Glasgow Science Centre
Construction Standards
Version 1.2 2019

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1. Introduction

This document aims to outline the standards and expectations to be adhered to during the design, fabrication and installation of all exhibits at Glasgow Science Centre (GSC). It should be used in conjunction with the Design Manual specific to each exhibition to ensure the delivery of a high quality, engaging, safe and accessible visitor experience.

These standards are intended **not to restrict creativity** but to provide parameters in order to ensure underlying design and fabrication cohesion throughout GSC exhibitions.

Exemptions and alternative suggestions are welcomed and should be submitted in writing to GSC for consideration.

2. Prototyping & Evaluation

Prototyping and evaluation is of fundamental importance to the development process at GSC. Rigorous testing and review helps ensure lessons are learned, an understanding of visitors' needs and requirements are developed and learning opportunities are maximised.

At fabrication stage, where descriptions are for standard science centre exhibits, extensive prototyping beyond functionality and ease of use is unnecessary. However, where an exhibit is bespoke or where there is a major change in the standard exhibit outcomes, prototyping and evaluation must be undertaken. Decisions on exhibits to be prototyped will be finalised in discussion with the fabricator, the GSC project team and the GSC Evaluation Officer. Evaluation and prototyping will be included in deliverables for staged payments.

Concept evaluation to check the exhibit meets the desired learning outcomes in terms of key message, interaction, enjoyment and interest levels will be carried out by GSC staff with target audience groups in the initial stages. However, as development of the exhibits progress, this evaluation should continue to ensure changes do not compromise the intended outcomes. Again this should be carried out at GSC and with the target audience.

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The exhibits should be evaluated throughout the development process by the fabricator for

- Health and safety (including assessment of risk)

- Robustness

- Accessibility

- Installation and ease of maintenance

- Ease of operation

- Consistency of operation

The Code of Practice produced by NMSI section on Comprehensibility and Evaluation (see extract in Appendix D) provides guidance for evaluating interactive exhibits and should be used as a default.

3. Health & Safety Standards

3.1   Overview

It is the obligation of exhibit designers to ensure that all exhibits conform to all applicable standards and legislation, whether or not explicitly referenced in these guidelines. Exhibits must be designed and constructed to minimise risk to reasonable levels whilst in normal working order or under fault conditions.

Protection must be provided against:

- Electric shock

- Effects of excessive temperature

- Effects of mechanical instability and moving parts

- Trapping

- Injury from sharp or abrasive surfaces

- External protrusions

- Fire

- The effects of hazardous substances

- Hazards as a result of wear and tear

3.2 Safety Legislation

All exhibits for the GSC must comply with the following safety legislations as a minimum:

- **The Machinery Directive (2006/42/EC – 2nd Edition - June 2010)** concerned with mechanical safety.

- **The Low Voltage Directive (2006/95/EC)** concerned with electrical safety.

- **The Electromagnetic Compatibility Directive (2004/108/EC)** concerned with radio-frequency emissions.

- **The Toy Safety Directive (2009/48/EC)** It improves the existing rules for the marketing of toys that are produced in and imported into the EU in view to reducing toy related accidents and achieving long-term health benefits.

- **The General Product Safety Regulations 2005** which implement Directive 2001/95/EC may cover any item which falls outside the above.

- **The Provision and Use of Work Equipment Regulations 1998** which require CE marking and Declaration of Conformity, along with specific requirements on stop, guarding dangerous parts, isolation, maintenance and training.

- **The Welfare in The Workplace (Health, Safety and Welfare) Regulations 1992** which cover slip and trip hazards associate with water exhibits and floor specifications, cleaning and waste.

- **The Equipment and Protective Systems Intended for Use in Potentially Explosive Atmospheres Regulations 2016** usually known as ATEX, for equipment and protective systems intended for use in explosive atmospheres.

- **The Fire (Scotland) Act 2005 (2005 (asp 5))** and **The Fire Safety (Scotland) Regulations 2006** where any changes (addition of exhibits) which may affect the Fire Risk Assessment would require review. Additionally, the Fire Strategy for GSC

would place standards on drapes and foams over and above the Furniture requirements.

In addition to the above, contractors should make themselves aware of the following regulations and apply them as necessary:

- **Construction (Design and Management) Regulations 2015 (CDM Regulations)** impose obligations on suppliers to ensure that the exhibits are safe to build, install and maintain, and that the installation process itself is conducted safely.

- **The Management of Health and Safety at Work Regulations 1999** as amended, apply to all venues where crowds may gather and require risk assessments to be carried out for all types of work.

Due to the lack of standards for exhibits, the British Standards applicable to play equipment have been adopted as a guide and the applicable rules are deemed to be:

- **BS EN 1176** applies to play equipment intended for permanent outdoor use. It gives guidelines for testing equipment for traps and operational hazards; a specification of performance and construction of different types of equipment; and a code of practice for installation and maintenance.

- **BS EN 1177** sets out methods of testing impact-resistant playground surfaces for durability, absorbency, flammability etc.;

All installations must comply with all applicable statutory standards and regulations, to those of the United Kingdom, Scotland and European Union.

3.3   Fire safety standards

Materials and furniture should satisfy the relevant fire safety standard:

- Ignition and cigarette test as laid down in British Standard **BS 5852:2006** Pt.1.

- British Standard **BS 5852:2006** Pt.2 'fire tests for furniture. Methods of tests for ignitability of upholstered composites for testing by flaming source' (for which latter standard crib ignition source 5 is the minimum requirement).

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In United Kingdom all items of domestic upholstered furniture must meet the **Furniture and Furnishings (Fire) (Safety) Regulations 1988** (as amended in 1989, 1993 and 2010) and **BS 7176 Fire test to Upholstered Furniture for Non-Domestic Seating.**

3.4 Electrical safety standards

All exhibits that use electricity must satisfy the following requirements:

- Electrical wiring must comply with the latest available edition of The Institute of Electrical Engineers Regulations.

- All electrical exhibits and components should have passed a Portable Appliance Test (PAT) and be clearly labelled and documented.

- All electrical and electronic products made or sold in the U.K. must comply with the Electromagnetic Compatibility Regulations 2006.

- All materials or component parts used in exhibits must function within the manufacturers recommended conditions for safety and reliability and no unauthorised modifications made.

3.5 Chemical Hazards

3.5.1 REACH

REACH (Registration, Evaluation, Authorisation and restriction of Chemicals) is the law that applies to suppliers of dangerous chemicals. Its purpose is to protect people and the environment from the effects of those chemicals by requiring suppliers to provide information about the dangers and to package them safely.

REACH requires the supplier of a dangerous chemical to:

- identify the hazards (dangers) of the chemical. This is known as 'classification';

- give information about the hazards to their customers. Suppliers usually provide this information on the package itself (e.g. a label); and

- package the chemical safely.

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3.5.2 Control of Substances Hazardous to Health Regulations 2002 as amended

Glasgow Science Centre is responsible for taking effective measures to control exposure and protect health. These measures can also improve production or cut waste.

Which substances are harmful?

- Dusty or fume-laden air can cause lung diseases, eg in welders, quarry workers or woodworkers.

- Metalworking fluids can grow bacteria and fungi which cause dermatitis and asthma.

- Flowers, bulbs, fruit and vegetables can cause dermatitis.

- Wet working, e.g. catering and cleaning, can cause dermatitis.

- Benzene in crude oil can cause leukaemia.

- Many other products or substances used at work can be harmful, such as paint, ink, glue, lubricant, detergent and beauty products.

- Ill health caused by these substances used at work is preventable. Many substances can harm health but, used properly, they almost never do.

- Substances can also have dangerous properties. They may be flammable, for example solvent-based products may give off flammable vapour. Clouds of dust from everyday materials, such as wood dust or flour, can explode if ignited.

- Legionella ACOP is enacted through COSHH and required the risk assessment of water systems to be reviewed for any changes by a qualified (external) competent agent

Provide information on each substance, including:

- Which substances are involved, and in what way are they harmful?

- Provide information safety data sheets on each substance

- Products in use may be 'dangerous for supply'. These products include common substances in everyday use such as paint, bleach, solvent or fillers.

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- When a product is 'dangerous for supply', by law, the supplier must provide a safety data sheet.

3.6 Biological Hazards

3.6.1 Approved Codes of Practice (ACOP)

To support COSHH, revised Approved Codes of Practice (ACOP) have been published. The major publication contains the general COSHH ACOP, the Carcinogens ACOP and the Biological ACOP rolled into a single publication. The substantive change is the incorporation of the new Biological Agents ACOP.

A new publication "Categorisation of *biological agents* according to hazard and categories of containment" (the Approved List) has been issued under the auspices of the Advisory Committee on Dangerous Pathogens. This is an abbreviated interim third edition of the ACDP's familiar "Categorisation of *pathogens* according to hazards and categories of containment" which it supersedes. Unlike its predecessor the new publication has legal status and the Health & Safety Commission is required in law to produce this.

The Approved List in its interim form merely lists the biological agents against containment level and indicates possible allergic effects, whether toxin production is involved, whether effective vaccination is available and those biological agents for which a list of workers exposed should be kept for 40 years from the last known exposure.

The Advisory Committee on Dangerous Pathogens (ACDP) defines a Biological Agent as: "Any micro-organism, cell culture or human endoparasite, including any which have been genetically modified, which may cause any infection, allergy, toxicity or otherwise create a hazard to human health."

Give details of all Biological Agents, and the ACDP group classification (1-4) where relevant:

- Categorisation of organisms can be found in the ACDP Biological Agent classification book.

- Blood and tissue samples and cell lines may contain Biological Agents. What are the possible agents (e.g. latent retroviruses)?

- If the Agent is disabled, the classification may be altered from that given by the ACDP.

What are the possible hazards of the use of, or exposure to, these Biological Agents?

- Consider all possible hazards e.g. possible allergic responses.

- Consider infection from potential transmissible pathogens, e.g. HIV, Hepatitis B, latent retroviruses.

What hazard minimisation or control procedures will be implemented?

- Are vaccinations, e.g. against Hepatitis B, required?

3.6.2 The Human Tissue (Scotland) Act 2006

The HTA must issue licences to all establishments that use, for the purpose of public display, the body of a deceased person, or relevant material which has come from the body of a deceased person and the storage of the body of a deceased person, or relevant material which has come from a human body for use for a Scheduled Purpose e.g. public display.

3.6.3 Specified Animal Pathogens Order 2008

This Order extends the definition of "specified animal pathogen" to include nucleic acid derived from a listed pathogen if it may be capable of producing that pathogen. It also prohibits the possession of the pathogens listed and the introduction into any animal of any pathogen listed, except under the authority of a licence issued by the appropriate Minister.

4. Ergonomic Standards

Glasgow Science Centre is committed to increasing access for all (see Equality Act 2010).

For each exhibit, every effort should be made to make it possible for any visitor of any age with any ability to use the unit comfortably. Please refer to the accessibility diagram in Appendix B.

It is the intention to use anthropometric data that is equivalent to male 50% percentile. Where this is not deemed feasible, the limitations should be noted on the drawings before they are submitted for approval.

4.1   Anthropometrics

The average eye line for various audiences groups is as follows

5 year old:	1050 mm
12 year old:	1420 mm
Adult:	1640 mm
Seated adult (above seat surface):	790 mm
Average wheelchair user:	1245 mm

4.2   Table exhibits

Engagement is expected to be less than 2 minutes

If user interaction with the exhibit is expected to be less than 2 minutes the height of the table should be 750-770 mm from the floor to the ***top surface*** in height.

Considerations must be given so that the exhibit can be fully accessed for by a wheelchair user coming alongside the exhibit.

Engagement is expected to be greater than 2 minutes

If interaction with the exhibit is expected to last longer than 2 minutes the exhibit should be designed to incorporate a movable seat and allow access for a wheelchair. The height of the exhibit should be 650 mm from the floor to the ***underside*** of the exhibit worktop/table. A legroom depth of a minimum of 400mm and maximum 500mm should be provided and the opening must be a minimum of 750 mm wide.

4.3   Seating

Stable seating should be provided throughout the exhibition in front of exhibits with longer engagement times. Seating should be easily moveable to allow access for wheelchair users. Seats should be the range 420 – 500 mm, ideally 460 mm high for an average visitor.

4.4   Wall mounted

To ensure the maximum accessibility to wall mounted exhibits and touchscreens they need to be mounted within the 'Maximum common reaching zone' for a standing adult and a wheelchair user which is 930 mm to 1385 mm. Ideally the exhibit should be located in the 'Comfortable common reaching zone' 930 mm to 1200 mm. See Figure 4.1, Reaching Zones.
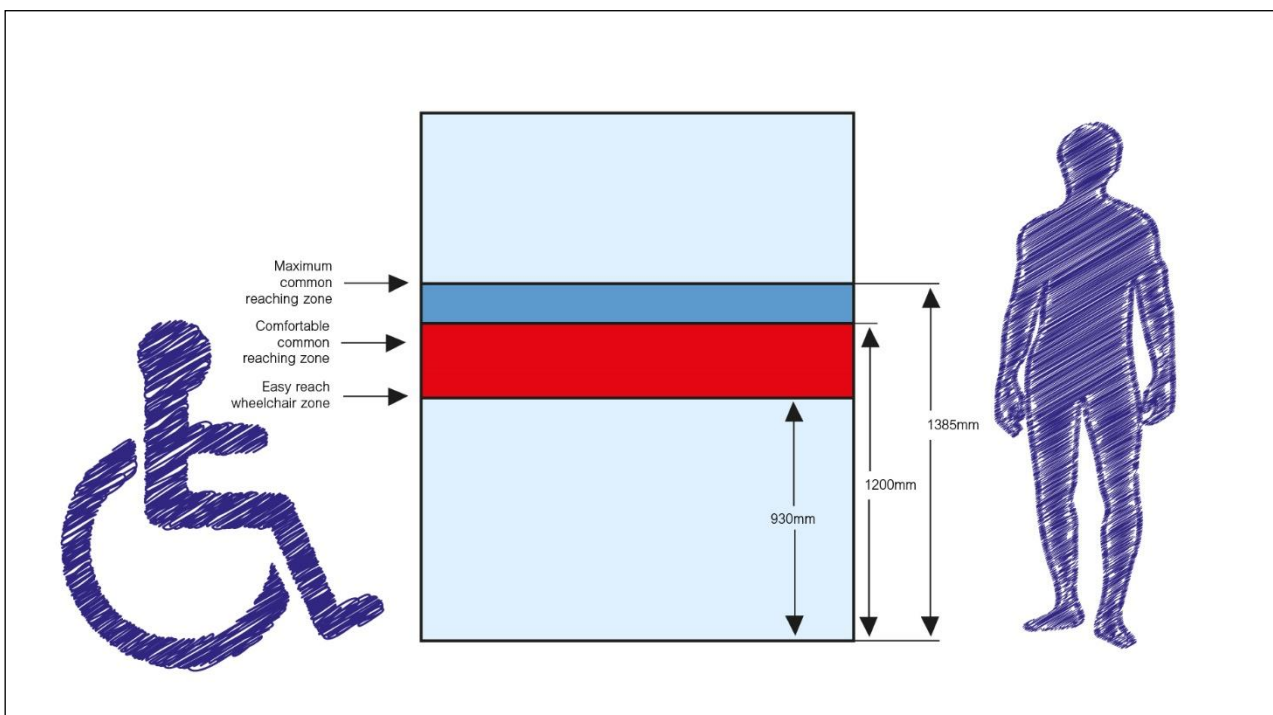

Figure 4.1   Reaching Zones

4.5   Hand reach

All parts of the exhibit that can be handled or controlled should be within a reach of 350 mm of the front edge. Control panels should be angled at 20°.

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4.6   Toe space

All exhibits that require visitors to stand very close to the exhibit structure or allow visitors feet to make contact with the base must have a kick plate of sufficient durability. The kick plate should be 180 mm in depth and 200 mm in height from the base.

4.7   Wheelchair space

Space to allow wheelchair to manoeuvre in front of exhibits should be 1200 mm

4.8   Visual Information

Visual information should be aimed to be presented Normal eye line with a cone of view cone of view 30º below the horizontal of eye line and 15º to left and right. See Figure 4.2.
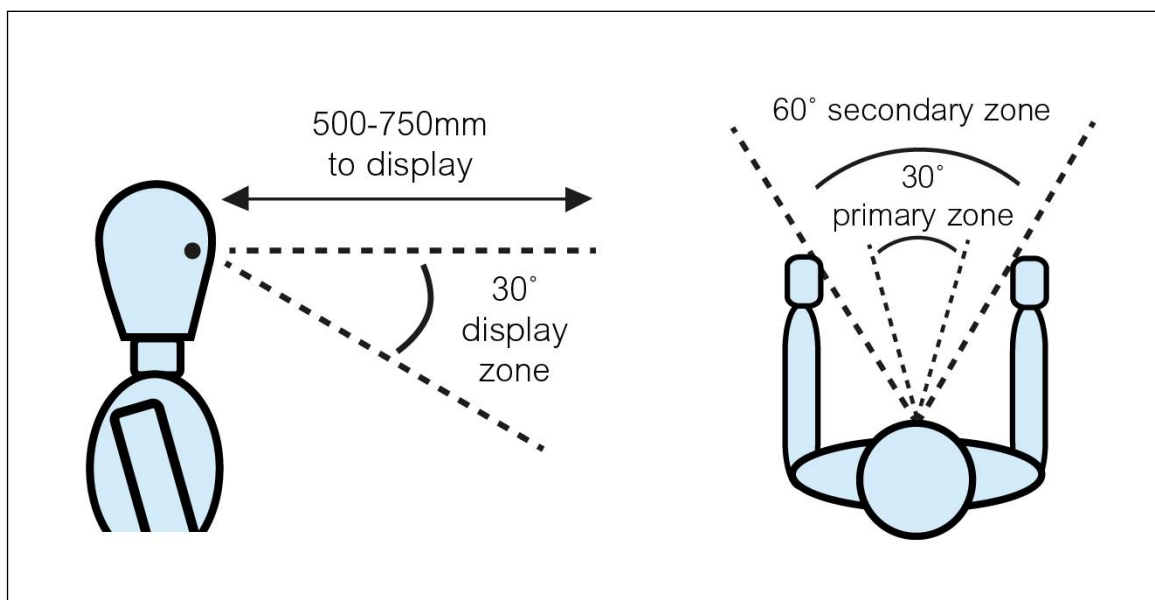
Figure 4.2 Cone of View

Optimum viewing band for exhibition elements 750 mm to 2000 mm.

Optimum viewing band for focal elements 1000 mm to 1600 mm.

Viewing band for children under 7 age group is floor to 1200 mm.

Interactive and interpretive text focus points must sit within the red zone.

Objects which the visitor sees as parts of a normal exhibit interaction (e.g. text, a computer screen) should not be centred more than 1270 mm above the floor.

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Big objects / attractors can be located above the band for exhibition elements.

The viewing distance of an object (text, object) of at least double the diagonal is required.

See Figure 4.3, Viewing Bands for a visual representation of the above.
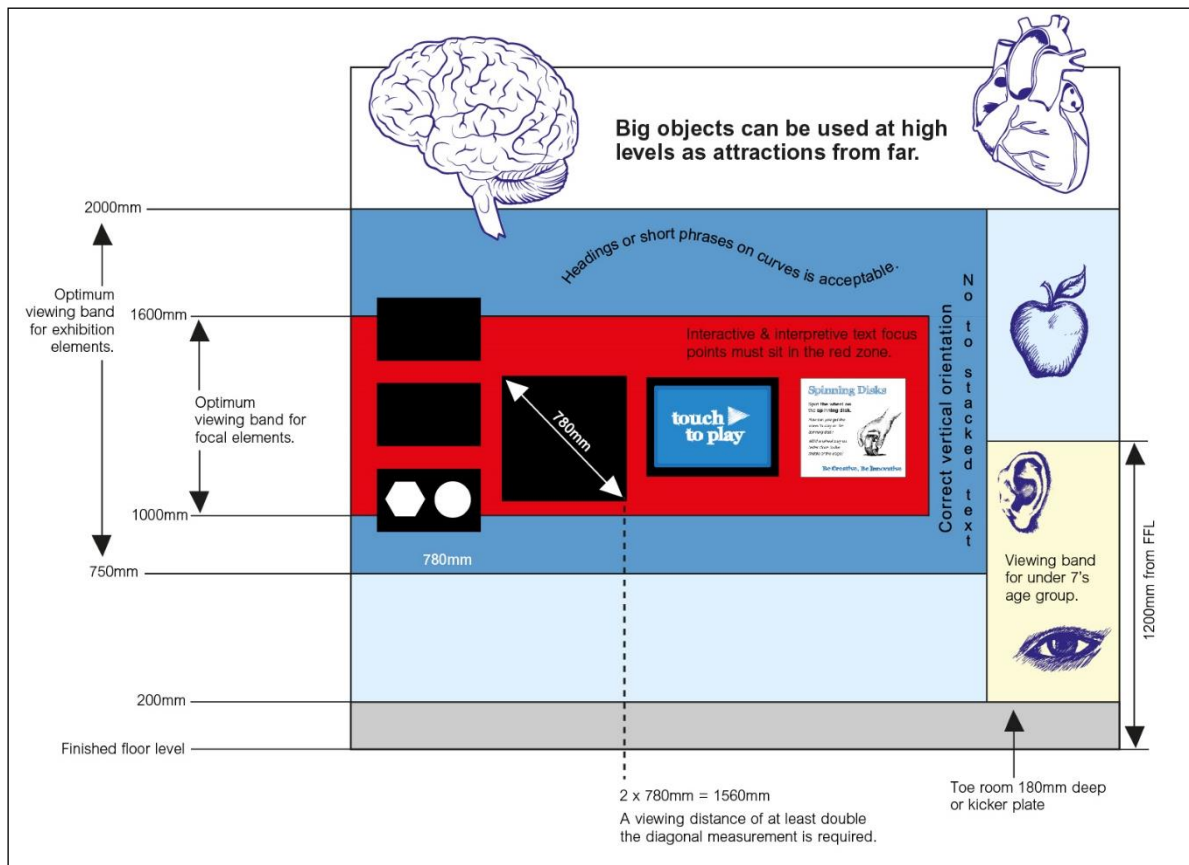
Figure 4.3 Viewing Bands

4.9   Header heights

No beam, structure or door should be less than 2040 mm above a walking surface. If this clearance cannot be obtained, the low beam or structure must be padded or clearly marked to protect the visitor from head injury.

5. Exhibition Text and Graphics

Specific rules for typefaces, fonts, sizes etc. will be developed as part of the Exhibition Graphic Style Guide design process. However, a sans serif typeface should always be

used in signage as it is easier for people with visual impairment to recognise the characters.

The design and format of exhibit labels, including text and graphics on AV exhibits, will be consistent across the exhibition and in keeping with exhibitions throughout GSC.

Exhibition text and graphics will be structured to serve the visitors' needs at different stages. When viewing the exhibition as a whole, only exhibit themes and exhibit names should be visible. Subtle graphics and visual cues can distinguish different zones of an exhibition. On approach to an individual exhibit, the following text should become visible: the invitation, the initial instruction, further instructions, and the relevance and scientific background to the exhibit. Illustrations or pictograms will be used as a replacement for text whenever possible, where the image makes it easier for the visitor to understand a concept or instruction.

For further details, see Appendix C, Graphic & Interpretative Text Diagram.

6. Construction Standards

6.1   Construction General

Partition walls should be at least 100mm wide and constructed from 18mm mdf or ply on 75mm x 45mm and 95mm x 45mm timber studs where required. All partitions require adequate support and should be laid out in such a way that they are inherently stable and shall be additionally secured as appropriate.

Cabinets that may have to be levelled should be fitted with adjustable feet in sufficient numbers to ensure stability and adequate load bearing and be located near the edge of the cabinet allowing access for adjustment.

Unless they are fixed to a floor plate or a flush finish is specifically required, a gap 20mm above finished floor level should be allowed around the base of all cabinets to allow for adjustment of feet, fork truck access and for imperfections in the floor surface.

All welded joints visible to the public should be full and ground smooth.

All welded joints not visible to the public should be cleaned and ground if necessary to remove sharp protrusions prior to paint or other surface treatment.

Bespoke components should ideally be avoided but obviously this is not always possible, the following points must be followed when designing these components.

- Where possible off the shelf parts/ components to be used in the fabrication.

- Fully toleranced component drawings to be supplied.

- Material lists and costings including supplier references must be supplied.

- Avoid the use of expensive or difficult to repeat processes in manufacturing components.

6.2 Materials

6.2.1 Wood

All wood should be flameproof to EU Standards and be from FSC accredited sources where practicable. Surfaces should be treated to prevent splintering.

All woods must be dried to <8% moisture content before use to prevent warping.

Joints should not be visible below the paintwork and be reinforced or braced using dowels or biscuits where practicable.

6.2.2 Finishes – Paint & Powder Coat

Paint finish and colour will be specified for each individual exhibit.

Metal frames to be powder coated.

Epoxy paint used in areas of either high wear or high moisture content should be 100% solvent free.

Interior of exhibit case work shall be painted with a fire retardant paint.

250 ml and RAL number of touch up paint and other finishes shall be supplied as appropriate.

All paint mixes should be documented.

6.2.3 Table Top Surface Materials

All table top surface materials are to comply with design specifications and could include laminates (Formica, Abet or similar and approved) and solid surfaces (Hi Macs, Hanex, Corian or similar and approved).

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Use only Work Surface grades of Laminate with a smooth satin, not textured, finish.

Use only manufacturer-approved adhesives.

6.2.4 Glass

Glass can be used when scratching of plastics could be a problem. Where glass is used as a minimum it should be laminated or toughened and at least 8mm thick depending on the application of use. Glass pipes or vessels must be annealed.

6.2.5 Metal

All edges must be smooth and free from burrs and swarf. Wear situations where the components could sharpen over time should be avoided.

Welds should be clean and free from spatter.

For electrically powered exhibits all metalwork must be earthed and comply with all relevant Health and Safety regulations.

6.2.6 Plastics

All plastics should be UV resistant grades.

Use only safe, flame retardant foams.

Sheet plastics should be used for high wear areas.

Acrylic for clear exhibit covers should be thick (typically 12mm) enough to withstand a hands on environment and should be self-supporting when opened. Joints must be exhibition grade 'cast' joints.

6.3   Physical Construction

Many exhibits depend on vigorous physical interaction for their operation and to provide a challenging and engaging experience for the visitor. This can pose safety risks for the visitor, a few of which are listed below but is by no means an exhaustive list.

6.3.1 Edges

The physical housing of an exhibit poses the hardest risk to eliminate. Typically the housing of an exhibit will have hard edges which are easy to bump into or fall against

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regardless of age or physical ability. Thus, wherever possible, the edges of the exhibit housing should be chamfered to spread the impact.

All finished surfaces should be checked for sharp edges, burrs or splinters.

Edges should be chamfered and corners rounded.

6.3.2 Fixings

Metric, stainless steel fixings are preferred. Some plastic fixings are acceptable if appropriate and clearance to use them is sought.

Wherever possible avoid visible fixings.

Where the floor is suspended it is possible to secure exhibits to the floor, again avoiding visible fixings where possible.

Fixing to the walls will depend on whether it is a structural wall or a set-work wall fabricated as part of the exhibition installation. This should be identified and checked at the contract stage.

6.3.3 Handling- Guidance

Exhibits and set-work lighter than 45kgs may be lifted onto a trolley for moving (a 4-man lift). Exhibits heavier than 45kgs should have reinforced points in the base, and the exhibit should be balanced so that the forks of a palette truck can be inserted and the exhibit lifted and moved.

6.3.4 Stability

It should not be possible to push an exhibit over, nor should it be possible for an exhibit to be toppled by visitors climbing on it. The Centre of Gravity of an exhibit should be a key consideration during the design stage.

Where possible an exhibit should be designed to be stable in all circumstances, where this is not possible for a particular exhibit it must be fixed to the floor and in some circumstances, if installing onto a suspended floor, it may be necessary to fix to the underlying concrete floor.

Generally, to allow for flexibility and longevity, exhibits should not use the building as part of their structure.

6.3.5 Loose Components

It is likely that several exhibits will require loose parts to function properly.

Loose components must:

- Not pose a choke hazard

- Not give possibility of swallowing powerful magnets

- Generally be too large to pocket

- Not be self-sharpening with wear

- Weigh less than 0.5kgs and not cause injury if dropped onto a foot

Specifically, regarding choke hazards, the following guidelines apply:
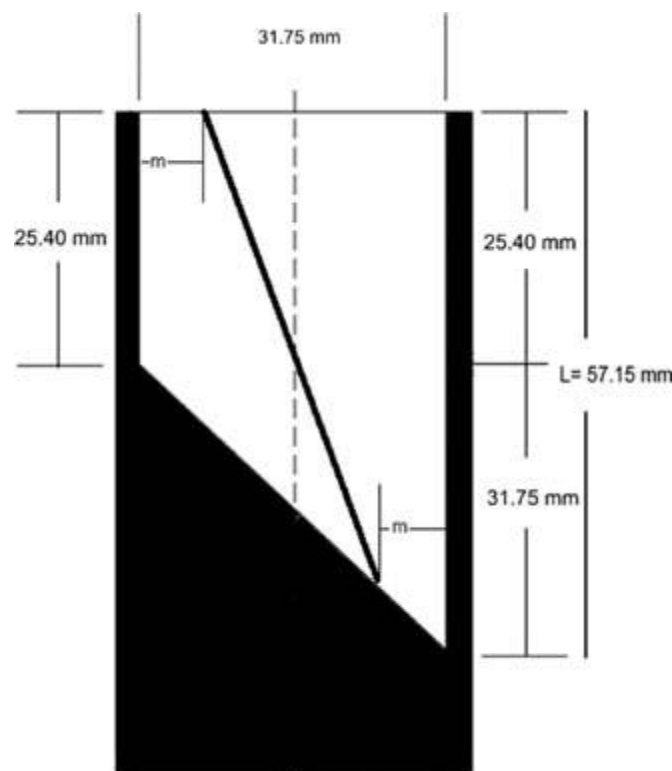
Choke Hazard- 'Small parts cylinder' test

The test uses the 'small parts cylinder'- loose components of exhibits that can fit entirely inside the cylinder are identified as choking hazards.

Magnets which have a flux of more than 50 kG2mm2 (0,5 T2mm2) and fit entirely in the small parts cylinder are not permitted for use.

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6.3.6 Moving parts

The European Standard applying to Children's Playground equipment may be of use here (EN 1176) and related safety regulations, such as the General Product Safety Directive.

Where possible moving parts should be guarded and where this isn't possible the area of the mating faces should be maximised to spread the pressure.

The weight of moving parts should be minimised.

It must not be possible to suffer a friction burn from any moving parts.

Where parts meet there must not be a pinch hazard, entrapment hazard, rotating bar access or in-running nip.

6.4   Services

Services are delivered through grommets in the floor beneath the exhibits- suitable holes should be made in the base of the exhibit to permit this.

6.4.1 Electrical

Single Phase Electrical supply is 240Vac at 50Hz.

Floor 3 has a suspended floor system with a void of approximately 490mm throughout. On this floor, power can be installed to suit the exhibition requirements.

Floor 2 has a part suspended floor (from core 1 to core 2) and the rest is concrete flooring. Power can be installed to suit the exhibition on the suspended floor and our preference is to utilise pre-existing power on the concrete flooring or to provide power from above where appropriate.

Floor 1 is entirely concrete and as such it is our preference that existing power is utilised. A location plan of existing power can be provided on request.

Exhibits requiring more than 13 Amps Single Phase supply must be identified at the contract stage.

Connection must be via a single lead, distribution boards should be mounted firmly within the exhibit.

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It must be possible to switch every exhibit off either via the Building Management System or a discrete external switch that is not obvious to the visitors. Exhibits requiring 24 hour supply must be identified at the contract stage.

Ultimately, it is the desire of GSC to have all exhibits switched on and off via a power management system dedicated to the exhibits. As such, all exhibits should be designed with this in mind, where the exhibit either has the capability to be integrated with such a system or can be easily modified to allow for this function.

There should be an earthing point near the power input to allow for ease of PAT testing.

All exhibits must be fitted with a standard UK three pin plug.

6.4.2   Compressed Air

Any exhibit that requires compressed air must be identified at the contract stage.

There is the facility for compressed air within GSC. The design and location of the exhibit should be discussed with the GSC Facilities department at the contract stage.

The public must not be exposed to air at pressures greater than 15psi. Higher pressures can cause embolisms. Dust and dirt blown by air escapes are an eye hazard and must be avoided.

Any air exhausts should be silenced.

6.4.3   Water

Water, which is not accessible to the public, should be treated to keep it clear and free of bio-hazards.

Any exhibit housing water must include a water drainage mechanism to allow for periodic emptying and refreshing of the water. It must have a suitable way of being filled, from a water supply pipe of no bigger than 22mm in diameter, and being emptied with a waste pipe of no bigger than 40mm in diameter.

Details of regular water treatment and refreshing must be provided by the manufacturer to GSC as part of the O&M manual. The GSC legionella risk assessor must be informed and the legionella assessment reviewed/updated.

6.4.4 Drainage

Water drainage will be via a sealed trap. Exhibits that only require periodic drainage can be drained via a temporary hose.

Any unavoidable leaks within an exhibit should be contained by drip trays within the exhibit, which should be emptied regularly. Wooden surface must not be allowed to become damp.

6.4.5 Lighting

All lighting shall be LED unless otherwise approved by GSC at the contract stage.

All lighting shall be protected from contact with or by the visitor.

GSC Science Mall has varying levels of ambient light due to the floor to ceiling windows on the North side of the building. This is a consideration when designing exhibits that require lower light level to function and should be discussed with the GSC Audio-Visual department and Facilities department.

If an exhibit requires specific lighting then the design should allow for including this.

Sufficient lighting must be present to avoid slips, trips and falls.

6.5   Components

6.5.1 Sources

Generally, all components used in the development of the exhibits shall be supplied from the RS catalogue (UK Edition) or be equivalent in form, fit and function to an RS component and of equivalent or better quality (i.e. CE marked, where this applies).

Where possible, standard parts should be used. (Standard parts mean off-the-shelf components, assemblies or units that would normally be available from the suppliers ex-stock).

Standard and other parts should be available in the UK. If parts are purchased outside the UK, proof that the same parts are available in the UK must be produced by contractors and written agreement given prior to purchase.

Parts should be chosen that maximise the chances that the part remains a standard item. Factors influencing the choice include the size and past history of the suppliers, choosing dimensions that are a part of a standard range of sizes and selecting assemblies or units that are widely used commercially or industrially.

Parts chosen should have a second source.

Custom parts must be fully documented and .DWG files supplied if requested.

6.6   Electrical

6.6.1 Electrical Components

All materials or component parts used in exhibits must function within the manufacturers recommended tolerances and conditions.

Any electronic equipment contained within an exhibit shall remain in its original housing unless approved by GSC.

Live parts shall be inside enclosures or behind barriers to prevent visitors and or staff unintentionally touching live parts. The barrier or enclosure shall be firmly secured in place and have sufficient stability and durability to maintain the required degree of protection and appropriate separation from live parts.

Live parts shall be completely covered with insulation which can only be removed by destruction.

It is the preference of GSC that any custom built electronic equipment shall have a built in self-diagnostic capability. It is acknowledged that this will have a cost implication and the fabricator is encouraged to present a cost for with and without this capability.

Any exhibit containing electronic equipment shall be equipped with a ventilation system-active or passive, depending on the circumstances.

6.6.2 Switches

Switches should be rated at not less than 10^6 operations.

Do not use capacitive type switches.

Must be securely mounted such that no part of the switch can be moved, or rotated.

6.6.3 Sensors/ remote components

These must be mounted so that they can be easily removed/ replaced if required.

6.6.4 Circuit boards

All main circuitry should be on a minimum number of PCBs.

PCBs to be fitted using transition pillars and metric screws.

Veroboards and wire wrap board should NOT be used.

6.6.5 Transformers

Toroidal transformers should be used where possible.

Where non-toroidal transformers are used the position of them should ensure that magnetic field leakage does not interfere with other circuitry.

Transformers must be securely mechanically mounted.

Toroidal transformers must not be mounted so that the central bolt can come into contact with the lid and generate a short circuit current.

6.6.6 Fuses

All fuse holders should be marked with the required fuse rating.

Mains fuse holders should be covered with a PVC insulating boot.

No exhibit should rely on the external mains fuse being correct, it should have a separate correctly rated internal mains fuse.

Secondary transformer windings should be separately fused.

6.6.7 Connectors

Mains (three phase)

- Circular multipole self-latching plastic   RS 237-3653 + range

- Circular multipole screw-lock shielded   RS 259-1110 + range

- D-connectors (standard or mixed contact)

Mains (single phase)

- IEC Socket, Single Fuse   RS 210-285 + range

- IEC Socket, Double Fuse   RS 188-9602 + range

- Computer systems, Audio/Video

- As per industry standards (D-connectors should be of filtered type)

6.6.8   Wiring

All exhibit wiring including earthing arrangements must comply with IEE wiring regulations BS7671.

6.6.9 Lamps

Must be securely mounted such that no part of the lamp can be moved or rotated.

All lamp holders should be clearly marked with the required rating.

6.6.10 Strobes

Where strobes need to be used as a fundamental part of an exhibit there must be a warning to potential photosensitive epileptics. The use of strobes within exhibits must first be discussed with the GSC Project Manager.

Strobe lighting should be of limited intensity and should avoid frequencies lower than 20 Hz.

6.6.11 Lasers

Use less than 1mW inherently safe lasers. Even with these lasers it should not be possible to look into the beam for prolonged periods (>4 s).

Laser exhibits must be marked with the appropriate laser class warning sticker.

Diverging lenses should be mounted to the laser output.

When multiple lasers are used it must not be possible for multiple laser beams to converge in a person's eye.

Beware of the effects of lenses, mirrors and gloss surfaces on the beam.

6.7   Mechanical Engineering

6.7.1 Materials

Materials need to be selected for specific purposes i.e. for hostile contaminants such as salt or water the use of plastics and / or stainless steel is recommended. Surfaces likely

to receive heavy wear must be either constructed from a self-colour material (e.g. plastics or metals) or protected with a hard-wearing laminate. The use of painted materials on high wear areas is unacceptable.

The use of new types of materials is encouraged preferably only when a real benefit can be displayed.

Laminates and covering materials to be selected for functionality before aesthetic appeal and never to the detriment of structural integrity or safety.

When using laminates, panels not forming an integral part of a structure i.e. doors, access panels etc. must be covered both sides with laminate to prevent distortion.

6.7.2   Framing systems

When using a framing system it must be remembered that all edges and corners have to be rounded, at least a 15mm radius is required for safety purposes.

When selecting a framing system a type that offers a good deal of flexibility is required. There are several types in use within the present exhibitions each with their own plus and minus points, these should be considered before any others are sought.

Exhibits must not be designed so as to use the frame as a locating point for highly toleranced parts or components that are difficult to align; it is preferable that mechanical sub assemblies are constructed that "drop in" to the system allowing them to be pre-set before final assembly.

6.7.3   Mechanical Input devices

6.7.3.1 Push Buttons & Switches

All pushbuttons should be robust, low voltage, equipped with insulated spade connectors, and easily removed and replaced for servicing.

Trackerballs should be replaced easily by members of GSC staff, but not be removable by GSC visitors.

Buttons, joysticks, trackerballs and other input devices should be sourced from the Suzo-Happ catalogue (UK edition). Otherwise, components should be arcade grade, equivalent

in form, fit and function to components from Suzo-Happ and be of equivalent or better quality.

6.7.3.2 Handwheels

Handwheels must be of a consistent design throughout the exhibition and of a type readily available.

Handwheels must be mounted to shafts via a key, turned shoulder and end screw.

Open spoked and lever arm type handwheels are not to be used.

Handles on handwheels must rotate freely.

Handwheels must not over run or be able to be back driven, these requirements can be met by gearing and using inline clutches.

Handwheel input speeds are to be kept below 200 rpm by the use of rotary dampers and / or gearing.

6.7.3.3 Levers

Levers must be of a consistent design throughout the exhibition, and must operate on bearings, bushes are not acceptable.

Lever inputs must be damped and avoid any possible finger trap, when levers are running in a slot internal stops must be incorporated to eliminate the possibility of trapping at either end of the travel, it is unacceptable to rely on a linear damper as the travel stop.

Secondary levers must be driven both ways either by push pull cables or solid rods, relying on counterbalance weights or springs is not acceptable.

6.7.4 Secondary Inputs

6.7.4.1 Gear Wheels

Gear wheels of a similar type must be used throughout the exhibition.

When using gear trains, gears meshing together must be of dissimilar materials i.e. Delrin to Steel, to avoid the need for oil baths and for quieter running.

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Gear wheels must be keyed to shafts and fastened in the same way as handwheels where possible, pinning gear wheels is only acceptable if it is necessary as a safety precaution.

When using angled gears only 1:1 ratios are permitted. Any gearing up or down should be achieved before or after an angled pair.

Gear tooth size selected must be appropriate to the loads likely to be encountered allowing for misuse or seizure of components.

6.7.4.2 Pulleys and Belts

Pulleys and belts used in the exhibition should be of a similar type throughout.

Pulleys must be keyed to shafts and fastened in the same way as handwheels where possible; pinning pulleys is only acceptable if it is necessary as a safety precaution.

Toothed belts and pulleys must be used when it is vital to maintain rotational alignment between the two wheels. The use of chains and sprockets is not acceptable.

Vee pulleys are an acceptable drive mechanism, but only where a minor slippage of the belt on one or other of the pulleys would not interfere with the working of the exhibit.

All belt drives must have either adjustment at one end or an automatic tensioning unit (or both), to maintain even belt tension.

6.7.5 Bearings

Bearings must be from the standard stock range of a reputable supplier, and all part Nos. supplied in the supporting exhibit documentation.

Where possible bearings should be sealed.

The correct type of bearing must be selected to suit the application and loads expected.

Bearings should ideally be fitted to a removable bearing housing to aid replacement and alignment. Bearings must be easily removable from any housing.

When using needle roller or roller bearings a sleeve must be used rather than running directly on the shaft, grease nipples must be fitted if unsealed.

Plastic bearings are acceptable where it can be shown to reduce maintenance and the tolerances of the rotating parts is such that they are appropriate.

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Linear slides can be used, but must be of a readily available type and mounted using an adequate number of adjustable runners.

Linear slides must be hardened and an adequate number of oilers used.

6.7.6 Shafts

Shaft materials and sizes should be standardised throughout the exhibition if possible, thus reducing the number of spares required.

Shaft over hang must be kept to a minimum and must never exceed the distance between the two supporting bearings.

Shafts must be able to be removed from one end; a shaft held captive by two bearings necessitating the removal of one of the bearings is not acceptable.

6.7.7 Pneumatics and Hydraulics

Only low pressure systems are to be used.

Air supply must be checked for moisture, if system is thought to be "wet" then an automatic drain and oilers must be fitted to protect components.

All pneumatic and hydraulic circuits to have logic diagrams which must be checked by a "competent person".

Systems must be designed so that loss of pressure or power results in the system going "slack" i.e. all moving parts can be manually forced back to their start points, it is important that there is no sudden movement in any direction caused by this loss.

6.7.8 Engineering Adhesives

Avoid butt joints if bond area is small, the use of scarf joints can increase the bond area to an acceptable limit.

Joints for sheet metals must be designed so that the main loading is in shear.

When using adhesives the following must be considered;

- joint must allow easy application of the adhesive;
- joint must be designed to give uniform stress;
- joint must be easily held in position whilst the adhesive cures;

- it must be possible to apply the adhesive to one side of the joint and for the adhesive to stay there until the two parts are brought together;

- selection of the correct adhesive to suit the application;

- all surfaces must be correctly prepared and primed, which may also include removal of sharp edges and substitution of a bevel or radius;

6.8 IT Equipment

Generally, all computers and Audio Visual equipment will be contained inside exhibit cabinets with adequate ventilation for the exhibits to operate at their normal free air temperature. Ventilation vents should not be on horizontal surfaces where they can be covered or on vertical surfaces where they can be blocked by a wall or adjoining exhibit. Inlet vents should have dust filters and the replacement schedule should be detailed in the PPM in the O&M manual.

6.8.1 Computers

All PCs/Macs must be provided with a minimum spec as detailed.

- Dual core processing

- 4GB of memory

- 250GB storage

- Appropriate graphics cards to meet minimum resolution of 1920 x 1080

- Onboard 10/100/1000Mbps Gigabit Ethernet Support

Mini PCs and Small Form Factor PCs are preferable to ensure a smaller footprint.

GSCs preferred manufacturer is Hewlett-Packard (HP), however other makes are permissible for specific exhibit requirements. Custom built PCs will only be considered providing all parts can be UK sourced and agreed at contract stage.

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6.8.2 Operating Systems

The following operating systems are recommended as of May 2019. GSC will consider new versions released after this date, but will not accept previous versions to those listed. The most up-to-date version of any software, including operating systems, is always preferred from a security point of view.

- PCs should operate on Windows 10
- Apple Macs should run on Mac OSX 10.14 Mojave
- Where applicable, servers should run Ubuntu 18.04 LTS or Windows Server 2019
- Where a database is required, there are multiple acceptable options, including MySQL, PostgreSQL, Microsoft SQL Server, SQLite, and MongoDB

6.8.3 Software

An IT exhibit designed for public interaction within a science centre requires additional considerations from general multimedia productions. These include:

- An attractor screen for when the exhibit is dormant
- 'Mouse down' activation when using touchscreens as input devices
- Editable preferences file that allows e.g. for the cursor to be switched on and off, and other configurable changes to the functioning of the exhibit.
- Exhibits should return to the attractor screen after a period of inactivity. The period of inactivity is determined by the specifics of the interactive but a good default starting point is 30 seconds.
- Before the exhibit automatically resets, a warning message should appear which gives the user a chance to cancel the reset and return to the software. The standard period of time for which such a warning displays is 10 seconds, preferably incorporating an on-screen countdown.

GSC also has software development requirements for all IT based exhibits:

- Development frameworks
  - HTML5 is GSC's preferred development platform due to its portability, ease of reuse and testing, and non-reliance on the underlying operating system.
  - Other platforms can be authorised on an exhibit-by-exhibit basis if they are deemed to be the best solution. Low-level languages, requiring

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additional support or libraries, should be avoided, but higher-level languages such as Ruby and Python will be considered.

- o Adobe Flash will reach end-of-life in 2020. To allow GSC to adequately maintain its exhibits into the long-term future, Flash **must not** be used for any new exhibit development.

- Deliverables
    - o It is always greatly preferable that GSC obtains the source code as well as any compiled application. The aim of this is to allow GSC to maintain the exhibit in the long-term future, and to allow for modifications to be made based on evaluation and eventual software deprecation.
    - o The provided source code should be sufficient to rebuild the application from scratch, given the necessary tools.
    - o Source code should be under some kind of version control (preferably Git) to facilitate any modifications.
    - o If there are reasons that the provision of source code would prove problematic, these should be discussed with GSC at the contract stage.
    - o Full documentation of any materials required to maintain or support the exhibit, including information on the necessary version of the operating system and any third-party programs/utilities required, should be provided.

- Security and access considerations
    - o All GSC's IT exhibits are unattended and accessible by the public, so any application must be able to be 'locked down' so that it is the only application available on the device that runs it. Visitors should not have any access to the operating system – this includes system menu bars, printing and networked resources. This also means that operating system features which are not necessary for the exhibit to function fully (such as right-click dialogues and touch cursors) should be hidden. Visitors should not be able to quit from a program under any circumstances.
    - o Should an interactive be running in a web browser, the exhibit must ensure that the visitor is not able to access the wider internet – whether this be via a typed URL or by following a link to an external site.

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- o Exhibits should be remotely accessible by GSC staff for monitoring, updates and troubleshooting. Currently TeamViewer 8 is the preferred software solution, but others such as VNC and SSH may be acceptable on a per-exhibit basis.
- o It is desirable to fit watchdogs to all IT based exhibit software. These ensure that should a program cease to run (i.e. it crashes) then the exhibit will be reset. Watchdogs should be set to reset the exhibit if required at least once every 30 seconds. The exact mechanism of such a watchdog is not prescribed, and this function may be fulfilled by the interactive itself.
- o GSC IT staff are able to assist with lockdown, watchdogs and remote access, and are likely to recommend the use of one of our existing solutions to these requirements.
- o Software should also follow good security practices such as complex passwords, escaping user input etc. It is incumbent on the application developer to be responsible for these security aspects.

- Licensing
  - o While open-source software solutions are always preferable, commercial software licenses may be obtained as part of the best solution for an exhibit.
  - o GSC must retain all licensing agreements and documentation for any registered software installed on IT exhibits provided. These must be handed over before the exhibit is installed at GSC.
  - o As a registered Scottish charity, GSC receives special rates, educational and charity pricing on all its software purchases. If large volumes of licensing are required, GSC may procure this directly.

6.8.4 Network

If an exhibit requires a network data cable then this should be identified at the contract stage.

Connection to the network services will be via a RJ45 plug and CAT5 cabled 100Mb Ethernet.

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6.8.5 Keyboards

Standard keyboards and standard mice should not be used for visitor interaction. If they are required within the exhibit for maintenance purposes they should be industrial grade and splash proof, with flat easy-clean keys.

6.8.6 Touchscreens

Touchscreens are the preferred input device and should preferably be capacitive, scratch resistant, multi-touch and with a bezel-free design.

6.9 Audio Visual Equipment

6.9.1 Monitors

All monitors should be provided with a minimum resolution of 1920 X 1080 and should be a minimum of 19" in size.

6.9.2 Data Projectors

All projectors must have minimum resolution of 1920 x 1080 and have a minimum light output of at least 2500 ANSI lumens.

Any projectors in areas where a large amount of natural light pollution is present should be specified appropriately with a high lumens output.

All projectors should have a network enabled input to allow remote monitoring.

6.9.3 Video Media Formats

Codecs required for video playback must be supplied, and if necessary licensed and the licence supplied to GSC. Most formats are acceptable, but the de facto standard is H.264 in an MP4 container.

6.9.4 Sound Stores

All audio files should be recorded and played back at the highest quality.

WAV and AIFF are preferable, but MP3 files with a minimum of 320kbps will be accepted.

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6.9.5 Headphones, Speakers

For maintenance issues we prefer if headphones are not used on exhibits. Speakers mounted on the exhibit but near to the visitors head are preferred. If headphones are fundamental for the purpose of the exhibit they must have armoured cable. Our preferred style is http://www.blackboxav.co.uk/amour-cable-headphones/ from Black Box-AV.

Where possible speakers should be discreet or flush mounted with fabricated walls or surroundings. GSC has no manufacturer preference, but expects all audio to be distributed to a high quality.

6.10   Sound & Noise

The visitor should not be exposed to noise levels greater than 85dB at a distance of 1m.

Where loud noises are unavoidable a warning should be given.

Sounds used in exhibits should be clearly distinguishable from fire alarms.

The sound levels within the exhibition space will be variable and exhibits with audio should have variable volume control.

6.11   Maintenance

The level of exhibit maintenance strongly affects attendance and is of crucial importance to a science centre, so every effort must be made to minimise maintenance and to make it more effective.

6.11.1 Operation & Maintenance Manuals

Every exhibit must come supplied with an O&M manual; this should include but not be limited to the following:

- Operational specification
- Planned Preventative Maintenance Schedule
- Design specification
- Exhibit visual record
- System (or Block) diagram (including any explanatory notes)

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- Circuit and wiring diagrams (including any explanatory notes). (If necessary repeat for other sub-systems such as pneumatics, water etc.)

- Component data

- Hardware specification

- Mechanical drawings (including any explanatory notes)

- Audio visual specifications

- Copies of all text and graphics

- Consumables specification

- Software Specification

- Data files

- Modification record

- PAT test Certificate

- Safety checks

- Safety summary sheet including Risk Assessment

- Development record

Full details of the O&M manual can be found in the documentation section.

6.11.2 General factors

Exhibits must be able to interface with the Building Management System.

Allen key heads are preferred whenever screws are called for. Philips cross head screws are acceptable alternatives. Slot head screws should not be used.

Exhibits must be designed for low maintenance.

Any mechanical or electrical equipment compartment in which servicing would be facilitated by having an electric light installed should be equipped with a switched mains light. This would apply to most such compartments with volumes of 1 m³ or more.

Exhibits should be designed on a modular basis, with the number of modules per exhibit being kept to a minimum.

Connectors should be capable of locking and use sufficient cable length to permit maintenance of sub-assemblies without disconnection.

Rotating parts should use sealed or self-lubricating bearings, low maintenance plastic-on-metal gear trains or sealed gear boxes.

6.11.3 Access

Access panels shall be equipped with some sort of positive hold open device or be completely removable.

Access to the interior of the exhibit shall generally be through discreet hatches or panels attached to the exhibit case structure by hidden hinges and equipped with GSC approved key locks.

Access panels intended for the servicing of the exhibit apparatus shall be sized appropriately to provide easy access to the equipment being serviced and to allow for the taking out of, and replacement of, whole units and parts for servicing and maintenance.

Any piece of electronic equipment contained within an exhibit shall have at least 50mm clearance all round to allow air circulation and easy removal and replacement.

It must be possible for all repair work to be carried out unhindered and conveniently such that a single maintenance staff person does not need to physically strain to carry out the work.

6.11.4 Safety of maintenance staff

Interactive casework must not have any sharp edges or points internally that could be hazardous to maintenance staff.

Access through the casework to the exhibit must be sufficient to permit safe working on the interactive.

Interlocks must be fitted if opening the casing gives access to intense visible or invisible light, including laser and ultraviolet radiation. If opening the casing gives access to hazardous moving machinery, then methods of locking the machinery stationary must be available.

Interactives must be constructed from and contain safe materials, in particular assessments must be done according to the COSHH regulations to avoid hazards to maintenance staff.

Interactives should not provide an additional hazard such as explosion or release of toxic or noxious fumes in the event of a fire.

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Interactives must be adequately labelled. Labelling requirements include start-up/shutdown sequences where appropriate, hazard labelling and operating instructions where appropriate.

Hazard labelling must include warnings of hazards from moving machinery, high or low temperatures, high voltages or intense visible or invisible light, including laser and ultraviolet radiation.

6.11.5 Removal and replacement of the exhibit or major component parts

The exhibit or major or components must be removable and replaceable safely and easily.

Manual handling of exhibits/major exhibit components should be avoided where possible.

If the exhibit or major components of the exhibit are not self-supporting when removed, a support frame is required to which a de-mounted exhibit can be fixed.

6.11.6 Cleaning

All equipment must be cleaned using GSC resources to a standard comparable with existing exhibits.

It must be possible to clean equipment without the need for unreasonably expensive cleaning agents or cleaning equipment

6.11.7 Corrosion

All parts of exhibits must be corrosion resistant, in particular:

- resistant to liquids used in cleaning in or on the floor or other fittings around the exhibit;
- where liquids are used as part of the exhibit.

6.11.8 Consumables

The cost of supplying an exhibit with consumable materials or services must be estimated and included at the concept stage and brought to the attention of GSC at that time.

Consumables must be kept to a minimum.

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7. GSC Local & Physical Parameters

7.1 Access

The public entrance to GSC is via the Atrium, facing the turning circle, to the East of the building. Public access to the Science Mall floors is via the goods lift, small passenger lift and escalators between the ground floor and 1st floor. There are four emergency stair wells, with three extending to the 3rd floor level. There is additional access for exhibits entering the building at the ground floor via the two double doors situated in the Clyde Suite alongside the River Clyde. The door dimensions are: H: 2920mm, W: 2920mm.

Goods delivery access is via the ramp to the right of the public entrance which enters at the basement level loading bay. The goods lift is directly opposite this entrance. The goods lift parameters are:

> Door- H: 2260mm, W: 1950mm,
>
> Inside- H: 2370mm, W: 2500mm, D: 3520mm
>
> The maximum load is 5000kgs or 5 Tonne.

7.2 Floor Make-up

Floor 3 has a suspended floor system with a void of approximately 490mm throughout. On this floor, power can be installed to suit the exhibition requirements.

Floor 2 has a part suspended floor (from core 1 to core 2) and the rest is concrete flooring. Power can be installed to suit the exhibition on the suspended floor and our preference is to utilise pre-existing power on the concrete flooring.

Floor 1 is entirely concrete and as such it is our preference that existing power points are utilised. A location plan of existing power can be provided on request.

7.3   Point Loading

All 3 upper floors in the Science Mall can take a Uniformly Distributed Load (UDL) of $6kN/m^2$ although a greater loading can be sustained at certain locations, i.e. on beam lines. The UDL on the ground floor is $10kN/m^2$.

8. Documentation

Manuals should contain the following sections where they apply in any way to specific items. Sections should be cross referenced wherever appropriate. The manual will also serve as the 'Technical Construction File' as required by the European EMC Directive and the 'Technical File' described in the Low Voltage Directive.

Title and contents

- Title, date, revision no.

- Author/s contact details.

- Contents page to include subheadings and figures where appropriate (see next section).

- Manufacturers contact address (name, address, tel. and fax).

Standard font and layout

- Page: A4 portrait

- Font: Arial

- Titles: All pages to have titles.

- Titles to be right justified; point size 16, Bold face

- Text: Point size 12, normal face.

Drawings

- All drawings to show dimensions (mm), surface finishes and tolerances.

- CAD drawings must be AutoCad DXF files, supplied in both hard copy and digital formats.

- All drawings to be suitable for use as a specification for a copy to be produced. All components to be fully cross-referenced with Component data section.

8.1 Contents

The following is a list of all categories which might apply to any exhibit. For individual exhibits, many sections may not apply, or contain very little material.

8.1.1 Operation

- Floor plan showing location of exhibit.

- Installation Method Statement.

- Schedule of Planned Preventative Maintenance and safety checks with service intervals including details of any limited life parts, approximate replacement intervals, and criteria to be used to test when replacement is required. This must include any servicing within the exhibit's lifetime that can be predicted. Any other maintenance that is required will be counted as a fault.

- Start-up and shut down procedures.

- Description of normal operation suitable for diagnosis of possible malfunctions i.e. power requirements, operating temp. ranges etc.

- Trouble shooting step-by-step response to selected potential problems and recovery plan.

- Schedule of cleaning requirements, cleaning methods and intervals.

- Access instructions.

- Disassembly and reassembly instructions.

- Any exhibit housing water must include details of regular water treatment and refreshing.

8.1.2 Design Specification

- Exhibit aims and objectives.

- Science explainer notes including concepts, activities, background, history, links to the Scottish Curriculum for Excellence.

8.1.3 Exhibit Visual Record

- Photographs/line drawings of whole exhibit and of any internal assemblies that will require maintenance. Where possible, these should be annotated.

8.1.4 System or block diagram including any explanatory notes

- Schematic diagram showing interconnections of main functional blocks.

- Circuit and wiring diagrams including any explanatory notes. If necessary repeat for other sub-systems such as pneumatics, water etc.

- Circuit diagram showing components and connections.

- Functional description.

- Wiring diagram giving plug, socket and cable connection data including details of wiring identification.

- Printed Circuit Board design with component overlays.

- Absolute maximum ratings or limits and a critical failure Risk Assessment.

8.1.5 Component data for each component show the following information, where applicable:

- Supplier's stock codes/reference sufficient to uniquely identify the component

- Supplier's contact information- name, address, tel. and fax.

- Sub-component warranties.

- Critical components ratings - bandwidths etc.

- Safety information- flammability, toxicity and hazard information, COSSH.

- Suppliers O & M manuals

- Test procedures giving procedures for tests and guidelines for interpreting data for diagnosis.

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8.1.6 Hardware

- List of exhibit hardware components.

- Mechanical data- ratings and operating limits of critical components.

8.1.7 Mechanical drawings including any explanatory notes

- General arrangement drawings (as-built).

- Component general arrangement drawings (as-built).

- Component drawings (as-built) including any adaptations of fittings made to brought-in components.

8.1.8 Audio visual

- Specifications of audio visual equipment.

- Details of formats used.

8.1.9 Labels

- Schematic (photocopy of instruction and information panels).

- Copies of all text/ graphics/ images, supplier details and any 'permission to use' contracts.

8.1.10 Consumables

- Exhibit consumables should be kept to a minimum.

- Specifications of all consumables and supplier details needed to keep the exhibits operational.

8.1.11 Software

- *Program listings*: Fully commented source code and a complete list of files to be supplied. This is likely to be most easily satisfied by holding the source code under a version control system - Git is preferred for this purpose.

- *Installation procedures*: A short guide on how to run the compiled/built application on a fresh machine. This must include the necessary directory structure needed by the software.

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- *Rebuild procedures*: A short but complete guide to how to compile or build the application from the supplied source code, including the software tooling required.

- *Third-party software requirements*: Information on the necessary version of the Operating System and any third party programs/utilities needed.

- *Copyright or licence details*: as required, including for third-party software.

8.1.12 Data files

- Type and format of data files.

8.1.13 Modification record

- Blank section for subsequent addition of details of modifications including reasons and associated documentation.

8.1.14 PAT test

- Certificate of PAT test (Portable Appliance Test).

8.1.15 Safety checks

- CE Declaration of Conformity (signed by the designated Responsible Person, and listing the appropriate safety standards that the exhibit conforms to).

- List of the essential health and safety requirements, transposed harmonised standards, standards and other technical specifications.

- Certificates.

- Comments by competent persons regarding safety.

- Any calculation notes, test results etc. required to check the conformity of the exhibit with essential health and safety requirements.
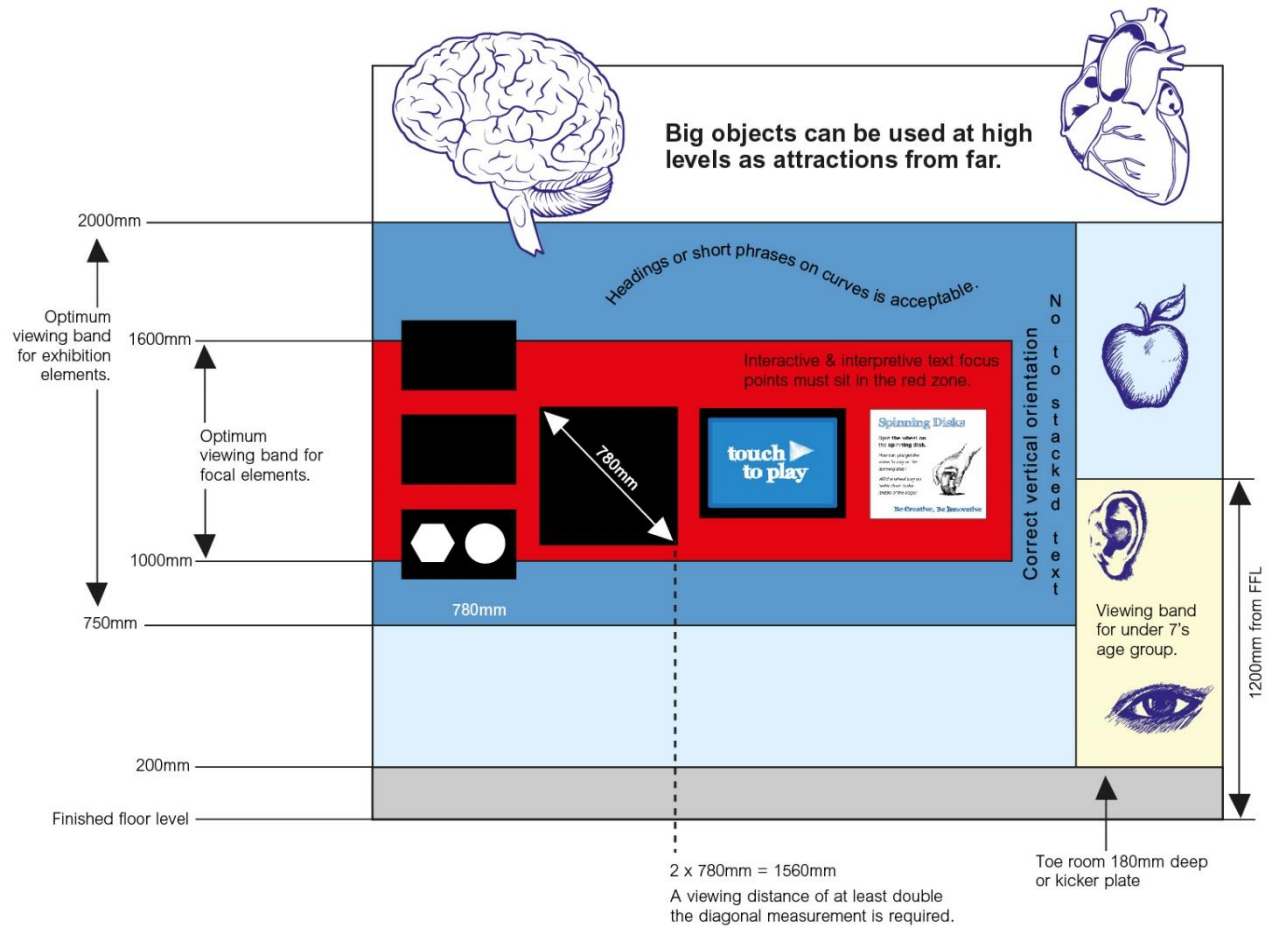
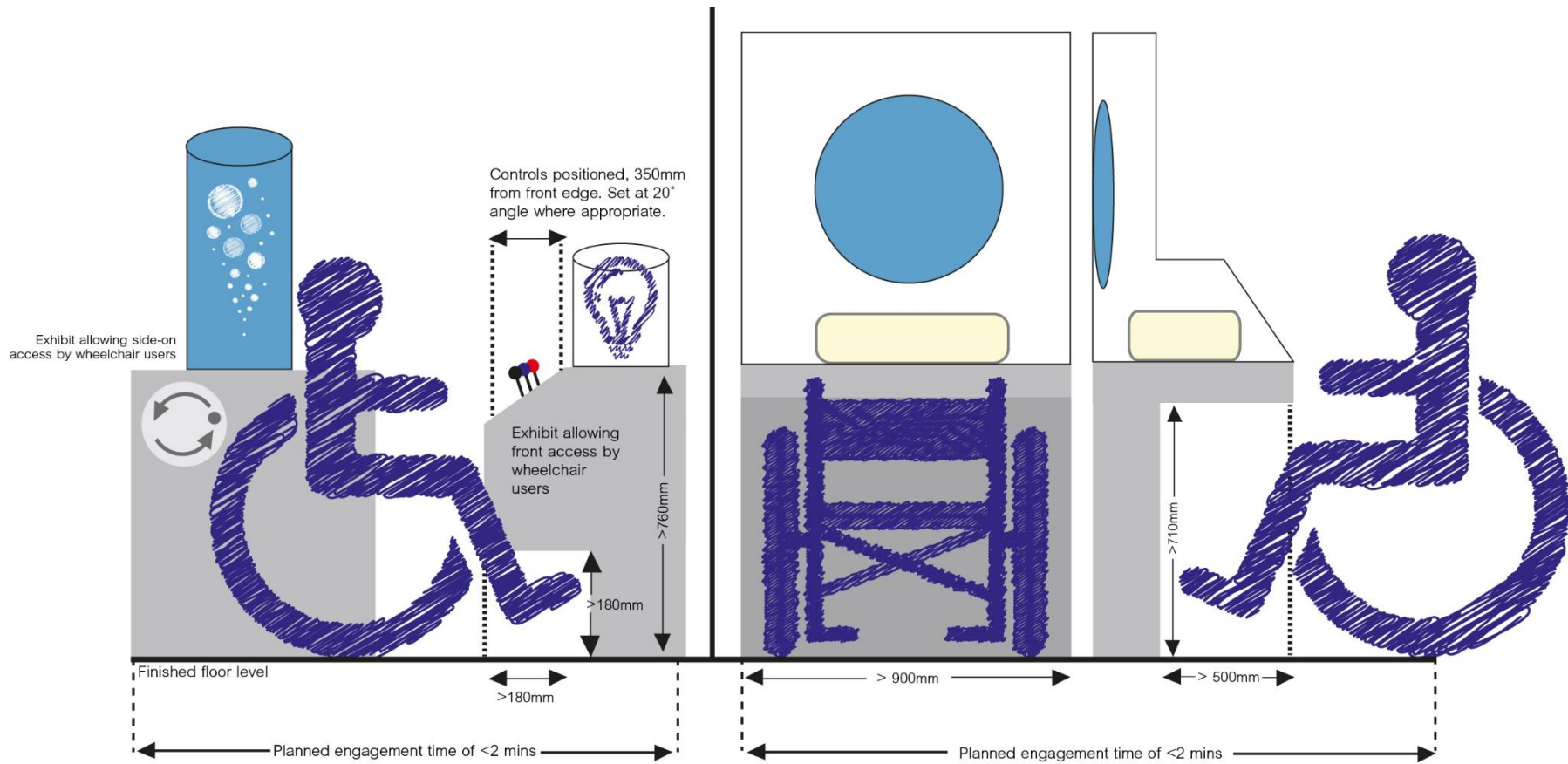*8.1.16 Safety summary sheet*

- Full risk assessment.

8.1.17 Development record

- Safety. Record of hazards identified in different categories during development and full details of measures taken to counter them.

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- Operation. Record of potential operational problems identified in different categories during development and full details of measures taken to counter them.

- Disabled Access. Record of access difficulties identified in different categories during development and full details of measures taken to counter them.

- Other issues. Record of other issues identified in different categories during development and full details of measures taken to counter them.

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9. Appendix A - Viewing bands

Big objects can be used at high levels as attractions from far.

2000mm

Optimum viewing band for exhibition elements.

Headings or short phrases on curves is acceptable.

1600mm

Interactive & interpretive text focus points must sit in the red zone.

Optimum viewing band for focal elements.

touch to play

Spinning Disks

780mm

Correct vertical orientation

No to stacked text

1000mm

780mm

750mm

Viewing band for under 7's age group.

1200mm from FFL

200mm

Finished floor level

2 x 780mm = 1560mm

A viewing distance of at least double the diagonal measurement is required.

Toe room 180mm deep or kicker plate

10. Appendix B - Accessibility diagram

Exhibit allowing side-on access by wheelchair users

Controls positioned, 350mm from front edge. Set at 20° angle where appropriate.

Exhibit allowing front access by wheelchair users

>760mm

>180mm

Finished floor level

>180mm

Planned engagement time of <2 mins

> 900mm

> 500mm

>710mm

Planned engagement time of <2 mins

11. Appendix C - Graphic & Interpretive text diagram

Reversed text can be more tiring to read. Use sparingly.

Avoid red-green colour combinations as it can be difficult for many people.

Avoid using colours of the same tone for text and background.

Dark text on a light or white background is best.

It is important to ensure there is sufficient leading or space between each line of text just like this paragraph.

Text with very little leading or space between each line of text reduces legibility.

Title text
Strapline as appropriate

Leading paragraph written in such a way that it stands alone. Visitors can only read this part and it still makes sense.

Sub heading

Sub headings should be used as necessary. Body text should be simple and in paragraphs.
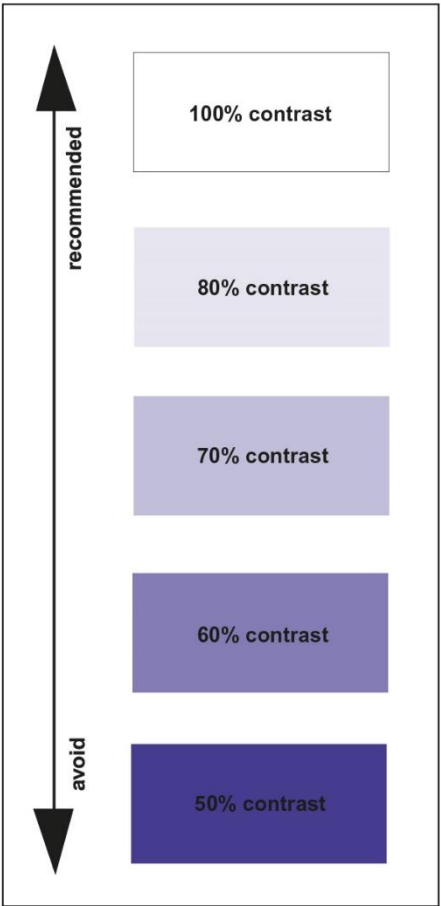
Text should be left justified and evenly spaced. Well spaced columns can be used to improve visibility.

Font size used should be no less than 14pt. Font type should be decided by the designer and consistent across the exhibition.

Text printed across a textured background reduces legibility
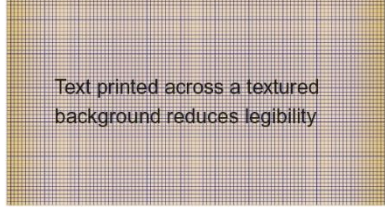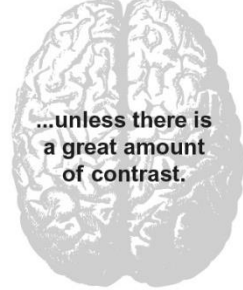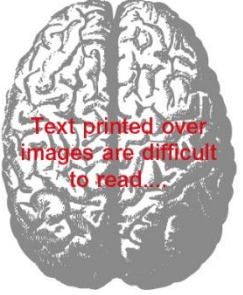
Contrast between type and a textured background is crucial.

Ensure at least 70% contrast across background with gradient tones.

Text printed over images are difficult to read...

...unless there is a great amount of contrast.

recommended

avoid

100% contrast

80% contrast

70% contrast

60% contrast

50% contrast

12.   Appendix D - Comprehensibility & Evaluation

Extract from NMSI Code of Practice 1998.

Outcomes

- Outcomes should be stated.

- Outcomes should be stated in terms of specific audience groups.

- Outcomes must be divided into motivational and cognitive types.

- Outcomes should be realistic and achievable.

- The outcomes must form a principal target for development.

Evaluation

- Determination of evaluation methodology and actual evaluations should be carried out by an independent group approved by the Museum.

- Evaluations will conclude with a list of recommendations, which will be adopted unless a reasonable justification to not so do can be established.

Key development issues

This key document states the current issues requiring resolution by the development process. Some will require evaluation, others may require consultation, technical testing or other appropriate methods.

Relevant key documents

A clear procedure regarding responsibilities involved in planning and conducting evaluations must be established, and staff and contractors must co-operate with this. It will include all communication associated with the process. Details of this will appear as a major part of the visitor studies key document.

At the start of the interaction

- The title should be short, use plain English, and refer as directly as possible to either the appearance of the exhibit or its method of operation.

- Attraction:

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- The exhibit should have features that attract visitors from the target audience.

- The attractive features (or 'hooks') should be visible or perceptible when the exhibit is in its reset or resting state (see 5A30)

- The attractive features (or 'hooks') should be visible or perceptible from a distance, including the area(s) of most common approach.

- Initial actions (excluding reading) of target audience, and feedback:

  - The three most likely initial actions should be identified using evaluation methods.

  - The three most likely initial actions should not lead to 'dead ends' (i.e. where the effect of the action does not increase the visitors awareness of what subsequent intended actions might be).

  - The single most likely action should give a response which 'rewards' the visitor (e.g. impresses, surprises, amuses, interests, intrigues).

  - The single most likely action should cause a response from the exhibit which stimulates the majority of visitors to a subsequent action which is compatible with the primary aim of the exhibit.

  - Touchscreen interfaces should be consistent and simple to learn. A visitor should be able to learn the user interface in less that 30 seconds. Note that trackerballs require simpler interfaces (because more time is spent understanding the trackerball function).

During the interaction:

- Controls of the exhibit

  - The number or variety of controls available or visible to the visitor at any time should not be off-putting to the visitor.

- Types of controls:

  - Switches should 'click' or change brightness (if illuminated) or otherwise indicate to the visitor that the switch has been operated.

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- Touchscreens should incorporate clear feedback when an active area or 'button' is successfully operated (e.g. audible clicks or a visual simulation of the button depressing).

- The largest possible active areas should always be used on touchscreens. (e.g. when a simple instruction is given such as 'touch the screen to continue, the whole screen should then become the active area).

- Flaps should carry graphics that are recognisable by the visitor as concealing information.

- Flaps should be designed such that the visitor is able to tell which way they open by looking.

- Flaps should be positioned sufficiently close to displays etc. to which they refer, that the association can be recognised by the visitor.

- Levers should be designed such that the visitor is able to tell which way they can be moved, and where the limits of travel are likely to be.

- Appearance of controls:

  - Controls should be differentiated from each other in a way which is recognised by the visitor.

  - Features should not be used if they resemble controls or are mistaken for controls by the visitor.

  - The result(s) of using a control should be recognised as being caused by using that control by the visitor.

  - If a control is used wrongly, there should be some feedback by which visitors recognise the action as 'incorrect', such that they do not deliberately repeat the action.

- Links between controls and affected parts:

- Controls should be arranged such that their direction of movement is not contrary to the direction of the main visible movement caused by them.

- Where the affect of a control can be considered as causing an 'increase' or 'decrease' (i.e. of volume or electrical signal etc.), the control should be arranged such that its direction of movement is not contrary to the normal associated direction (e.g. 'up', 'forward' or 'clockwise' = 'increase').

- Controls should follow other normal conventions where appropriate (such as 'red' = 'active'; 'green' = 'start' etc.).

- The majority of visitors should be able to recognise the correct causal link between their use of a control and its action(s).

- Workings of the exhibit

  - The workings of an exhibit should not be exposed where this is not necessary, unless the stated 'aims' of the exhibit make this desirable.

- Feedback from the exhibit

  - Feedback from the exhibit (particularly any audio or visual information) should be clear and consistent to the visitor.

- Operational pathways

  - Visitors should be able to recognise the likely consequences of their actions in terms of the type of pathway the action will lead to (e.g. moving to the next screen, or entering a branch by consulting a reference database).

  - Visitors should always have the option to retrace their steps by return to the previous steps along the pathway they have followed.

  - If the consequence of an action will lead to an irreversible change (without resetting the exhibit), then the visitor should receive: a warning that this is the case, an option to NOT proceed and a

request for a further action before the irreversible change can be completed.

- Length of interaction

    The holding power and motivation generated by the exhibit must be sufficient for visitors to remain interested for the duration of the complete interaction.

- Competition

    Competitive tasks should be used with caution and the desire to 'succeed' should not reduce the visitors learning experience.

Concluding the interaction

- The conclusion of the interaction should be recognisable as such by the visitor.

- If no action is taken with any control for a period of approx. 30 seconds, the exhibit should reset to its resting state.

- For computer exhibits, the reset should be preceded with a message prompting the visitor to take some action. If no action is taken within approx. 10 seconds of the prompt appearing, the exhibit should reset.

- The timing periods should be easily adjustable by maintenance staff.

Composition of visitor group

- Group co-operation

- Copying others

- School groups

    - Curriculum links

    - Reproducible in simpler form in school

- Family groups

    - Parents helping their children

- Age

- Other

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Relationship/context

- The ability of visitors to comprehend the correct relationship or context of the exhibit with its surroundings must, so far as is possible, be confirmed through evaluation.

- Personalisation/links to the familiar/everyday are generally desirable, but should be made with reference to the aims/objectives of the exhibit.

Metaphors and analogies

The ability of visitors to comprehend the correct meaning of the metaphor or analogy must be confirmed through evaluation.