ERGONOMIC RECOMMENDATION FOR ATM DESIGN

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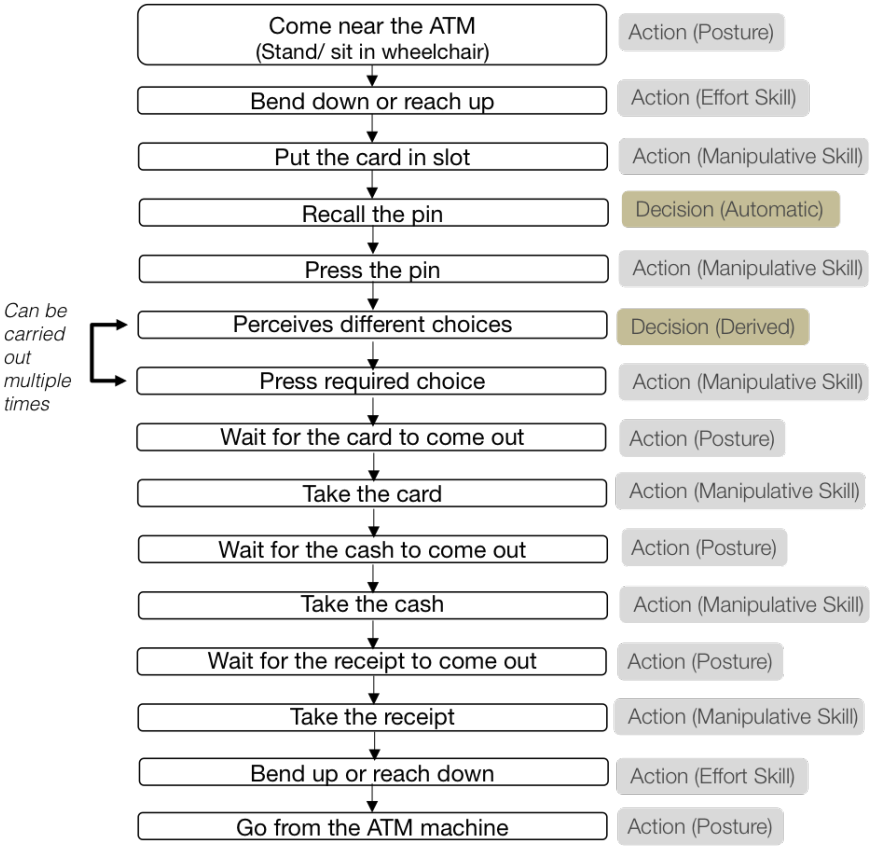
Automated Teller Machine (ATM) is a universal money withdrawal machine provided by majority of the banks around the world. All the users using the ATM are the target users of the ATM. Major UK banks have programs to offer ATM debit cards to children over the age of 11 years old (Barclays[1] & HSBC[2]). This makes the target user population too broad with a wide range of limiting users and abusers. Limiting users are the group of users that are the tightest fit to the design. ATM abusers are the people directly or indirectly trying to harm the system.

The task of using an ATM comprises of various activities, and activities happens within a context. Therefore, contextual analysis can be undertaken to analyse the target user in different context to figure out the limiting users and abusers. Three types of context are considered viz. organizational, social and physical. Organizational context is the top-down approach to know the banks relationship with customers and its working culture that might affect the ATM usage. Social context defines the time taken per transaction and the waiting time in the queue. Physical context represents the ATM's location, security considerations and environmental conditions such as sunlight, rain and noise [3].

From the contextual analysis, the limiting users found are visually impaired people, old people, wheelchair users, hearing impaired people, pregnant women and tourists. For example sunlight falling directly on the ATM screen will affect the visibility, specifically making it difficult for people with weak eyesight to use the ATM such as visually impaired and old people. Similarly, the abusers found are thieves sneaking over the ATM user's shoulder (commonly known as "shoulder surfing" [4]), bank staff, identity theft, street beggars, public demonstrators and heavy alcohol consumption people. Example of an abuser through contextual analysis can be a bank staff or an individual who installed the ATM machine, who can engage in data breaches or other such frauds.

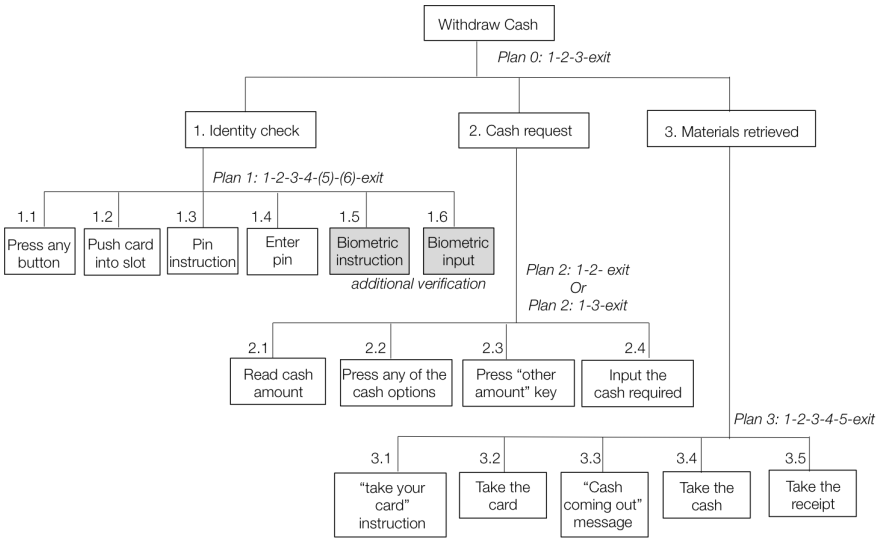
Task analysis is performed to find the user's goals, how the user is achieving those goals, what factors are influencing and affecting them during the completion of the goal. Firstly, a simple task analysis (shown in figure 1) is done by breaking down the tasks into interactions or task elements. This

Figure 1: Task description of withdrawing cash from ATM



makes it easy to understand what kind of action the user is going to take and does it depend on cognitive or physical actions.

Figure 2: HTA of Cash withdrawal process from ATM



Hierarchical task analysis (HTA) is performed next(shown in figure 2) for error identification in an interactive system. By analysing the tasks and subtasks it can easily help us to see what kind of errors might occur.

Hexagon-spindle model can also be considered to determine the problems that are of ergonomic concern over time. As ATM involves a wide range of users and tasks this model can provide holistic approach to identify the key issues in organisational, personal and contextual sector [5]. However, due to the short transaction time per user in the ATM this would not have a high impact compared to a more dynamic setting with high usage time.

1 WORKSPACE DESIGN

Workspace is the space in which a particular task is performed. In this particular scenario, the workspace for ATM is located in an outdoor environment. It is set-up with a hole in the wall along the footpath. Workspace design will include factors such as reach, posture, clearance, access, safety and security, vision and strength of the user [6].

Table 1: Facts and statistics

Physical weakness	**Population in UK**
Wheelchair users	1.2 million [7]
Visually impairment	2 milliom [7]
Elderly people	10 million [8]

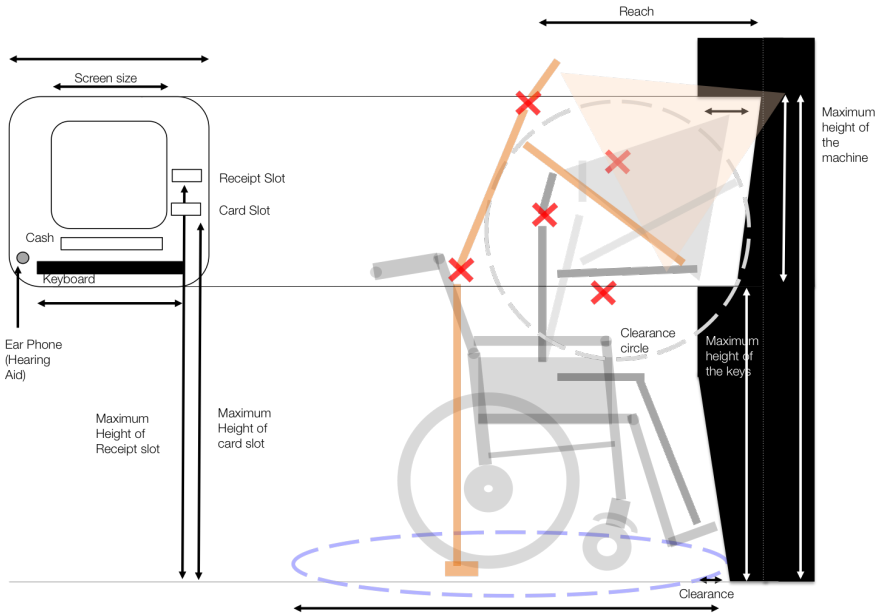
Inclusive design principles would include anyone using the ATM should be comfortable [9], therefore it is important to focus on the limiting user for whom the constraints would be maximum. Limiting user with the most direct impact on the workspace design is chosen, i.e. the wheelchair users. Moreover the wheelchair users have high level of physical disabilities which imposes a lot of constraints and in UK there are up to 1.2 million wheelchair users (see table 1).

Contextual analysis is limited to the actions that occur in the context. A detailed analysis is needed on various actions performed which can be achieved by involving the stakeholders. Therefore, stakeholder analysis is necessary. This can be done by interviewing the users and the maintenance staff of the ATM to bring insights such as suggestions, advice and problems, as they are directly under the influence of ATM workspace. For example from the interview with the maintenance staff, it was found that the workspace should have constraints and security measures which are difficult for the ATM service users to access but on the same time should be easily accessible to the maintenance staff.

On-site guerilla observation can be helpful in different ways. Guerilla observation provides a unbiased natural way of people using the ATM. It can help to understand the way people use street ATM machines in UK, the postures they make, the body parts they use for executing the task, their reactions to in-situ environmental conditions and the way they handle things they carries in their hands.This could be done as a pedestrian, although this might include privacy and ethical issues which needs to be considered and in some case permission can be taken from the user. For example: An user showed discomfort when sunlight was directly into the screen making him use his other hand, this also made the posture a bit uncomfortable

and increased the transaction time. This could be frustrating for someone standing in the queue. In such conditions the display of the ATM could use anti-reflective coating. For extreme environmental conditions protective glass, that could protect scratches, dust, rain etc can be used to withstand the weather. Whereas, during the night the ATM should be well lighted.

Figure 3: A general overview of workspace of an ATM with a normal user and a wheelchair user



Ergonomic standard data provided by the government needs to be applied in various circumstances of designing the ATM. For example the clearance of the wheelchair user, which in this case is the limiting user, can be according to the standards. The data about the wheelchair users could be used as par the British Standards (BS:8300) "Design of buildings and their approaches to meet the needs of disabled people – Code of practice" [10].

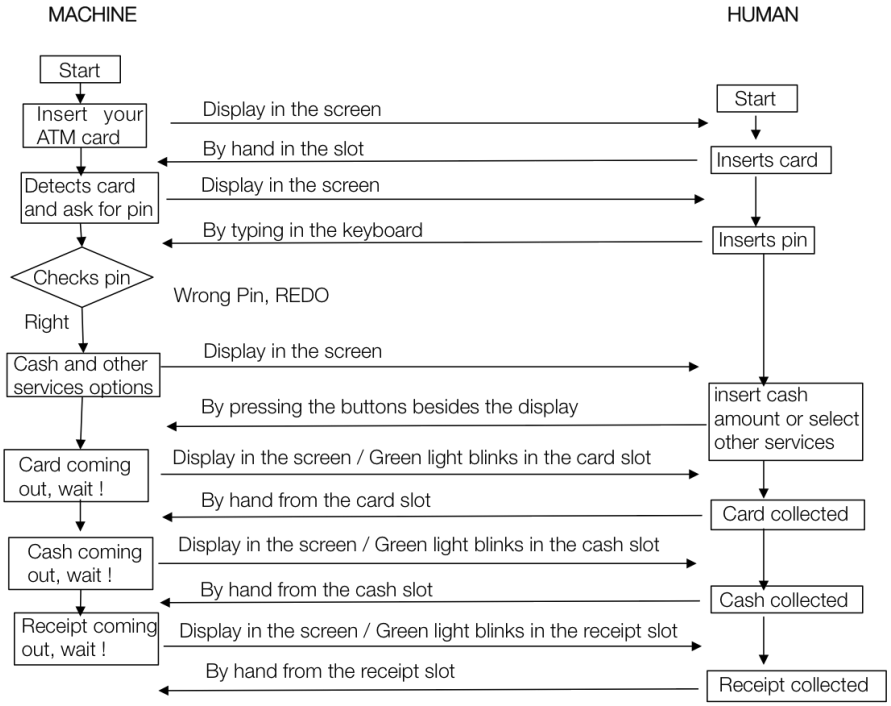
Static and dynamic anthropometric data can be used to find out the three dimensional(3D) space where the physical task is been executed at that fixed location. For example anthropometric data can be used to find out the reach of the slots. There are three slots used for input and output. This includes the card slot for entering and returning the card, the money slot through which money comes out of the machine and the receipt slot through which the receipt comes out. Further anthropometric data can be used to find out the visibility angle for the interaction area (the area in workspace where the user interacts with the machine physically), the reach of the buttons and the keypad. We use 5%ile of the limiting user to decide the reach while 95%ile of user could reach everything within the 3D space with this measurement. For example to calculate the reach of the ATM keypad a combination of data from anthropometric measures and British standards are needed. In this case, it is the reach of the 5%ile of a female wheelchair user, where wheelchair data is taken from British standards(BS:8300) and the dynamic stature of female sitting taken from the anthropometric measures. However, anthropometric data are theoretical estimation which might be limited to

the existing data, therefore the measurements needs to be adjusted through a proper fitting trial.

Mock-ups and fitting trial will give a subjective view as we are designing for humans and factor such as strength and comfortability are subjective. A sample size of different users along with the limiting user will be more effective. It is important to see if real users can use it without any discomfort and same comfort. A limited sample size can be biased, but role-play with different set-up can be used by the designer to know the users feeling and comfortability. For example, a role-play can be done by using a chair with the same height of a wheelchair for replicating the wheelchair experience and using the wall to check if the anthropometric data are comfortable and within reach.

2 HUMAN–MACHINE INTERFACE DESIGN

Figure 4: Partial operational sequence diagram of Cash withdrawal process from ATM



Usability deals with efficiency, effectiveness and satisfaction [11]. Considering the ergonomic factors into the human-machine interface design will increase the usability of the ATM system. Hence, increase in usability will decrease the training time while increasing the productivity of the system.

Gathering user requirements is the most important task while designing for human-machine interface. This will give insight on various kind of task the ATM can be used for which will be useful to analyse ergonomic concerns. Stakeholder interview are useful to gather goals and requirements, primarily by interviewing with the bank staff. For example the interview with the bank staff will provide information on the kind of services the

bank offers and how the bank was offering such services before ATM?; If the machine is replacing the task of a human, how the human to human communication (i.e the interaction between bank staff and bank user) was carried out and the set of instructions and authentication followed at such consequences?; What kind of maintenance work and at what time of the day will it be carried out?.

Partial Operational Sequence Diagram (Partial OSD) (see figure 4) is used to understand interaction and information flow between the interface and the ATM user. It also gives an insight on the problems that would affect the task. From Partial OSD, it was found that the primary interaction between the ATM user and the system was done through the user's eyes and fingers. Therefore, weakness in the sense of vision and sense of touch will be the highest level of constraint affecting the usability of the system. Based on these factors limiting users were chosen from the target users, i.e. the visually impaired people and the old age people. Visually impaired people lacks sight whereas old age people lacks both strength and vision due to age. Considering the limiting users, it is preferable to have hard-wired component such as keypad and buttons as input to the machine such as entering the pin and selecting choices of transaction. Hard-wired components would give tangible feeling as input to the user while output can be display, lights and sounds. While display is the primary output. Sound can be used for various alert tones but more importantly it can be the secondary mode of feedback for people lacking vision.

Based on partial OSD, three key ergonomic issues were found, namely: privacy, cognitive load and environmental conditions such as ambient noise, sunlight. For example, ambient noise brings hearing issue that can be critical for visually impaired people as for them sound feedback is important for using the ATM. Therefore, earphone slot can be installed in the ATM dock and the users might be recommended to use an earphone for better hearing; and to reduce the cognitive load of searching for the card, receipt and money slot, video can be shown in the display while flashing light and alert sound could be helpful indicating machine is giving out cash or returning the card or receipt.

Contextual analysis that was used to find limiting and abusers can be important for human-machine interface as well. For example through contextual analysis it is realised to have an optional blind mode that could be used to activate instructional speech from the machine. Also this analysis hints us to consider security and context that can avoid shoulder surfing by disabling the display in blind mode and ignoring the ambient noise by use of an earphone.

While designing the hard-wired input component such as buttons and keypad, ergonomic guidelines must be followed on various factors, few of those are mentioned below. *(Note:The following guidelines are based on [12])*

1. The **size and shape** of the buttons needs to be easily recognizable with affordance of pressing.
2. The **labelling** of the buttons should be engraved in a way that it is easily recognizable by touching the button. Braille text should also be imprinted while labelling.
3. **Colour coding** can be used for sequencing and grouping the buttons according to functionality.
4. Display and hard-wired components relationship should be **mapped** accordingly, so that proper **feedback** can be seen with each press of

the button. Also, correct sensitivity is necessary for the buttons to react accordingly.
5. Use of **stereotypes** is important for identifying colors, labels etc. Stereotypes can be natural, cultural and standard.
6. Comfortable button press needs to be designed which can be pressed with minimum **strength**.
7. Affect of environment is important. For example back-lit can be used in the night etc.

Display is the most important feedback system. It should be easy to read, clear, simplified and of high resolution. Display can heavily reduce the cognitive load of the ATM user. Norman's ten principle of heuristics [13] are proven to be effective in interface evaluation and using those principle for taking ergonomic decisions is important. For example, recognition than recall could help reduce the mental load by guiding the user in each step with instructions rather than having a tutorial before the transaction. Other guidelines that can be considered are familiarity, consistency and visibility which includes standards, fonts, navigation, colors and context-awareness [12].

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