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Virtual User Concept for Inclusive Design of Consumer Products and
User Interfaces

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1 Introduction

The goal of this report is to discuss the economic potential impact of the tools, technologies and concepts developed by the VICON project.

This report brings together a literature review about the economic benefits of the Virtual User Model approach (VUM) and the findings from VICON deliverables D5.2, D5.3 and D6.4 to discuss the economic potential impact of the VICON approach.

In the following chapters we review literature on major chances and obstacles to benefit from the market of the ageing population in Europe and worldwide. We then describe how the results of VUM and of VICON in particular would benefit actors on the market in various perspectives e.g. increase of customer base, reduce of design costs and raise of the awareness by the producer of consumer products and a broad range of actors who could benefit from the new developments like inclusive design, usability and accessibility agencies. However we suggest that there exist significant opportunities for these niche actors e.g. inclusive design, usability and accessibility agencies that do not require wholesale change in the workflows and processes and can offer their consultancy services using VICON to larger designers and producers of consumer products, which could seed future revolutionary change.

We conclude that the VICON results have the potential to affect multiple dimensions of economic life, with a net effect for the single actors that is impossible to predict exactly.



2 The Business Case for Creating Inclusive Consumer Products

The benefits of inclusive design can be categorized under social benefits, business benefits and compliance with legislation. All benefits, however, stem from the following two goals:

- A product is designed so that it is as easy to access, understand and use as possible;
- This leads to an increase in the number of people who can access, understand and use that product.

VICON as described in D6.7 and D6.4 has produced marketable results, which would help to achieve the above mentioned goals.

The wider consequences of achieving these two goals are discussed here.

2.1 Social Benefits

2.1.1 The Aging Population

The age-distribution of the world's population is changing dramatically. In the UK, a baby girl born in 2011 has a one in three chance of living to 100 and a baby boy has a one in four chance (DWP, 2011). By the year 2021, it has been predicted that 15 percent of the Irish population will be over the age of 65 years and the number of people over 80 years of age will have increased by two-thirds (Connell and Pringle 2004). By 2050 it is estimated that there will be two people working for each pensioner in Ireland, in comparison to six for every one at present (ISME 2005). These projections are similar across Europe (Grundy 1996) and globally (United Nations 2001).

As a person ages, his or her ability to remain independent can decrease considerably. The effect of aging on general functional abilities can include slower ability to learn new skills; limited short-term memory; slower ability to react; slower to interpret complex display scenarios; slower to retrieve information from memory; and lower coordination, vision and hearing capacity (Eckberg, 1999).

Within the coming decades in Europe, the number of people who are available and capable of assisting and caring for elderly people will decrease considerably. The ability of a person to remain as independent as possible can be influenced by how accessible and usable products are. Factors that promote independent living, such as inclusive design, therefore have a key role to play in dealing with this global issue. VICON addressed as its beneficiary users older people with aim to create inclusive consumer products for them.

2.1.2 Economic benefits to societies

As D5.3 highlighted, it has been argued that inaccessible technologies create a financial burden on societies due to older and disabled people being prevented from participating in employment or taking part in economic activity and requiring greater support and welfare payments due to reduced independence. A 2007 UK report estimated that each additional digitally-engaged citizen adds more than £200 (€252) to GDP over three years (Gov3 2007). A research report compiled by the Work Research Centre for the National Council for the Blind of Ireland estimated the following specific benefits for Ireland from greater accessibility of ICTs (WRC 2008):

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- A productivity gain for the overall economy valued at between €39M and €99M per annum if 1% more people with disabilities of working age were able to gain employment due to more accessible technologies.
- Welfare cost savings of €8 to €20 million per annum for each 1% of people with disabilities who transfer from disability payments to employment as a result of being able to use ICTs.
- A €68.9M increase in GDP over three years if the 76% of Irish adults with a disability who are not currently using the internet were to become internet users.
- Savings of almost €4 million if just 20% more people with disabilities were able to use the internet for eGovernment transactions.

Combining the changing demographics with the increasing move to online-only services, this burden can only grow. Using inclusively designed products as possible when using the VICON tools would allow older people to stay longer independent at home and by that increase the life quality for this group and on the same time decrease the costs of moving these people to care homes.

2.1.3 Accepting Disability as a Universal Experience

"Universal design...assumes that the range of human ability is ordinary, not special" (Ostroff 2001).

No two people have exactly the same ability. There is considerable variation both between and within people, and it is influenced by a number of external and internal factors. Ability, for example, can vary according to the type of activity in which a person is participating or the environment in which that person is carrying out the activity. This highlights a major difficulty with categorising people as "disabled" or "not disabled".

Every person experiences reduced functioning at some stage during his or her lifetime. This can be a result of illness, injury, tiredness, aging, geographic location (such as an inability to understand a foreign language), unfamiliarity with an environment, or other factors. This further complicates the "disabled" versus "not disabled" classification of people.

Terminology published in the World Health Organisation's (WHO, 2001) International Classification of Functioning, Disability and Health (ICF), highlights that disability is a universal experience. Within this new vocabulary, the term disability serves as an umbrella term for impairments, activity limitations and participation restrictions. It includes people who encounter an inability to execute a task or action (activity limitation) and people who encounter an inability to become involved in a life situation (participation restriction). By this definition, every single member of the global population at some stage during his/her lifetime experiences at least one activity limitation or participation restriction, and therefore every person at some stage experiences disability. The tools developed in VICON would allow prototyping and simulation of usage scenario highlighting issues in the usage of consumer products and by that increasing awareness and acceptance of disabilities.

2.1.4 Social Wellbeing

The stressful nature of modern day life has prompted an increasing amount of research into the area of social wellbeing, with the emergence of a new branch of psychology called "positive psychology" (Peterson, 2006). While some products are intended for leisure or entertainment purposes, many are crucial to participation in society. Mobile phones, computers and televisions,



for example, provide access to communication and information without which we would be isolated from the outside world. While washing machines allow us to easily carry out an important activity of daily living.

A potential benefit of making a product more accessible and usable, is a decrease in the degree of stress experienced while using it. A significant decrease in stressful situations should then have positive consequences on quality of life, invoking the positive attitudes that are typically associated with equality, respect, inclusion and the feeling of belonging. Consumer products produced using VICON contain less issues for older people which means they would have less stress in their daily life and an increased social wellbeing.

2.2 Compliance with Legislation and Standards

The most relevant legislation and policy, in the context of the inclusive design, is that which promotes social inclusion. The Irish Government's Office for Social Inclusion defines social inclusion as a process which involves providing people with access to adequate income and resources (material, cultural and social) to enable participation in activities which are considered the norm for other people in society. Relevant legislation and policy includes human rights laws, disability rights laws and sustainable development initiatives.

Legislation provides a list of essential requirements that, by law, must be put in place. However it does not explain precisely how these requirements must be implemented. Appropriate government initiatives, standards and guidelines must also be developed to explain to the general public how this legislation applies to them, if anything specific is required of them, and, if so, what is required.

Standards and guidelines provide specifications which, if followed, should guarantee compliance with legislation. The specifications and minimum requirements provided in standards and guidelines are often in line with accessibility and usability recommendations. So, with regard to the design of a product, inclusive design is an approach that promotes compliance. The area of usability and accessibility is being meanwhile worldwide regulated through standards and legal decrees. VICON will help design, accessibility and usability agencies to evaluate such products an matching the legal requirements, which benefits the purchasers of such products and increase the income of such agencies.

2.3 Business Benefits

In D5.3 representatives from a number of product design companies were interviewed. The most common reason cited by all of the companies that practice inclusive design was that is made good financial business sense. One company said that inclusive design is "company policy that gives us a business edge, a competitive advantage".

2.3.1 Increased Market

Inclusive design aims to provide a design which is accessible to and usable by as many people as possible. One implication of this is an increase in the market potential (Keates & Clarkson, 2004; National Council on Disability, 2004; Story et al., 1998). Not only does a product become more available to a higher number of potential customers, but it covers a wider range of potential customers as well.



2.3.2 Enhanced Customer Satisfaction

If a product is as usable as possible to as many people as possible, customers will get more enjoyment from accessing and using that product. The level of customer satisfaction should therefore increase. There is a positive association between customer satisfaction and shareholder value (Matzler et al. 2005).

2.3.3 Enhanced Customer Retention

A potential consequence of enhancing customer satisfaction is an increase in customer loyalty to a particular brand, company or product line (Story et al., 1998). Loyalty can even advance as far as a person developing an "emotional relationship" with a product (Lidwell et al. 2003; Norman, 2004). Many people, for example, name their car. If a product generates high customer satisfaction the likelihood of customer retention should also increase.

2.3.4 Word of Mouth Marketing

A second knock-on effect of enhancing customer satisfaction could be the free publicity benefits of word of mouth. A satisfied customer will tell other people about the product, increasing awareness and potentially creating new custom. Similarly, past negative experiences influence choice. In D5.3 we would that some beneficiaries disliked particular designs based on past experience. Regardless of whether or not the design has since improved, the past negative experience was enough to lead some beneficiaries to avoid that design in future purchases. Furthermore, there was a clear dependency by some beneficiaries on the advice and opinions of friends, family and sales people, suggesting that word-of-mouth marketing is very important. Therefore a brand or product that is known to be easy to use is more likely to be recommended and purchased again in future.

2.3.5 Cost of Non-Compliance with Legislation

If a business does not comply with legislation, an employee, customer or official may be entitled to make a claim against that business. These costs can range from a fine, to the legal costs of a claim that goes to court. By meeting the requirements of legislation, a business could avoid this risk (Keates & Clarkson, 2004).

2.3.6 Market Crossover Success

Products that are aimed at a specific target group can sometimes generate interest and demand from unforeseen markets (NCSU, 2007). The OXO Good Grips range (OXO 2013) is a well cited case study of how a specialized product design (designed with older people with arthritis in mind) can generate widespread demand.

2.3.7 Consumer Pressure

In recent decades, the voice of the general public has become more prominent and more influential. People are more confident to speak up when they have a complaint and information and communication technologies (ICT) have made this increasingly easier to do. As a direct result of pressure from consumer groups, businesses could be encouraged and even forced to change practices. Shopping sites, such as Amazon, allow consumers to review products and give them a



mark out of five stars. Similar products can be easily compared side by side and it is likely that higher marking products will be chosen over those with bad reviews.

As more products become available on the market, and more designers create products that meet the demands of consumers, the less likely consumers should be to tolerate bad design. A product that meets the demands of consumers could be promoted as such.

Our beneficiary research (see D5.3) indicated that usability and ease of use are very important factors influencing product choice. Ease of use appears to become more important with age. Furthermore, the beneficiaries demonstrated an awareness of differences between products with respect to usability and easy of use and a desire to determine, prior to purchase, if a product is easy to use. Therefore products that have been designed with usability and ease of use in mind are more likely to be purchased.

2.3.8 Accept or Reject at First Use

The nature of human decision making processes (Anderson, 1980, 1981) means that a consumer will form an opinion about a product at first use, or even first sight. A recent study suggested that internet users take less than 50 milliseconds (one twentieth of a second) to judge the visual appeal of a website they have visited (Lindgaard et al., 2006).

If a first impression is negative, a consumer is not likely to pay for a product. If a product is simple, clear, easy to access and easy to use, it is more likely that a positive opinion will be formed, which in turn should increase the willingness of the consumer to pay money for it.

D5.3 identified that aesthetics was an important factor (for female consumers in particular) when choosing a product. Therefore, among the beneficiaries interviewed in this project, there appears to be a market for inclusively designed products that do not compromise on aesthetics.

2.4 Good Design Benefits All

The human-centred approach to design that inclusive design supports is user-friendly and convenient, but also respectful of user dignity, rights and privacy (from Sandhu et al., 2002).

The range of difficulties (Vanderheiden, 2000) that arise when people with wide and varied abilities use a product can range from:

- A person who has no significant problems but who would appreciate a well-designed accessible and usable product;
- People who have little difficulty with all features;
- People who have difficulty with some features;
- People have trouble with most features;
- People who are unable to use the product at all.

The degree of personal benefit will therefore vary accordingly, but the bottom line is that if a product is well designed, with accessibility and usability in mind, all of the people in the categories above will benefit.



3 The Business Case for an Inclusive VUM toolset

3.1.1 Reduction in costs and time to market

VUMs can reduce or eliminate the need for the production of real prototypes and real user testing, allowing easier and earlier identification of ergonomics problems, and thus enabling changes to be made to the design without increasing time to market (Badler et al. 1993; Morrissey 1998; Zhang and Chaffin 2000; in Zhang and Chaffin 2005).

Zhang and Chaffin (2005), found that while there is an additional implementation and training cost in the initial stage, the use of digital human modelling, digital prototyping, and virtual testing in a computer-aided design or ergonomics process can quickly lead to reduced cost and shorten time.

The RAMSIS human model software is used by up to 60% of car manufacturers, including Audi, BMW, Porsche and Daimler, for ergonomic design and simulation, to bring factories on-line faster, to enhance manual workflow, to improve worker safety and to reduce training costs. (Human Solutions 2013)

A comparison of costs for an automobile manufacturer was carried out (Kiel and Van der Meulen 2007) to compare 20 ergonomic studies using real users with 20 studies using RAMSIS alone demonstrated an annual saving of 210,200 Euro when using a modelling tool like RAMSIS in the car manufacturing process. Kiel and Van der Meulen (2007) add that "While designing a highly complex and regulated product such as a car, the need for physical test will never be completely eliminated, but by conducting many ergonomic studies digitally, the number, extent and costs of physical tests can be reduced significantly."

The Finnish research centre VTT (2013) announces to specialize in applying digital human models for human-centred design and human factors engineering. They claim that when VUM simulation is combined with participatory design methods (such as user testing), it can lead to considerable cost savings:

- During factory design stage, a significant error in work area was identified and removed. One week was saved from the ramp-up time, giving at least €250,000 saving.
- Error in material logistics was found at the factory design stage. The error identification produced €150,000 saving.
- In a factory, 78% hazards and design mistakes were identified during design stage. Based on customer's estimations savings were about €200,000.
- Improved ergonomics of 20 workplaces in light assembly resulted in less back disorders leading to sick leaves, saving four person months per year.
- Error in maintenance hatch design avoided, potentially saving €100,000 from re-design and re-installation.



In D5.3 two companies that do not currently use VUM identified time and cost saving as a potential benefit of using VUM (“It would save a lot of time and money and allow you to avoid mistakes” and “I expect it to help save time, use less people”).

3.1.2 Earlier testing

Testing with VUM does not require a physical prototype and therefore testing can be conducted at a far earlier stage than traditional testing methods. In D5.3, two companies identified earlier testing in the product development lifecycle as a perceived benefit of VUM, with one explaining that “the first prototypes you show to the users must be quite usable already, have the right direction. We do some final tests of the product but there’s no time to make modifications. It would be good to be able to make virtual tests before that”.

3.1.3 Increased product quality

The use of VUMs may allow more frequent or extensive testing within the development timeframe, ultimately helping to increase product quality (Kiel and Van der Muelen 2007).

3.1.4 Reduced need for designers’ ergonomic experience

Chaffin (2001) reviewed case studies ranging from manufacturing workspace design to space station maintenance task design. He found that designers or engineers with limited or no ergonomic expertise can quickly and competently examine ergonomic issues using digital human models. He also found that human modelling allowed product or process designers to better understand the potential problems and associated risks a particular population subgroup could face when operating or servicing a proposed design.

4 Benefits to VICON Industrial Partners (Confidential)



5 The Economic Potential Impact of VICON

The findings in this study and of previous studies of VUMs (Kiel and Van der Meulen 2007; VTT 2013), suggests that time and cost savings are a very real advantage of implementing VUM in product development. Companies have embraced digital manufacturing technologies with good reason. CIMdata (2006; in Demeril and Duffy 2007), a Product Lifecycle Management consultancy, "concluded that on average organisations using digital manufacturing technologies can reduce lead time to market by 30%, the number of design changes by 65% and time spent in the manufacturing planning process by 40%. Production throughput can be increased by 15% and overall production costs can be cut by 13%."

VUMs can reduce costs directly by using free virtual users in place of real users who would have to be paid to take part in development. They also have the potential to eradicate design errors earlier and more often in the design process than real user testing, as there is no requirement for a physical prototype with which to test. VUMs can also reduce the time required for user involvement if they can simplify and speed up the testing processes themselves.

At the same time, the key barriers to uptake of inclusive design in industry are the time and cost of training and implementation (Vanderheiden and Tobias 2000, Saito 2006). If the use of VUM can reduce the time and cost associated with involving real users in testing and with learning and using other inclusive design tools, then it may help to overcome two of the biggest barriers to inclusive design.

VUMs can be used in conjunction with real user testing by allowing testing at times where testing with real users is not possible or feasible. This combined approach is confirmed by studies of VUM currently in use in industry, where the ideal situation is identified as a combination of real and virtual testing, rather than exclusively one or the other (Kiel and Van der Meulen 2007; VTT 2013). VUMs therefore have the potential to reduce the overall product development time and costs required for inclusive design by allowing virtual testing to be carried out earlier and at more frequent intervals than would be possible for real user tests.

A VUM toolset that is designed to work on designs at the earliest stages and to include user characteristics that are difficult to source or replicate in the user population, this should allow companies to develop inclusive designs without sacrificing the speed of getting time-critical products into the marketplace.

The economic potential of the VICON toolset, or of inclusive design in general, for a given company is impossible to quantify, as it will be different for each company and possibly different for each project.

To provide an analogy, every company has a different budget and a different strategy for marketing. The return on investment for one marketing campaign may be far greater than for another less successful one. In a similar way, the degree to which a designer or design company gets a return on investment for inclusive design activities may differ between projects, and may be influenced by factors such as the ability, knowledge and experience of the design team lead, the ability to correctly interpret user data and the success in addressing user results with effective design solutions. In D5.3, one designer described the variation in time required to do a user test depending on the nature of the test and the user profile required, stating that it can take from half an hour to several weeks to design a test.



The VICON toolset has already been shown (see D5.2, summarised in Section 4 above) to positively affect the existing design processes of both Doro and Arçelik, providing two major advantages: shortening the design cycle and reducing the prototype costs by enabling designers to evaluate the product in a virtual environment. The Toolset therefore has the potential to enable designers to shorten their design cycle and to enhance their product development process.

Virtual Modelling, and in particular modelling users with impairments, therefore offers both the industry and the design practitioner an opportunity to apply the principles of Inclusive Design in a way that potentially reduces the problematic financial and time expense of iterative prototype development and user testing.

As defined in VICON the direct end users of these tools and approaches are the designers of consumer products, the beneficiaries are the users of the inclusively designed consumer products, including older people.

The group of target customers of the VICON tools include designers, producers, marketers of consumer products, usability and accessibility organisations across Europe, policy makers and training centres. The following table shows the major economic impact for the different roles:

Potential users of VICON tools	Potential economic benefit of the VICON results
PLM and CAD design agencies	<ul style="list-style-type: none"> • Tools, models and recommendations to support the design process • communication tool in design teams • training tool to teach new designers about the needs of specific user groups • widening of the target user range of the design to cover new groups like elderly • reduce design costs • reduce user testing costs • increase the customer base
Consumer product producer	<ul style="list-style-type: none"> • producing inclusive consumer products and by that cover new end user groups like older and disabled persons • reduce production costs • reduce user testing costs • increase of customer base
Consumer product marketing companies	<ul style="list-style-type: none"> • marketing inclusive consumer products and by that cover new end user groups like older and disabled persons • increase of customer base
National Agencies, NGOs and European Commission	<ul style="list-style-type: none"> • using recommendations and models as a foundation for political decisions or legislation • using the simulation tool for awareness raising • increase work coverage and satisfy larger portions of population
Companies developing CAD and PLM software	<ul style="list-style-type: none"> • A strong common methodology that enables PLM and CAD software developer, and



<p>e.g. Siemens</p>	<p>technical companies that implement them, to maximise benefit from their tool - wider take-up and use, especially by designing for older and disabled users.</p>
<p>Design, usability and accessibility consultancy agencies</p>	<ul style="list-style-type: none"> • using evaluation tools to provide customers with testing results about user interfaces of consumer products • increase customer base
<p>Academic institutions providing education</p>	<ul style="list-style-type: none"> • cover new topics of teaching • work with new standards and recommendations • increase student base • offer consultancy services on usability, accessibility and simulation

The road map for marketing the VICON products has been described in D6.4 and D6.7



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