop, communicate and interpret the service of accessible online experiences.
  - o Financial
    - - Reduced costs - by winning over key influencers, hence reaching whole communities at a relatively low expense
    - - Improved ROI - by advertising quick wins from innovative, accessible websites to other stakeholders in the museum
    - - Avoid legal costs/damage

IBM's intranet (OneVoice 2010)

- Outcomes/effects
  - o Financial
    - - A 40% reduction in bandwidth costs after introducing an accessible solution

CNET's website (OneVoice 2010)

- Outcomes/effects
    - o Market/customers
        - - A 30% increase in traffic from Google following the launch of a version of the website that provided transcripts

Tesco's online home grocery service (OneVoice 2010)

- Outcomes/effects
    - o Financial
        - - A £13 million increase in annual revenue from a £35,000 investment to develop an accessible website

Virgin's website (OneVoice 2010)

- Outcomes/effects
    - o Financial
        - - A 68% uplift in revenue to £62 million after a redesign to incorporate accessibility standards