Reducing Risk through Human Centred Design

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ABSTRACT

The National Academy of Science's report on Human-System Integration in the system development process (NAS HSI report) [12] explains how human needs can be integrated into system design using an incremental systems engineering development process that continually assesses risks at each phase of the system development. This paper suggests how appropriate Human Centred Design (HCD) methods can be selected to mitigate risks to project success.

1. RISKS IN SYSTEMS DEVELOPMENT

The NAS HSI report points out that the ultimate goal of system development is to produce a system that satisfies the needs of its operational stakeholders (including users, operators, administrators, maintainers and the general public) within acceptable levels of the resources of its development stakeholders (including funders, acquirers, developers and suppliers). Operational stakeholders need a system that is effective, efficient and satisfying [1]. Developing and delivering systems that satisfy all of these success-critical stakeholders usually requires managing a complex set of risks such as usage uncertainties, schedule uncertainties, supply issues, requirements changes, and uncertainties associated with technology maturity and technical design.

Boehm and Lane [4] suggest five principles for managing these risks:

1. *Stakeholder satisficing*; identifying the success-critical stakeholders and their value propositions (what is offered at what cost); negotiating a mutually satisfactory set of system requirements, solutions, and plans; and managing proposed changes to preserve a mutually satisfactory outcome.
2. *Incremental growth of system definition and stakeholder commitment*: incremental discovery of emergent human-system requirements and solutions using such methods as prototyping, testing with users, and use of early system capabilities.
3. *Iterative system development and definition*: cyclic refinements of requirements, solutions, and development plans. Such iteration helps projects to learn early and efficiently about operational and performance requirements.
4. *Concurrent system definition and development*: that includes concurrent engineering of requirements and solutions without waiting for every requirement and subsystem to be defined.
5. *Risk management – risk driven activity levels and anchor point milestones*. The level of detail of specific products and processes should depend on the level of risk associated with them.

Principles 2, 3 and 4 are consistent with approaches to human centred design, such as recommended in ISO 13407.

The other two principles (*Stakeholder satisficing* and *Risk management*) provide a means to determine which human centred design activities and methods are needed in a project to be confident that the final system will be acceptable to the operational stakeholders.

This contrasts with existing approaches to human centred design, which are commonly based on a one-size-fits-all methodology (e.g. [5], [14]) that may be justified by a cost benefit analysis to assess the potential business benefits of producing a more usable system [3].

The additional expenditure needed for human centred activities is often difficult to justify because the budget holder for project development usually does not personally gain from longer-term benefits such as increased sales or reduced whole life costs.

Project managers are much more likely to be influenced by the risks of not achieving stated project objectives. It is thus useful to recast the potential cost benefits of usability as risk reduction strategies. Table 1 restates the list of cost benefits in [2] as potential project risks.

2. HUMANCENTRED DESIGN ACTIVITIES

Looking for advice on which methods to use for human centred design can be bewildering.

Ferré [6] analyzed the methods contained in six popular HCI textbooks and identified 96 categories of HCD techniques. Individual textbooks each contained between 21 and 43 of these categories of technique:

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Table 1. Risks mitigated by HCD

A: Increased development costs to produce an acceptable system

- Not detecting and fixing usability problems early in the development process
- Increasing the cost of future redesign or radical change of the architecture to make future versions of the product more usable
- Increased costs due to unnecessary functionality
- Increased costs due to additional documentation
- Product fails

B: Web site usability: poor web sales

- Users cannot find products that they want to purchase
- Users cannot find additional information (e.g. delivery, return and warranty information)
- Dissatisfied users do not make repeat purchases
- Users do not trust the web site (with personal information and to operate correctly)
- Users do not recommend the web site to others
- Web site fails to increase sales through other channels
- Increased support costs

C: Product usability: poor product sales

- Competitors gain advantage by marketing competitive products or services as easy to use
- Dissatisfied customers do not make repeat purchases or recommend the product to others
- Poor ratings for usability in product reviews
- Brand damage

D: Poor productivity: risks to purchasing organisation

- Slower learning and poorer retention of information
- Increased task time and reduced productivity
- Increased employee errors that have to be corrected later
- Increased employee errors that impact on the quality of service
- Increased staff turnover as a result of lower satisfaction and motivation
- Increased time spent by other staff providing assistance when users encounter difficulties

E: Increased support and maintenance costs

- Increased support and help line costs
- Increased costs of training
- Increased maintenance costs

Author	*Number of categories*
Constantine [5]	31
Hix [7]	21
Mayhew [10]	31
Nielsen [11]	25
Preece [13]	43
Shneiderman [15]	29

ISO PAS 18152 contains an exhaustive list of 125 human systems (HS) activities that are needed for all aspects of systems development. These were derived from an analysis of best practice in human centred design in civilian and military systems. The categories of activity are:

HS.1 Life cycle involvement activities

HS.1.1 HS issues in conception
HS.1.2 HS issues in development
HS.1.3 HS issues in production and utilization
HS.1.4 HS issues in utilization and support
HS.1.5 HS issues in retirement

HS.2 Integrate human factors activities

HS.2.1 HS issues in business strategy
HS.2.2 HS issues in quality management
HS.2.3 HS issues in authorisation and control
HS.2.4 Management of HS issues
HS.2.5 HF data in trade-off and risk mitigation
HS.2.6 User involvement
HS.2.7 Human-system integration
HS.2.8 Develop and re-use HF data

HS.3 Human-centred design activities

HS.3.1 Context of use
HS.3.2 User requirements
HS.3.3 Produce design solutions
HS.3.4 Evaluation of use

HS.4 Human resources activities

HS.4.1 Human resources strategy
HS.4.2 Define standard competencies and identify gaps
HS.4.3 Design staffing solution and delivery plan
HS.4.4 Evaluate system solutions and obtain feedback

In [12] Table 3-A-1, the HS activities in ISO PAS 18152 have been categorised by type of system development activity:

1. Envisioning opportunities
2. System scoping
3. Understanding needs
4. Requirements
5. Architecting solutions
6. Life-cycle planning
7. Evaluation
8. Negotiating commitments
9. Development and evolution
10. Monitoring and control
11. Operations and retirement
12. Organizational capability improvement

An elaborated version of the table is included as an annex to this paper.

3. SELECTING HUMAN CENTRED DESIGN METHODS

The steps needed to select human-centred methods for an individual project are thus:

1. Identify the success-critical stakeholders.
2. Identify which potential consequences of poor usability affect the success-critical stakeholders.
3. Assess the likelihood and impact of these consequences.
4. Identify which categories of HS activities can reduce the risks.
5. Identify which HCD methods in each category are most cost-effective. The alternative methods should be assessed against criteria such as:

- To what extent will each possible method address the activities that have been identified as important?
- How cost effective is each method likely to be, given the time and effort required and constraints such as available skills, access to stakeholders and other users, etc.?

The needs for usability evaluation in particular should be judged in the broader context of the relative importance of usability evaluation in relation to other HS activities. For example, when designing and developing for a new context of use, the major risks might be associated with requirements, so that the majority of HCD resources might be devoted to early life cycle activities (which could include evaluation of early concepts and competitive evaluation).

4. CONCLUSIONS

This paper suggests how HCD can be justified as part of systems development and how the most appropriate HCD methods can be selected on a project-by-project basis.

This will enable HCD resources to be used most effectively for individual projects. The author would be happy to advise on or support the application of this approach to selecting HCD methods in a real development project.

The prerequisites for successfully using this approach include having usability experts in the development team who:

- can convince the project of the specific risks associated with poor usability;
- have sufficient experience to be able to select the most cost effective HCD methods; and
- have the expertise and resources to apply a wide range of different types of methods.

5. REFERENCES

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Annex A. Examples of methods that can be used to support HS best practices

Activity category	Best practices for risk mitigation with ISO 18152 clause reference	HCD methods and techniques
1. Envisioning opportunities	•Identify expected context of use of systems [forthcoming needs, trends and expectations]. •Analyze the system concept [to clarify objectives, their viability and risks].	-Future workshop -Preliminary field visit -Focus groups -Photo surveys -Simulations of future use environments -In-depth analysis of work and lifestyles
2. System scoping	•Describe the objectives which the user or user organization wants to achieve through use of the system.	-Participatory workshops -Field observations and ethnography -Consult stakeholders -Human factors analysis
	•Define the scope of the context of use for the system.	-Context of use analysis
3. Understanding needs a) Context of use	•Identify and analyze the roles of each group of stakeholders likely to be affected by the system. •Describe the characteristics of the users. •Describe the cultural environment/ organizational/ management regime. •Describe the characteristics of any equipment external to the system and the working environment. •Describe the location, workplace equipment and ambient conditions. •Decide the goals, behaviours and tasks of the organization that influence human resources •Present context and human resources options and constraints to the project stakeholders.	-Success critical stakeholder identification -Field Observations and ethnography -Participatory workshop -Work context analysis -Context of use analysis -Event data analysis -Participatory workshops -Contextual enquiry
b) Tasks	•Analyze the tasks and worksystem.	-Task analysis -Cognitive task analysis -Work context analysis
c) Usability needs	•Perform research into required system usability.	-Investigate required system usability -Usability benchmarking -Heuristic/expert evaluation
d) Design options	•Generate design options for each aspect of the system related to its use and its effect on stakeholders. •Produce user-centred solutions for each design option.	-Early prototyping & usability evaluation -Develop simulations -Parallel design (tiger testing)
4. Requirements a) Context requirements	•Analyze the implications of the context of use. •Present context of use issues to project stakeholders for use in the development or operation of the system.	-Define the intended context of use including boundaries
b) Infrastructure requirements	•Identify, specify and produce the infrastructure for the system. •Build required competencies into training and awareness programs. •Define the global numbers, skills and supporting equipment needed to achieve those tasks.	-Identify staffing requirements and any training or support needed to ensure that users achieve acceptable performance
c) User requirements	•Set and agree the expected behaviour and performance of the system with respect to the user. •Develop an explicit statement of the user requirements for the system. •Analyze the user requirements. •Generate and agree on measurable criteria for the system in its intended context of use.	-Scenarios -Personas -Storyboards -Establish performance and satisfaction goals for specific scenarios of use -Define detailed user interface requirements -Prioritize requirements (eg QFD)
5. Architecting solutions a) System architecting	•Generate design options for each aspect of the system related to its use and its effect on stakeholders. •Produce user-centred solutions for each design option. •Design for customization. •Develop simulation or trial implementation of key aspects of the system for the purposes of testing with users. •Distribute functions between the human, machine and organizational elements of the system best able to fulfil each function. •Develop a practical model of the user's work from the requirements, context of use, allocation of function and design constraints for the system. •Produce designs for the user-related elements of the system that take account of the user requirements, context of use and HF data. •Produce a description of how the system will be used.	-*Function allocation* -Generate design options -Develop prototypes -Develop simulations
b) Human elements	•Decide the goals, behaviours and tasks of the organization [that influence human resources] •Define the global numbers, skills and supporting equipment needed to achieve those tasks. •Identify current tasking/duty	-Work domain analysis -Task analysis -Participatory design -Workload assessment -Human performance model

	•Analyze gap between existing and future provision •Identify skill requirements for each role •Predict staff wastage between present and future. •Calculate the available staffing, taking account of working hours, attainable effort and non-availability factor •Identify and allocate the functions to be performed Functional decomposition and allocation of function. •Specify and produce job designs and competence/ skills required to be delivered •Calculate the required number of personnel. •Generate costed options for delivery of training and/or redeployment •Evolve options and constraints into an optimal [training] implementation plan (4.3.5) •Define how users will be re-allocated, dismissed, or transferred to other duties. •Predict staff wastage between present and future. •Calculate the available staffing, taking account of working hours, attainable effort and nonavailability factor. •Compare to define gap and communicate requirement to design of staffing solutions.	-Design for alertness -Plan staffing
c) Hardware elements	See a) System architecting.	-Prototyping and usability evaluation -Physical ergonomics -Participatory design
d) Software elements	See a) System architecting.	-User interface guidelines and standards -Prototyping and usability evaluation -Participatory design
6. Life-cycle planning a) Planning	•Develop a plan to achieve and maintain usability throughout the life of the system. •Identify the specialist skills required and plan how to provide them.	-Plan to achieve and maintain usability -Plan use of HSI data to mitigate risks
b) Risks	•Plan and manage use of HF data to mitigate risks related to HS issues. •Evaluate the current severity of emerging threats to system usability and other HS risks and the effectiveness of mitigation measures. •Take effective mitigation to address risks to system usability.	-HSI program risk analysis
c) User involvement	•Identify the HS issues and aspects of the system that require user input. •Define a strategy and plan for user involvement. •Select and use the most effective method to elicit user input. •Customize tools and methods as necessary for particular projects/stages. •Seek and exploit expert guidance and advice on HS issues.	-Identify HSI issues and aspects of the system requiring user input -Develop a plan for user involvement -Select and use the most effective methods -Customize tools and methods as necessary
d) Acquisition	•Take account of stakeholder and user issues in acquisition activities.	-Common Industry Format
e) Human resources	•Implement the HR strategy that gives the organisation a mechanism for implementing and recording lessons learnt •Enable and encourage people and teams to work together to deliver the organization's objectives. •Create capability to meet system requirements in the future (conduct succession planning) •Develop and trial training solution to representative users. •Deliver final training solutions to designated staff according to agreed timetable. •Provide means for user feedback [on human issues].	
7. Evaluation a) Risks	•Assess the health and well-being risks to the users of the system. •Assess the risks to the community and environment arising from human error in the use of the system. •Evaluate the current severity of emerging threats to system usability and other HS risks and the effectiveness of mitigation measures. •Assess the risks of not involving end users in each evaluation.	-Risk analysis (process and product)
b) Plan and execute	•Collect user input on the usability of the developing system. •Revise design and safety features using feedback from evaluations. •Plan the evaluation. •Identify and analyze the conditions under which a system is to be tested or otherwise evaluated. •Check that the system is fit for evaluation. •Carry out and analyze the evaluation according to the evaluation plan. •Understand and act on the results of the evaluation.	-Obtain user feedback on usability -Use models and simulation
c) Validation	•Test that the system meets the requirements of the users, the tasks and the environment, as defined in its specification. •Assess the extent to which usability criteria and other HS requirements are likely to be met by the proposed design.	-Compare with requirements -Common Industry Format for usability reports -Performance measurement
d) HSI knowledge	•Review the system for adherence to applicable human science knowledge, style guides, standards, guidelines, regulations and legislation.	

e) Staffing	•Decide how many people are needed to fulfill the strategy and what ranges of competence they need. •Develop and trial training solution to representative users. •Conduct assessments of usability [relating to HR]. •Interpret the findings •Validate the data. •Check that the data are being used.	*HR*
8. Negotiating commitments a) business case	•Contribute to the business case for the system. •Include HS review and sign-off in all reviews and decisions	-Program risk analysis
b) requirements	•Analyze the user requirements. •Present these requirements to project stakeholders for use in the development and operation of the system. •Identify any staffing gap and communicate requirement to design of staffing solutions.	-Value-based practices and principles (identify success critical stakeholder requirements) -Common Industry Specification for Usability Requirements -Environment/organization assessment
9. Development and evolution	•Maintain contact with users and the client organization throughout the definition, development and introduction of a system. •Evolve options and constraints into an implementation strategy covering technical, integration, and planning and manning issues. •	-Risk analysis (process and product) -User feedback on usability -Use models and simulation -Guidelines: Common Industry Format for usability reports -Performance measurement
10. Monitoring and control	•Analyze feedback on the system during delivery and inform the organization of emerging issues. •Manage the life cycle plan to address HS issues. •Take effective mitigation to address risks to system usability. •Take account of user input and inform users. •Identify emerging HS issues. •Understand and act on the results of the evaluation. •Produce and promulgate a validated statement of staffing shortfall by number and range of competence.	-Organizational and environmental context analysis -Risk Analysis -User feedback -Work context analysis
11. Operations and retirement a) Operations	•Analyze feedback on the system during delivery and inform the organization of emerging issues. •Produce personnel strategy. •Review the system for adherence to applicable human science knowledge, style guides, standards, guidelines, regulations and legislation. •Deliver training and other forms of awareness-raising to users and support staff. •Assess the effect of change on the usability of the system. •Review the health and well-being risks to the users of the system. •Review the risks to the community and environment arising from human error in the use of the system. •Take action on issues arising from in-service assessment. •Perform research to refine and consolidate operation and support strategy for the system.	-Work context analysis -Organizational and environmental context analysis
b) Retirement	•Collect and analyze in-service reports to generate updates or lessons learnt for the next version of the system. •Identify risks and health and safety issues associated with removal from service and destruction of the system. •Define how users will be re-allocated, dismissed, or transferred to other duties. •Plan break-up of social structures. •Debriefing and retrospective analysis for replacement system.	
12. Organizational capability improvement a) HSI capability data collection, analysis, and improvement	•Identify and use the most suitable data formats for exchanging HF data. •Have a policy for HF data management. •Perform research to develop HF data as required. •Produce coherent data standards and formats. •Define rules for the management of data. •Develop and maintain adequate data search methods. •Feedback into future HR procurement, training and delivery strategies.	-Assess and improve HSI capability
b) Organizational skill/career and infrastructure development planning and execution	•Define usability as a competitive asset •Set usability, health and safety objectives for systems •Follow competitive situation in the market place •Develop user-centred infrastructure. •Relate HS issues to business benefits. •Establish and communicate a policy for human-centeredness. •Include HR and user-centred elements in support and control procedures. •Define and maintain HCD and HR infrastructure and resources. •Increase and maintain awareness of usability. •Develop or provide staff with suitable HS skills.	-Develop and maintain HSI infrastructure and resources -Identify required HSI skills -Provide staff with HSI skills -Establish and communicate a policy on HSI -Maintain an awareness of usability

	•Take account of HS issues in financial management •Assess and improve HS capability in processes that affect usability, health and safety. •Develop a common terminology for HS issues with the organization. •Facilitate personal and technical interactions related to HS issues. •Feedback into future HR procurement, training and delivery strategies. •Create capability to meet system requirements in the future (conduct succession planning) •Identify any opportunities for redeployment. •Develop a strategy for [HR] data gathering	