

NATIONAL INFRASTRUCTURE COMMISSION



DESIGN
PRINCIPLES:
LITERATURE
REVIEW

PRODUCED BY
FRAME PROJECTS



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Any enquiries regarding this publication should be sent to us enquiries@nic.gsi.gov.uk

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1. BACKGROUND

This literature review provides background information on the application, scope and nature of existing design principles applied to infrastructure in a wide range of contexts. It has been carried out to inform the development of design principles to apply to Nationally Significant Infrastructure Projects (NSIPs). The National Infrastructure Commission (NIC)'s National Infrastructure Assessment, published in 2018, commits to the publication of design principles to inform design review panels for NSIPs. The NIC commissioned Frame Projects to conduct research and developed an evidence base, from which a set of principles could be produced.

NSIPs - large-scale projects that usually require a Development Consent Order or a Hybrid Bill to proceed - can be found in the energy, transport, water and waste sectors. The literature review has, however, focused on identifying existing design principles in a broader range of infrastructure sectors relevant to the NIC's remit, and has included digital, energy, flood risk, transport, waste, water and sewerage.

A search has been conducted within these sectors to identify published design principles in use in the UK and internationally. More than sixty separate publications have been reviewed as a result. The review was conducted on a broad basis, ranging from academic literature that aims to inform the design of infrastructure strategy and projects, to project-level design principles and guidance.

The review also includes reports published by the National Infrastructure Commission, including those commissioned by the Design Task Force - the forerunner to the NIC's Design Group which was established in Spring 2019 - as background research to inform the production of design principles for national infrastructure. These are therefore a particularly important source of guidance on the scope, form and content of the ultimate outputs from this research.



2. PUBLICATIONS REVIEWED

National Infrastructure Commission

Britain Thinks. 24 April 2017. 'National Infrastructure Commission Report from Citizen Research'.

Expedition Engineering / Marko&Placemakers for the National Infrastructure Commission. 2018. 'Design Task Force: The Value of Design in Infrastructure Delivery'.

National Infrastructure Commission. 2017. 'Data for the Public Good'.

Publica for the National Infrastructure Commission. 2018a. 'Design Task Force: Design and Infrastructure - Sector Review of Attitudes'.

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Government design policy and principles

Building Services Research and Information Association (BSRIA) and the Usable Buildings Trust (UBT). 2018. 'Soft Landings Framework'.

Cabinet Office. 2013. 'Government Soft Landings'.

Department of Energy and Climate Change. 2011. 'Overarching National Policy Statement for Energy'.

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'Ek, K., Pettersson, M., Alexander, J-C., Beyers, J., Pardoe, S., Priest, C., Suykens, and van Rijswijk, H.F.M.W. 2016. 'Strengthening and Redesigning European Flood Risk Practices Towards Appropriate and Resilient Flood Risk Governance Arrangements'. STAR-FLOOD, European Union.

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Cross-sectoral design principles

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Global Infrastructure Hub. 2019. 'Leading Practices in Governmental Processes Facilitating Infrastructure Project Preparation'.

iBUILD Infrastructure Research Centre. 2018. 'Closing the Gap: Local infrastructure business models to support inclusive growth'. Newcastle University

National Infrastructure Planning Association. May 2017. 'Towards a Flexibility Toolkit'. NIPA Insights II.

OECD. 2017. 'Getting Infrastructure Right: A Framework for Better Governance'.

Royal Academy of Engineering. 1999. 'Principles of Engineering Design'.

Royal Institute of British Architects. 2018. 'Joining the Dots: A New Approach to Tackling the UK's Infrastructure Challenges'.

Supply Chain Sustainability School. October 2017. 'Social Value and the Design of the Built Environment'.

Industry design principles

Asensio Villoria, L., Georgoulas, A. and Kara, H. eds. 2017. 'Architecture and Waste: A (Re)Planned Obsolescence.' Cambridge, MA: Harvard University Graduate School of Design.

Balfour Beatty. 2017. 'Ten Steps to Efficiency in Flood and Coastal Risk Management'.

Centre for Digital Built Britain. 2018. 'The Gemini Principles.'

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Highways England. 2017. 'Strategic Design Panel Progress Report'.

Highways England. 2018. 'Good Road Design: Highways England's Design Vision and Principles'.

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HS2 Ltd. 2018. 'Design Vision'.

Jacobs and Arup. 2009. 'Forth Replacement Crossing Managed Crossing Scheme. Scheme Definition Report.'

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SSE. September 2014. 'Slough Multifuel CHP Design and Access Statement'

Thames Tideway Tunnel. 2013. 'Design Principles'.

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User experience design principles

de Bres, W. 2016. 'Digital Product Design Principles'. 2016.

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3. METHODOLOGY

The literature below has been identified through a combination of desk research, using both bibliographies in existing literature and new research to identify design principles in as wide a set of contexts as possible. Expert advice has also been taken from NIC Design Group members and the many other professionals interviewed as part of the project.

The purpose of the literature review is to inform the development of design principles through investigation in the following areas:

- Status and scope: the nature, scope and coverage of existing principles and related literature.
- Objectives: the priority and focus given to design.
- Format: the way principles are formatted and communicated.

The review is divided into the following categories, which categorise the publications reviewed by scope and status. The NIC's Design Task Force reports have been separated, to reflect their particular status in relation to the project's remit.

1. National Infrastructure Commission
2. Government design policy and principles
3. Cross-sectoral design principles
4. Industry design principles
5. Project specific design principles
6. User experience design principles

Each publication is summarised below, to explain its relevance to the overall task of developing design principles for the UK's national significant infrastructure projects.



3.1 NATIONAL INFRASTRUCTURE COMMISSION

Britain Thinks. 2017. 'National Infrastructure Commission Report from Citizen Research'.

https://britainthinks.com/pdfs/NIC_Citizen-Research_Full-Report.pdf

Research commissioned by the National Infrastructure Commission surveyed public views on issues relating to infrastructure provision. A set of 'Key Insights' are reported, a number of which have potential to inform what 'Design Principles' could achieve:

- Infrastructure, particularly transport and digital, is thought to be critical to supporting a good quality of life.
- There are concerns about infrastructure provision, particularly in relation to transport and flood protection, both of which are thought to require improvement and investment.
- People feel that behaviour change is needed on waste management, with new systems from providers to reduce waste.
- Digital infrastructure is expected to improve over the next 30 years, the only sector where this is the case, and expectations for provision are high.

Participants wanted infrastructure that protects the environment, is resilient to change and is invested in to save money in the long term.

The report also questions the language used to communicate with the public, suggesting the term 'infrastructure' is associated with transport and housing rather than other sectors, and that technical language is confusing. The public also tends to be less engaged with water, and to a lesser extent energy, than other infrastructure types, means the challenges facing these systems are not as well-known.

Expedition Engineering / Marko&Placemakers for the National Infrastructure Commission. 2018. 'Design Task Force: The Value of Design in Infrastructure Delivery'.

<https://www.nic.org.uk/supporting-documents/design-task-force-the-value-of-design-in-infrastructure-delivery/>

The Design Task Force commissioned report defines design as about more than aesthetics and architecture; it is about effective problem solving from the outset, making infrastructure human-scale and user-friendly, enhancing the environment and improving quality of life not only for those who benefit directly but also for the communities

and places nearby. It uses the Design Council's 'double diamond' process diagram to illustrate the iterative nature of design and its role throughout the process.

The report highlights three particular benefits of design:

- Successfully integrating stakeholders of major transport networks to create a gateway to the city and a civic hub.
- Redesign of procurement approach to enable collaborative innovation processes.
- Extending the function of utility buildings beyond energy generation to act as an education hub and a new city landmark.

A series of case study projects are categorised using six areas in which design delivers value:

- Customer experience - user experience
- Social value - beyond users to the wider community
- Placemaking - identity of place and wider context
- Capital cost - investment to bring project into operation
- Whole life cost - maintenance and operation
- Environmental - carbon footprint and sustainability

Publica for the National Infrastructure Commission. 2018a. 'Design Task Force: Design and Infrastructure - Sector Review of Attitudes'.

<https://www.nic.org.uk/supporting-documents/design-task-force-design-and-infrastructure-sector-review-of-attitudes/>

The National Infrastructure Commission's Design Task Force set out an approach to infrastructure design based around four principles:

- Thinking creatively about the processes involved in providing infrastructure.
- Problem-solving from the outset of a project.
- Making infrastructure human-scale and user friendly.
- Enhancing the environment and improving quality of life for local people and nearby communities.

It commissioned Publica to carry out a review of attitudes towards and perceptions of design in infrastructure planning and delivery, to identify existing barriers and opportunities for new approaches, particularly using design as a process for problem-solving.

Barriers identified are:

- A lack of champions in the way projects are governed.
- A lacuna in design knowledge among those running national infrastructure projects.
- A failure to embed design in the day to day working practices of those responsible for programme delivery.
- A deep-seated perception that good design adds cost and poses risks to delivering projects on time and on budget.

- Multiple conflicting perspectives over the role of design and who should deliver it.
- Cultural barriers between disciplines.
- Lack of infrastructure delivery experience in design teams.
- Poor project briefs, short-sighted planning.
- Inflexible planning policies.

National Infrastructure Commission. 2017. 'Data for the Public Good'.

<https://www.nic.org.uk/wp-content/uploads/Data-for-the-Public-Good-NIC-Report.pdf>

This National Infrastructure Commission report explores the role data can play in addressing the challenges set out in the NIC's National Infrastructure Assessment by helping to 'extract more value from every unit of infrastructure benefit'. It does not address design in particular, but sets a context within which smart infrastructure can enable data sharing through wider collaboration, using existing technology. It proposes that data sharing will enable benefits through improved infrastructure performance, enabling better design of infrastructure systems. This can result in reduced environmental impact, lower bills and better, more efficient transport. Data can enable design to be adapted within the lifetime of an asset, through monitoring changes – known as 'effective operation'. An improved understanding of how assets are performing can also lead to 'better economic design'. Recommendations include a digital framework to allow secure data sharing, a digital twin of Britain's infrastructure to manage performance.

Publica for the National Infrastructure Commission. 2018b. 'Design Task Force: Developing Design Principles for National Infrastructure'.

<https://www.nic.org.uk/supporting-documents/design-task-force-developing-design-principles-for-national-infrastructure/>.

Publica's second report for the NIC Design Task Force set out a framework and agenda for developing cross-sectoral design principles for nationally significant infrastructure. Key considerations are identified for design principles - questions to be answered to achieve clarity on what from principles should take and what they should aim to achieve:

- General v specific - small number of all-encompassing core principles, specific guidance for individual projects.
- Measurable outcomes - clearly defined, capable of having measurable outcomes, translated into KPIs.
- Relationship of design principles to design panels - should be regularly reviewed by NIDG.

- Form of design principles - simple, clear, accessible.
- Flexibility - provide for variety of contexts and substantial change.
- Communication - easy to understand, conversation opened up so all can have a say.
- Ownership - need to be owned by client, consultant, contractor, community, users.
- Embedding - into structure of projects from earliest stages.

Initial themes are proposed for design principles, drawn from initial research to inform thinking:

1. Context - beyond immediate site boundaries.
2. Communities - improve local quality of life.
3. Resilience - withstand long-term change.
4. Value the process - multi-disciplinary teams, time to design
5. Security - designed in.
6. Functionality - user experience.
7. Sustainability - environment, ecology, landscape, heritage
8. Ambition - enduring quality.
9. Inclusivity - easy to access and use.

Value categories are proposed for consideration as a potential structure for design principles, rather than a final structure:

- Customer experience
- Social value
- Placemaking
- Capital cost
- Whole life cost
- Environmental

Another set of emerging themes is identified for further consideration as a part of a set of design principles:

- Client design leadership
- Invest in design upfront
- Integrated approach delivers multiple benefits
- Collaboration result in innovation
- People focus
- Simple sustainable outcomes



3.2 GOVERNMENT DESIGN POLICY AND PRINCIPLES

Building Services Research and Information Association (BSRIA) and the Usable Buildings Trust (UBT). 2018. 'Soft Landings Framework'.
https://www.designingbuildings.co.uk/wiki/Soft_landings

Cabinet Office. 2013. 'Government Soft Landings'.
<https://www.cdbb.cam.ac.uk/system/files/documents/GovernmentSoftLandingsExecutiveSummary.pdf>

The Soft Landings Framework, first published in 2009, has been developed to improve the performance of built projects after completion, shown by research to be consistently sub-optimal, and to do so by bridging the gap between construction and operation. It consists of six stages:

- Inception and briefing
- Design
- Construction
- Pre-handover
- Initial aftercare
- Extended aftercare and post occupancy evaluation

The framework has been officially adopted by the public sector, with the Government requiring the use of a parallel process called Government Soft Landings (GSL) on all centrally funded projects. It recognises that 'the ongoing maintenance and operational cost of a building during its lifecycle far outweighs the original capital cost of construction' and aims to recognise this through early engagement of the end user for the project, and a commitment to aftercare post-occupancy evaluation. The latter is required to measure specific outcomes under the headings:

- Functionality and effectiveness
- Environmental performance
- Cost performance

Soft landings are not specific to infrastructure, but GSL is applicable nationally significant infrastructure projects and sets out measurable requirements of their design.

Department of Energy and Climate Change. 2011. 'Overarching National Policy Statement for Energy.'

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/47854/1938-overarching-nps-for-energy-en1.pdf

Department for Environment Food and Rural Affairs. 2013. 'National Policy Statement for Hazardous Waste'.

<https://www.gov.uk/government/publications/hazardous-waste-national-policy-statement>

Both policy statements – on hazardous waste and on ports were issued under the 2010-15 Government. They include the same wording in sections on 'Criteria for 'good design in energy infrastructure'' and 'Criteria for 'good design in hazardous waste infrastructure''. These state that 'good design' in the context of energy projects should result in sustainable infrastructure that is sensitive to place. Construction and operation should be resource and energy efficient their construction and operation. The appearance of infrastructure should 'demonstrates good aesthetic as far as possible', but also states that 'the nature of much energy infrastructure development will often limit the extent to which it can contribute to the enhancement of the quality of the area.'

Department for Transport. 2012. 'National Policy Statement for Ports'.

<https://www.gov.uk/government/publications/national-policy-statement-for-ports>

Department for Environment Food and Rural Affairs. 2012. 'National Policy Statement for Waste Water'.

<https://www.staffordshire.gov.uk/environment/planning/aZ/DefraDesigningwastefacilitiesaguidetomoderndesigni.pdf>

These two policy statements, issued under the 2010-15 government, includes a section on 'Criteria for 'good design' in waste water' and 'Criteria for 'good design' in ports.' Both include the wording in statements above that the nature of the infrastructure will 'often limit the extent to which it can contribute to the enhancement of the quality of the area.' They also include a description of good design as requiring the creation of 'attractive, usable, durable and adaptable places and contributing to sustainable development' and specify landscaping as a design consideration, and required landscape character, landform and vegetation to be taken into account.

Department for Transport. 2014. 'National Networks National Policy Statement.'

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/387223/npsnn-web.pdf

This policy statement, issued under the 2010-15 government, includes a section on 'Criteria for 'good design' in national network infrastructure'. This includes the same wording as the hazardous waste and ports statements above that the nature of the infrastructure will 'often limit the extent to which it can contribute to the enhancement of the quality of the area.' It also emphasises that 'visual appearance should be a key factor' in designing network infrastructure, and that good design should also support 'improvements to operational efficiency', be sustainable, durable, adaptable and take account of aspects of landscape design and impact.

Ek, K. Pettersson, M. Alexander, J-C. Beyers, J. Pardoe, S. Priest, C. Suykens, and van Rijswijk, H.F.M.W. 2016. 'Strengthening and Redesigning European Flood Risk Practices Towards Appropriate and Resilient Flood Risk Governance Arrangements'. STAR-FLOOD, European Union.

<http://www.starflood.eu/documents/2016/04/design-principles.pdf>

EU design principles for resilient, resource efficient and legitimate flood risk governance. These address system design required to enable five flood risk management strategies: risk prevention, flood defence, flood mitigation, flood preparation and flood recovery through eight principles:

1. Selected flood risk management measures (e.g. defence and mitigation) should be tailored to local circumstances (e.g. risk, vulnerability, institutional and economic context).
2. Flood risk (prevention) should be incorporated within spatial planning decision-making to i) discourage development in known areas of flood risk ii) ensure that development in at-risk areas is adaptive, and iii) ensure that development does not heighten risk.
3. Systems for forecasting and warning (preparation) should be effective and warnings should be transmitted with sufficient lead time.
4. Effective and proactive arrangements are in place to enhance emergency preparation and response to flooding.
5. Strategies to recover from flood events should be available for all citizens.
6. Opportunities for social and institutional learning should be created.
7. Climate change and future uncertainties are accounted for in the development of law, policy and planning.

Enviros Consulting Ltd for DEFRA and CABE. 2008. 'Designing Waste Facilities: A Guide to Modern Design in Waste'.

<https://webarchive.nationalarchives.gov.uk/20090904080211/>

<http://www.defra.gov.uk/environment/waste/pdf/designing-waste-facilities-guide.pdf>

This guidance, produced by national government and its then design agency, is the only set of design principles identified that are particular to waste facilities. It defines good design using three categories: Quality, Time and Cost.

1. Quality
 - will it harmonise with the setting?
 - is the facility fit for purpose?
 - can the site accommodate the proposed use?
 - does it minimise the use of resources?
 - will the building be flexible/ adaptable? is there suitable access?
2. Time
 - need to meet appropriate timescales in terms of getting the facility financed, permitted, designed, built, fitted out and ready for service.
3. Cost
 - increasing the flexible use and adaptation of a property reducing the whole-life cycle costs and environmental impacts of a project
 - maximising the value of a building
 - minimising the waste produced by the construction process
 - minimising maintenance and upgrading costs
 - maximising the longevity of a development

Design principles are divided into three categories:

1. Setting the design agenda
 - define the project needs/challenges.
 - identify potential locations/sites.
 - identify potential technologies/treatments.
 - consider funding mechanism.
 - assemble project team.
 - identify overall project manager.
 - set aims and objectives.
 - define strategy and programme.
 - collate available data.
 - undertake site analysis and appraisals - planning policy, character, environmental issues, engineering/ground conditions.
 - meet and discuss with local stakeholders.
 - consider service provision.
 - establish design principles and visions for site.
 - define criteria.

2. Core design
 - prepare and evaluate design options.
 - outline development form.
 - undertake relevant assessments, for example environmental impacts.
 - define and justify solution.
 - identify means for delivery.
 - continue local consultation.
 - identify priorities.
 - develop delivery programme.
 - refine masterplan and building design.

3. Design realisation and operation
 - confirm arrangements for implementation.
 - adopt plans and designs.
 - develop delivery programme.
 - refine masterplan and building design.
 - maintain local engagement with stakeholders.
 - building maintenance.
 - maintain clean and tidy site.
 - educate and inform.
 - review facility performance.

Infrastructure and Projects Authority. 2017. ‘Transforming Infrastructure Performance’.

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/664920/transforming_infrastructure_performance_web.pdf

The Infrastructure and Projects Authority’s long-term ‘integrated change’ programme to improve the delivery and performance of infrastructure is backed by a series of process principles. They provide a wider framework for establishing a context where higher quality infrastructure design can be achieved. Four categories are used:

- Benchmarking for better performance.
- Alignment integration to support priority environment, social and economic principles.
- Procurement for growth through smarter relationships between clients and suppliers.
- Smarter infrastructure, using technology to drive productive delivery.

A key objective is to ensure all projects are selected and prioritised using benchmarked data on costs and performance. Benefits realisation should include business cases that consider ‘the widest possible range of benefits’, with relevance to the delivery of benefits offered by design quality. The IPA also commits to working widely to develop a system of metrics to measure performance of ‘assets, networks and systems.’

Infrastructure and Projects Authority. 2017. 'Common Minimum Standards for Construction'.

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/600885/2017-03-15_Construction_Common_Minimum_Standards_final__1_.pdf

The IPA's construction standards include, among other sections, specifications for minimum standards of design. These standards are intended to enable delivery of 'design excellence in accordance with the principles set out in the Government Construction Strategy (below). As well as mandating the use of Government Soft Landings (see above), it requires project design briefs to 'address the client's aspirations for the building and the project's physical and social context'. To achieve this 'all stakeholders', including end users, should be involved in developing the brief and measuring its success.

Infrastructure and Projects Authority. 2016.' Government Construction Strategy 2016-20'.

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/510354/Government_Construction_Strategy_2016-20.pdf

The Government's Construction Strategy does not address design in detail, but it does set out four principle objectives on process:

- to improve central government's capability as a construction client.
- embed and increase the use of digital technology, including Building Information Modelling .
- deploy collaborative procurement techniques that:
- enable early contractor and supply chain involvement.
- develop skills capacity and capability, including by delivering 20,000 apprenticeships through central government procurement.
- promote fair payment.
- enable and drive whole-life approaches to cost and carbon reduction across the construction, operation and maintenance of public sector buildings and infrastructure.

These have broad implications for the design process which cannot realistically be separated from construction.

Land Transport Authority, Singapore. 2015. 'Industry Matters. Architectural Standards: Development, Building, Construction & Utility Works'.

<https://www.lta.gov.sg/content/ltaweb/en/industry-matters/development-and-building-and-construction-and-utility-works/architectural-standards.html>

The Land Transport Authority in Singapore has identified architectural design criteria for road and railway systems. Design objectives sit under an overall principle that all land transport facilities 'shall be representative of [the people of Singapore's] sophistication, dignity and achievements.'

Architectural standards are structured in categories that include:

1. Architectural aims (including use of materials, lighting, volume, colour etc., scale and context).
2. Clarity and simplicity (including efficient use of space, views between levels).
3. Buildability (including innovative approaches to construction).
4. Integration with commercial or other facilities (prioritising development that does not compromise transport function).
5. Existing infrastructure (reflecting and integrating existing heritage).
6. Future expansion (accommodating future increase in use).

Ministry of Housing, Communities & Local Government. 2019. 'National Planning Policy Framework'.

<https://www.gov.uk/government/publications/national-planning-policy-framework--2>

Section 12 of the UK's National Planning Policy Framework establishes the objective of 'Achieving Well-Designed Places'. It defines good design as an element of sustainable development, and requires clarity about design expectations, and how these will be tested. Further key points include:

- design policies should be developed with local communities, so they reflect local aspirations, and are grounded in an understanding and evaluation of each area's defining characteristics.

Planning policies and decisions should ensure that developments:

- will function well and add to the overall quality of the area, not just for the short term but over the lifetime of the development
- are visually attractive as a result of good architecture, layout and appropriate and effective landscaping.
- are sympathetic to local character and history, including the surrounding built environment and landscape setting, while not preventing or discouraging appropriate innovation or change (such as increased densities).

- establish or maintain a strong sense of place, using the arrangement of streets, spaces, building types and materials to create attractive, welcoming and distinctive places to live, work and visit.
- optimise the potential of the site to accommodate and sustain an appropriate amount and mix of development (including green and other public space) and support local facilities and transport networks.
- create places that are safe, inclusive and accessible and which promote health and well-being, with a high standard of amenity for existing and future users; and where crime and disorder, and the fear of crime, do not undermine the quality of life or community cohesion and resilience.

Natural England. 2009. 'Green Infrastructure Guidance'.

<http://publications.naturalengland.org.uk/publication/35033>

Natural England's guidance builds on literature developing the concept of green infrastructure, beginning with Ian McHarg's 'Design with Nature' and Nan Fairbrother's 'New Lives, New Landscapes', both published in the early 1970s, which were early expressions of the role strategic landscape planning can play in delivering multiple functions and benefits.

The guidance emphasises the role green infrastructure can play in the place-making process. It recommended the formulation of design principles based on a holistic understanding of place, which:

- respond to landscape character, vernacular and sense of place.
- identify opportunities for community involvement in projects through design and implementation to foster ownership and involvement.

It also makes a clear statement of the status that green infrastructure should have within the planning system, as not just as a 'nice to have, but also as a must have'.

3.3 CROSS-SECTORAL DESIGN PRINCIPLES

Building Research Establishment. 2019. 'CEEQUAL Version 6.'
<http://www.ceequal.com/Version-6/>

CEEQUAL is commercial system for rating the sustainability of infrastructure projects. It uses a comprehensive selection of:

Category	Assessment issues
1. Management	1.1 Sustainability leadership 1.2 Environmental management 1.3 Responsible construction management 1.4 Staff and supply chain governance 1.5 Whole life costing
2. Resilience	2.1 Risk assessment and mitigation 2.2 Flooding and surface water run-off 2.3 Future needs
3. Communities and stakeholders	3.1 Consultation and engagement 3.2 Wider social benefits 3.3 Wider economic benefits
4. Land use and ecology	4.1 Land use and value 4.2 Land contamination and remediation 4.3 Protection of biodiversity 4.4 Change and enhancement of biodiversity 4.5 Long-term management of biodiversity
5. Landscape and historic environment	5.1 Landscape and visual impact 5.2 Heritage assets
6. Pollution	6.1 Water pollution 6.2 Air, noise, and light pollution
7. Resources	7.1 Strategy for resource efficiency 7.2 Reducing whole life carbon emissions 7.3 Environmental impact of construction products 7.4 Circular use of construction products 7.5 Responsible sourcing of construction products 7.6 Construction waste management 7.7 Energy use 7.8 Water use
8. Transport	8.1 Transport networks 8.2 Construction logistics

The CEEQUAL system produces a percentage score through internal assessment by a trained assessor, which is then verified independently and externally. The pass rate is set at a point 10-15 per cent above legally required compliance levels, and the system is designed to stretch and improve organisations. Each version raises the bar for achievement. It is also designed to apply beyond projects, by influencing and improving the culture of organisations and the culture of collaboration between organisations. Once endorsed by government, this is no longer the case as recent administrations have reduced sustainability commitments, but the tool has no competitors in the UK since its recent merger with BREEAM Infrastructure, which had a similar application.

Burgstahler, S. 2015. 'Universal Design: Process, Principles, and Applications'.

https://www.washington.edu/doiit/sites/default/files/atoms/files/Universal_Design%20Process%20Principles%20and%20Applications.pdf

Universal Design is 'the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design'. They are intended to be applied to the widest possible range of products or environments, from workplaces to web pages:

1. Equitable use. The design is useful and marketable to people with diverse abilities. For example, a website that is designed to be accessible to everyone, including people who are blind and use screen reader technology, employs this principle.
2. Flexibility in use. The design accommodates a wide range of individual preferences and abilities. An example is a museum that allows visitors to choose to read or listen to the description of the contents of a display case.
3. Simple and intuitive. Easy to use, regardless of the user's experience, knowledge, language skills, or current concentration level. Science lab equipment with clear and intuitive control buttons is an example of an application of this principle.
4. Perceptible information. The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities. An example of this principle is captioned television programming projected in a noisy sports bar.
5. Tolerance for error. The design minimizes hazards and the adverse consequences of accidental or unintended actions. An example of a product applying this principle is software applications that provide guidance when the user makes an inappropriate selection.

6. Low physical effort. The design can be used efficiently, comfortably, and with a minimum of fatigue. Doors that open automatically for people with a wide variety of physical characteristics demonstrate the application of this principle.
7. Size and space for approach and use. Appropriate size and space are provided for approach, reach, manipulation, and use regardless of the user's body size, posture, or mobility. A flexible work area designed for use by employees who are left- or right-handed and have a variety of other physical characteristics and abilities is an example of applying this principle.

A process is also laid out to apply Universal Design Principles:

1. Identify the application.
2. Specify the product or environment to which you wish to apply universal design.
3. Define the universe. Describe the overall population (e.g., users of service), and then describe the diverse characteristics of potential members of the population for which the application is designed (e.g., students, faculty, and staff with diverse characteristics with respect to gender; age; size; ethnicity and race; native language; learning style; and abilities to see, hear, manipulate objects, read, and communicate).
4. Involve consumers. Consider and involve people with diverse characteristics (as identified in Step 2) in all phases of the development, implementation, and evaluation of the application. Also gain perspectives through diversity programs, such as the campus disability services office. Make these processes known with appropriate signage, publications, and websites.
5. Adopt guidelines or standards. Create or select existing universal design guidelines/standards. Integrate them with other best practices within the field of the specific application.
6. Apply guidelines or standards. Apply universal design in concert with best practices within the field, as identified in Step 4, to the overall design of the application, all subcomponents of the application, and all ongoing operations (e.g., procurement processes, staff training) to maximize the benefit of the application to individuals with the wide variety of characteristics identified in Step 2.
7. Plan for accommodations. Develop processes to address accommodation requests (e.g., purchase of assistive technology, arrangement for sign language interpreters) from individuals for whom the design of the application does not automatically provide access.

8. Train and support. Tailor and deliver ongoing training and support to stakeholders (e.g., instructors, computer support staff, procurement officers, volunteers). Share institutional goals with respect to diversity and inclusion and practices for ensuring welcoming, accessible, and inclusive experiences for everyone.
9. Evaluate. Include universal design measures in periodic evaluations of the application, evaluate the application with a diverse group of users, and make modifications based on feedback. Provide ways to collect input from users (e.g., through online and printed instruments and communications with staff).

Construction Industry Research and Information Association (CIRIA) / Department for Environment, Food and Rural Affairs (DEFRA). 2015. The SUDS Manual.

<http://www.scotsnet.org.uk/documents/NRDG/CIRIA-report-C753-the-SuDS-manual-v6.pdf>

This publication, from CIRIA, is a substantial (nearly 1000 page) guide to sustainable urban drainage systems. It includes a detailed SUDS Design Process, and discusses the multiple potential benefits offered by SUDS. As well as direct functional benefits, these also include indirect benefits such as:

- Supporting local natural habitats and associated ecosystems by encouraging biodiversity and linking habitats.
- Creating attractive places where people want to live, work and play through the integration of water and green spaces with the built environment.
- Supporting the creation of developments that are more able to cope with changes in climate.
- Delivering cost-effective infrastructure that uses fewer natural resources and has a smaller whole-life carbon footprint than conventional drainage.

City of Oslo - Department for Health and Social Affairs. 2014. 'The Common Principles of Universal Design'.

<https://extranet.who.int/agefriendlyworld/wp-content/uploads/2015/06/The-Common-Principles-of-Universal-design-City-of-Oslo.pdf>

The Kommune of Oslo, Norway (the city government) has set up a plan for universal design (UD) covering transportation, communication, construction, public property, outdoor areas, and information and communication technology. It requires UD to be implemented from project inception, and to be included as part of the project costs. This is based on the Norwegian government's requirement that UD be adopted by 2025, to ensure the enactment of

the requirements of the disability and accessibility act (2009). Oslo's objective is to achieve a universally designed city by 2025 practical requirements are set out under the following categories:

- Transportation and communication: cyclists and pedestrians, public transport and information.
- Planning for buildings, properties and outdoor areas: planning and property development, building development, outdoor areas.
- Information and communications technology: information and services for public use.

Commission for Architecture and the Built Environment. 2006. 'The Principles of Inclusive Design'.

<https://www.designcouncil.org.uk/sites/default/files/asset/document/the-principles-of-inclusive-design.pdf>

CABE's document sets out three guiding statements:

- Inclusive design is about making places everyone can use.
- Inclusive design is everyone's responsibility.
- Good design is inclusive design.

It then develops five guiding principles for inclusive design:

1. Inclusive design places people at the heart of the design process.
2. Inclusive design acknowledges difference and diversity.
3. Inclusive design offers choice where a single design solution cannot accommodate all users.
4. Inclusive design provides for flexibility in use.
5. Inclusive design provides buildings and environments that are convenient and enjoyable to use for everyone.

Cumberlidge, C., and Musgrave, L. 2007. 'Design and Landscape for People: New Approaches to Renewal'. London: Thames and Hudson.

A series of case studies are assessed, all of which fall into the broad category of social infrastructure. Twenty-three projects are examined, in locations in the Americas, Europe, Africa and Asia, under four categories: Utility, Citizenship, Rural, Identity and Urban. The projects selected date from 1990 onwards and are diverse, ranging from water pumps in South African townships to school food growing in California. They share common principles that underlie their success: they are cross-disciplinary, socially engaged, environmentally aware and inventive. Many are in peripheral locations and fall outside the expectations of conventional architecture, planning or urban design.

Cumberlidge and Musgrave make proposals for new approaches they argue are required to assess projects such as these. A 'pre-requisite for success' is 'openness': leaving space for appropriation by including the idea of continuous change and projects and structures as unfinished, leaving space for community appropriation. They raise the possibility that value should be judged through the integrity of the process that creates them, which in turn leads to material success. They also advocate participation, explicitly challenging the 'tick-box' approach to community consultation and proposing a debate between public, professional and political audiences as a means of unlocking different solutions.

Design Council. 2012. 'A Design-Led Approach to Infrastructure'.

<https://www.designcouncil.org.uk/resources/guide/design-led-approach-infrastructure>

Ten principles produced by the Design Council to help Nationally Significant Infrastructure Project applicants create successful proposals meeting the criteria for good design set out in the National Planning Policy Framework, which states that 'Good design is a key aspect of sustainable development, is indivisible from good planning and should contribute positively to making places better for people.'

1. Setting the scene

Design thinking should be part of creating the vision and designing the brief for a new project.

2. Multi-disciplinary teamwork

Collaborations between stakeholders must begin early and be sustained. Stakeholders may include, among others, the client, the design team, technical experts, the community and the local planning authority.

3. The bigger picture

Holistic thinking is required to ensure that projects are part of an integrated process that fits into bigger strategies such as regional or sub-regional planning. Potential synergies in an area should be explored in great detail.

6. Site masterplan

A facility that responds to its context. Understanding the structure of its surroundings, topography and adjacent land use at each site should be the starting point for master-planning.

7. Landscape and visual impact assessment

Each context requires a different appreciation of how to handle scale and how the project relates to the environment.

8. Landscape design

Intelligent landscape design mitigates the impact of an infrastructure installation and can enhance its setting. It should be developed in parallel with the proposal.

9. **Design approach**

Infrastructure projects benefit society as a whole and should be celebrated. Different structures will require different levels of architectural ambition.

10. **Materials and detailing**

High quality materials and careful detailing will limit the need for maintenance and allow schemes to weather and age well.

11. **Sustainability**

Sustainability must be integral to the design from the very beginning.

12. **Visitor centre**

Many large infrastructure proposals offer the opportunity to provide a centre where visitors can learn about the plant operation and be introduced to the concepts of sustainability, energy generation, waste management and humanity's impact on the environment.

Gehl, J, and Gemzøe, L. 2004. 'Public Spaces, Public Life, Copenhagen'. Copenhagen: Danish Architectural Press & the Royal Danish Academy of Fine Arts, School of Architecture Publishers.

Gehl, J. 2010. 'Cities for People'. Washington, D.C and London: Island Press.

'Public Spaces, Public Life' analyses the development of Copenhagen city centre and its public life is tracked between 1963, when the first street was pedestrianised, to 1996. It records the change in mentality that led to a shift from car-dominated streets to a 'people-oriented city center'. This has resulted in spaces being 'reclaimed' and new spaces being created for people to use. A strong case is made for public space as the infrastructure underpinning city life. Copenhagen's policies have, Gehl argues, led to a city centre that is now used by a much more diverse range of age groups, at all times of year, and has a greatly improved street life which makes it attractive to all. The public space network is part of the city's transport infrastructure, with pedestrian connections to stations significant. The city centre improvements are seen as a starting point for a wider agenda of improvement to public space across Copenhagen, encompassing residential areas too.

'Cities for People' develops the city design agenda, setting out a manifesto for pedestrianism and city space as the priority to avoid the multiple, damaging effects of cars on urban life. It emphasises the potential of high-quality space networks to contribute to lively, safe, sustainable and healthy cities, and places particular emphasis on the small scale at which designers need to work to realise these benefits.

Global Infrastructure Hub. 2019. 'Leading Practices in Governmental Processes Facilitating Infrastructure Project Preparation'.

https://gihub-webtools.s3.amazonaws.com/umbraco/media/2341/gih_procurement-report_case-study_korea_final_web.pdf

The Global Infrastructure Hub – an organisation funded by global governments to develop infrastructure in developed and emerging markets – has published a case study looking at South Korea's approach to infrastructure project preparation, in which the country is considered a pioneer. Five lessons are specified:

1. Establish transparent procedures to facilitate unsolicited proposals in BTO projects.
2. Clearly define roles for project stakeholders.
3. Incentivise the unsolicited project proponent during project implementation.
4. Maintain independence in project evaluation through the bid process.
5. Innovative citizen engagement methods to improve project branding and equity.

iBUILD Infrastructure Research Centre. 2018. 'Closing the Gap: Local infrastructure business models to support inclusive growth'. Newcastle University

<https://research.ncl.ac.uk/ibuild/2018finalreport/iBUILD-Report-web-compressed.pdf>

The purpose of the iBUILD report is to improve the quality of infrastructure for all, and it makes recommendations to achieve this:

1. Adopt a broader, integrated and more holistic appreciation of infrastructure.
2. Enable greater action at the local scale that reflects the distinctive nature of place but also connects with the national level.
3. Facilitate and capture all forms of long-term value.
4. Deliver infrastructure more efficiently and with less waste by aligning organisational capabilities and applying circular economy principles.
5. Accelerate uptake through practical action and demonstration.

While these recommendations do not deal directly with design, the priorities proposed can only be delivered through design, amongst other mechanisms. For example, the focus on action at local scale to enhance distinctiveness of place could be applied directly to design, as could the proposal that, to enabled this, 'greater local autonomy is required in the strategic planning, funding, financing and delivery of infrastructure.'

National Infrastructure Planning Association. May 2017. 'Towards a Flexibility Toolkit.' NIPA Insights II.

[https://www.nipa-uk.org/uploads/news/NIPA_Insights2_D4b_PRINT_\(1\).pdf](https://www.nipa-uk.org/uploads/news/NIPA_Insights2_D4b_PRINT_(1).pdf)

This report is based on research to support the efficient delivery of Nationally Significant Infrastructure Projects. It seeks to address concerns that the process suffers from too much detail during planning, limiting flexibility during delivery and hindering design development and innovation. The project reviews experience of engagement, and looks for mechanisms that have been, or could be used to support greater flexibility through planning, better project outcomes, and appropriate safeguards for communities, stakeholders and environments. It describes a route for building a flexible consenting strategy based on four principles:

- Building trust through early engagement.
- Providing evidence to justify the flexibility required .
- Appropriate controls - specify transparent and effective control mechanisms.
- Adaptive delivery to respond to changing circumstances.

The report also proposes the creation of a Flexibility Toolkit which will support the adoption and dissemination of good practice.

OECD. 2017. 'Getting Infrastructure Right: A Framework for Better Governance'.

<http://www.oecd.org/publications/getting-infrastructure-right-9789264272453-en.htm>

An OECD survey of infrastructure governance in 27 countries, with tools to help policy makers manage infrastructure. These mainly relate to governance structures and processes but, among other issues, the following are specified:

- A long-term strategic national vision for infrastructure service needs.
- Clear criteria to guide the choice of delivery modes.
- A consultation process that begins early enough for decisions to benefit from 'real stakeholder engagement'.

Royal Academy of Engineering. 1999. 'Principles of Engineering Design'.

<https://www.raeng.org.uk/publications/other/armstrong-keynote>

A working paper set out the RAEng's approach to design principles for engineering. It proposes that they should 'provide a total context for good design'. Engineering design is divided into three stages:

- Need. Defining the need to be met, including social, economic and human need.
- Vision. Conceiving a response to that need through a creative vision.
- Delivery. Delivering a solution by assembling and managing skills and resources.

These stages are summarised in three statements:

- All design begins with a clearly defined need.
- All design arises from a creative response to need.
- All designs result in a system, process or product which meets the need.

Royal Institute of British Architects. 2018. 'Joining the Dots: A New Approach to Tackling the UK's Infrastructure Challenges'.

<https://www.architecture.com/knowledge-and-resources/resources-landing-page/joining-the-dots>

RIBA has produced a set of cultural, operational and design recommendations to address what it identifies as an urgent agenda for new infrastructure in the UK.

Generating the right options:

1. Focus on generating options rather than justifying decisions.
2. Early cross-departmental cooperation to enable integrated strategies to be properly considered alongside individual schemes.
3. Ensure local knowledge is integrated into option consideration and analysis.
4. Set clear objectives and identify evaluation criteria before commencing construction. Continuously collect and share data on operational projects using accessible formats.
5. Use strategic modelling (such as Integrated Urban Modelling and Foresighting) to evaluate options early on, across multiple outcomes.

The right framework for decision making:

1. Require spatial plans to reference all relevant plans in their area.
2. Clarify how Strategic Economic Plans and neighbourhood plans relate to local plans.
3. Public bodies across appropriate market areas should be required to agree a statement of common ground in relation to infrastructure before funding is made available.
4. Local authority planning departments should have funding ring-fenced.
5. Initiatives to boost the planning profession should be supported such as the recently launched Public Practice, a scheme for planners along the lines of Teach First and Frontline CPO

- compensation should be set at existing use value, with an additional premium provided to compensate land owners.
6. The Housing Infrastructure Fund should be expanded.
 7. Local authorities should be permitted to pool and co-ordinate locally generated housing and infrastructure funding streams.
 8. Strike new devolution deals until there is a solution in place for every area of the country.
 9. Create a pathway to deepening devolution deals to ensure powers can be at least as extensive as those held by the Greater London Authority.
 10. Develop a National Spatial Strategy to create a framework which aligns infrastructure and economic development with housing growth.

Promoting good design:

11. Include compulsory requirements for design quality in technical documents, such as the Design Manual for Roads and Bridges.
12. Public bodies delivering large infrastructure projects should set out ambitious design visions, which apply across the sites they are involved with.
13. The National Infrastructure Commission should establish a national design panel and build a 'what works' evidence base.

Supply Chain Sustainability School. October 2017. 'Social Value and the Design of the Built Environment'.

[https://www.supplychainschool.co.uk/about/news/592/how-design-for-social-value-can-place-people-at-the-heart-of-a-project-](https://www.supplychainschool.co.uk/about/news/592/how-design-for-social-value-can-place-people-at-the-heart-of-a-project)

This report promotes the role of design in promoting social value, addressing six separate categories: Education, Housing, Retail, Health, Offices and Infrastructure.

It proposes that social value can be 'consciously created during the design, construction and operation of built environment assets.' Designers and architects can generate social value by:

- Integrating people's views into design decision making.
- Supporting cultural integration and social cohesion.
- Designing assets that promote the health and wellbeing of users.
- Enhancing lifespan and value of assets.
- Supporting economic prosperity.
- Doing business, responsibly.

The report contains multiple case studies of successful community engagement across the six sectors, and identifies social value trends and challenges.



3.4 INDUSTRY DESIGN PRINCIPLES

Asensio Villoria, L. Georgoulas, A. and Kara, H. (eds.) 2017.
'Architecture and Waste: A (Re)Planned Obsolescence'. Cambridge, MA: Harvard University Graduate School of Design.

A collaboration between academia and practice, this text book makes the case for architects to engage with the design of Waste-to-Energy (WtE) facilities. It highlights the probable increase in need and demand for WtE facilities, which provide an acceptable and renewable energy source for densifying cities. These are often seen as beyond conventional architectural practice, but provide a bridge in terms of scale, function and output between conventional industrial buildings and infrastructural facilities such as power stations or airports.

The book provides a guide for architects involved in infrastructural and industrial design. It proposes a precise methodology to assist architects with these types of project, and contains a detailed inventory of WtE components, requirements and a catalogue of WtE plant design strategies, tactics and spatial configurations.

Balfour Beatty. 2017. 'Ten Steps to Efficiency in Flood and Coastal Risk Management'.

<https://www.balfourbeatty.com/media/195818/ten-steps-to-efficiency-in-flood-and-coastal-risk-management.pdf>

This publication, produced by private sector construction company Balfour Beatty, is intended to help deliver savings in the flood defence budget required by Government

Based on experience of delivering flood management and defence projects, it proposes ways to 'drive efficiencies' 'without compromise on quality'.

Five steps for commissioning authorities and contractors:

1. A collaborative approach: encouraging innovation
Allowing contractors to play a part in developing solutions.
2. Investing in strong relationships
Early contractor involvement to create efficiency savings.
3. Better procurement
Use of collaborative framework agreements.
4. Undertaking schemes simultaneously
Tendering in packages for efficiency savings.

5. A longer-term view
Working over longer periods to increase social value and wider benefits.

Five steps for government:

1. A long-term funding approach
Longer-term capital and maintenance programme rather than one-off funding injections.
2. Rebalancing the economy
Addressing bias towards richer areas contained in Government's economic formula for allocating spending.
3. Better use of data and information
Making use of improved climate change and flood risk to inform decisions.
4. Working with nature
Collaboration with all local stakeholders at river catchment scale.
5. A comprehensive strategy
Flood risk strategies needed from the devolved administrations, linking it to wider urban development planning.

Centre for Digital Built Britain. 2018. 'The Gemini Principles'.

<https://www.cdbb.cam.ac.uk/Resources/ResoucePublications/TheGeminiPrinciples.pdf>

The Gemini Principles are intended to inform the production of a National Digital Twin - a digital model of the UK's built assets that will create an information management framework enabling smarter infrastructure. The production of the digital twin reflects a move towards understand data itself as a part of our national infrastructure that requires the same level of consideration as physical infrastructure assets.

The principles will guide the production of this framework, and consist of nine requirements in three overall categories. They are presented as a matrix, emphasising their interconnectedness:

- Purpose: must have clear purpose
- Public good: must be used to deliver genuine public benefit in perpetuity.
- Value creation: must enable value creation and performance improvement.
- Insight: must provide determinable insight into the built environment.

- Trust: must be trustworthy
- Security: must enable security and be secure itself.
- Openness: must be as open as possible.
- Quality: must be built on data of an appropriate quality.
- Function: must function effectively
- Federation: must be based on a standard connected environment.
- Curation: must have clear ownership, governance and regulation.
- Evolution: must be able to adapt as technology and society evolve.

The benefits of applying these principles are also stated, as:

- Benefits to society: Improved stakeholder engagement. Better outcomes for the ultimate customers (the public - taxpayers/bill payers/fare payers/voters). Improved customer satisfaction and experience through higher-performing infrastructure and the services it provides.
- Benefits to the economy: Improved national productivity from higher-performing and resilient infrastructure operating as a system. Improved measurement of outcomes. Better outcomes per whole-life pound. Improved information security and thereby personnel, physical and cyber-security.
- Benefits to business: New markets, new services, new business models, new entrants. Improved business efficiency from higher-performing infrastructure. Improved delivery efficiency, benefiting the whole construction value chain - investors, owners, asset managers, contractors, consultants, suppliers. Reduced uncertainty and better risk management.
- Benefits to the environment: Less disruption and waste. More reuse and greater resource efficiency - a key enabler of the circular economy in the built environment.

Construction Industry Council. 2016. 'Essential Principles: Creating an Accessible and Inclusive Environment'.

<http://cic.org.uk/admin/resources/cic-essential-principles-guide-for-clients-contractors-and-developers-2018.pdf>

The CIC's principles, which relate to construction as a whole, do not mention infrastructure. However, they set out the objective of creating environments, through construction, which can be "accessed and used safely, easily and with dignity by everyone." Five principles of inclusive design are set out:

1. Place people at the heart of the design process.
2. Acknowledge diversity and difference.

3. Offer choice where a single solution cannot accommodate all users.
4. Provide for flexibility in use.
5. Create an environment that is convenient and enjoyable for everyone to use.

Inclusive Design Visions and Strategies are recommended to help deliver these principles.

Department for Transport / Highways England / HS2 Ltd / Network Rail / Transport for London. 2019. 'Transport Infrastructure Efficiency Strategy. One Year On Report'.

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/782158/ties-one-year-on-report.pdf

The Transport Infrastructure Efficiency Taskforce, consisting of senior managers from each of the partner organisations, produced its first annual report on progress against indicators it has set out:

1. Improving our understanding of costs and performance
 - Creation of a benchmarking forum to share best practice and innovation.
 - Establishing a common approach to cost estimation.
2. Exploiting digital technology
 - Exploiting digital technology and standardising assets to enable the adoption of best practice from the manufacturing sector.
 - Challenging standards to enable innovation and drive efficiencies.
3. Enabling delivery
 - Judging strategic choices and trade-offs.
 - Improving the way we set up projects.
 - Promoting long term collaborative relationships with industry.

These provide a framework that government and key transport organisations have committed to deliver and, as such, set an agenda for the sector that is relevant to enabling the take-up of design principles. The purpose of the Task Force is to enable coordination on ways of working, which builds a context for the take-up of measurable design principles in the sector.

The HS2 Design Vision is underpinned by detailed guidance in the form of technical standards. These include requirements for monitoring the performance of asset created through the project, setting standards for monitoring design quality 'for the purpose of improving its own performance and that of future projects.' This

includes the requirement to collect data on the performance of assets, including via real-time instruments, to inform 'debugging'.

van Hagen, M., and de Bruyn, M. 2012. 'The Ten Commandments of How to Become a Customer-Driven Railway Operator'. European Transport Conference, 8-10 October 2012.

<https://nodes-toolbox.eu/wp-content/uploads/VanHagen-DeBruyn-The-Ten-Commandments-def.pdf>

Netherlands Railways (NS) formulated ten basic rules for becoming a customer-driven railway operator.

1. The customer comes first. Focusing on the customer is the best way forward.
2. Find the investment-value equilibrium. Customers are prepared to invest money, time and effort for the right value.
3. Define a hierarchy of quality needs. Define all quality dimensions and the hierarchy of importance for the customer, such as safety, reliability, speed, ease, convenience and experience.
4. Distinguish three management dimensions. Quality requirements consist of three factors that make up the customer experience: the service processes, the people and the service environment.
5. Manage customer expectations. The customer's chosen means of transport is based on the expected investment and value.
6. Measure the actual quality. Measure the quality experience of your service for the entire journey.
7. Stop once it is good enough. Stop investing in basic qualities once they reach an acceptable level.
8. Make customers happy. Once basic qualities are at an acceptable level, start investing in experience.
9. Focus on the total experience. Customer satisfaction is based on the total customer experience.
10. Learn from experiments. You only learn what works best by experimenting. The customer is unable to imagine and articulate abstract improvements.

Highways England. 2017. 'Strategic Design Panel Progress Report'.

<https://www.gov.uk/government/publications/highways-england-strategic-design-panel-progress-report>

The Highways England Strategic Design Panel, which developed the Design Vision and Principles subsequently published by Highways England (below) also identified a set of key aspirations to raise the standard of road design:

- Clear and consistent consideration of design at the earliest stage of scheme development.

- Building in greater flexibility to later stages of scheme design, within the constraints of the consenting process.
- Emerging schemes to learn lessons from completed schemes and other parts of built environment sector.
- Post-opening review to consider design principles.
- Importance of inter-disciplinary design.
- Aspiring for more than mitigation.
- Landscape-scale vision and early engagement of landscape professionals.
- Better quality design of essential features.
- Opportunities for incorporating so called 'green and blue infrastructure'.
- More inclusive engagement with local communities and users.
- Better planning for non-motorised users.
- Inspiring innovation through design competitions.

Highways England. 2018. 'Good Road Design: Highways England's Design Vision and Principles'.

<https://www.gov.uk/government/publications/the-road-to-good-design-highways-englands-design-vision-and-principles>

Highways England has set out a vision for an inclusive, sustainable and resilient road network that is also elegant, reflecting and enhancing the beauty of the natural and historic environment. This vision is supported by a set of principles for good road design under the themes of people, places and processes.

1. Connecting people

Good road design:

- makes roads safe and useful.
- is inclusive.
- makes roads understandable.

2. Connecting places

Good road design:

- fits in context.
- is restrained.
- is environmentally sustainable.

3. Connecting processes

Good road design:

- is thorough.
- is innovative.

Network Rail. 2015. 'Station Design Principles for Network Rail'.

<https://cdn.networkrail.co.uk/wp-content/uploads/2018/04/S1-Station-design-principles.pdf>

Network Rail's has defined a station design policy for new and existing station buildings based on a commitment to the Vitruvian architectural qualities of 'Firmness, Commodity and Delight'. In this context good station design is defined as:

1. Safe
2. Accessible
3. Inclusive
4. Delightful
5. Sustainable

Twelve criteria are also identified as both the prime drivers and metrics of station design. Eight have the potential to create customer dissatisfaction ('dissatisfiers'):

- Safety and security
- Intermodal exchange and wayfinding
- PPM targets and reliability
- Whole life cost and operation
- Inclusiveness and accessibility
- System approach
- Capacity and future proofing
- Sustainability

Four can generate customer satisfaction ('satisfiers'):

1. Urban integration
2. Standardised approach
3. Retail, social and business
4. Passenger experience and delight

Design checklists are set out for each principle.

Network Rail. 2019. 'Our Principles of Good Design'.

<https://cdn.networkrail.co.uk/wp-content/uploads/2019/03/Our-Principles-of-Good-Design.pdf>

Network Rail's principles of good design are intended to ensure their vision of providing world class rail assets can be delivered. They set out the aim of enhance their identity as an organisation by connecting assets to communities and seeking to capture wider benefits from their work.

The vision and aims will be achieved through applying nine principles of good design:

1. Identity - a strong heartbeat defines our identity across the network.
2. Passengers - The needs of passengers are at the heart of everything we do.

3. Community focused - Local communities are placed at the heart of decisions.
4. Collaborative - Exploring the benefits of the heartbeat through dialogue.
5. Inclusive - Placing people at the heart of the design process.
6. Connected - The heartbeat of the network will be felt across the community.
7. Contextual - The heartbeat of the network reaches every corner of Britain.
8. Enhancing Heritage - Our heritage is the historical heart of the network.
9. Innovative - Giving new ideas strength through the pulse of the heartbeat.

Skinner, P., Maher, R., Hetherington, K. and McAlpine, F. 2012. 'The Public Face of Rail: Australian Station Design Guidelines'. Cooperative Research Centre for Rail Innovation (Australian Government).

http://www.railcrc.net.au/object/PDF/get/download/id/r1134_station_design_final_report_updated

The guidelines aim to place rail station design within a wider social, economic and environmental framework, sitting above the technical, design manuals and guidance used by Australia's state rail and transport authorities to discuss the urban, social and experiential dimensions of a rail station design. It focuses particularly on access to stations, circulation and the functional interface between the station and its users, and on sustainability.

The guidance is based on the Rail Station Design Concept Field, which uses the following structure to present issues that should be considered in station design from the viewpoints of three types of stakeholder:

1. Individual
 - Access
 - Wayfinding
 - Facilities
 - Quality of experience
2. Operator
 - Economics
 - Future planning
 - Infrastructure and maintenance
 - Station operation
 - Health, safety and security
3. Society
 - Public perception
 - Social interaction and equality
 - Ecological sustainability

Design guidelines are also set out under three categories:

4. Experience
 - Urban role
 - Social space
 - Personal response
5. Function
 - Access
 - Circulation in stations
 - Station operations
6. Performance
 - Station context and facilities
 - Sustainable performance
 - Station typology

Tiller, R. M. 1973. 'Concrete Footbridges.' London: Cement and Concrete Association.

This 1973 design guide consists of 56 case studies of concrete footbridges built at various points between 1949 and 1970. Contexts and sizes vary greatly, from the Forton Services bridge across the M6 to a simple bridge over a stream, without railings, at Henbury Hall in Cheshire. The purpose of the guide is to demonstrate that the architect has a clear role to play in designing what might at first glance appear to be an entirely functional piece of architecture. It warns against the standardisation of potentially overlooked, lower-profile components of cities, noting that contexts such as the footbridge 'the enthusiastic designer can still express his individuality free from recriminations based on relative economics'.

UK Green Building Council. 2017. 'Demystifying Green Infrastructure'.

<https://www.ukgbc.org/ukgbc-work/demystifying-green-infrastructure/>

The UKGBC's guidance was published to help simplify existing green infrastructure principles for non-specialists. It analyses and explains the role of green infrastructure in enabling social and environmental benefits, under the headings of:

- Healthy communities
- Secure and cohesive communities
- Prosperous and fair communities
- Smart communities
- Sustainable communities

It recommends that clients and developers produce a green infrastructure strategy for any site, whatever its size. Principles should be applied to maximise benefit, including involving 'real people', connecting beyond the site, and thinking about the multiple functions that it can provide.



3.5 PROJECT SPECIFIC DESIGN PRINCIPLES

Argent Related. 2019. 'City-Making Principles. Brent Cross South.'
Paper only.

Published for the Brent Cross South Partnership, these principles set out an approach to a major city redevelopment in North London. It sets out five city-making principles which will be used to guide the development:

1. Clearly Brent Cross South – design and built for people.
2. Belonging – everyone is welcome.
3. From the Ground Up – the right infrastructure in place early.
4. Ever Evolving – there is no 'end product'.
5. Deeply Rooted – part of something bigger than itself.

These principles emerged from masterplanning workshops which explored the idea of 'a day in the life' of future residents. The publication also includes work by artists and writers exploring what they mean to people who will live there. They will be used to help build consensus in the long-term about what is considered good development for the new town. The principles include specific discussion of infrastructure, looking at the energy, communications and social infrastructure needed to make the place work, and the need for adaptability to future change in technology, needs and preferences.

Crossrail. undated. 'Crossrail's Approach to Design - Stations, Art and Public Space'.

<http://www.crossrail.co.uk/route/design/>

Seven principles have underpinned the designs for stations on the Elizabeth Line:

- Identity: deliver a consistent brand through a modern and contemporary transport mode, responsive to its local contexts.
- Clarity: create an understandable environment for passengers from the start to the end of their journey.
- Consistency: implement a coherent line-wide design language, established through common materials and components within the Transport for London family.
- Inclusivity: ensure the Elizabeth Line is for everyone.
- Sustainability: a best practice design that minimises waste, maximises material qualities, reduces energy consumption and is cost efficient.

- Security: provide safe and secure design solutions.
- People focused: designed to balance functional and people needs.

Three overarching themes are also specified:

- Integrated design - stations, surrounding areas, and oversite development designed together
- Sustainability - social, economic and environmental impacts an important consideration throughout design and construction
- Designed for growth - more entrances and space below ground to allow future growth in train length and passenger numbers

E.ON. 2008. 'Blackburn Meadows Biomass - Renewable Energy Plant. Design and Access Statement.'

https://www.eonenergy.com/-/media/pdfs/generation/biomass/1_eon_bbm_renewable_energy_plant_other_material_-_design_and_access_statement.pdf

The Design and Access Statement produced by operators E.ON for the biomass plant on the site of the demolished Tinsley Power Station. It set out a design concept and elements, including key elevations and focal points. It also emphasises the use of selected materials to deliver the architectural character and aesthetic quality as the core of the proposed design concept.

Halton Borough Council. 2011. 'The Mersey Gateway Design and Access Statement'.

https://www4.halton.gov.uk/Pages/planning/policyguidance/pdf/MerseyGateway/Mersey_Gateway_Delivery_Phase_DAS.pdf

The Design and Access statement produced for the new Mersey Gateway bridge between Runcorn and Widnes sets out overarching design principles to apply throughout the project. This describes:

- Context
- Function
- Appearance - of the bridge structure including the design approach to the elements that make up the structures, as well as views, finishes, vegetation, signage, lighting, surfacing and acoustic barriers
- Landscape

The project is included in the review as an example of a design and access statement for a large-scale infrastructure project with an acknowledged high level of design quality. The bridge has won awards since it opened, from bodies including the Royal Institute of Chartered Surveyors (RICS) and the Institution of Civil Engineers (ICE).

HS2 Ltd. 2018. 'Design Vision'.

<https://www.hs2.org.uk/building-hs2/design-vision/>

The HS2 Design Vision is used by the Independent Design Panel to as a framework to advise and hold to account HS2 and its contractors. It is based on three overall principles:

1. People
 - Designing for the needs of our diverse audiences.
 - Engaging with communities over the life of the project.
 - Talent - inspiring excellence through creative talent.
2. Place
 - Designing places and spaces that support quality of life.
 - Identity - celebrating the local within a coherent national narrative.
 - Environment - demonstrating commitment to the natural world.
3. Time
 - Adaptability - designing to adapt for future generations.

The vision also describes what design success looks like:

- Everything we make works intuitively and well for all our audiences.
- And contributes to one seamless and enjoyable experience.
- We deliver above and beyond the design brief.
- Bringing benefits of many kinds to UK citizens.
- All the elements are fit for purpose and sensitive to their context
- National pride in the system is matched by a sense of local ownership.
- Small elements and big schemes meet rigorous environmental standards.
- And, collectively, add to our cultural and natural heritage.
- Every requirement for a high-speed rail system is met.
- And we have designed in the needs of the future too.
- We have joined up the nation with a system to last and evolve.
- And created a national project to be proud of for many years to come.

Jacobs & Arup. 2009. 'Forth Replacement Crossing Managed Crossing Scheme. Scheme Definition Report'.

<https://www.transport.gov.scot/media/33661/j10724c.pdf>

This report set out a design vision for what was to become, when constructed, the Queensferry Crossing. The vision is expressed in a

sentence: 'To deliver an iconic project that respects the environment, contributes to sustainable economic growth at both regional and Scottish levels and facilitates efficient public transport whilst minimising disruption to the community and reducing the use of non-renewable resources during its construction and throughout its life'. These headline requirements for the bridge's design combine expectations on construction, benefit and resource use as an integral part of the overall objective - 'an iconic project'. These were used to select the option - the D2M Cable Stayed bridge - which was then taken forward to construction.

Mayor of London, and Transport for London. 2017. 'Silvertown Tunnel Design Principles'.

<https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/TR010021/TR010021-001645-TfL%207.4%20Design%20Principles%20R3.pdf>

An overall design vision sets out objectives for the above ground elements of the Silvertown Tunnel:

- High quality and appropriate architecture.
- Built in reliability, robust materials and detailing.
- Integrative landscape design.
- Sustainability through design.
- Safe, secure and smart infrastructure.

The principles are also included that the design of the scheme should be reviewed by the Silvertown Tunnel Design Review Panel and consultation undertaken with the Stakeholder Design Consultation Group.

A more detailed set of design principles are structured under the following project elements:

- Landscape
- Integration of permanent structures
- Tunnel portals
- Pedestrian and cycle bridge
- Sustainability and environment
- Public art design
- Advertising and commercial activity
- Signage and wayfinding
- Lighting

Paoletti, R. 1999. 'Architectural Design of the Jubilee Line Extension Stations'. Proceedings of the Institution of Civil Engineers - Civil Engineering 132 (6): 19-25.

<https://www.icevirtuallibrary.com/doi/10.1680/icien.1999.132.6.19>

Paoletti's paper on the design of the late 20th century Jubilee Line Extension stations in London explains that the design approach was coordinated using a small number of design priorities:

- generous and easily understood space, with daylight wherever possible.
- clear and direct passenger routeing.
- a sufficiency of escalators, wherever possible in banks of three
- lifts for the mobility impaired.
- safety in all its aspects, but particularly by the provision of abundant protected escape routes.

It shows how these are applied to the design of the Jubilee Line's stations, and illustrates their application with case studies.

SSE Generation Ltd. September 2014. 'Slough Multifuel CHP Design and Access Statement'.

<https://sse.com/media/270877/Design-Access-Statement.pdf>

The Design and Access Statement produced by energy firm SSE for a new combined heat and power plant in Slough, as part of an existing power station complex. It proposes a set of what 'Design Principles' for the construction of the new plant. These would be better described as a design brief, with the overarching aim of delivering low carbon infrastructure. Specifications are structured under themes: Area, Layout, Scale, Landscaping, Appearance, Sustainability, Lighting, with a separate set of access principles. These are all project specific.

Thames Tideway Tunnel. 2013. 'Design Principles'.

https://infrastructure.planninginspectorate.gov.uk/wp-content/ipc/uploads/projects/WW010001/WW010001-001202-7.17_Design_Principles.pdf

This report describes the design principles that underpin the design of the permanent ground level and above-ground elements and spaces of the Thames Tideway Tunnel project. The overall vision is that the project should build on the Victoria sewerage legacy, maintain London's long-term sustainability and improve the quality of the River Thames.

Design principles are laid out to achieve this vision:

- a. Being responsible:
 - respecting and contributing positively to each site's individual context and surroundings.
 - reducing the impacts of operations on local communities, the environment and third-party interests as far as reasonably practicable.
 - listening to and working with stakeholders, being open to new ideas and identifying areas of mutual interest with others.
 - challenging operational and functional requirements to create sites that meet the functional requirements, work within the day-to-day life of the city, and reflect local community and environmental considerations.
 - ensuring that the principles of sustainability are integral to designs by incorporating environmental solutions and environmental mitigation.
 - developing a signature across the sites that recognises the collective importance of the project and the sites to the river.
- b. Being flexible and creative:
 - where opportunities arise, we shall seek to create new, high quality, public spaces and enhance habitats and biodiversity.
 - where there is existing site development, we shall work with known developers to find solutions that are conducive to both parties. Where development proposals are less certain, we shall provide flexible solutions to meet operational needs that are also able to respond to changing future circumstances.
 - at existing Thames Water operational sites, designs shall be a simple expression of the functional requirements that respect the context and enhance the wider surroundings.
- c. Meeting functional requirements
 - developing high quality, well-designed and durable solutions that protect and respect the environment and amenity of the areas in which they are located.
 - providing safe sites for operations staff and (where relevant) the public that are accessible to all.
 - developing low maintenance solutions that meet operational and functional requirements using existing Thames Water assets wherever possible.
 - ensuring that spaces that would be handed over to others could be maintained to a good standard in the long-term, having due regard to planning policy and best practice.
 - reinstating and extending the Thames Path where practicable.

Generic design principles then cover the individual elements within the project:

- Functional components
- Heritage design
- Riparian and in-river structures
- Landscape design
- Lighting design
- Site drainage

Transport for London. 2015. 'London Underground Station Design Idiom'.

<http://content.tfl.gov.uk/station-design-idiom-2.pdf>

The TfL Design Idiom underpins design across the London Underground network, ensuring 'high quality design uniformity'. The guidance is structured under ten principles, with further detail under each heading.

1. Achieve balance across the network
2. Look beyond the Bostwick [station security] gates
3. Consider wholeness
4. Prioritise comfort for staff and customers
5. Delight and surprise
6. Use materials to create atmosphere
7. Create ambience with lighting
8. Integrate products and services
9. Prepare for the future
10. Flashcards (palettes and examples by station type)



3.6 USER EXPERIENCE DESIGN PRINCIPLES

de Bres, W. 2016. 'Digital Product Design Principles'. 2016.
<https://dev.degreed.com/digital-product-design-principles-8bc9eb6c080c>

Degreed, a learning and skill website, has published twelve design principles they use to make decisions:

1. Define the problem first
2. Create more value by creating less
3. Design performs
4. Focus the user on one primary action at a time
5. Minimize user input
6. Use your user's language
7. Make decisions for the uses
8. Design with strong visual hierarchy
9. Align elements
10. Don't go for 'WOW', go for 'of course'

Brown, D. 2010. 'Eight Principles of Information Architecture'.
Bulletin of the American Society for Information Science and Technology 36 (6): 30-34.

This paper codifies principles for designing websites under the following categories:

1. The principle of objects — treat content as a living, breathing thing, with a lifecycle, behaviours and attributes.
2. The principle of choices — create pages that offer meaningful choices to users, keeping the range of choices available focused on a particular task.
3. The principle of disclosure — show only enough information to help people understand what kinds of information they'll find as they dig deeper.
4. The principle of exemplars — describe the contents of categories by showing examples of the contents.
5. The principle of front doors — assume at least half of the website's visitors will come through some page other than the home page.
6. The principle of multiple classification — offer users several different classification schemes to browse the site's content.
7. The principle of focused navigation — don't mix apples and oranges in your navigation scheme.
8. The principle of growth — Assume the content you have today is a small fraction of the content you will have tomorrow.

d.school. undated. '8 core abilities.' Stanford University, USA.

<https://dschool.stanford.edu/about/>

d.school is part of Stanford University and provides a structure for enabling people to unlock and apply their creative potential. Its '8 core abilities' summarise what makes a good designer. Its avoids discussion of aesthetics and are intended to inform approaches to solving complex problems with no single solution through collaborative design:

1. Navigate ambiguity - the ability to recognize and persist in the discomfort of not knowing, and develop tactics to overcome ambiguity when needed.
2. Learn from others (people and contexts) - empathizing with and embracing diverse viewpoints, testing new ideas with others, and observing and learning from unfamiliar contexts.
3. Synthesis information - make sense of information and find insight and opportunity within.
4. Experiment rapidly - being able to quickly generate ideas - whether written, drawn, or built.
5. Move between concrete and abstract - understanding stakeholders and purpose in order to define the product or service's features.
6. Build and craft intentionally - thoughtful construction: showing work at the most appropriate level of resolution for the audience and feedback desired.
7. Communicate deliberately - the ability to form, capture, and relate stories, ideas, concepts, reflections, and learnings to the appropriate audiences.
8. Design your own design work - recognizing a project as a design problem and then deciding on the people, tools, techniques, and processes needed to tackle it.

Google. undated. 'About Us | Google'.

<https://www.google.com/about/philosophy.html>

Google has published 'Ten Things We Know to be True' - ten principles applied to the running of their business. The first is the most relevant beyond the world of technology companies.

1. Focus on the user and all else will follow.
2. It's best to do one thing really, really well.
3. Fast is better than slow.
4. Democracy on the web works.
5. You don't need to be at your desk to need an answer.
6. You can make money without doing evil.
7. There's always more information out there.
8. The need for information crosses all borders.
9. You can be serious without a suit.
10. Great just isn't good enough.

Government Digital Services. 2012. 'Government Design Principles'.gov.uk.

<https://www.gov.uk/guidance/government-design-principles>

The Government Digital Service has produced a set of ten Government Design Principles. They are notable for a particular focus on the delivery of services rather than websites, and have since been applied to all the services provided through the Gov.uk website:

1. Start with user needs.
2. Do less.
3. Design with data.
4. Do the hard work to make it simple.
5. Iterate. Then iterate again.
6. This is for everyone.
7. Understand context.
8. Build digital services, not websites.
9. Be consistent, not uniform.
10. Make things open: it makes things better.

H.M. Government. undated. 'Service Standard - Gov.uk'.

https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/765914/resources-waste-strategy-dec-2018.pdf

The Government Service Standard is used to test whether all public-facing transactional services provided by departments and Gov.uk are fit for purpose. It uses fourteen principles:

1. Understand users and their needs.
2. Solve a whole problem for users.
3. Provide a joined-up experience across all channels.
4. Make the service simple to use.
5. Make sure everyone can use the service.
6. Have a multidisciplinary team.
7. Use agile ways of working.
8. Iterate and improve frequently.
9. Create a secure service which protects users' privacy.
10. Define what success looks like and publish performance data.
11. Choose the right tools and technology.
12. Make new source code open.
13. Use and contribute to common standards, components, patterns.
14. Operate a reliable service.

The Interaction Design Foundation. undated. 'What Are Design Principles?'. <https://www.interaction-design.org/literature/topics/design-principles>

The digital user experience organisation, Interaction Design Foundation, defines design principles as 'widely applicable laws, guidelines, biases and design considerations, all reflecting researchers' and practitioners' accumulated knowledge and experience.' Alternatively, they can be described as 'laws with leeway'. The Foundation uses ten 'commandments' to guide digital design:

- Keep users informed of system status with constant feedback.
- Set information in a logical, natural order.
- Ensure users can easily undo/redo actions.
- Maintain consistent standards so users know what to do next without having to learn new toolsets.
- Prevent errors if possible; wherever not, warn users before they commit to actions.
- Don't make users remember information; keep options, etc. visible.
- Make systems flexible so novices and experts can do more or less.
- Design with aesthetics and minimalism in mind - don't clutter with unnecessary items.
- Provide plain-language error messages with problems and solutions.
- Offer easy-to-search troubleshooting resources, if needed.

U. S. Digital Service. undated. 'The Digital Services Playbook'. <https://playbook.cio.gov/>

The U. S. Government's digital presence uses thirteen principles, or 'plays', to guide its approach to design:

1. Understand what people need.
2. Address the whole experience, from start to finish.
3. Make it simple and intuitive.
4. Build the service using agile and iterative practices.
5. Structure budgets and contracts to support delivery.
6. Assign one leader and hold that person accountable.
7. Bring in experienced teams.
8. Choose a modern technology stack.
9. Deploy in a flexible hosting environment.
10. Automate testing and deployments.
11. Manage security and privacy through reusable processes.
12. Use data to drive decisions.
13. Default to open.

Each is accompanied by a checklist of actions e.g. 'Early in the project, spend time with current and prospective users of the service' and a list of key questions e.g. 'What user needs will this service address?'



4. THEMES

A number of themes, relevant to the production of national infrastructure design principles, can be identified across the documents assessed:

Value

Value is a broad category, and the way it is understood by different industries, and discussed in different context, highlights underlying variations in design ambition. In some contexts, value is discussed only in terms of cost. For example, the Enviro guidance 'Designing Waste Facilities' includes recommendations to maximise value through cost, and to minimise maintenance and upgrades. The Supply Chain Sustainability School discusses improving value by 'enhancing lifespan of assets'.

The Design Task Force report, 'The Value of Design in Infrastructure Delivery', lays out a wider categorisation of the potential values to be derived from infrastructure. It combines economic categories - including capital and whole life cost - with social value - including customer and placemaking value- and environmental value. The Centre for Digital Built Britain's Gemini Principles establish the need to 'enable value creation', and provide a similar, but more restricted, definition of the potential benefits from doing so. This can generate social, customer, economic, business, and environmental benefit.

Research commissioned from Britain Thinks by the NIC implies the need to take into consideration strong relationships between people and infrastructure, which is believed by those interviewed to be 'critical to supporting a good quality of life'. However, value is not widely represented in the literature in terms of quality of life. The National Planning Policy Framework sets out a restricted approach, requiring projects not to 'undermine quality of life'. The HS2 Design Vision is unusual in its commitment to 'designing places and spaces that support quality of life.'

Green infrastructure emerges as a powerful way to reconceptualise value, as well as infrastructure. The idea of multiple benefits is an inherent part of the concept of green infrastructure, as a network that connects everything around it. The UK Green Building Council expresses its value types in term of economic, social, and environmental benefits to 'communities': healthy communities, secure and cohesive communities, prosperous and fair communities, smart communities, sustainable communities. This emphasises not only the range of value types that can be associated with infrastructure design, but also the change of perspective that can use value to suggest new priorities and objectives for infrastructure.

People

The importance of placing people at the heart of infrastructure design is represented throughout the literature. These principles cover different areas of focus - consultation, engagement and participation, as well as inclusion.

Inclusion is often discussed in terms of access to services. Digital design principles are almost all based on the primacy of the user, as the rationale for everything that follows. 'Universal Design' represents the most comprehensive system of principles, specifically designed to promote equitable opportunity for all, regardless of who they might be. It is focused on the needs of those who use systems and structures. This approach is related to the priorities for those, such as Highways England, whose design principles are intended to deliver benefit through the function and inclusivity of road projects.

The relationship of a major project to people other than users is represented in different ways. For example, the HS2 Design Vision specifies 'People' as one of its three headline themes, and includes a commitment to 'engagement' with communities. The HS2 Design Vision is also unusual in that it includes 'creative talent' within its people theme, combining community engagement with the need for the right quality of professional expertise to deliver its ambitions.

Thames Tideway includes engagement as part of its commitment to 'being responsible', including 'reflecting local community considerations'. Network Rail, meanwhile, places communities 'at the heart of the design process'. The Supply Chain Sustainability School recommends a deeper engagement with communities, by 'integrating people's views into design decision making', and connecting this process with contributions to health and wellbeing.

Gehl's work on public space is based on a wider understanding of who the people served by street design are. He recognises that changing the understanding of those who could benefit from public space design entirely alters the accepted design approach. By 'people', the literature generally means users of the services provided by infrastructure, a definition that excludes those with other relationships other than as customers. Cumberlidge and Musgrave, however, make a strong case for participation as the means to ensure a design process has integrity. They argue that, without an open process, design is not equipped to deliver full value.

Place

The concept of place-specific design, suited to its particular location, feature across the literature documents. The National Planning Policy Framework requires projects to 'establish or maintain a strong sense of place', resulting in 'distinctive places'.

A place-specific design approach is reflected in several principles as 'context'. Highways England specifies good road design that 'fits in context'. The Infrastructure and Projects Authority proposes, as a minimum, addressing 'the project's physical and social context'. iBUILD also connects locally appropriate design to local engagement, suggesting that 'greater action at the local scale that reflects the distinctive nature of place.'

Defining the context for a project is necessary to deliver aims such as these. Context can be architectural, influencing design decisions, as expressed by the Singapore Land Transport Authority. It can be plan-based, such as the Design Council's requirement for masterplanning to be undertaken to ensure 'a facility that responds to its context'. It can be physical, for example Transport for London's 'Station Design Idiom' which includes the requirement to look beyond the station's gates. Thames Tideway emphasises the aim of improving a place through infrastructure design - 'contributing positively to each site's individual context.' Argent Related's Brent Cross South City-Making Principles are unusual in that they reflect infrastructure within a wider discussion of the characteristics of a place that works well for the people that live there, and consider 'social infrastructure' alongside more traditional interpretations of what 'infrastructure' means.

Environment

The need to ensure infrastructure design meets sustainability requirements is widely represented, although it is often presented outside the context of design as part of the broader process of construction and delivery. Process-based principles often include environmental performance as a headline objective, such as the 'Soft Landings Framework'. Environmental and cost benefits are also linked in the literature, for example in Enviros' 'Designing Waste Facilities'.

This emphasis is supported by Britain Thinks' research for the NIC, which reports that people would prefer infrastructure that 'protects the environment'. They specify resilience to change as an important aspect of the relationship between infrastructure and the environment. The NIC's 'Data for the Public Good' report also links data use to improved environmental performance. Transport for London's 'Silvertown Tunnel Design Principles' also make this connection, specifying 'sustainability through design' to enable flexible, adaptable design that reduces future environmental impact. Use of terminology varies, with 'sustainability' understood in different ways. The UK government's energy policy requires infrastructure to be 'sustainable', and for waste water to 'contribute to sustainable development'. Network Rail also simply requires 'sustainability'. Crossrail incorporates sustainability as a description of 'social,

economic and environmental impacts', as well as in relation to resource use. Notably, the digital sector principles reviewed do not incorporate any reference to environmental performance or impact.

However, references to climate change are notable by their absence from the literature. Ek et al.'s flood risk report for the EU includes the requirement that 'climate change and future uncertainties are accounted for in the development of law, policy and planning.' Balfour Beatty also references climate change in its flood risk principles, but the publications reviewed include limited consideration of the role of infrastructure in directing shaping and enabling future sustainability, or of how design might enable it to do so.

Measurement

There is wide recognition of the need for performance measurement, and the use of data to inform design. This is expressed in several different contexts. Balfour Beatty urges the use of data to inform flood risk planning, applying measurement to defining the problem for design to solve. RIBA also identifies the importance of data in project planning, through early establishment of outcome criteria and subsequent data sharing.

Performance monitoring features in several documents including HS2's Technical Standards, which specifies instrumentation to permit monitoring of assets. The digital user experience version is similar, but more succinct - for example, the U. S. Digital Service's injunction to 'use data to drive decisions'.

Taking active steps to learn lessons from previous projects is specified in the Highways England 'Strategic Design Panel Progress Report'. Data can also be used to learn lessons in real time, with the Interaction Design Foundation suggesting keeping users informed through 'constant feedback'.

Measurement is implicitly linked to culture by some organisations. Netherlands Railway emphasises the measurement of the actual quality of customer experience. The H. M. Government Service Standard links measurement to openness, committing to 'define what success looks like and publish performance data.'



5. CONCLUSIONS

Overall conclusions can be drawn about from the selection of documents reviewed that are relevant to the production of national infrastructure design principles.

5.1 OVERVIEW

There is little consistency in the way the six sectors in the NIC's remit address design, or the extent to which principles are in place. The majority of the principles identified are in the digital and transport sectors. The fewest relevant publications were identified in the energy, flood risk, waste and water and sewerage sectors.

No current equivalent to the design principles commissioned by the NIC has been identified. The review includes one example of nationally applicable, cross-sector principle – the Design Council's 'Design-Led Approach to Infrastructure' – which was intended to apply across the sectors included in the 2008 planning policy definition of NSIPs. This publication was produced to promote the Design Council's own design review services, and not apparently based on research and consultation across the relevant sectors. It therefore has a different application, although its areas of focus overlap with those of the NIC. It does not, however, incorporate an understanding of the digital sector as a part of the nation's infrastructure.

The work to produce principles for national infrastructure principles work is therefore by necessity pioneering, but can still be informed by sector and project-specific work already carried out around the world. Any set of principles intended to have such wide application will also require a clear relationship to existing design principles in operation across these sectors.

Apart from the Design Council's work, the closest existing infrastructure design principles are those, such as the HS2 'Design Vision' or the Network Rail 'Principles of Good Design', which are intended to encompass a broad set of different project types. Railways systems have, in some ways, an equivalent breadth of remit to the NIC: they encompass everything from hard engineering to pure customer service. The principles employed on projects such as these are fewer in number and wider in scope, allowing space for detail to be developed at project design level.

A number of the most comprehensive sets of principles use a pyramid structure, with

- a small number of headline objectives comprising the 'design vision', which explain what the project aims to achieve overall.
- a set of principles beneath those that explain, still in broad terms, how the vision will be achieved.
- a further set of project level objectives that detail what will be done to deliver the vision and principles, sometimes at site level.


However, few principles include project-level objectives. It is much more common to set higher level aims and indicate processes, rather than specifying what will be delivered to achieve this.

The transport sector, as an inherently public-facing form of infrastructure, reflects most clearly the significance of design in delivering an effective service most clearly. The culture of design, in contexts such as London Underground stations, is clearly expressed and understood as part of a heritage. While design heritage clearly applies to other infrastructure sectors too, there is much less evidence that it is being understood and applied to inform future design quality. The report from Jacobs and Arup on the Forth Replacement Crossing is unusual in specifying an 'iconic' structure as a design requirement. While an intention to deliver iconic design does not necessarily lead to a significant result, these principles show a clear understanding of the potential of this particular project to create heritage value.

The digital sector is responsible for almost all the reviewed examples of user experience design principles. This industry, and its ways of working and conceptualising its objectives, would perhaps be seen as entirely separate to the architecture and construction industries. Nevertheless, outputs from this sector have been included in this review because of the different perspective they offer, and their potential relevance to traditional built infrastructure projects. There are clear differences between the private sector tech industry, concerned with the function of online products for a select audience, and the need for NSIPs to deliver public benefit on an inclusive, rather than a selective basis. However, the focus on meeting user needs which dominates the user experiences principles, is relevant to delivering public benefit through infrastructure.

UK planning policy sets out ambitious place-making objectives, but the infrastructure-specific policy guidance reviewed lays emphasis on the limited scope for infrastructure to avoid adverse impact. Because of its very nature, some see infrastructure as intrusive and problematic – especially those who suffer local impact in exchange for national benefit.

Selected academic literature is reviewed, and its collective contribution to infrastructure thinking is to reveal how changing the overall conception of purpose can change everything else. For example, Jan Gehl's work on understanding streets and public spaces as a means to enable pedestrian activity, rather than to facilitate vehicular access, led to fundamental re-evaluation of street design around the world.



5.2 APPLICATION TO NATIONAL INFRASTRUCTURE DESIGN PRINCIPLES

The review provides thinking with the potential to inform the status, scope, objectives, format and of NIC design principles:

Status and scope

The review suggests that those projects that aim to influence a broad set of design contexts and outcomes do so by setting a smaller number of high-level objectives. If the NIC aims to express ambition, show leadership and to exercise influence over a diverse range of sectors, focusing on a few absolute priorities could be a powerful way to do so.

The relationship between national principles and those already in place in UK infrastructure sector may benefit from careful consideration. National infrastructure design principles could be distinguished from existing project and sector-level principles if they are to serve a different purpose. If the aim is to provide a set of principles that work easily alongside cross-sectoral principles they may need to avoid replicating existing principles, especially those that are already accepted and used, and instead seek to complement them. This could involve a clear hierarchy, expressed through the level of ambition set out by the NIC's principles. A new set of principles could be designed to fit with existing, established principles in use at organisations such as Highways England and Network Rail.

Objectives

Design is a widely used term, but has different meaning and significance for the various professional and lay groups involved in shaping and delivering infrastructure. If the principles are to be used by a wide audience with different approaches to interpreting design, it may be useful to define how design will be conceptualised in the NIC principles. A definition of design may could set the basis for what follows.

Many potential design objectives that could be included in a set of principles for national infrastructure. A list can be drawn from the review, and their relative significance tested in interviews. A top ten list of potential areas for focus, replicating the standard format used by UK principles, could prompt discussion.

Principles could, like some of those reviewed, aim to express the overall purpose of infrastructure, and therefore the benefits of good design. They could answer questions about what infrastructure can enable in relation to individual lives; how it contributes to a better society; and what quality of life it aims to make possible. Design principles can also focus on process, identifying the resources, skill combinations, knowledge, checks and assurances required to achieve design ambitions. They could combine both as some of the publications reviewed do, showing how processes can lead to design quality outcomes, and the benefits that can be achieved as a result.

There may be limits to the shorter-term measurability of higher-level project objectives. Their success of the project, as measured against these objectives, may only be evidenced and measurable in relation to the eventual built output. However, the requirement to measure project success, and to identify the means by which this will be achieved, could be specified. Established mechanisms for measuring project performance against detailed sustainability criteria exist in the form of the CEEQUAL framework. This level of comprehensive, shared assessment is the type of tool that allows major projects to set high levels of ambition for what they can measure.

Format

Nearly all the principles reviewed that are not in book format are presented as lists. It is unusual to find more than ten items, with maximum of 13. There are a small number of diagrammatic examples.

Direct, non-specialist language is common. Principles make regular use of a small number of single word or short headline statements expressing overall intent - usually three - with more detail beneath. There are few principle lists that are intended for direct application which use specialist language, as opposed to example of guidance and standards intended for groups of professionals. Precision is also important, and the review includes various examples of principles that make careful use of language to express complex requirements.

Existing principles are generally disparate in look and feel, with little in common on the surface and little evidence of interconnection. Most give the impression that they are stand-alone projects. National

infrastructure principles could therefore aim to unify, through simplicity and an intuitive approach. The language used in the principles could take a cue from the most accessible principles, which are undoubtedly those produced by digital service providers to set user experience standards. The vast difference between these and technical guidance for professionals may seem a problem, but could also be viewed as an opportunity to prioritise clear language in sectors not currently known for it.

There could be a risk of confusion, at least among a non-specialist audience, with many government agencies and departments and professional institutions already involved in providing their advice or requirements for aspects of infrastructure design. Most of these address design tangentially or in relation to different priorities, so the risk is not of duplication but that the distinct purpose of the NIC's principles may be lost if they are not easily distinguishable. A simple, accessible format would help to achieve this.



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Report by Tom Bolton.

The Frame Projects team was Tom Bolton, Deborah Denner, Sam Richards and Sarah Thwaites.

Design by Maria Zak.



Frame Projects
Unit 14 Waterside
44-48 Wharf Road
London N1 7UX
020 3971 6168
office@frame-projects.co.uk
frame-projects.co.uk

