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Cost benefits evidence and case studies

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Contents

This paper summarises the benefits that can be obtained from use of user centered design, and discusses how to select appropriate methods and justify their cost benefits. It includes two case studies of the cost benefits of using a usability maturity model to improve the usability capability of an organisation.

1 – Potential benefits of usability

The objective of introducing user centered methods is to ensure that web sites and products can be used by real people to achieve their tasks in the real world. This requires not only easy-to-use interfaces, but also the appropriate functionality and support for real business activities and work flows. According to IBM (1999), developing easy-to-use products "makes business effective. It makes business efficient. It makes business sense".

User centered design can reduce development and support costs, increase sales, and reduce staff costs for employers. The checklist in Table 1 can be used to identify the potential benefits.

Table 1. Potential benefits of user centered design

A. Development costs can be reduced by: 1. Producing a product that has only relevant functionality 2. Detecting and fixing usability problems early in the development process 3. Reducing the cost of future redesign or radical change of the architecture to make future versions of the product more usable 4. Minimizing or eliminating the need for documentation 5. Redesigning web sites to increase revenue, not just to change the image 6. Reducing the risk of product failure
B. E-commerce sales can be improved by increasing the number of web site customers who will:
1. Be able to find products that they want 2. Find supplementary information easily (e.g. delivery, return and warranty information) 3. Be satisfied with the web site and make repeat purchases 4. Trust the web site (with personal information and to operate correctly) 5. Not require any support, or use the web site for support rather than calling the support center 6. Recommend the site to others 7. Support and increase sales by other channels
C. Product sales can be increased as a result of the usability of the product:
1. Improving the competitive edge by marketing the product or service as easy to use 2. Increasing the number of customers satisfied with the product who will make repeat purchases and recommend the product to others 3. Obtaining higher ratings for usability in product reviews
D. Employers can benefit from easier to use systems in the following ways:
1. Faster learning and better retention of information 2. Reducing task time and increased productivity 3. Reducing employee errors that have to be corrected later 4. Reducing employee errors that impact on the quality of service 5. Reducing staff turnover as a result of higher satisfaction and motivation 6. Reducing time spent by other staff providing assistance when users encounter difficulties
E. Suppliers and/or employers can benefit from reduced support and maintenance costs in the following ways:
1. Reducing support and help line costs 2. Reducing costs of training 3. Reducing maintenance costs

1.1 Development savings

Many existing development processes focus exclusively on adherence to technical and process specifications. Incorporating user centered methods can reduce development time and cost. The user interface may account for up to 66% of the lines of code in an application and 40% or more of the development effort (MacIntyre et al 1990). During software development, usability engineering can reduce the time and cost of development efforts through early definition of user goals and usability objectives, and by identification and resolution of usability issues.

The main areas of saving are to:

1.1.1 Reduce the development time and cost by producing a product that has only relevant functionality

- "In one large commercial client, the time to execute a quality assurance test fully was reduced by 85% because of a decrease in features brought about through the application of formal usability engineering and testing during the early phases of development. This amounted to a savings of approximately $15 million and a reduction in schedule by 18 months over the prior software development iteration." (Mauro, 2002)
- "In traditional software, and even more so in large E-com web development efforts, about 5% of features available to the customer are used 95% of the time. A more staggering statistic is the fact that some 70% of user-interface design features are never or rarely used." (Mauro, 2002).

1.1.2 Reduce the development time and cost by detecting problems early in the development process

- A change may cost 1.5 units of project resource during conceptual design, 6 units during early development, 60 during systems testing and 100 during post-release maintenance (Pressman, 1992).
- "[Usability engineering techniques] are quite effective at detecting usability problems early in the development cycle, when they are easiest and least costly to fix. By correcting usability problems in the design phase, American Airlines reduced the cost of those fixes by 60-90%." (Bias & Mayhew, 1994)

1.1.3 Reduce the cost of future redesign of the architecture to make future versions of the product more usable

- "In one large study undertaken by MauroNewMedia involving an E-Com site selling consumer products, the site's search engine returned a wrong or incomplete list of search queries 57% of the time. On average 46% of the site's customers left without locating the items they wished to purchase even though such items existed and were available on the site. By applying professional usability testing in the design of the search query system, the E-Com site could have been improved by a full order of magnitude. Waiting until the database and related search functionality was complete, however, meant spending more than $1 million in re-design and programming. The cost of a professional usability testing study early in development would have been about $25,000." (Mauro, 2002)

1.1.4 Reduce costs by minimizing or eliminating the need for documentation

- Usability work eliminated the need to reprint and distribute a manual, saving one company $40,000 in one year. (Bias & Mayhew, 1994)

1.1.5 Redesign web sites to increase revenue, not just to change the image

- In several large studies conducted by MauroNewMedia during the past 5 years, it was clear that spending large sums on web site design (re-design) efforts produced almost no benefit it terms of improving the business performance of large E-Com offerings. In one large client's case, serial re-design efforts by several large web development firms used approximately $100 million in development fees. Yet the number of new customers declined, those retained remained level, and almost no customers were migrated to other services or were involved in cross purchasing of products or services. (Mauro, 2002)

1.1.6 Reduce the risk of product failure

- The Standish Group (2003) found that only 34% of IT projects completed were on time, on budget, and delivering the functionality required; 51% of IT project were "challenged"—meaning that they were not on time, not on budget, or not delivering the functionality required; and 15% of IT project failed or were abandoned. One of the major causes is inadequate user requirements.
- User centred design is a very cost-effective means of identifying user requirements and reducing the financial risk of releasing a system which will fail to meet its objectives in use (Landauer, 1996).

1.2 Increase e-commerce sales

Usability is critical to the success of a web site:

- 42% of US Web buying consumers made their most recent online purchase because of a previous good experience with the retailer (Forrester, 2001a)
- Commodities buyers ranked usability as their top requirement for picking an eMarketplace (Forrester, 2001a)
- B2C site managers rated ease-of-use as the most important element of their site's design (Forrester, 2001a)

Even though consumers, business customers, and site executives underscore the need for usability, reviews of 150 web site reviews showed that most sites fail to support user goals (Forrester, 2001a)

Improved web site usability produces the most direct benefits for ecommerce web sites, but is also important for sites that rely for their traffic or subscriptions on users finding information.

1.2.1 Increase the number of customers who can find products that they want

- "A study from Zona Research found that 62% of Web shoppers have given up looking for the item they wanted to buy online (and 20% had given up more than three times during a two-month period)." (Nielsen, October 1998)
- "In Jared Spool's study of 15 large commercial sites, users could only find information 42% of the time even though they were taken to the correct home page before they were given the test tasks." (Nielsen, October 1998)
- "You can increase sales on your site as much as 225% by providing sufficient product information to your customers at the right time. In our recent research, we found that the design of product lists directly affected sales. On sites that did not require shoppers to bounce back and-forth between the list and individual product pages, visitors added more products to their shopping cart and had a more positive opinion of the site. By understanding your customer expectations and needs, and designing your product lists accordingly, you can significantly increase your sales." (User Interface Engineering, 2001)
- "After move.com completed the redesign of the home "search" and "contact an agent" features based on a UI consulting firm's recommendations, users ability to find a home increased from 62% to 98%, sales lead generation to real estate agents increased over 150%, and [move.com's] ability to sell advertising space on move.com improved significantly." (Vividence, 2001)
- "IBM's Web presence has traditionally been made up of a difficult-to navigate labyrinth of disparate subsites, but a redesign made it more cohesive and user-friendly. According to IBM, the massive redesign effort quickly paid dividends. The company said in the month after the February 1999 re-launch that traffic to the Shop IBM online store increased 120 percent, and sales went up 400 percent." (Battey, 1999)
- "More than 83 percent of Internet users are likely to leave a Web site if they feel they have to make too many clicks to find what they're looking for, according to Andersen's latest Internet survey." (Arthur Andersen, 2001)

1.2.2 Find supplementary information easily

<If you know of any examples, please send me details>

1.2.3 Increase the number of satisfied customers who will make repeat purchases

- "Staples.com determined that the key to online success and increased market share was to make its e-commerce site as usable as possible. Staples.com spent hundreds of hours evaluating users' work environments, decision-support needs, and tendencies when browsing and buying office products and small business services through the Web. Methods included data gathering, heuristic evaluations, and usability testing. [They achieved these results]: 67% more repeat customers 31-45% reduced drop-off rates 10% better shopping experience 80% increased traffic Increased revenue" (Human Factors International, 2001a)
- "In a 1999 study of Web users, respondents were asked to list the five most important reasons to shop on the Web. Even though low prices definitely do attract customers, pricing was only the third-most important issue for respondents. Most of the answers were related to making it easy,

pleasant, and efficient to buy. The top reason was "Easy to place an order" by 83% of the respondents." (Nielson, February 1999)

- "A positive experience leads to loyalty. Forrester's Consumer Technographics®data shows that 42% of US Web buying consumers made their most recent online purchase because of a previous good experience with the retailer" (Forrester, 2000b)
- "Commodities buyers recently ranked usability as their top requirement for picking an eMarketplace" (Forrester, 2000a)
- "One study estimated that improving the customer experience increases the number of buyers by 40% and increase order size by 10%." (Creative Good, 2000)
- "The repeat customers are most valuable: new users at one e-commerce site studied spent an average of $127 per purchase, while repeat users spent almost twice as much, with an average of $251." (Nielsen, August 1, 1997).
- "At HomePortfolio.com we monitored site traffic, observed consumers in usability studies and worked with internal business groups. This helped us make changes that made the site's purpose clearer and increased transaction rates measurably. The change increased the traffic up 129% the week we put it up." (Interaction Design, Inc., 2001)

1.2.4 Increase the number of customers who will trust the web site and complete the purchase

- "User trials were used to redesign the EuroClix Website before its launch. In its first six months, it convinced more than 30,000 users to sign up. This study clearly shows that consumers' trust concerns can significantly be alleviated by providing relevant information when and where users need it." (Egger & de Groot, 2000)

1.2.5 Increase the number of customers who will use the web site for customer support

- "37% of online consumers have used customer support on a site. B2B companies estimate that online service is $5 to $25 cheaper, per incident service" Forrester (2001a)

1.2.6 Increase the number of customers who will recommend the site to others

<If you know of any examples, please send me details>

1.2.7 Support and increase sales by other channels

<If you know of any examples, please send me details>

1.3 Product sales

1.3.1 Improving the competitive edge by marketing the product as easy to use

- Wixon and Jones (1995) document a case study of a usability-engineered product that achieved revenues that were 80% higher than for the first release developed without usability engineering, and 60% above project expectations.
- "In today's market, usable products are desirable products. Ease of use differentiates them in a highly competitive market place. Ease of use brings an added value that culminates in a higher degree of customer satisfaction, continued business and higher revenues. Customer service and satisfaction provide market differentiation (Jones and Sasser, 1995, Prokesch, 1995). Companies committed to ease of use do more than meet customer expectations, they can actually exceed anticipated earnings" (Karat, 1997).

1.3.2 Increase the number of satisfied customers who will make repeat purchases and recommend the product to others

<If you know of any examples, please send me details>

1.3.3 Obtain higher ratings for usability in product reviews

<If you know of any examples, please send me details>

1.4 Usage benefits for employers

Companies that purchase or produce usable systems for their employees also see impressive returns on their investment.

1.4.1 Faster learning and better retention of information

<If you know of any examples, please send me details>

1.4.2 Reduce task time and increase productivity

Better task focus. A good interface to a well-designed product will allow the user to concentrate on the task rather than the tool. If the interface is designed appropriately, it will allow them to operate effectively and efficiently, rather than lose vital time struggling with a poorly designed user interface and badly thought-out functionality.

- "With its origins in human factors, usability engineering has had considerable success improving productivity in IT organizations. For instance, a major computer company spent $20,700 on usability work to improve the sign-on procedure in a system used by several thousand people. The resulting productivity improvement saved the company $41,700 the first day the system was used. On a system used by over 100,000 people, for a usability outlay of

$68,000, the same company recognized a benefit of $6,800,000 within the first year of the system's implementation. This is a cost-benefit ratio of $1:$100." (Bias & Mayhew, 1994)

- "The average software program has 40 design flaws that impair employees' ability to use it. The cost in lost productivity is up to 720%." (Landauer 1995).
- "Design changes due to usability work at IBM resulted in an average reduction of 9.6 minutes per task, with projected internal savings at IBM of $6.8 Million in 1991 alone." (Karat 1990).
- "The average user interface has some 40 flaws. Correcting the easiest 20 of these yields an average improvement in usability of 50%. The big win, however, occurs when usability is factored in from the beginning. This can yield efficiency improvements of over 700%." (Landauer, 1995)

1.4.3 Reduce employee errors that have to be corrected later

A significant proportion of so-called "human error" can be attributed to a product with a poorly designed interface that is not closely matched to the users' task needs, or to their mental model of the task. Avoiding inconsistencies, ambiguities or other interface design faults, while adhering to user expectations in terms of task structure and sequencing, has the potential to significantly reduce employee errors that create additional overheads to monitor and correct.

1.4.4 Reduce employee errors that impact on the quality of service

Some employee errors will directly result in a poorer service to customers.

<If you know of any examples, please send me details>

1.4.5 Reduce staff turnover as a result of higher satisfaction and motivation

- "When systems match user needs, satisfaction often improves dramatically. In a 1992 Gartner Group study, usability methods raised user satisfaction ratings for a system by 40%." (Bias & Mayhew, 1994)
- "Reduced staff turnover resulting in lowered personnel costs associated with the employees who have lower turnover rates and higher satisfaction with their work environment." (Karat 1993a)
- "One airline's IFE (In-flight Entertainment System) was so frustrating for the flight attendants to use that many of them were bidding to fly shorter, local routes to avoid having to learn and use the difficult systems. The time-honored airline route-bidding process is based on seniority. Those same long-distance routes have always been considered the most desirable. For flight attendants to bid for flights from Denver to Dallas just to avoid the IFE indicated a serious morale problem." (Cooper, 1999)

1.4.6 Reduce time spent by other staff providing assistance when users encounter difficulties

- Because in-house PCs are often hard to use, companies have to provide about $3150 worth of technical support for every user (Gartner Group, 1997).

- Non-technical employees take 4-10% of their time to help co-workers solve their computer problems at a cost of $10,500 a year for each computer (Nolan Norton Institute, 1997).
- Unproductive activities with computers (support and housekeeping, response time delays, checks for accuracy, etc) cost another $5590 per computer per year (Gartner Group, 1997).

1.5 Reduce support and maintenance costs

1.5.1 Reduce support and help line costs

Significant savings of help-desk calls and service costs are another added bonus when products are made to meet user needs.

- "lucy.com found that improving descriptions and images on product pages meant that users did not have to call or email customer support with simple questions like 'What does a shirt look like from the back?' The changes paid off when product-related inquiries dropped by more than 20%." Forrester (2001a)
- "Microsoft tracks its support call costs and has seen a significant cost savings resulting from improving the usability of its products, such as Word." (Reed 1992).
- "Design changes from one usability study at Ford Motor Company reduced the number of calls to the help line from an average of 3 calls to none, saving the company an estimated $100,000." (Kitsuse 1991).
- "At Microsoft several years ago, Word for Windows's print merge feature was generating a lot of lengthy (average = 45 minutes) support calls. As a result of usability testing and other techniques, the user interface for the feature was adjusted. In the next release, support calls 'dropped dramatically'; Microsoft recognized 'significant cost savings." (Bias & Mayhew, 1994)
- "A certain printer manufacturer released a printer driver that many users had difficulty installing. Over 50,000 users called support for assistance, at a cost to the company of nearly $500,000 a month. To correct the situation, the manufacturer sent out letters of apology and patch diskettes (at a cost of $3 each) to users; they ended up spending $900,000 on the problem. No user testing of the driver was conducted before its release. The problem could have been identified and corrected at a fraction of the cost if the product had been subjected to even the simplest of usability testing." wrote the researcher." (Bias & Mayhew, 1994)

1.5.2 Reduce costs of training

Organizations that ensure their employees are furnished with easy-to-use products see dramatic reductions in training time and, subsequently, great reductions in training cost.

- Karat (1993b) documents a case study of a usability engineered product that required a one-hour training session as compared to one week of training for similar systems built and used within the organization. The investment in usability save the organization millions of dollars in training costs and in the opportunity costs of the employees' time in the first year alone.

- "At one company, end-user training for a usability-engineered internal system was one hour compared to a full week of training for a similar system that had no usability work. Usability engineering allowed another company to eliminate training and save $140,000. As a result of usability improvements at AT&T, the company saved $2,500,000 in training expenses." (Bias & Mayhew, 1994)

1.5.3 Reduce maintenance costs

When an organization tries to recover from significant usability problems in a released product, the costs of post-release changes are unaffordable for many organizations.

- "80% of software life cycle costs occur during the maintenance phase." (Pressman 1992).
- "80% of maintenance is due to unmet or unforeseen user requirements; only 20% is due to bugs or reliability problems." (Pressman 1992).

2 – Estimating costs

Chapter 3 of this volume illustrates the cost of a relatively sophisticated usability engineering plan that takes account of the time of usability engineers, developers, mangers, and users. This chapter shows how to calculate costs in the situation where only a limited number of usability methods are to be used, and the time of the usability engineers is the main cost. It also shows how to use a usability maturity model to assess what additional user centered methods an organization should use.

2.1 User centered design methods

The essential activities required to implement user centered design are described in ISO 13407 (User-centred design process for interactive systems, 1999) under the following headings:

1. Plan and manage the human centered design process
2. Understand and specify the context of use
3. Specify the stakeholder and organizational requirements
4. Produce design solutions
5. Evaluate designs against requirements

The EC INUSE project developed a structured and formalized definition of the human-centered processes described in ISO 13407 (Earthy, 1998). An improved version has subsequently been published as ISO TR 18529 (2000).

The usability maturity model in ISO TR 18529 describes seven processes each of which contains a set of base practices (Table 2). The base practices describe what has to be done in order to represent and include the users of a system during the product lifecycle.

Table 2. Human-Centered Design (HCD) processes and their base practices

1	**Ensure HCD content in system strategy**
1.1	Represent stakeholders
1.2	Collect market intelligence
1.3	Define and plan system strategy
1.4	Collect market feedback
1.5	Analyse trends in users
2	**Plan and manage the HCD process**
2.1	Consult stakeholders
2.2	Identify and plan user involvement
2.3	Select human-centred methods and techniques
2.4	Ensure a human-centred approach within the team
2.5	Plan human-centred design activities
2.6	Manage human-centred activities
2.7	Champion human-centred approach
2.8	Provide support for human-centred design
3	**Specify the stakeholder and organisational requirements**
3.1	Clarify and document system goals
3.2	Analyse stakeholders
3.3	Assess risk to stakeholders
3.4	Define the use of the system
3.5	Generate the stakeholder and organisational requirements
3.6	Set quality in use objectives
4	**Understand & specify the context of use**
4.1	Identify and document user's tasks
4.2	Identify and document significant user attributes
4.3	Identify and document organisational environment
4.4	Identify and document technical environment
4.5	Identify and document physical environment
5	**Produce design solutions**
5.1	Allocate functions
5.2	Produce composite task model
5.3	Explore system design
5.4	Use existing knowledge to develop design solutions
5.5	Specify system and use
5.6	Develop prototypes
5.7	Develop user training
5.8	Develop user support
6	**Evaluate designs against requirements**
6.1	Specify and validate context of evaluation
6.2	Evaluate early prototypes in order to define the requirements for the system
6.3	Evaluate prototypes in order to improve the design
6.4	Evaluate the system to check that the stakeholder and organisational requirements have been met
6.5	Evaluate the system in order to check that the required practice has been followed
6.6	Evaluate the system in use in order to ensure that it continues to meet organisational and user needs
7	**Introduce and operate the system**
7.1	Management of change
7.2	Determine impact on organisation and stakeholders
7.3	Customisation and local design
7.4	Deliver user training
7.5	Support users in planned activities
7.6	Ensure conformance to workplace ergonomic legislation

A full implementation of user centered design would conform to ISO 13407 and use all the relevant base practices in the usability maturity model.

Our experience has been that the core set of methods illustrated in Figure 1 (also listed in Table 4) provide the essential activities necessary to achieve user centered design in a wide range of projects (Bevan, 2000a). The exact nature of the activity has to be customized to the needs of each organization and project. Not all activities may be needed for every project, and for some projects additional activities may be required (for example field studies to gather information from existing users).

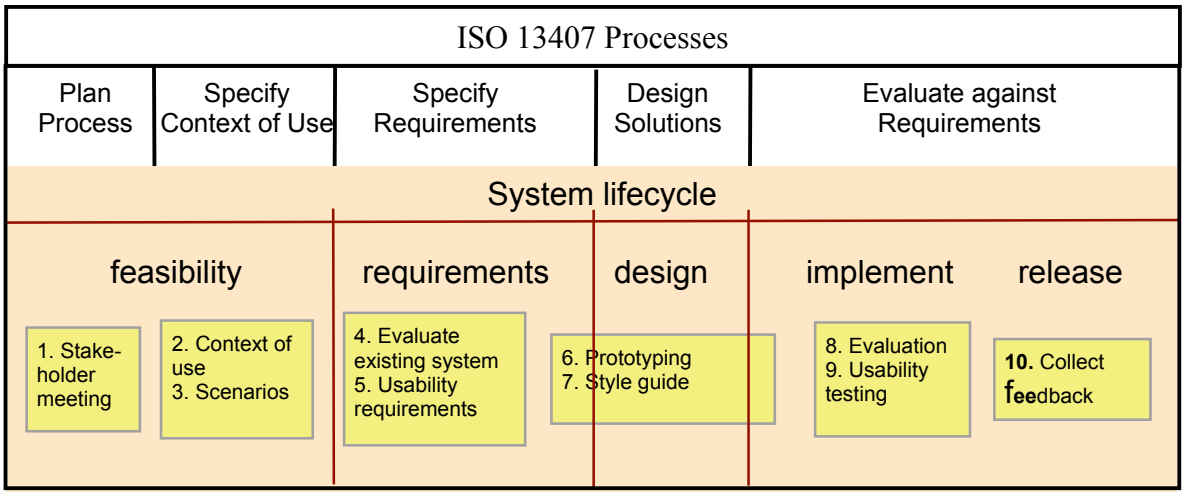

Figure 1. TRUMP methods for user centered design

2.2 Costs of user centered design

Most user centered design techniques are relatively simple to apply. The major costs are the time of the people who apply the methods. The methods chosen will depend not only on the overall budget, but also on the available skills and experience and practical constraints such as project deadlines and the availability of users.

Table 3 shows the typical range of effort and people required for each of the methods, providing a total that ranges from 26 to 80 person days.

For some projects, even the lower end of this scale may be too ambitious or beyond the available budget. In that case an essential subset of the activities could be used (see for example Bevan 2000b).

The minimum figures estimate the effort required by experienced facilitators (sometimes working alone) to obtain basic results when there are no complications. The maximum figures could be exceeded in some cases., particularly for a larger project the activities are repeated for different parts of the system.

Table 3. Number of people and person days required

	Plan/ report (person days)		Execute (person days)		Total (person days)		Usability experts (number)		Managers/ developers (number)		Users (person days)	
	min	max	min	max	min	max	min	max	min	max	min	max
Maturity assessment	2	10	1	15	3	25	1	2	2	10		
1. Stakeholder meeting	1.5	3	.5	2	2	5	1	2	2	10	.5	2
2. Context of use	2	3	.5	2	2.5	5	1[1]	2	2	6	.5	2
3. Scenarios of use	1	2	.5	1	1.5	3	1	2	1	4	.5	2
4. Baseline existing system	2	4	.5	4	2.5	8	2	2	0	4	.5	2
5. Usability requirements	1	2	.5	1	1.5	3	1	2	1	4	.5	2
6. Paper prototyping	3	6	1	6	4	12	2	2	0	6	.5	3
7. Style guide	1	10[2]	.5	3	1.5	13	1	1				
8. Evaluate machine prototype	2	6	.5	6	2.5	12	1[1]	2	0	6	.5	3
9. Test against requirements	2	7	2	6	4	13	2	2	0	6	.5	3
10. Feedback from use	3	5	1	5	4	6	1	1			*[3]	*[3]
Total	18.5	48	7.5	36	26	80						

3 – Making the cost-benefit case

Having made an estimate of the financial benefits and knowing the effort required for each method, cost benefits can be calculated for the intended set of user centered activities. There are several situations where a cost-benefit analysis can be useful:

- A financial case can be made for the budget required to carry out intended user centered methods.
- The choice of user centered methods within a limited budget can be prioritized and justified.
- Cost benefits can be calculated at the end of a project to provide a case study for future use.

[1] Possible with one person, but two people recommended.
[2] More effort would be required for a style guide that covers multiple products or platforms.
[3] Variable.

Increasingly, the question will become not "usability, yes or no?" but "usability, which methods when?"

The steps to follow are:

1. Decide which user-centered design methods are intended to be used. This will depend on the nature of the project, the anticipated benefits, and any budget or time constraints.

2. For each method, sum the person-days required to perform it:

   (Preparation time x People) + (Application time x people) + (Reporting time x people)

3. Multiply the person-days by the appropriate day rate(s) to give a total labor cost, and add any other costs (such as laboratory hire or recruiting):

   Total cost = ∑(Person days x Day rate) + ∑(Other chargeable costs)

4. Decide which of the benefits listed in Table 1 the methods will contribute to. For example does the method contribute to lower development costs, increased sales, improved productivity and/or reduced support?

5. Estimate the financial benefits that come from use of the methods:

   Total financial benefit = ∑(Financial benefits for relevant items in Table 1)

6. Calculate the cost-benefit ratio:

   (Total financial benefit) / (Total cost)

7. If there is a need to prioritize the use of methods within a limited budget, or to justify the use of a specific method:

   a. Decide how each method will contribute to the overall benefits identified in step 4. (Group together into one composite method any component methods that are used together, such as a usability test followed by an interview and a questionnaire.)

   b. As later methods typically depend on the results of methods carried out earlier (for example scenarios depend on the context of use), the overall cost benefits cannot be partitioned between the individual methods. Instead the potential value of a particular method can be assessed by recalculating the estimated cost benefits when that method is excluded. For example it might be concluded that the additional benefits obtained by carrying out a late usability test did not justify the additional cost. By comparison an evaluation to baseline the usability of an existing system might be estimated to provide a much greater benefit for a similar cost.

For organizations already committed to user-centered design a cost-benefit analysis is not essential but it can provide a valuable input when formulating a usability plan. Cost benefits could be recalculated as a development project progresses to reassess the importance of various activities.

4 – Case studies

The objective of the EU-funded TRUMP project (Bevan, 2000a) was to improve the usability capability of the development processes in two organizations: Inland Revenue/EDS (IR/EDS) in the UK and Israel Aircraft Industries (IAI) in Israel, and to demonstrate the cost benefits of applying user centered methods. The steps taken over a period of two years were to:

- Identify needs for usability process improvement by using the usability maturity model in ISO TR 18529 to assess the current capability of each organization (Bevan and Earthy, 2001).
- Make the identified improvements to the software development processes, by introducing simple user-based methods implementing ISO 13407 (Bevan et al., 2001).
- Identify the cost-benefits of the improvements, and integrate the methods into the documented processes.

The usability maturity model in ISO TR 18529 was used to assess the usability capability at IR and IAI, and to identify any gaps in their ability to apply user centered design. Each organization was free to decide which of the 44 usability maturity model base practices were within the scope for potential process improvement.

In the assessments, each base practice was rated on the scale:

- Not performed
- Partly performed
- Largely performed
- Fully performed

4.1 Israel Aircraft Industries

The LAHAV division of Israel Aircraft Industries has a group of about 100 people developing aircraft avionics. IAI uses a well-established development methodology, but their process for specifying operational requirements was not supported by any specific methods and techniques.

A one-day workshop provided the basis for agreeing the scope for process improvement at IAI. The activities in the usability maturity model were used as a good practice checklist. The author rated the extent to which each activity was currently performed, based on a short discussion with one or two developers or managers who were most knowledgeable in each area. Although some ratings may not have been completely representative, they were sufficient to provide the basis for an agreed program of improvement.

LAHAV selected the development of a new Mission Planning Center (MPC) using the Windows NT Interface as a trial project. An MPC enables a pilot to plan an airborne mission that is then loaded onto a data cartridge and taken by the pilot to the aircraft.

The user centered design methods used, and the IAI comments are shown in Table 4.

Table 4. IAI and IR/EDS experience with TRUMP methods for user centered design

Method	Description	IAI comments	IR comments
1. Stakeholder meeting	A half-day meeting to identify and agree on the role of usability, broadly identifying the intended context of use and usability goals, and how these relate to the business objectives and success criteria for the system.	Conducting a Stakeholder meeting allowed IAI to identify previously unforeseen users and stakeholders, better understand the project scope and objectives, define the success factors and identify some different interpretations for follow-up discussions and resolution. Involvement of senior managers and marketing personnel contributed for identification of some strategic issues.	No stakeholder meeting held, as usability activities were already planned as part of the normal development process.
2. Context of use	A half-day workshop to collect and agree on detailed information about the intended users, their tasks, and the technical and environmental constraints.	We never used this method before. The facilitator guided us through a long checklist covering many aspects of the user's skills, tasks and the MPC working environment. Most of the data captured was not new to the participants due to their existing familiarity with the users' environment. The checklist of issues should be tailored to IAI's needs.	The user's skills, tasks and the working environment were defined. The value of documenting this corporate knowledge should not be underestimated. Our IT supplier does not have staff with an intimate knowledge of our core processes or organizational culture. There was a feeling that we had this knowledge "in our bones" and could pass this on to the IT supplier when requested. Context analysis proved there was a better way to spread that knowledge around and the document has been used time and again by all involved to act as a reminder of what and whom we were trying to design for.

3. Scenarios of use	A half-day workshop to document examples of how users are expected carry out key tasks in specified contexts, to provide an input to design and a basis for subsequent usability testing.	This method contribution for MPC system was low because the operational scenarios required for the MPC are obvious to Pilots. [In most development environments, this is a valuable means of transferring information about user tasks to the development team. As the people collecting requirements at IAI were themselves pilots, the main beneficiary was the usability engineer who needed this information for later parts of the usability process.]	We all took this technique to our hearts. It was relatively simple to pick up as it involved the end users documenting what they did on a daily basis back in the office. This knowledge could then be captured before every function design workshop and not only used to focus what the IT was being developed for but used in conjunction with other techniques such as task analysis and paper prototyping to verify the emerging design was meeting the needs of users and then used again to validate the final IT prototype was correct.
4. Baseline existing system	Evaluate an earlier version or competitor system to identify usability problems and obtain baseline measures of usability as an input to usability requirements.	Four users evaluated the existing system. Each user was given short (15 minutes) training on the system. The user was given a mission to prepare and commented as he went along. Comments were captured by the facilitators generating a detailed list of about fifty problems. The problems were reviewed by the pilots defining the new system to find ways to avoid them in the design of the new system. The users filled out SUMI questionnaires after the evaluation to give a baseline for satisfaction. The technique was very productive even though applied in a semiformal way.	A usability analyst and seven users evaluated the existing system out in the local office network. Each user was given a short introduction and then observed using the system to do the same key tasks. Comments were captured by a usability analyst which generated a problem list and a report was produced which was fed into the development team before design of the new system began. We should also have used the opportunity to gain effectiveness, efficiency and satisfaction figures for later use.

5. Usability requirements	A half-day workshop to establish usability requirements for effectiveness, efficiency and satisfaction the user groups and tasks identified in the context of use analysis and in the scenarios.	Goals for task time and satisfaction were agreed, and a list of potential user errors were identified.	The various estimates for effectiveness and efficiency had to be agreed and then verified out in local offices on the existing system. We made the mistake of not growing and refining the requirement sufficiently as our understanding of the system matured which meant that when we came to do the final usability test, adjustments had to be made to ensure it reflected that latest views of the business. In hindsight it is clear however that the advantages do outweigh the time spent. All parts of the project team had a clear, common understanding of what is an acceptable standard for the usability of the system and we were able to evaluate if that benchmark was being met so helping improve and control the quality of the system. The skills necessary to set a requirement were easily transferred from the facilitator to the business and are already being applied on other projects.

6. Paper prototyping and affinity diagramming	Evaluation by users of quick low fidelity prototypes (using paper or other materials) and construction of affinity diagrams to clarify requirements and enable draft interaction designs and screen designs to be rapidly simulated and tested.	IAI had not used this method before and had doubts about it's value, mainly because it is very easy to create computer-based UI prototypes. In practice the potential users and developers liked the method and its contribution to MPC usability. Mockups of screens were posted on the wall and provided the "Big Picture". Each screen was subsequently displayed using an overhead projector resulting in very fruitful and productive discussions by potential users.	We used affinity diagramming to construct a model of key functions and then to logically group them. After they were grouped the structural hierarchy was developed and verified by use of task scenarios. It proved a simple technique to use and helped us resolve a problem that would have had a major impact on the usability. Paper prototyping was already widely used on other projects but was formalized for the trial project and (this is probably the most important part) linked to the preparation activities before the workshop and the use of task scenarios during it. As a technique it was easily picked up by the analysts and end users.
7. Style guide	Identify, document and adhere to industry, corporate or project conventions for screen and page design.	Off the shelf style guides were provided to the developer. It turned out that these style guides are very detailed and difficult to use. Given intuitive visual development tools, developers prefer to learn by click and see rather than reading lengthy manuals. IAI realize the need for a style guide, but currently don't have one with an appropriate level of detail.	Our usual practice had been to leave Graphical User Interface standards to individual projects, which meant applications were delivered to the business with a different look and feel. A corporate style guide and an overview of the chosen user interface style were provided to the development team. Developers involved in previous projects commented that as a result much less pointless discussion was spent on names and placement of controls.

8. Evaluation of machine prototypes	Informal usability testing with three to five representative users carrying out key tasks to provide rapid feedback on the usability of prototypes.	Software developers were present and observed the evaluation. In general the developers were very receptive and co-operative. A summary meeting was held at the end of the evaluation. Comments were listed and prioritized, and it was agreed to fix 93 of the 97 problems.	The system was only partially developed. Nevertheless the major usability and window design issues could be verified. The developers were present, assisted in the evaluation and could not have been more co-operative and supportive. Analysis identified 32 problems, including 3 major usability issues, all of which were formally logged on the IR problem management process and prioritized for fix.
9. Usability testing	Formal usability testing with eight representatives of a user group carrying out key tasks to identify any remaining usability problems and evaluate whether usability objectives have been achieved.	The system was tested against timing and satisfaction requirements. First, 2 hours MPC training was given to the pilots following by individual hands-on practice for another two hours. Each pilot then received written instructions regarding the mission he had to plan and modify, and worked without assistance. He also could write down comments on printed versions of the screens. The facilitators and developers observed the work and documented their observations. All pilots were happy with the MPC, which was confirmed in the SUMI results, which were well above the industry average. The overall duration of the tasks was within requirements.	We have been using summative usability testing for a number of years but this time introduced scoring against a detailed usability requirement for all the main business tasks. The use of a detailed requirement that formed part of the wider business requirement and that had the buy in of the whole project meant the results of the exercise carried much more credibility and empowered the usability analysts in their discussions about resolution of the problems that has been discovered.

A second workshop to assess the improvements was held 16 months later. IAI commented (Bevan et al., 2000):

> *"The one-day assessment format was appropriate for LAHAV since it is a) a relatively small organization, and b) it has a lasting culture, commitment and infrastructure for process improvement.*
> *The first assessment revealed many areas that needed improvement including some organizational issues. These were used to select UCD methods for trial. The second assessment purpose was to evaluate the improvements made. The detailed results are very valuable and will be used in further dissemination activities in LAHAV and other IAI divisions."*

4.1.1 Cost benefits

After the methods had been used, IAI estimated what it would cost to carry out the methods again, and what it would have cost to make the same fixes and changes at a later stage (Table 5). The estimated durations in hours assume that the work is carried out by a member of the development team who is experienced in the methods, and that no formal documentation is required.

Table 5. IAI estimated costs and benefits

Technique	Durat-ion [hours]	Number of people participat ing	Preparation and documentat ion [hours]	Total number of HF person days	Equivalent later costs [$]	How cost effective was the technique?
Stakeholder meeting	3	6	2	2.5	50K	High
Context of use analysis	3	4	6	2.3	30K	Medium
Affinity diagramming	6	5	5	4.4	40K	High
Scenarios of use	2	5		1.3	-	Low
Baseline existing system	2	4	5	2.1	30K	High
Usability requirements	3	5	3	2.3	5K	Medium
Paper prototyping	5	5	10	4.4	70K	High
Use style guide	2	1	0	0.3	-	Low
Evaluate computer prototype	2	5	6	2.0	40K	High
Test usability against requirements	4+1.5	10	5	4.0	20K	High

Reduced development costs

IAI estimated that all the methods used (except Style Guide and Scenarios of Use) resulted in savings in development costs of between $5K and $70K for each method, with a total saving of $330K. The cost of using the methods was only $22K, giving a cost-benefit ratio of 1:15.

Sales benefits of increased usability

IAI market the MPC independently of other avionics. Increased sales because customers would be more likely to buy the product were estimated to be $400K.

Support

Reduced costs of developing and providing training and support were estimated at $50K.

Overall cost benefits

The overall costs of the maturity assessments and use of methods was $27K. The total estimated savings and increased sales is $780K, giving a cost-benefit ratio of 1:29.

4.1.2 Conclusions

The techniques were assessed as very cost effective and low cost. IAI had found that introducing changes into an organization can be a lengthy, costly and complicated process. It requires convincing many people to invest time and money and then demonstrate the benefits versus costs. In the recent years it became even more difficult due to staff shortage and the requirement to reduce the time to market.

TRUMP was the exception due mainly to its low cost, and obvious benefits. When the developers only have to invest a few days in applying the methods and see the results on the spot, convincing the managers is very simple and performing cost-benefit analysis is simply not needed.

In view of the short time and effort it took to practice these techniques and the strong impact they had on the quality of the system, they are being incorporated in LAHAV's development process.

4.2 Inland Revenue/EDS

The Inland Revenue in the UK provides data processing support for 60,000 staff in more than 600 local offices. At the time of the trial, the Inland Revenue employed a well-defined JAD (joint application design) and RAD (rapid application design) methodology with its IT partner EDS.

At Inland Revenue, usability capability was assessed using a conventional software process assessment procedure based on Process Professional Assessment (Compita, 1997) was used. This lasted one week and was carried out by two trained assessors, assisted by two usability specialists who identified opportunities for process improvement. A total of 13 stakeholders associated with the trial project at different levels in Inland Revenue and EDS were interviewed in twelve 3-hour sessions, resulting in a detailed profile and rich information about where improvements would be beneficial.

The main conclusions were that:

- User centered information exists, but not always at the right time or in the right place.
- Usability requirements are either not documented or documented much too late.
- Building usability into the development process is only partly documented and managed.

A feedback meeting on the last day of the week provided the basis for an agreed set of improvement activities.

1. Extend and integrate the user centered design methods employed early in the lifecycle:
   - Scope who will use the system and what tasks they will undertake.
   - Produce task scenarios to cover all the main tasks.
   - Set usability requirements for the success rate, accuracy, task time and satisfaction for these tasks.
2. Employ more user and task-based methods in the JAD workshops:
   - Focus on real life task scenarios.
   - Use different prototyping approaches to design windows.
   - Adhere to corporate and industry guidelines.
   - Test the paper mock-ups from a user perspective using the task scenarios.
   - Produce a preparation pack for each function that collates the context analysis, task scenarios, IT requirements and design thoughts so the organization shares a common view of what they need to deliver from the JAD.
3. Methods used after JADs were to:
   - Evaluate the usability of an IT functional prototype to validate the emerging design.
   - Test the business system against the usability requirement.

Inland Revenue commented (Bevan et al., 2000):

> "*It was however a wary project team that was brought together for the first maturity assessment, uncertain what they had let themselves in for. The maturity assessment however opened everyone's eyes to:*
>
> - *The different ways users could and should be involved throughout the lifecycle.*
> - *The benefits that could accrue to both the project and IR/EDS.*
> - *Professional support available from usability engineers.*
>
> *Output from the assessment was not only a clear eyed assessment of the level of maturity in this area but it provided a straightforward model for raising that level aimed at the heart of the development lifecycle, the facilitated workshops which are the engine of design and development stages."*

IR/EDS experience with using the methods is shown in Table 4.

Twelve months later when the improvements had been made, a second similar assessment was carried out to see whether the agreed improvements had been achieved. Significant progress had been made (Table 7). When the results were presented to a meeting of senior stakeholders, the benefits were sufficient for the meeting to authorize incorporation of most of the methods into the standard Inland Revenue/EDS documented processes. The meeting also suggested that regular

usability capability assessments should be arranged to monitor improvement in the user centered design process.

4.2.1 Cost Benefits

After the methods had been used, IR estimated the resources that would be required to carry out the techniques again (Table 6).

Table 6. IR estimated benefits

Technique	Duration (hours)	People involv-ed	Prep. &/or Analysis (hours)	People involv-ed	Total resource in person-days	No. of skills transfer sessions needed	Contribution to a better system
Usability Maturity assessment	4	20	4	20	20		
Context of use analysis	2	4	4	1	1.5	None	Medium
Scenarios of use	2	4	0	0	1 per function	1	High
Usability requirements	4	8	32	1	3	1	Medium
Baseline existing system	1	7	32	1	5 per event	None	High
Affinity diagramming	2	6	0	0	2 per event	1	Medium
JAD: Preparation Pack	1	8	8	1	2 per function	1	High
JAD: Paper Prototyping	2	8	0	0	2 per function	1	High
JAD: Manage issues	2	8	0	0	2 per function	1	High
JAD: Smaller teams	2	8	0	0	2	None	Medium
JAD: Project glossary	1	8	0	0	1	None	Medium
Style Guides	1	8	160	2	21	None	Low
Evaluate Usability of Prototype	2	8	104	3	15 per event	1	High

Reduced development costs

The methods used to improve JADs were: context of use analysis, set usability requirements, task analysis, task scenarios, preparation pack, paper prototyping, managing issues, using smaller teams, a project glossary and style guides.

These saved staff time by bringing a degree of engineering to the workshops that hadn't previously existed, and provided a framework for end users to make an effective contribution.

For a system with 20 functions the value of the total saving in staff time was estimated to be £231,000 ($390,000). The cost of using these methods in JADs was estimated to be £88,500 ($150,000), giving a cost benefit ration of 1:2.6 for these methods.

Use

Evaluation of the existing system, several prototypes and live running cost a total of £51,500 ($88,000). Evaluating an existing system clarified requirements, and the evaluations ensured that the requirements were met and enabled additional improvements to be made, which will lead to benefits in use.

It was not possible to estimate the use and support benefits, but usability testing verified that staff could complete tasks quickly and to acceptable quality standards on their first day of using the on-line system. The user centered methods employed during development that ensured that the system was designed to meet real work scenarios played an important part in achieving these results.

Overall cost benefits

The overall cost of the maturity assessments, development and evaluation methods was £152,000 ($260,000). The cost benefits of using all these methods based only on estimated savings in development costs, is 1:1.5. The potential benefits of savings in use have not yet been estimated, but are likely to be substantial, with 30,000 users whose time costs over one dollar a minute. Thus the actual cost benefits of using these techniques were almost certainly much higher.

4.2.2 Conclusions

The value of the methods to the business was sufficiently clear at the time of the second maturity assessment to commit to their wider usage without the need for a cost-benefit analysis. The cost benefit analysis confirms the value of that decision.

The Inland Revenue was subsequently awarded UK Central Government Beacon status for their work on user centred design and usability.

4.3 Comparison

The usability maturity model was a valuable tool for identifying needs for process improvement in both organizations (Table 7). IR valued the detailed information obtained from a summative assessment requiring three person-weeks effort, while for the smaller development group at IAI many of the benefits were gained from a simpler formative one-day assessment.

Table 7. Comparison of assessments

	Inland Revenue/EDS	IAI
Number of design and development staff	>200	40
Use a fully documented process?	Yes	No
Importance of end user needs	High	High
Experience with usability	Moderate	None
Attitude to process improvement	Committed	Committed
Number of stakeholders interviewed	13	8
Number of usability maturity model base practices judged relevant and assessed	39	33
Initial number of activities partially or not performed	19	24
Final number of activities partially or not performed	3	2

Particular user centered design methods were not of equal value to both organizations. For example, IAI staff were much more familiar with the usage environment, so that context of use and scenarios were of less benefit than at the Inland Revenue, where scenarios were important in establishing a common understanding. At Inland Revenue use of an in-house style guide was an important factor in maintaining consistency in a large organization, while at IAI GUI interfaces were not developed sufficiently often to justify development of a style guide.

The base practices in ISO TR 18529 are generic, but the methods used to implement them need to be selected and tailored to meet the needs of the project, development environment, timescales and budget.

4.4 Taking up the methods

Both organizations found the results so beneficial that they have adopted the methods as a normal part of their development process. At IR the methods are applied by usability specialists, while IAI found them sufficiently intuitive that they plan to train existing members of the development team to use them (calling on expert assistance when required).

Does this provide a model for how to introduce user-centered design in other organizations? Jokela & Iivari (2001) found assessments based directly on ISO TR 18529 less successful, which led them to develop a new assessment process based on the intended outcome of each process, rather than the specific practices. Although an ISO TR 18529 assessment can also be based on outcomes (which are listed for each process), most of the TRUMP assessment centered on the base practices, which were found easy to interpret. The comparative success may have been due to the high degree of familiarity of the assessors with the ISO TR 18529 model, and the common goals of IAI and IR to:

- provide systems that meet user needs
- improve their processes.

This management commitment to improvement and change may have been lacking in some of Jokela & Iivari's assessments.

But even IR/EDS and IAI had initial difficulty in understanding the assessment model and potential benefits of the user centered methods, which differ in nature from other software engineering activities. Jokela & Iivari report similar difficulties in conveying the meaning of the model in advance of their assessments. It is still not clear how best to present the proposed user centered design activities in a way that can be understood and appreciated by designers and developers.

We nevertheless believe that the assessment processes used in TRUMP are an effective way to successfully implement user centered design, and that the cost benefits obtained by IAI and IR could be replicated in other similar organizations.

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Section 1 includes some of the examples in: Return on Investment for Usable User-Interface Design: Examples and Statistics, by Aaron Marcus.

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