



Deposited via The University of Sheffield.

White Rose Research Online URL for this paper:

<https://eprints.whiterose.ac.uk/id/eprint/10291/>

---

**Monograph:**

Judge, Simon and Colven, David (2006) Switch access to technology - A comprehensive Guide. Manual. The ACE Centre , 92 Windmill Road Headington Oxford OX3 7DR.

---

**Reuse**

Items deposited in White Rose Research Online are protected by copyright, with all rights reserved unless indicated otherwise. They may be downloaded and/or printed for private study, or other acts as permitted by national copyright laws. The publisher or other rights holders may allow further reproduction and re-use of the full text version. This is indicated by the licence information on the White Rose Research Online record for the item.

**Takedown**

If you consider content in White Rose Research Online to be in breach of UK law, please notify us by emailing [eprints@whiterose.ac.uk](mailto:eprints@whiterose.ac.uk) including the URL of the record and the reason for the withdrawal request.

# Switch access to technology

A comprehensive guide

David Colven & Simon Judge



## Acknowledgements

The authors would like to thank the many people who over the years have contributed new ideas to this field. Thanks in particular are due to the staff of the ACE Centre, CALL Centre and ACT who have given much useful feedback and shared their considerable practical experience.

We also acknowledge the group who came together to create the original document, *A Common Terminology for Switch Controlled Software*<sup>1</sup>, on which this one is based. That group being Mike Detheridge, David King, Chris Page, Peter Head, Patrick Poon, Stan Cocking, Roddy Boyes, Robin Beste, Chris Hopkins, Paul Skinner, Jeff Wardle, Paul Nisbet and Robert Wills.

David Colven      david@ace-centre.org.uk  
Simon Judge      simon.judge@sbpct.nhs.uk

©2006 ACE Centre Advisory Trust and ACT (Access to Communication in Technology)

First edition published June 2006

Published by the ACE Centre Advisory Trust  
92 Windmill Road  
Headington  
Oxford  
OX3 7DR  
[www.ace-centre.org.uk](http://www.ace-centre.org.uk)

Cover artwork: Michelle Turton [www.michelleturton.co.uk](http://www.michelleturton.co.uk)

# Switch access to technology

A comprehensive guide



# Contents

## Introduction 1

## Terminology 3

## Alternative Access Systems 5

The Spectrum of Input .....	5
Switches .....	5
Direct input devices .....	6
Alternative Pointing Devices .....	6
Keyboards .....	6

## Characteristics of Users 7

Motor Control Problems .....	7
Visual Problems .....	7
Cognitive involvement .....	7
Developmental Needs .....	8

## The User Interface for Switching 9

Presenting choices .....	9
Selection sets .....	9
Single line presentation .....	10
Grid presentation .....	10
Flip chart presentation .....	10
Pop up presentation .....	10
Custom presentation .....	10
Items .....	10
Grouping .....	10
Highlighting .....	11
Feedback and Output .....	12
Aesthetics .....	12

## Control and Selection 13

Scanning Sequencing Methods .....	13
Simple Scan .....	13
Group Scan .....	14
Directed Scan .....	15
Highlighter movement control .....	15
Autoscan .....	15
User Scan .....	16
Critical Overscan .....	16

Step Scan .....	17
Step Scan Switch Alternation (Swap Switch) .....	17
Manipulating the Highlighter Movement .....	18
Auto – Restart, Starting and Restarting .....	18
Repeating items .....	18
Dealing with errors .....	18
Error items: .....	18
Scan errors: .....	18
Selection.....	19
Dwell Selection .....	19
Switch Encoded Selection.....	19
Combinatorial Encoding: .....	19
Time Encoded Selection.....	20
Switch Actions .....	20
Type Ahead .....	20
Numbers of Switches .....	20
Half Switches.....	21

## Timing and Input Filtering 23

Timing parameters .....	23
Scan Time .....	23
Initial Scan Time .....	23
Scan Pause .....	23
Dwell Time .....	24
Repeat Functions.....	24
Repeat Delay .....	24
Repeat Time .....	24
Auto-repeat .....	24
Input Filtering .....	24
Debounce Time .....	25
Acceptance time .....	25
Post-acceptance Time .....	25

## Conclusions 27

## Appendix 1: Connecting switches to a computer 29

Switch Software .....	29
Ports .....	29
Switch Interfaces.....	30
USB .....	30
Keyboard.....	30
Parallel Port .....	30
Older Interfaces .....	30

## Appendix 2: Switch control of systems 31

## Appendix 3: Summary of Terminology 33

## Appendix 4: Ports and interfaces for switch access 37

## Appendix 5: Summary of parameters and values 39

Some suggested parameter ranges.....	39
Data file structures.....	40
User configuration selection.....	40

**Appendix 6: 41**

**Implementation of scanning within software 41**

Minimum implementation.....	41
Connections.....	41
Switches/Devices.....	41
Scanning methods.....	42
Small selection sets (less than 10 items).....	42
Larger selection sets.....	42
Pull down menus.....	42
Point and click environments.....	42

**Selected Resources 45**

Resources.....	45
----------------	----

**References 47**



# Introduction

You can skip this section if you are already familiar with scanning and assistive technology - you may wish to start from the *User Interface for Switching* chapter on page 9.

Most of us take typing for granted, even if some of us aren't very good at it. Most of us are also used to being able to speak, turn on the lights and be mobile – all normal interactions with the world. But for a significant part of the population some or all of the above are difficult or impossible. For some people their interactions with the world take place through a single switch – imagine having to control everything you want using a light switch. Small differences to how you use this switch will make a massive impact on your life! This is the reality for a number of people. Consider Stephen Hawking, or Jean-Dominique Bauby who wrote *The Diving Bell and the Butterfly*<sup>2</sup> by blinking an eyelid.

Surely it's only possible to control a *single* thing using a *single* switch? Not so. With the sacrifice of time, it's possible to control as many things as you want – be it the lights in your house, a virtual keyboard on a computer, a games console, or a communication aid.

Scanning is the answer to controlling many things by using a single indication or switch: to scan a list of things, each item is presented to you one at a time, and you indicate (for example by blinking or pressing a switch) when the thing you want is presented. It's a bit like a sushi bar, you can't reach all the dishes from where you sit, and you have to wait until the one you want turns up in front of you.

Scanning isn't actually that specialist – if you look you will see it all around you. With a single switch the speed at which you select things is under the control of a system, like the sushi bar moving at a continuous rate. If you can use two or more switches then it *may* be easier to control the scan yourself. This is common on mainstream technologies such as television on-screen menus and mobile phone controls, and is also hidden in other things. You can, for example, access the Internet with just two keys, Tab and Return. Tab takes you from link to link, and Return chooses the link – try it out.

It usually requires specialist software to give a user effective scanning. There's a range of software and devices, collectively known as Electronic Assistive Technology (EAT), that are designed for switch users. Whatever an EAT device looks like, it's almost always controlled by software run on some sort of computer.

Over the years, in order to give users flexible and efficient access to their environment, Assistive technology software engineers and practitioners have developed specialised scanning techniques for communication, environmental control, mobility and leisure activities. This document describes these techniques and the processes behind them.

# Terminology

Switch control of computers and other equipment via scanning systems is an area where a confusion of terms has grown up over the years. This paper contains a terminology lexicon which agrees as closely as possible to that currently used in the UK and within the English-speaking community. Where there are alternative terms, these are cross-referenced. Terms follow closely those published in *A Common Terminology for Switch Controlled Software*<sup>2</sup>. A summary of terms is also included in Appendix 3 (page 33).

Sticking to a defined terminology has several important advantages. Standardisation is essential for any area that wishes to mature and grow:

- It allows a constructive discussion on the topic and avoids confusion.
- It allows standardised storage of parameters surrounding switch access, thus making 'porting' of users settings between software and 'tailoring' software easier.
- It promotes the potential for a universal access module (as proposed by Lundlav et al<sup>3</sup>).
- It encourages further research and development and ensures and ensures that this is clearly defined.

Before looking at the various variables and characteristics of switch scanning in later sections, we'll introduce a range of alternative input devices and some of the characteristics of users of such systems.

For ease, we'll refer to 'Software' – however we are including any assistive technology incorporating switch access.

“Standardization is simply another aspect of cultural constraints. With standardization, once you have learned to drive one car, you feel justifiably confident that you can drive any car, any place in the world... When we have standardization of our keyboard layouts, our input and output formats, our operating systems, our text editors and word processors, and the basic means of operating any program, then suddenly we will have a major breakthrough in usability”

Don Norman, *The Psychology of Everyday Things*<sup>4</sup>



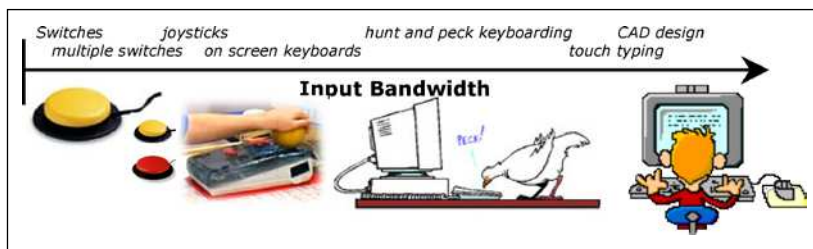
# Alternative Access Systems

In this section we deal with alternative access systems – we describe the range of equipment used for alternative access to computers and other technology. In addition we describe the characteristics of some users of alternative access.

## The spectrum of input

There is a considerable range of alternative access systems to assist users of technology and an even greater range of access difficulties that may present themselves. The following list is designed to give just an indication of this range. In this document we are principally considering the use of switch control.

Input to a computer can be considered described on a spectrum or in terms of bandwidth: Touch typists and computer-aided-designers at one end, hunt-and-peck typists in the middle and switch users at the other end.



**Fig 1: The input bandwidth spectrum**

## Switches

A person who may only have one or two reliable physical movements may be able to use switches if the switches are placed in the correct place. An enormous range of switches is available from many suppliers. The ACE Centre website links to many of these suppliers' sites.

Switches come in a large range of sizes and can be placed almost anywhere and accommodate most types of movement. The largest group of switches are for limb or head operation. These include simple lever or pressure switches that can be used with a single movement of any part of the body. Grip and thumb switches, pneumatic pressure switches, tilt or posture switches, touch and proximity switches and even 'wobble' sticks also exist.



**Fig 2: A standard switch**

This transmits just one bit of information: on or off. However for some people this is their means of interface with the world.



**Fig 3: Child using a touchscreen**

Touch sensitive screens are commonly used as an alternative access device, as well as on 'mainstream' devices. Touchscreens are now very accurate but require a very fine level of control on the part of the user. They can be particularly useful for the developmentally young - giving direct and immediate access to 'dynamic' keyboards and content.



**Fig 4: Child using a concept Keyboard**

The Concept Keyboard and Intellikeys are types of touch sensitive boards that can be configured into any keyboard layout. Any number of keys and labels can be used (e.g. symbols, pictures etc). These membrane keyboards are very popular because of their flexibility of input to the computer.

Other switches can be operated by suck, blow, blink, muscle, sound or almost any other voluntary action.

### **Choosing switch settings for users**

The number of switches a user needs is the principle setting, although this choice may change as the user progresses. All the other settings are generally subsidiary; depending on the user's other abilities and needs. Details of the settings needed for switch controlled scanning systems are documented in the Control and Selection chapter on page 13.

## **Direct input devices**

### **Alternative Pointing Devices**

These include mice, tracker balls, joysticks and touch sensitive screens and devices such as head or eye pointers. It must be noted there are two types of joysticks: the analogue joystick and the switched joystick, which is really a number of switches in fixed positions operated by a single lever.

Most software now uses the mouse pointer for control, often providing no alternative. The mouse not only requires moderate to good hand/eye co-ordination but also very good fine motor control – and a wide range of users may struggle with its use. The use of alternative mice such as trackerballs and joysticks can alleviate some problems.

### **Keyboards**

The standard keyboard can be regarded as a multiple switch bank. Alternative configurations of keyboards, one handed keyboards, keyguards, and other alternative physical keyboards exist.

Users who are able to manipulate a mouse cursor but who are not able to use a conventional keyboard might use an On-Screen Keyboard.

# Characteristics of Users

A wide range of disabilities and conditions (including old or young age) will affect people's interaction with technology<sup>5</sup>. It is not possible to list all the conditions, their characteristics and how they effect someone's access to technology – not least since each person is entirely unique. The sections below give a guide to some of the characteristics of users that are relevant to access.

## Motor control problems

The ACE Centres' work is focused on children and young people. 60% of the children seen at the ACE Centres have cerebral palsy, the majority of whom have severe athetosis. This means that their fine and/or gross motor control is often very poor and as a result they may only be able to use one or two switches. Regional Assistive Technology services, such as ACT, see a wide range of people, including adults with degenerative neurological conditions, such as Motor Neurone Disease (MND). People with MND and other conditions will experience deterioration in their physical ability whilst often retaining fine control of some muscles (e.g. a finger, or eyelid). In addition people with traumatic injuries (such as stroke or spinal cord injury) will experience sudden changes in their physical function maybe including complete paralysis of a majority of their body.

## Visual problems

Some Assistive Technology users may have visual or visual perception problems – these may be often be in conjunction with other problems and may be undiagnosed or even unrecognised. The implications of this to switch interfacing mainly impinge on the selection of scanning methods (see below); feedback through other media and aesthetic issues of size and contrast.

## Cognitive involvement

The use of switches and the process of scanning can be a relatively complex task and different methods require a number of prerequisite skills. People with learning, memory, processing or other cognitive and learning problems may have different needs (for example increased support or simpler structures) with respect to switching and scanning, compared with others.

## Developmental needs

Users of switch controlled system do not remain static in their needs. Switch systems must, therefore remain flexible in terms of types of control, scanning and response so that they can always match the user's needs.

A typical user would tend to move through a series of different control methods as they mature and develop. Their control may improve or deteriorate. For example, at first they may use single switch with cause and effect programs, they may then progress to making choices with a very slow single switch automatic scan. Alternatively, a two switch step scan where they have complete control of the scan with one switch and item selection with the second switch may be best.

Some people will develop sufficient compensation or control in movement combined with learning and practice, so that their access through scanning can further improve in either speed and/or method.

However, this over-simplification hides a range of needs that can be helped by quite subtle differentials in switch interfacing. In the next section we will illustrate the range of different methods of presentation of choices, before moving on to look at the different methods of choice selection. The application of these possible variables to provide an appropriate switch interface for a user is the black art of switch scanning.

# The User Interface for Switching

In this section we explain the process of controlling the computer / software with switches. Users who access computers with one or two switches generally do so by means of on-screen selection sets, also known as keyboards, grids or pages etc (there are other methods of providing a user-interface for switching, such as coded input). Items in the selection set are highlighted either one at a time or in groups to allow the user to choose the desired item. The different methods of layout are detailed in this section.

## Presenting choices

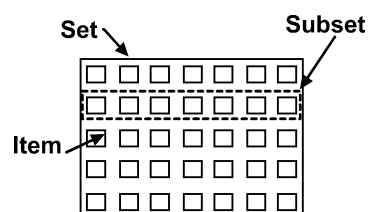
To input information into a machine you need to have information presented to you in a form that allows you to make an informed selection. For keyboard users this selection is through pressing a labelled key on the keyboard – this can be thought of as a bank of some 100 or so switches for which each switch represents a single possible item.

A disabled user may want to input the same information with just a single switch. To do this, time is introduced into the procedure – i.e. a sequence of items is presented to the user at a pre-defined rate, the desired item is selected by the user activating the switch at the appropriate time. Scanning is the process of presenting the possible items for selection. These methods are described in more detail in this section.

## Selection sets

The set of all the items from which choices are made is called the selection set. At any one time it may be more appropriate to present only a sub-set (or group) of this – this is discussed further in the Control and Selection chapter on page 13.

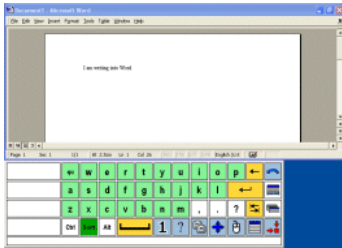
If the number of items is larger than can be displayed on one screen (page) then further pages are required. The set can now be thought of as a book or card index rack with some items providing links between the different pages/cards.



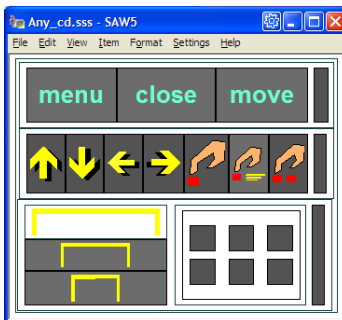
**Fig 5: Sets subsets and items within a selection set**



**Fig 6: Single Line Presentation (Clicker Talking Book)**



**Fig 7: Grid Presentation (The Grid)**



**Fig 8: Custom Presentation (SAW)**

There are a number of ways of presenting a selection set to the user:

**Single line presentation (see fig 6)**

Where the visual representations are in a single simple line - 'line' is used rather than 'row' so as to include all possible orientations.

**Grid presentation (see fig 7)**

When there are large numbers of items it can be convenient to present them in the form of a two-dimensional grid.

**Flip chart presentation**

Individual items, or some parts of the selection set, may be displayed one at a time in sequence rather like turning the cards in a rotary file index. The existence of other parts of the selection set may be indicated behind the part currently displayed.

**Pop up presentation**

Pop ups are pages (groups) that are displayed 'within' the current page. Normally a new page would replace the previous one. Pop ups are usually only displayed for the time required to make a single choice.

**Custom presentation (see fig 8)**

There may be cases where it is best to use some quite non-standard method of presentation. This allows items to be given higher priority or visual prominence, or for customisation to a particular application or task.

**Items**

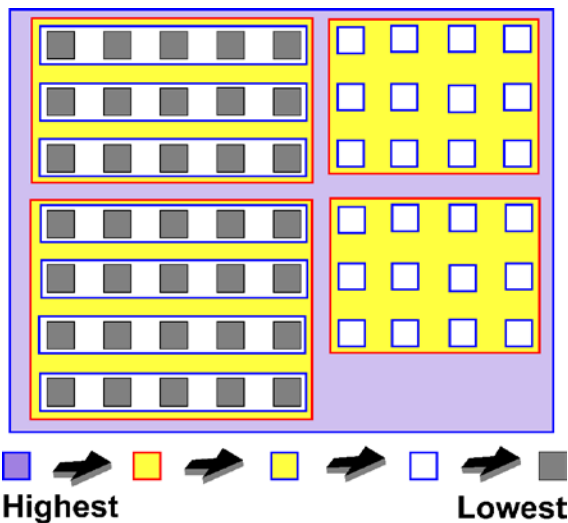
A single element of an on-screen selection set is called an item (or cell). For an 'on screen keyboard' the item would represent a letter. However items can represent a range of options:

- Alphanumeric characters (letters, numbers etc)
- Words
- Pictures or symbols
- Sounds (including text-to-speech)
- Concepts
  - Navigation to another page (on a theme)
  - Encoded symbol linking
- Functions
  - Computer control
  - Environmental control
  - Internal operations (scan speed etc)
- Link items – link to another group/page of items (see below)
-

## Grouping

When there are a large number of items to choose from some level of grouping is required. Groups (or sub-sets) may be presented in a variety of formats: pages, tabs, views, rows, columns etc.

In general items can be constructed into a selection set in a layered hierarchy. At the lowest level there are individual items. These can be contained within groups which themselves can be within super-groups etc. Each level may have an associated range of properties that describe the appearance and actions of items.



**Fig 9: Scanning Hierarchy**

The lowest level items are not necessarily at the same level of the hierarchy

Most 'simple to medium' complexity switch input systems allow a two level hierarchy of scanning. Some are more complex, allowing for an unlimited hierarchy. There are good arguments for both approaches.

To reduce the amount of visual load of scanning systems the total selection set is often sub-divided into groups which are displayed separately (normally called pages).

Moving between pages normally happens on selection of a 'link' item. This is similar to the concept of hyper linking on the Internet.

Where the number of items to be selected is very small (<10) then a simple single level, single page presentation is normally used.

## Highlighting

Highlighting is a general term for any system which indicates the currently active item (or group of items) in the selection set. An appropriate switch selection at this moment will select this item.

Visual highlighting is often used when an item (or group of items) is to be visually different from the rest – for example having a **thick red border**.

Auditory highlighting (also called auditory prompting) announces each item (or group of items) in turn as they are presented. Tactile or haptic (e.g. vibration) highlighting may also be provided.

## Feedback and output

Feedback is important to indicate whether a switch press has been detected or to confirm the action taken by the machine following a switch press. The output from the system will depend on the type of system and the items selected. In some cases (e.g. a communication aid) the output will mostly be obvious, however in other cases it will be more obscure and indirect (e.g. environmental control).

It may be particularly important to provide feedback for systems where there is not direct cause and effect between pressing a switch and the desired outcome/output or where the output is not obvious.

Visual feedback may be a change in the highlighting; auditory may be an announcement or beep. Options for visual and auditory feedback should contrast with the visual and auditory highlighting (e.g. different voice, sound or colour).

People with visual loss may require auditory representations (sounds or speech) or tactile/haptic representation (e.g. vibration, texture or position). A Braille keyboard might be the example of a tactile representation. Aural representation may involve the items being “spoken” with speech synthesis or pre-recorded speech.

## Aesthetics

The visual presentation is very important in order to ease and speed the process of making choices. For example, the screen background colour (paper colour) and the text colour (‘ink’ colour) of the selection sets should be configurable for use by those with visual problems to suit individual preferences. Ideally it should also be possible to control both the size and contrast of the visual representations.

Visual representation of items will depend on the item and system – however, they are generally letters, symbols, icons or pictures indicating the output resulting from selection of the item.

Having displayed the possible choices, we now need to allow the user to make the choice – there are a number of ways of doing this and these are presented in the next section.

# Control and Selection

Scanning is a general term used to describe the process of moving between and selecting items from a selection set using a switch or switches. Items or groups of a selection set are highlighted in turn over time. The movement of this highlighter and selection of the items can be controlled in the variety of ways described in this section.

We present information about scanning sequencing methods, the control of the highlighter, the manipulation of the highlighter movement and selection of the choice. All of these characteristics can be considered separately and are not necessarily interdependent. The choice of these characteristics will depend mostly on the requirements of the user, and to some extent on the complexity of the selection set itself.

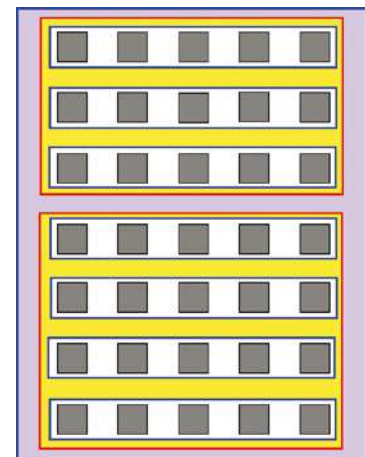
## Scanning sequencing methods

The scanning process involves a highlight moving from one item/group to the next in a set order through the selection set hierarchy. The scan normally starts in the top left corner and moves rightwards and downwards (although some cultural groups may prefer different scan directions). The scan sequence follows the selection set hierarchy and so the exact nature of the scanning will depend on the hierarchy imposed on the selection set by the designer.

When groups (pages) are used the scanning sequence method (hierarchy) is generally consistent across pages, however it could be set exceptionally for some pages. Popups can form for an invisible part of the page's hierarchy whereas pages do not.

### Simple scan

A simple or tracking scan has only one level and thus no hierarchy – although there may be multiple pages. The items are highlighted one at a time and selection is made when the required item is highlighted. The scan proceeds from one item to the next as programmed by the designer of the selection set.



**Fig 10: Selection set with groups at two levels: blocks (red) and rows (blue)**

## Group scan

In a group scan (see fig 10) the whole selection set is divided into groups of items and these are then individually highlighted (see the grouping section above). The user firsts selects a group, after which the individual items (or further groups) in that same group are scanned. The hierarchy of subgroups is scanned until one reaches the level of single items. When the item is selected the scan (usually) will be re-set to the top level again.

Obviously, groups can be any size or shape, however, a number of common forms exist:

### Row/Column - Column/Row Scan

Row/column and column/row scans (see fig 11) are special cases of the general group scan. They are set out in rectilinear grids where either the rows or columns are defined as the top level groups and the columns in the rows or the rows in the columns are the bottom level items. These set-ups have the advantage of being easily automated and are widely used in the UK.

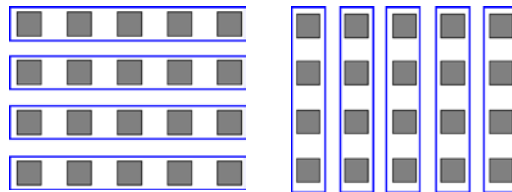


Fig 11: Row/column (left) and Column/row (right) scanning

### Mixed Row/Column and Group Scan

Some systems employ a mixture of group and row-column scanning – for example, a rectilinear grid can be initially split into two halves as super-groups and then inside these super groups there can be sub-groups with items arranged in rows and columns (see fig 12).

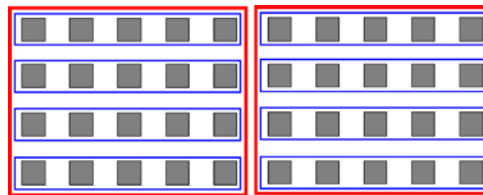


Fig 12: Mixed row/column scanning: selection set scanned by halves, rows then columns

### Progressive Segmenting Scan

Also known as 'scan direct', 'quartering', 'halving' etc... in this type of group scan the selection set is, with every selection, progressively split into two (or four). This provides a constant number of selections for any item on a selection set of a given size (see fig 13).

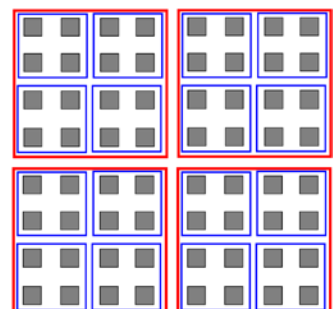
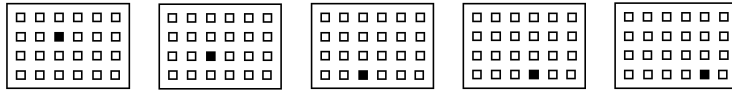


Fig 13: Progressive segmented scanning:

64 items arranged in a hierarchy selected by quartering the selection set. Any item can be chosen with three selections, choosing from four items each time

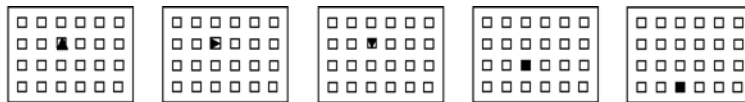
## Directed scan

Directed scans (fig 14 and 15) are used to emulate direct selection. The direction of the highlighter movement is controlled by switch operations. The scan movements required are Up, Down, Left and Right or combinations that give a 45-degree movement. The system has to decide which the next item in any of those directions is and send the highlight to that item. Selections can then be made either with a switch press or by dwell selection.



**Fig 14: Directional scan:** An example of a directional scan pattern and a set of directional switches (these could be in a switched joystick)

The 'natural' setup for this would normally involve one switch operation per direction, however fewer switches can be used, eg using Right and Down only and ensuring the scan loops back to the start when it reaches the edge of the page; alternatively this could involve a rotating arrow indicating possible directions of scan and a switch selection to implement that direction.



**Fig 15: Rotational, directed scan:** For one or two switches

In general it is difficult, though not impossible, to apply a directed scan to anything other than a rectilinear grid. The start point for directed scan layouts would normally be set at the centre of the grid to give faster access to extreme items.

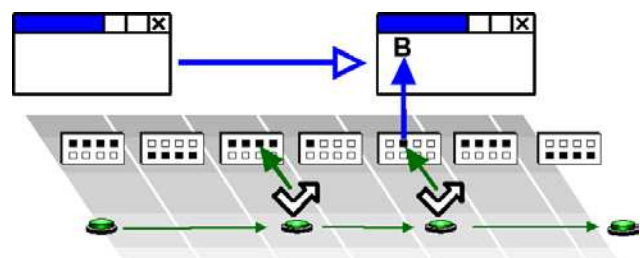
## Highlighter movement control

As we have seen the highlighter must move from group to group or from item to item. The timing of this movement can be controlled either by the switch user or by the machine. Where the machine controls the scan it is essential to be able to customise the scan speed to suit the needs of the user.

There are a large different number of different ways of controlling the scan from one item/group to the next. The methods listed below are those in common usage, however they should not be considered to be the only available methods. For simplicity, in the next section, we will use the term item to encompass individual items and also groups, in addition the term 'switch press' is used to mean any switch action (further expanded upon in the switch actions section below).

## Autoscan

With this scan method the device automatically progresses the highlight and the user presses a switch to select an item or group of items (see fig 16). The highlight starts at the first item in the selection set and scans the items in order. Once the last item has been scanned the scan repeats from the first item. When the switch is activated the currently highlighted item is selected. Autoscan generally requires a single switch.

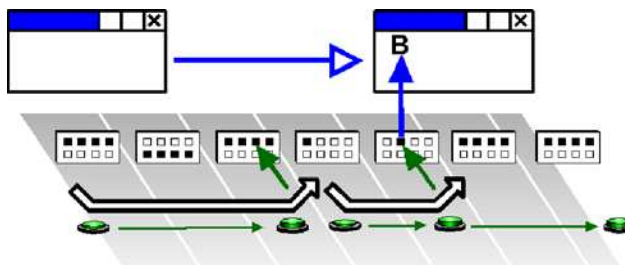


**Fig 16: Autoscan**

### User scan

With this scan method the machine progresses the highlight only whilst the user is activating the switch (see fig 17). User scan generally requires a single switch. In this case the scan does not start until a switch press is detected. The machine then progresses the highlight at a predetermined rate (as in autoscan) until the user releases the switch.

Fig 17: Userscan

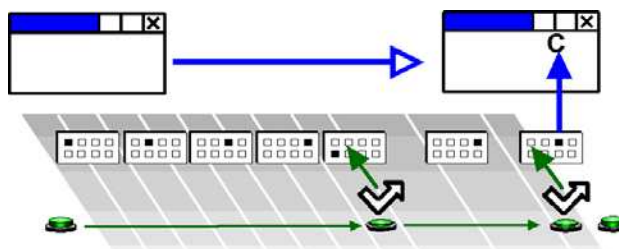


With a single switch the currently highlighted item is selected on switch release or after a dwell time. With two switches the second switch is used to activate the currently highlighted item and the first used to progress the scan.

### Critical overscan

This scan control is devised to give a rapid access to items in a large selection set without the complications of subsets. The machine controls the progression of the highlight which moves initially very quickly, the user then presses the switch to slow the scan and then select an item.

Fig 18: Critical overscan



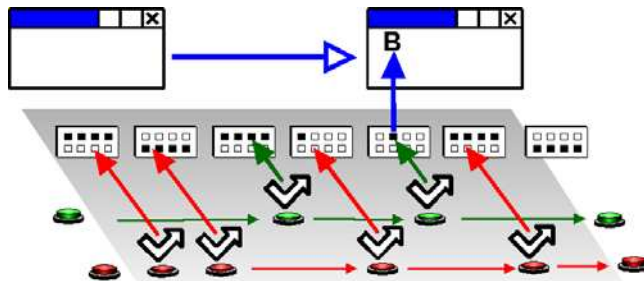
The highlight progresses as in Autoscan but at a significantly faster rate than the user's Autoscan rate. The user presses the switch at about the time when the highlight is on the desired item - however because of the scan speed the highlight will probably have progressed past this point. The highlight then retraces the items at the normal rate and the user activates the switch to select the desired item (see fig 17).

One possible problem with critical overscan is caused if this first switch is pressed too soon and the highlighter scans backwards away from the item the user wants. This can be ameliorated through appropriate setting of the scan, for example re-starting the fast forward scan after a certain number of slow reverse scans.

## Step scan

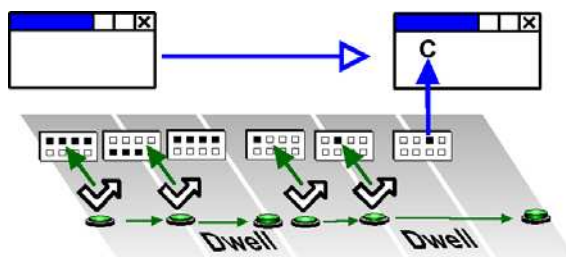
In step scan the user controls the movement of the highlight and the selection of the items (see fig 19). Step scan generally uses two switches.

Two switch use: pressing the first switch progresses the highlight by one item, the second switch is then used to select the highlighted item.



**Fig 19: Step scan (two switch**

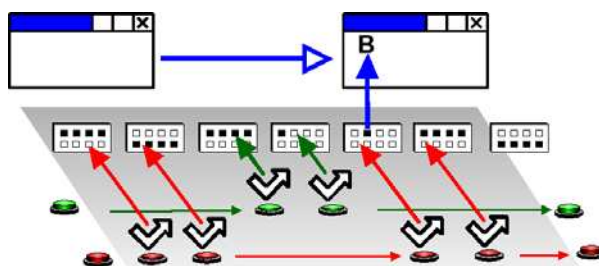
One switch use (see fig 20): pressing the switch causes the highlight to progress by one item, the item is selected either through dwell select or another method (see the 'selection' section below).



**Fig 20: Step scan (one switch use)**

## Step scan switch alternation (swap switch)

In the case of step scanning with two switches it may be desirable to alternate the function of the switches (see fig 21).



**Fig 21: Swap switch scan**

When the switch function is alternated this means that when a selection has been made with a particular switch its function swaps so that it becomes the switch which advances the highlighter. The other switch then takes on the role of selecting. After the next selection the roles reverse again. Alternating the switches may distribute the pattern of switch presses more evenly between the two switches.

## Manipulating the highlighter movement

As well as the alternative methods of moving the highlight, as listed above, it is possible to further manipulate the control of the highlighter movement.

### Auto – restart, starting and restarting

After selecting an item the highlight can be restarted by either continuing from the position of the last item selected, or by starting from the initial item again.

Starting and restarting the scan, can either be automatic (the machine restarts the scan) or manual (wait for the user to press the switch to start). Obviously this only applies for scanning methods where the machine progresses the scan highlight.

It may also be required to restart more complex scans after a given number of passes (for example to control selection errors in critical overscan - where after two slow backward passes (say) the scan restarts to move forward).

With scans where the highlight is moved by the machine, it may be beneficial for the system to highlight the first item for a longer period than the other items.

### Repeating items

On some occasions a user will want to be able to repeat the item that they have just selected (for example, channel up on a TV control). In general this is easier with two switches but should also be considered for other scanning methods.

### Dealing with errors

The cost of the errors for switch users is much greater than for other people since it takes more time and effort to correct wrong selections. There are a number of methods of correcting errors:

#### Error items:

- 'backspace' – this will undo the last character;
- 'undo'/'redo' – this should undo/redo the last 'operation'
- 'back' – this is specific to groups and pages and will reverse the last group/page change

#### Scan errors:

Errors in switch selections may not trigger an output, without a method of correcting a scan error the user is required to make an inappropriate selection and then undo that selection (a very costly process). Scan errors can be overcome in a range of ways:

- Empty items – to allow users to select an item that does not result in an output and resets the scan

- Cancel scan option – some systems have a specific method for ‘offering’ a scan cancellation – for example highlighting all the items in the current group.
- Switch manipulation – it is possible to use a specific type of switch activation (eg a long hold) to cancel the scan. See the ‘selection’ section below.

## Selection

The simplest selection process is where any currently highlighted item is selected by a switch action. In autoscan processes this will be the only switch action. In addition to these ‘standard’ methods of selection there are a number of other options, described below.

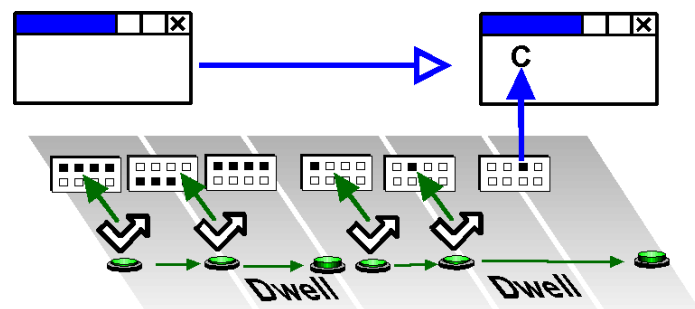
### Dwell selection

To select a highlighted item with this method, the user simply waits for a specified time (see fig 21).

For example, with a ‘User Scan’, the user may progress the highlight to the desired item using the switch, once on the desired item the user will wait – the item will be activated after the ‘dwell time’ has expired.

This method is not appropriate with some scan methods, for example Autoscan, since there is no opportunity to dwell!

This method is also used with other alternative access devices (described earlier) such as head pointers.



**Fig 22: Dwell selection**

### Switch encoded selection

In some senses, all types of (switch) access involve ‘encoding’ – you are sending information into the computer based on a ‘pattern’ of switch presses. As well as the methods described above there are other, more direct, methods of encoding.

#### Combinatorial Encoding:

Given two switches there are four possible combinations of switch states, off/off, off/on, on/off, on/on, with three switches there are eight combinations et. The ‘chording’ keyboards that court typists use between five and ten keys and allow the whole alphabet to be produced. You also use combinatorial encoding everyday when you press the ‘SHIFT’ key.

Combinatorial encoding can offer speed advantages (as seen by the court-typist scenario), but have other drawbacks.

With respect to switches, combining switches can be used for occasional ‘power functions’ (e.g. cancel/delete etc), to switch between modes (e.g. Environmental Control and communication) or other functions.

It is also possible to use this method with some scanning methods, particularly the 'Quartering/Halving' methods – where combinations of keys select indicated groups/items.

#### **Time Encoded Selection**

Switches may also be used in sequence – the classic example of this is Morse-code. With switch sequences the number of items that can be selected depends on the number of switch sequences allowed.

The selection is indicated by the number and/or timing of the key presses – think about the double click on a mouse, this is a time-encoded selection!

Time codes included Morse code<sup>6</sup>, both standard and two switch tapping systems. Examples of this type of system are included in some keyboard emulators and communication aids.

Either the relative or absolute lengths and sequences of switch presses can be monitored, for example: a long press is sometimes used to cancel a scan – monitoring the absolute length of the press; whereas morse code monitors the relative length of the dots and dashes.

### **Switch actions**

Usually it is the change of state of the switch from on to off, or from off to on, which causes the system to respond. The switch action from off to on is called the leading edge, (positive) and the action from on to off is called the trailing edge (negative).

In all the descriptions above we have assumed that it is the leading edge which the computer response to. This is called 'press'. If the computer responds to the trailing edge this is 'release'. It can be useful in some situations to give users the choice as to whether press or release triggers the system.

There are, however, some instances where events are not edge triggered, for example: in User Scan the system responds to both edges; repeating actions with some systems is enabled by holding the switch down.

### **Type ahead**

Type ahead is caused when presses are made as the programme is carrying out a slow process. Actions are stored in a buffer and fed to the programme as soon as the programme is ready. This can be useful, or a nuisance.

## **Numbers of switches**

The number of switches is a key determining factor in switch access, but actually, it is mainly a by-product of a number of other decisions (i.e. those detailed above).

The table below shows the common setups for different numbers of switches - it should be noted that this is by no way the only way of doing things. For example, adding half switches or combinatorial encoding could radically alter a user's switching setup.

**Table 1: Common scanning modes for different numbers of switches**

<b>No. of Switches</b>	<b>Common scan or selection modes</b>	<b>Other scan or selection modes</b>
1	Auto Scan User Scan	Step Scan with Dwell Select Halving with Dwell Select Critical Overscan Encoding (Morse)
2	Step Scan User Scan	Autoscan Halving/Quartering Time Encoding - Two Switch Morse Directed scan with Dwell select
3	Auto Scan Step Scan User Scan All with repeat or reset on the third switch	Directed Scan Halving/Quartering Encoding with Quartering
4	Directed scan – Dwell Select Directed scan – Switch select	Combinatorial Encoding (e.g. Chording) 'Direct' Quartering
5	Directed scan - all directions & select	Combinatorial Encoding (e.g. Chording)
Multiple	Encoding Directed Scan Direct access	Keyboard Combinatorial Encoding (e.g. Chording)
Half Switches	Adds an extra functionality to any of the above for infrequent use.	

## Half switches

An extra switch is often added to scanning systems where an infrequent action or 'power function' can be assigned to it. Even switch users with poor control can sometimes utilise this extra 'Half switch' to do things like changing between computer control and wheelchair driving. A half switch would always be used to achieve a single function, i.e. it would not be used as part of the scanning process.



# Timing and Input Filtering

In addition to the possible different scan methods described in the previous sections, a range of other parameters exist with respect to the timing of the scanning process. Most of these timing parameters apply to Automatic scan methods although a few of them will also apply to scanning movements controlled by the user.

The various parameters are described below; again these are not necessarily exhaustive. Many systems use essentially random measures of time (based on the system clock) – this causes variability across systems. There is a sensible and well established unit of time that could be used - the second (millisecond)!

## Timing parameters

### Scan time

This is the time it takes for the highlight to move from one object (group or item) to the next. Where appropriate the switch user should be able to change the speed themselves. If this option is provided there must be a mechanism by which the user can escape from a situation where the rate is set to fast! A short trial process would be a way of achieving this.

### Initial scan time

When the scan starts at the top of the selection set it is often useful to some users to have an extra delay before the scan moves to the first item. A percentage or multiplying factor (of the scan time), or a discreet time is probably the best way to set this parameter.

### Scan pause

It can be beneficial to allow users to collect their thoughts before the next stage of the scan. A delay between pages/groups may aid some users in this. This only applies to scan methods where the highlighter is progressed by the machine and is hierarchical (i.e. has groups/pages). Again, a percentage or multiplying factor (of the scan time) or discreet time is probably the best way to set this parameter.

## Dwell time

This is the time used for some control methods to action the selection of a group or item when a switch action to carry this out is not possible. If the highlight is stationary for longer than this time, then a selection is made.

## Repeat functions

Some of the items selected from sets will be of greater use if they can be repeated without having to be reselected. Three parameters are needed to control this function - auto-repeat, repeat delay and repeat time. It is particularly useful to provide auto-repeat on for example arrow keys or mouse movements. Note the subtle difference between scan time and repeat time.

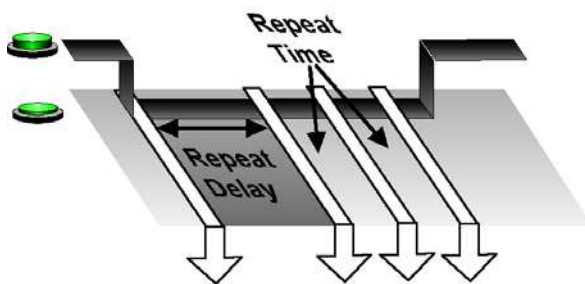


Fig 23: Repeat delay

### Repeat delay

This is the time for which a switch state must be held before the repeat starts (see fig 23). The users may need some time to transfer their attention to the repeated action or time to avoid errors. The repeat delay, similar to the repeat delay on the keyboard, is a period of time which must pass before the first repeat action happens.

### Repeat time

This is the time between successive repeats once the item has started to repeat. In some cases it may be possible for the repeat time to accelerate. For example, the function might first repeat slowly and then more quickly (e.g. with a mouse movement). This could use the same time as the scan time but in practice it is better to have a separate time. It is again similar to the setting in Window's keyboard accessibility options.

### Auto-repeat

With the auto-repeat on, once an action has been selected, the output will be repeated until another press/release event is detected. With the auto-repeat off, only one output will be sent for each switch action. The repeat happens at the rate set by the repeat delay/repeat rate setting. An example of this might be a volume up item on an Environmental Control, keyboard actions (e.g. PgUp) or mouse actions (e.g. move mouse right).

## Input filtering

This is the process of removing all unwanted switch actions. These may have a number of causes:

- Switch bounce. When mechanical switches are pressed or released there is a natural springing of the mechanism and this can cause some additional 'phantom' activations. Corroded contacts can also cause the same problems.

- Involuntary actions by the user (ataxia or tremor etc) may result in accidental switch presses in close succession. This could be just before, or just after the intended press.

When there is any type of input filtering it can be particularly important for some users that clear feedback is provided to demonstrate whether a switch action has both been recognised and accepted.

Another list of the different types of input filtering is provided below, this list has the same health warning of all the others – “there are other ways of doing this”:

### Debounce time

This is the time after a switch press before a switch release will be recognised by the system (see fig 24). Thus the system will not respond to the rapid changes following a press or release action. This helps to overcome switch bounce caused by imperfect electrical contacts and can help with some problems of tremor.

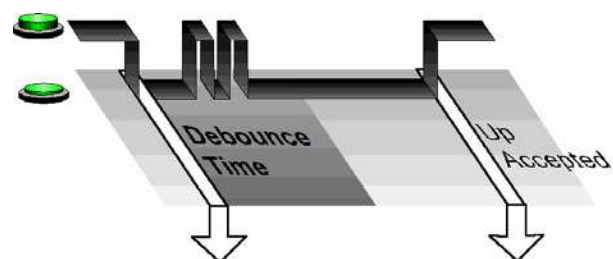


Fig 24: Debounce time

### Acceptance time

The acceptance time is the time the switch must be held down for before the system recognises the switch action (see fig 25). This can also apply (less commonly) to switch releases. This can be helpful for some people with tremors or other disabilities that may either cause them to make accidental (but brief) switch presses. It may also be relevant when a user ‘drags’ over switches and then ‘rests’ on the desired switch.

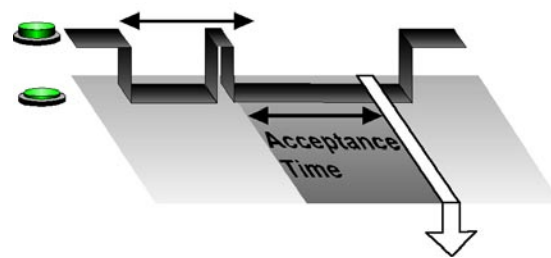


Fig 25: Acceptance time

### Post-acceptance time

This is the time after the last switch press after which the computer will accept another switch press (see fig 26). There is a subtle, but important, difference between this and the debounce time where the switch release is involved! This is intended to filter out some tremor problems. Switch events should not be looked for by the computer until a given time after the last switch event has been accepted. This can often be quite long to take account of the user making further involuntary actions after the intended switch press. In such circumstances it is likely that setting this parameter will make setting up a de-bounce delay unnecessary.

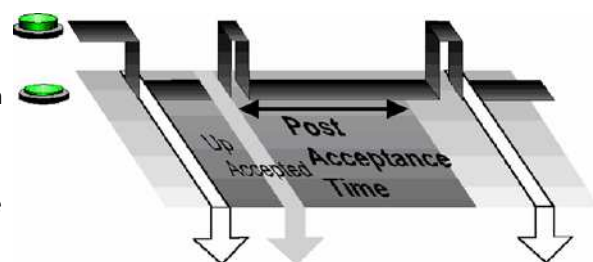


Fig 26: Post-acceptance time



# Conclusions

It is hoped that this document has provided a clear and consistent description of the switching process. As stated we have deliberately not made any specific recommendations within this document – this is not because we have nothing to say on the subject – but because we believe this document is the foundation for any further discussion, research and evidence on the topic of switching and scanning.

Hopefully this document will define a standard vocabulary, terminology and parameters for switch access and scanning. Ultimately we hope it will lead to more and better switching systems that users can move between easily.

We welcome and encourage comments and suggestions on this document – we hope that it will evolve and improve with suggestions before releasing it as a proposed standards document. You may wish to place and develop suggestions on the Assistech WIKI (<http://tinyurl.com/n4k96>) or email one of the authors:

**David Colven**  
colven@ace-centre.org.uk

**Simon Judge**  
simon.judge@sbpct.nhs.uk



## Appendix 1:

# Connecting Switches to a Computer

Switches are used with a large number of Assistive Technology devices. These devices can be roughly grouped into two – dedicated proprietary devices and computer based devices. Most devices are microprocessor or computer based, but proprietary devices will be dedicated to a single or small number, of tasks. Proprietary devices will normally have switch access incorporated into the device and will allow you to configure the scanning through an interface on the device.

To plug switches into non-proprietary computer based devices you need a connector (switch interface) and software that will do something useful with the switch inputs. Luckily, with the use of USB, plugging switches into a computer has become very easy. The information below is provided as a full reference on this topic however.

## Switch software

The full range of Assistive Technology software is beyond the scope of this document, however 'switch driving' software is of note. This software allows switches (connected via the switch interfaces listed below) to be 'mapped' to any key or mouse function. This enables the switches to be used with Assistive Technology software that does not have an inbuilt switch driver. It also allows the switches to be used with standard software such as PowerPoint (indeed a large number of switch accessible PowerPoint resources exist within the SEN Assistive Technology community). Some switch drivers will detect the currently used application and automatically configure the switches appropriately. USBKeys ([www.switchindex.com/usb-keys.htm](http://www.switchindex.com/usb-keys.htm)) and the Sensory Switch Driver ([www.sensorysoftware.com](http://www.sensorysoftware.com)) are examples of switch driver software.

## Ports

Switches are connected to a computer via a port – for example USB, Serial etc. Switches can be connected directly to a port (rare these days) but are usually connected via a 'switch interface'. The switch is normally plugged into the switch interface using a standard connector.

Use of switches was pioneered in British Education system mainly on BBC and Apple II computers. The BBC had an 8 channel port called the user

port which allowed up to eight switches to be connected at once. Switch interfaces are standardising on using USB, however the number of switch inputs seems to be decreasing. See Appendix 4 for a table of ports - operating systems and interfaces.

## Switch interfaces

It is important that switch controlled systems should allow connection of switches through the full range of available ports and interfaces. Users and their facilitators do not want to be continually changing connections as different software is used. Unfortunately there is no agreed universal standard – although the ease of use of USB interfaces is increasingly making these the standard. Common interfaces are:

### USB

It is possible to get a range of different USB switch connectors – these emulate a games port (fire buttons). For example: JoyCable, JoyBox, CrickBox, AnyCom etc...

### Keyboard

Using the keyboard as a switch input designates some of the keys as switch inputs and a keyboard-switch interface would allow switches to activate these keys. Using the keyboard has the advantage of making reading switches easy. The disadvantage is that the designated keys may not be used by a helper to assist the switch user. Don Johnston and Inclusive Technology are among the suppliers of keyboard interfaces. Overlay keyboards could also be used as a switch.

### Parallel port

The Words+ system uses the printer port for multiple switch input but includes a 'dongle' which locks out other software interfacing. So far they have resisted giving any information on how to read the switch connections. The parallel printer port is now being phased on portable devices.

### Older interfaces

- The 'Linx box', related to the UK Concept Keyboard, sending coded signals into a comms port (up to 4). This is no longer available.
- Serial (dead) mouse as used by Switch Access to Windows (SAW) users and some other software. This has complications over clashes with proper mice but can be simple to set up.
- Serial Port using interconnections of the handshake line on a comms port, for up to 4 or more switches but commonly only uses 2 inputs. The Flipper type switch interface can be used by Clicker 4, Widget Software and SEMERC (SEMERC II)

# Appendix 2: Switch Control of Systems

**Table 2: Summary table of switch control systems**

<b>No. of Switches</b>	<b>Control</b>	<b>Other names</b>	<b>Comment</b>	<b>Parameters</b>	<b>Priority</b>
1	Autoscan		Probably the most popular and most efficient system for users with good timing	Scan time Start delay Autostart Autorepeat Repeat delay Repeat time	Essential
1	User scan	Reverse scan	For those whose release is more controlled than their press	Scan time Start delay Autorepeat Repeat delay Repeat time	High
1	Critical overscan autoscan		A way of giving users with poorer control of timing faster access to larger grids with least effort.	Scan time Start delay Autostart Autorepeat Repeat delay Repeat time	Low
1	Critical overscan user scan		A way of giving users with poorer control of timing faster access to larger grids with least effort.	Scan time Start delay Autorepeat Repeat delay Repeat time	Low
1	Single step scan		Gives control to the user and takes away the pressure for the need to 'get it right'	Autorepeat Dwell time Repeat delay Repeat time	Low
1	Directed		A way for single switch users to control their own movement over a large number of options at one level	Scan time Start delay Autostart Autorepeat Repeat delay Repeat time	Lowest

<b>No. of Switches</b>	<b>Control</b>	<b>Other names</b>	<b>Comment</b>	<b>Parameters</b>	<b>Priority</b>
2	Autoscan		Not frequently used but possibly should be considered more frequently. It can speed up access for two switch users and can be a bridge to single switch usage.	Scan time Start delay Autostart Autorepeat Swap Repeat delay Repeat time	High
2	User scan	Reverse Inverse	Similar to autoscan but giving more control to the user.	Scan time Start delay Autorepeat Swap Dwell time Repeat delay Repeat time	Essential
2	Single step scan		The most frequently used two switch scanning method. Gives complete control to the user.	Autorepeat Swap Dwell time Repeat delay Repeat time	Essential
1	Morse - one switch		Can be user-defined codes	Dwell time	Low
2	Morse - two switch		Involves timing even with two switches	Dwell time	Low
3	Two switch directed scan		The third switch selects	Scan time Start delay Autostart Autorepeat Repeat delay Repeat time	Low
4	Joystick directed Scan (dwell select)		For those who find accessing a faster switch difficult	Scan time Start delay Autorepeat Dwell time Repeat delay Repeat time	High
5	Joystick directed scan and select		Gives more control to the joystick user who can access a faster switch.	Scan time Start delay Autorepeat Repeat delay Repeat time	High
N	N-way Encoding (sequential)		This was popular among some advanced users with the Mac-Apple Switch word processor and it can be very rapid.	Dwell time	Low
N	N- way encoding (Simultaneous)	Chord keyboards	Not applicable to Scanning Systems	Repeat delay Repeat time	N/A

# Appendix 3: Summary of Terminology

**Table 3: Common switch scanning terms**

<b>Term</b>	<b>Definition</b>	<b>Other equivalent terms</b>
Acceptance	The registration by the system that a valid switch press has been made following switch filtering.	Hold down time
Accepted	The registration by the system that a valid switch press has been made following switch filtering.	
Auto Restart	When a scanning system resets the current highlight back to the start position of the scan rather than carrying on to the next item.	
Control	The way in which switch actions control the way a scan moves.	
Critical Over-scan	A system of scanning where the scan initially moves very fast and then does a slow reverse scan to enable speed with accurate selection	
Dwell Select	The process of having items in a selection set chosen by doing nothing or holding a switch down for a set time.	
Debounce	A way of removing unwanted switch signals caused by poor electrical contacts in the switch itself	Tremor delay
Event	The signal that something has happened such as switch down (pressed) or switch up (released)	
Facilitator	A helper who aids the user and may adjust the user's system.	
Filtering	The process of eliminating incorrect switch actions caused by the user's involuntary actions.	
Grid	A rectilinear selection set of items arranged in rows and columns. Scanning may be carried out by simple scanning, row/column or column/row.	
Group	A sub-set of items grouped together so that the groups can be scanned and then chosen by the process of selection to then be scanned internally. This is a way of defining the hierarchy of the selection set.	Row, Column

<b>Term</b>	<b>Definition</b>	<b>Other equivalent terms</b>
Highlight	The indicator used to show that any item or group is available for selection at that time.	
Item	A single selectable element of a selection set. The item that contains the text or command to be acted upon.	
Method	The way in which a scan moves by the process of highlighting across a selection set so that choices can be made.	
Post acceptance delay	A time following an event that has been accepted by the controlled device in which all further events are ignored.	Tremor delay
Press	The 'switch down' event	
Release	The 'switch up' event	
Scan	The movement of the highlight from one item to the next. This will either happen at pre-set times or following a scan switch press being accepted.	
Selection Set	A complete set of items and/or groups of items that are presented to the user for selection at any one time. Some of the groups or items may be hidden until required.	Grid, On-screen keyboard
Scan Reset	See Auto Restart	
Toggle	A switch or other control that is activated (e.g. pressed) once for on, then again for off.	
User Scan	A scan which proceeds as long as a switch is help down.	Inverse scan Reverse scan

**Table 4: Common assistive technology terms**

<b>Device</b>	<b>Description</b>
Tracker Balls or Trackball	A mouse pointer controller that uses a ball to move the mouse pointer when the ball is rolled in a given direction. This is in fact the first type of computer pointer controller dating back to the mid-1960's.
Touchscreen	A way of directly moving the pointer and clicking by touching a screen. There are three main types: Resistive; can be operated with the flat of a finger. Capacitive; needs a sharp point to move the pointer such as a finger nail. Active Pen; needs a compatible electronic pen to move the pointer.

<b>Device</b>	<b>Description</b>
Head Pointers	Systems which interpret head movement and move the screen pointer appropriately.
Assistive Technology	Any technology that can enable someone to overcome a handicap imposed by their environment.
Bandwidth	The amount of information that can be passed through any given channel. The more information the higher the bandwidth.
Joysticks:	Devices that can control computer screen pointers, games, wheelchairs (or aeroplanes!) by moving a gimbaled stick in from its rest position.
Analogue Joystick	The cursor/selection speed varies with deflection of the joystick. The joysticks usually have unlimited two dimensional movement. These devices can be used to move the mouse pointer as a mouse emulator or as a games device.
Switched Joystick	The cursor/selection speed is constant when the stick is pressed in a limited number of directions – usually 4 or 8. The system being controlled can act continuously or with a single action each time the joystick is moved.
Eye Pointers	Systems that translated movement of a person's eye into screen pointer movement.
On-Screen Keyboards	Virtual keyboards that appear on computer screens and have the same function of physical keyboards. Some can be accessed with the screen pointer and others with switches or both
Layered Hierarchy	A way of arranging large numbers of items in groups and sub-groups so that they can be accessed faster or with less effort.
3.5mm jack connectors	The current 'standard' for switch connection the same size as Walkman headphone connectors. In the USA this is 5/8" which is almost identical. These are usually mono (single channel) connectors with two contacts but two switches can be connected through stereo jacks with three connectors.
USB	The Universal Serial Port now fitted to all computers, both PC and Mac. Devices of many kinds can be connected to USB ports. Most AT devices imitate Mice, Keyboards or Games controller fire buttons.



## Appendix 4:

# Ports and Interfaces for Switch Access

**Table 5: Computer ports and switch access interfaces**

Interface	PC/ Mac	Port	No I/P	Manufacturers / Suppliers	Web Site	Compatible Software (eg)	Notes
Serial Switch Box	PC	Serial	2	SEMERC, Inclusive Technol- ogy, Crick Software, Widget	<a href="http://www.inclusive.co.uk">www.inclusive.co.uk</a>	Clicker 4, The Grid, SAW	Now obsolete as many computers do not have standard RS232 serial ports particularly laptops.
USB Mouser 4	PC	USB mouse	3	SEMERC, Inclusive Technology	<a href="http://www.inclusive.co.uk">www.inclusive.co.uk</a>	Any that uses mouse button clicks	Allows switches to be connected to the left, middle and right mouse buttons
PS/2 Mouser	PC	PS/2 mouse	2	SEMERC, Inclusive Technology	<a href="http://www.inclusive.co.uk">www.inclusive.co.uk</a>	Any that uses mouse button clicks	As above but now obsolete as PS/2 interfaces are withdrawn from new computers particu- larly laptops.
Switch Interface Pro	PC & Mac	PS/2 or ADB Keyboard	5	Don Johnston	<a href="http://www.donjohnston.com">www.donjohnston.com</a>	Any software that can use a keyboard key input as a switch.	Limited to a few key combinations controlled by the keyboard lock keys
Switch Interface Pro 5	PC & Mac	USB Key- board	5	Don Johnston	<a href="http://www.donjohnston.com">www.donjohnston.com</a>	Any software that can use a keyboard key input as a switch.	Limited to a few key combinations con- trolled by the state of switches on the box itself.
iMate	Mac	USB- to-ADB adapter		Don Johnston, Griffin Technolog, Inc	<a href="http://www.donjohnston.com">www.donjohnston.com</a>	As above	Allows you to connect any ADB peripheral to newer USB-equipped Macintosh comput- ers. Discover:Kenx, Discover:Switch, Discover:Board or Switch Interface Pro.
Quizworks	PC & Mac	USB Key- board	5	Inclusive Technology	<a href="http://www.inclusive.co.uk">www.inclusive.co.uk</a>	Any software that can use a keyboard key input as a switch.	Allows switches to send space, enter, tab, esc, backspace, up arrow, down ar- row, left arrow, right arrow, 1, 2, 3, 4, 0 and click.
SwitchBox	PC	PS/2	8	Inclusive Technology	<a href="http://www.inclusive.co.uk">www.inclusive.co.uk</a>	Any software that can use a keyboard key input as a switch.	

### appendix 4: ports and interfaces for switch access

Interface	PC/Mac	Port	No I/P	Manufacturers / Suppliers	Web Site	Compatible Software (eg)	Notes
Joybox		USB Games	12	Sensory Software	<a href="http://www.sensorysoftware.com">www.sensorysoftware.com</a>	The Grid, Clicker, SAW etc.	This switch adaptor is supported by most switch accessible software and will instantly work with Clicker, SAW and The Grid. It comes with Sensory's Switch Driver software to allow it to be used with programs that use keyboard keys.
Joycable		USB Games		Sensory Software	<a href="http://www.sensorysoftware.com">www.sensorysoftware.com</a>	The Grid, Clicker, SAW etc.	As above
Sensory Radio Switch Connector	PC	USB or Serial (two versions)		Sensory Software	<a href="http://www.sensorysoftware.com">www.sensorysoftware.com</a>	Should be able to access any scanning software	Connect the receiver to the serial port (or USB port) of your computer. Then just plug your switch(es) into the transmitter(s).
Crick USB Switch Box	PC & Mac	USB Games		Crick Software	<a href="http://www.cricksoft.com">www.cricksoft.com</a>	Should be able to access any scanning software	This box will instantly work with Clicker, SAW and The Grid. For other switch accessible software, USB Keys is included, a small software application which converts switch presses from the USB switch box into key presses or mouse clicks.
Discover Switch	PC & Mac	USB		Madentec	<a href="http://www.madentec.com">www.madentec.com</a>		Discontinued
Discover:Kenx	PC & Mac	PS/2 or ADB	8	Madentec	<a href="http://www.madentec.com">www.madentec.com</a>	Discover:Kenx software	Comes with the Discover Kenx software for computer access
Intellikeys	PC & Mac	USB	2	Intellitools, Inclusive Technology	<a href="http://www.intellitools.com">www.intellitools.com</a>	Should be able to access any scanning software	Software can customize the switch inputs to match switch controlled software
Goldfinch Switch Adapter 8 (2)	PC	USB	8 (2)	Unlimiter	<a href="http://www.unlimiter.com.tw">www.unlimiter.com.tw</a>		Imitates key strokes or mouse functions - programmable
EZKeys	PC	Parallel Printer	2	Words+	<a href="http://www.words-plus.com">www.words-plus.com</a>	Words+ software	A dongle that only works with Words+ software
Mini-SwitchPort	PC & Mac	USB	2	RJ Cooper	<a href="http://www.rjcooper.com">www.rjcooper.com</a>	Mini-SwitchPort uses the Switch-Hopper software for Windows and Mac OS 9, and SAM-X for OS 10	Can be configured to be any mouse click or keystroke

## Appendix 5:

# Summary of Parameters and Suggested Values

The range we have found users need for Scan speed is from 0.3 to 5 seconds. For completeness this should be set as a range 0.2 to 10 seconds in increments of 0.05

The debounce time needs to be settable by the user as different switches have different behaviour. Usually it can be quite short as the mechanical vibrations of the contact of any rapid 0.01 to 0.1 sec in steps of 0.01 sec is usually an adequate range from this parameter.

The user may make involuntary switch actions of short duration caused by dragging a hand or finger over a switch before the desired key/switch is wanted. The acceptance delay is a filtering time which eliminates false switch/key presses made before the intended switch/key press. The range is from 0 (zero or off) in steps of 0.05 (if any value cannot be input) to 1.0 seconds. This should cover most needs.

### Some suggested parameter ranges

**Debounce time**

0.01 to 0.1 steps in 0.01 sec

**Input acceptance time**

0 to 10 steps in 0.1 sec

**Repeat acceptance delay**

0.1 to 10 steps in 0.1 sec

**Post acceptance delay**

0.1 to 10 steps in 0.1 sec

**Repeat time**

0.1 to 10 steps in 0.1 sec

**Repeat acceptance delay**

0.1 to off with a maximum time of 10 sec

## Data file structures

Many different systems use different methods and formats for storing user and selection set configurations. This ensures that moving a user between devices is as difficult as possible, since the values have to be re-entered and customised. It is hoped that this document will evolve into a standards document for terminology, but also for configuration. Thus it is suggested that a standard file structure is used for storing variables. The data might be stored in an XML format or ASCII configuration file in parametric form in the structure and agreed by the educational software development forum (UK) for concept keyboard files, viz:

```
debounce_time 0.1 < LF > < CR >
```

The default delimiters are taken as <, > or <space>.

A suggested set of data is listed below together with a statement of the parameters. It would be quite possible for developers with special requirements to extend this list provided that they use compatible terms.

## User configuration selection

**Table 6: User configuration statements and parameters**

<b>data statement</b>	<b>Parameters</b>
control_method	simple group directed
scan_method	auto user single step toggled
No_of_switches	N
scan_time can	n.n
scan_delay	n.n
swap_switch	on off
Autostart	on off
scan_reset	on off
scan_pause	0.nn
critical of the scan	on off
debounce_time	o.nn
input_acceptance_time	n.n
post_acceptance_delay	n.n
repeat_delay	n.n (0 for no repeat)
repeat_rate	n.n ( 0 for repeat only)
selection_time	n.n (user = 0.0)
set_colours	background, foreground, highlight background, highlight foreground, border, highlight border

Note: “|” denotes alternative data, a comma or space denotes separate data required.

## Appendix 6:

# Implementation of Scanning Within Software

Within the definition of the terms in this document we have covered the principal scanning methods. However, it is possible to design a multitude of variations on this that may suit particular users of particular software requirements. We hope that within the vocabulary defined here there exist sufficient terms to be able to describe any system accurately. Although the terms may be clear, it may be less easy to see how this can be put into practice to suit different purposes. Examples from existing software have been used throughout the document to illustrate various terms.

We have described the simple (minimum) system. The broad range of possible ways in which switch input can be implemented within devices or software is covered in the detailed control appendix.

## Minimum implementation

### Connections

It is to be hoped the developers will accommodate switches operating from any port which the hardware supports as listed in the ports sections. A minimum could include USB (Joystick), Serial and Keyboard.

### Switches/devices

In the same way that all ports should be accommodated, it is desirable for the software to run with as many input devices as possible. As a minimum, both single, two switch and directed operations need to function in any switch application. It would also be expected that mouse input would be possible. The minimum configurations for switches (press action only) are:

- Single switch with automatic scanning of the items and ability to set scan timing, input acceptance and debounce.
- Two switch single step scan with one switch to scan and the other to select (same switch operations). Again there should be the ability to set input acceptance and debounce.
- Three, four or five switch directed scanning. With two, three or four directions and one select switch.

The suggested parameter ranges listed previously would be applicable to the above configurations.

## Scanning methods

### Small selection sets (less than 10 items)

A single row of items presented at the bottom of the screen (if only one position is possible) as described in the 'Presenting Choices' section. After a switch press, a simple scan should start - the scan should be highlighted by either inverse colour or a coloured box – as described in the 'Aesthetics' section.

### Larger selection sets

A rectilinear grid of items is the default presentation. A number of options for scanning this can be provided, described in the 'control and selection' section:

- **Simple Scan**  
In the manner similar to that for smaller selection sets - this would probably not be the default since this is likely to be conceptually easier but significantly slower.
- **Group Scan**  
Providing the options for row/column, column/row or block scanning, as described in the 'control and selection' section.

### Pull down menus

If switches are to be implemented as an extra input to a standard menu system it is suggested that the highlight should scan over the items in the top menu with a standard highlighter (usually reverse graphics). When the selection is made the appropriate sub-menu drops down. The sub-menus then scanned in the same way and upon and so on. This is repeated until the final choice is selected. It is important that the switch user is able to escape the menu hierarchy at any point.

### Point and click environments

For switch users the GUI (Graphical User Interface) presents special problems. If they are presented with a screen of items for double-clicking, how do they access the applications, etc.? There are two suggestions that can be made:

- A box frame is used to highlight each icon/hotspot in turn. When the selection is made the actions connected with either single or double-clicking any of the possible mouse buttons on the items can be presented to the switch user as a simple scan choice. The input application needs to recognise the presence and position of icons on the screen

for scanning, and then be able to give a switch selection of the mouse action. If there are different functions for single and double-clicking, some sub menu process will be necessary.

- Mouse emulation controls can be scanned by the switch user. These control items will need to include point of movement controls (course and fine) and the mouse button actions. This form is much more flexible in its application but more difficult and slower to use.

The user may prefer to have on-screen moving indicators of the current mouse pointer position in the form of cross-hairs or circular 'radar' scans to make it easier to move to distant targets. The alternative is to have a selection set containing mouse control items scanned on-screen or externally.



# Selected Resources

This section is deliberately small! We have endeavoured to make this document a useful introduction to the process of switches and scanning and also for it to be considered a standards document. With this in mind we have tried to not quote evidence surrounding switching or to make any clinical recommendations.

## Resources

**www.switchscanning.org.uk**

Site created by Gary Derwent (Royal Hospital for NeuroDisability, Putney) to demonstrate and train people in the process of using simple switching techniques. Also contains some other resources and links.

**CALL Centre** <http://callcentre.education.ed.ac.uk/>

The CALL Centre (Communication Aids for Language and Learning) provides expertise in technology for children with communication problems.

**OneSwitch** [www.oneswitch.org.uk/](http://www.oneswitch.org.uk/)

Resources and games for switch users

**Trace Centre** <http://trace.wisc.edu/>

The main American site for accessibility resources and information.

**Emptech** [www.emptech.info/subcategories.php?ID=16](http://www.emptech.info/subcategories.php?ID=16)

A database of assistive technology including switches and switch access.



# References

1. **Colven, D and Detheridge, T** A Common Terminology for Switch Controlled Software, ACE Centre/NCET 1990, ISBN 85379 112 1
2. **Bauby, Jean-Dominique** The Diving Bell and the Butterfly – A Memoir of Life in Death, ISBN 0007139845 (translated from the French)
3. **Lundlav et al** COMLINK, an open and component based development environment for communication aids, October 1999
4. **Norman, D** The Psychology of Everyday Things, 1988, ISBN 0 465 06710 7
5. **Microsoft survey** referencing ageing and disability: [www.microsoft.com/enable/research/agingpop.aspx](http://www.microsoft.com/enable/research/agingpop.aspx)
6. **King, TW, Allyn & Bacon** Modern Morse Code in Rehabilitation and Education, ISBN 0-205-27326-2
7. **Colven, D and Lysley, A** Making Software Inclusive, 2005, ACE Centre [www.ace-centre.org.uk](http://www.ace-centre.org.uk)



When most of us use a computer we use the standard interface – a keyboard and mouse. However, what do you do if you cannot use a keyboard or mouse? A number of alternative access systems exist, for example: alternative keyboards, tracker balls, touchscreens, head pointers etc. But for some people these devices are also an impossibility, and this is where switches 'kick in'. The main subject of this document is the switch user. For completeness we have included a brief mention of other input devices, which may be grouped together as 'alternative access systems'.

We aim to:

- Encourage developers to include switch access into their products
- Standardise practice and terminology

This document explains some of the issues involved for people with severe physical difficulties who access computers and other electronic devices with switches. It details the ways in which switch users interact with computer programs and other technology designed to be directly accessible to them. The document includes some precise definitions of terms. It also attempts to survey the whole range of issues associated with switch use. As such it should be useful to professionals working or entering the field, those software developers considering switch users for the first time and also for those already developing in this area.

A more in-depth look at the development and programming issues for 'mainstream' software and resources can be found in the ACE Centre publication *Making software inclusive and digital publications accessible*<sup>7</sup> which describes in detail the sometimes small changes required to make applications accessible to the switch users.

This document is a description of switch access and deliberately does not present any evidence or research, it should be considered more as a guide to promote standards and a common understanding and nomenclature for switch use. A small amount of evidence surrounding switching does exist. It is hoped that the adoption of the terminology and approach detailed in this document should help improve the development of evidence on switch access.