



Lloyd's Register
Foundation



Insight report on sharing engineering data

Using data for the public good



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About Lloyd's Register Foundation

Lloyd's Register Foundation is a charity that helps to protect life and property and support education, engineering-related research and public engagement.

Our vision is to be known worldwide as a leading supporter of research, training and education – relevant to the field of engineering – which makes a real difference in improving the safety of the critical infrastructure that is vital to modern society. To support this, we promote scientific excellence and act as a catalyst working with others to achieve maximum impact.

www.lrfoundation.org.uk

About The Open Data Institute

The Open Data Institute (ODI) works with companies and governments to build an open, trustworthy data ecosystem, where people can make better decisions using data and manage any harmful impacts. The ODI was co-founded in 2012 by the inventor of the web Sir Tim Berners-Lee and artificial intelligence expert Sir Nigel Shadbolt to advocate for the innovative use of open data to affect positive change across the globe.

www.theodi.org

The Lloyd's Register Foundation report series

The aim of this report series is to openly disseminate information about the work that is being supported by Lloyd's Register Foundation. It is hoped that these reports will provide insights for the research community and also inform wider debate in society about the engineering safety-related challenges being investigated by the Foundation.

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Registered office: 71 Fenchurch Street, London EC3M 4BS, UK

T +44 20 7709 9166

E info@lrfoundation.org.uk

www.lrfoundation.org.uk



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Executive summary

Around the world we are facing a range of social, economic and environmental challenges. A safer, sustainable and more resilient future will require us to innovate and adapt the ways in which we engineer and maintain our infrastructure, energy and transport networks.

Data has a role to play in addressing these challenges. But to maximise value from data we need to increase access in ways that build trust, conform to legal and ethical frameworks, and deliver value for the public good.

This report explores how increasing access to data and strengthening data infrastructure across the engineering sector can deliver a range of benefits, not least by increasing safety. It highlights a range of examples of where projects across the engineering related sectors are demonstrating value and discusses some of the barriers to sharing data. It also briefly looks at how other sectors are overcoming these barriers using a range of regulatory and community driven approaches.

The UK government and Lloyd's Register Foundation are both funding work that explores how to increase safety, drive change in our utility sectors and change how we build, maintain and monitor the built environment for the public good. It is important that we look for opportunities for these programmes to complement one another to create impact, help scale innovation and build data infrastructure – including those shared across international boundaries.

The Open Data Institute (ODI) and Lloyd's Register Foundation's **Manifesto for sharing engineering data for the public good** is intended to build alignment and a shared vision across engineering programmes and sectors. The manifesto recognises the need for leadership from across the sector, and sets out recommendations for governments, regulators, industry bodies and the private sector. Sixteen organisations including the UK's Health and Safety Executive, Royal Academy of Engineering and Mott MacDonald Smart Infrastructure have already endorsed this manifesto (on pages 5 to 10) and others are encouraged to do the same.

A safer, sustainable and more resilient future will require us to innovate and adapt the ways in which we engineer and maintain our infrastructure, energy and transport networks



By taking a purposeful, challenge-led approach to solving the challenges we face, the ODI and Lloyd's Register Foundation want to help embed best practices and explore new business models and ways of working. This needs to be balanced with investment in strengthening and maintaining the data infrastructure that enables innovation. The engineering sector needs to explore and use the full range of data access models, creating new institutions where needed, to help build a data ecosystem where important data is accessible and data is used and shared in trustworthy ways.

While sharing and opening data will be an important part of addressing our global challenges, governments, regulators, industry bodies and the private sector must also encourage and enable an open culture, which applies open standards, open access, open source and open innovation to drive innovation that shares engineering data and makes it work for the public good.



Foreword

Lloyd's Register's heritage comes from sharing data for public good. The first Register, issued in 1764, allowed the analysts of the day to understand and manage shipping risks. The original aim was to bring transparency of information to merchants and underwriters on the quality of their vessels. This need for transparent and auditable data remains a fundamental aspect of ensuring the safety of engineered systems today, but the full benefits of sharing such data are yet to be realised.

The Open Data Institute, founded in 2012, works with companies and governments to build an open, trustworthy data ecosystem, where people can make better decisions using data and manage any harmful impacts. In 2014 the Foundation published its Foresight review of big data which identified the need to apply open data principles to engineering data. The author of that review, Sir Nigel Shadbolt, is the founding Chair of the Open Data Institute and this insight report is the next step in a collaboration between the two organisations.

This Insight report on sharing engineering data describes how sharing engineering data can bring benefits to society. It gives a succinct description of the potential value of sharing data across engineering sectors and systems, the barriers to sharing and the lessons we can learn from others. We are grateful to have been supported by like-minded organisations, that have also provided leadership, and together we have set out our manifesto for sharing engineering data which sets out the vital steps needed for maximising public good from engineering data. To date 16 organisations have signed up to this manifesto and we encourage others to follow.

Our organisations are putting these principles into practice and we are committed to supporting others to do the same.

Professor Richard Clegg
Foundation Chief Executive
Lloyd's Register Foundation

Dr Jeni Tennison
Chief Executive Officer
Open Data Institute

Lloyd's Register's
heritage comes
from sharing data
for public good



Photo by Leon Matapagal from Pexels

A manifesto for sharing engineering data

Globally we are facing a range of social, economic and environmental challenges. To create a safer, more sustainable and resilient future we need to improve our energy and transport networks, adapt our built environment and infrastructure to a changing climate, and create safer working conditions across a range of industries.

Increasing access to data, while preserving trust and ensuring benefits to the public good, are key to ensuring that our economies and societies will thrive.

Making better use of data will enable us to innovate, create more efficient and effective services and products, increase resilience and fuel economic growth and productivity.

To create a world where data works for everyone will require leadership from across the engineering sector. Change will require experimentation and trialling new approaches and ways of working.

The organisations endorsing this manifesto believe that the following principles and actions are vital steps towards maximising value of data for the public good.

1. Data is infrastructure

Data is infrastructure that powers our societies and economies. Data infrastructure consists of data assets, the technologies, standards and guidance that inform their collection and use, and the organisations and communities that manage, use and benefit from it.

To treat data as infrastructure:

- Governments should identify data that is part of our national infrastructure and ensure it is invested in to ensure access, quality and security
- Standards bodies must work with the engineering sector to support the development and adoption of data and metadata standards that support the sharing and use of data
- Professional bodies and societies should define and enforce codes of practice and guidelines that will inform how data is accessed, used and shared.



2. Data must be stewarded

Data should be managed as an asset to maximise its value to society. Managing data as an asset will make it easier to access, use and share.

Treating data as an asset will require:

- Making data discoverable and accessible, ensuring it is well-documented and accompanied by standard metadata that describes its provenance, quality and limitations
- Ensuring sustainable long-term access to data, through skilled curation and use of appropriate approaches to data sharing and archiving
- Industry collaboration to design and adopt principles and frameworks, such as the Gemini Principles¹, that will guide the collection and use of data
- Organisations involved in delivering projects and maintaining infrastructure must adopt approaches to deliver projects that support collectively managing data for the public good.

3. Opening and sharing data unlocks value

Data should be as open as possible, while protecting people's privacy, commercial confidentiality and national security. Data from multiple organisations is needed to address challenges and the data needs to be accessible.

To unlock value from data:

- Governments should publish foundational data assets, like geospatial and weather data, under an open licence
- The private sector must share and open datasets to increase access to data that will drive innovation and support research
- The public sector must embed requirements for opening and sharing data within procurement processes and should not sign contracts that allow for exclusive access to data
- Funders and regulators should use their powers to increase access to data.



4. Explore new data sharing models

Trustworthy data infrastructure will be independently governed and sustainably funded to ensure equitable access to the data and the benefits created from it, while minimising any harmful impacts.

To enable new models for sharing data:

- Funders, legislators and regulators should create incentive schemes that encourage collaboration and the sharing of data
- Governments and regulators should invest in platforms and approaches that will facilitate the sharing and exchange of data
- The public and private sector should recognise the range of approaches to increasing access to data and adopt models that will help to maximise the value of data while minimising harms.

5. Use challenges to drive innovation that solves problems

Open innovation can enable new solutions to important social, economic or environmental challenges, like increasing safety in the workplace or on our road networks.

To drive innovation through a challenge-led approach:

- Governments and civil society should work together to highlight key social, economic and environmental challenges that might be addressed through innovative approaches
- Funders should invest in programmes that will enable collaboration across the private sector, startups and researchers, to solve specific challenges through the better use of data
- Funders should help innovators to scale and develop their solutions by supporting the creation of necessary data infrastructure that underpins these new products and services.

6. Regulation must adapt to new technologies and uses of data

As new technologies, like autonomous vehicles, are designed and deployed it is important that the necessary data is available to enable innovation, provide evidence of safety and inform public policy.

To help adapt regulation to new technologies and uses of data:

- Existing regulation that applies to the engineering sectors will need to be extended or adapted to meet this changing environment by increasing access to data
- The regulators themselves will also need to develop their own capacity to use data, their understanding of the role data plays in their sector, and their understanding of when, where and how to intervene in the sector.

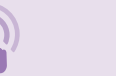
7. Building data literacy and skills

Organisations need the capacity to make use of data and an understanding of how to share it safely. To achieve this, data literacy and skills will need to increase across the engineering professions and organisations, and a range of stakeholders will need to collaborate.

To help build data literacy and skills in the engineering sector:

- Professional bodies and societies should ensure that their professional development and certification courses are building data skills
- Universities and research organisations must ensure that they are teaching the necessary data skills required for the future of the profession
- Private sector companies should design their internal skills and learning programmes to build an understanding of the value of data at all levels of their organisation.





8. Ensure data is used legally and ethically

Increasing volumes of data are being collected about homes, buildings, roads and transport networks, and employees in the workplace. This data must be used in ways that bring value for the public good, while minimising any harmful impacts that data use could bring.

To ensure data is used legally and ethically:

- Organisations must comply with relevant legislation
- Organisations collecting personal data should be transparent about how it is being collected, used and shared. They should also engage with their workforce and communities to understand both their needs and their expectations about how data about them might be used
- Professional bodies and individual organisations should develop and enforce codes of practice that will guide the ethical use of data, and ensure that the choices made about what data is collected and how it is used should not be unjust, discriminatory or deceptive.

9. Share knowledge and insight

Not every solution will work everywhere but, to achieve the greatest benefits to the public good, knowledge and insight should be shared within organisations, across the sector and internationally.

Countries differ in the state of their physical and data infrastructure, in their laws and regulations and in their attitudes to sharing and using data. But, by sharing experience and best practices, it will make it easier to tailor those insights to local contexts.

To support sharing of knowledge and insight:

- Funders of engineering research should mandate open access and open data to ensure the widest dissemination and application of its results
- Individuals leading projects within organisations and across sectors can share insights and best practices
- Professional bodies should develop case studies, tools and guidance that will facilitate the sharing of best practices.

This manifesto has been endorsed by:

Assuring Autonomy International Programme

Blue Marine Foundation

Bryden Wood

Cambridge University Press

Centre for Digital Built Britain

Colouring London

CRA Corporate Risk Associates

Energy Systems Catapult

Health and Safety Executive

Mott MacDonald Smart Infrastructure

Royal Academy of Engineering

Sowen Strategy Consulting

Structural-Safety

The Alan Turing Institute

The Chartered Institute of Plumbing and Heating Engineering

Tideway

Other organisations across engineering related sectors are encouraged to endorse this manifesto and collaborate to achieve this shared vision.

For more information about endorsing the manifesto, visit

<http://theodi.org/article/engineering-data-for-the-public-good-a-manifesto/>

or email info@theodi.org



Background

The Open Data Institute (ODI) and Lloyd's Register Foundation have engaged with a range of engineering and safety organisations across the UK, to explore how increasing access to data can help inform engineering design, monitor safety, and improve operations of key infrastructure.

The ODI and the Foundation hope to encourage and enable the engineering sector to adopt more open approaches to accessing, using and sharing data that will deliver benefits for the public good, with an emphasis on increasing safety. This report outlines a vision for the future, identifies some of the challenges and opportunities around increasing access to data, and summarises experiences from other sectors. It also includes a manifesto that identifies some key principles and recommendations to encourage change across the sector.

The approach to this project is outlined below.

Industry focus

Projects, programmes and case studies in a broad range of industries and areas in which engineering plays a key role have been considered, including:

- construction and maintenance of the built environment including infrastructure projects
- manufacturing
- transport, including maritime and shipping
- energy and utilities, including water, electricity, oil and gas
- general health and safety reporting across sectors.

It was recognised that different industries and communities are at different stages in how they are adapting or transforming with increased access to data, computing and new technologies.

The ODI and the Foundation have engaged with a range of engineering and safety organisations across the UK

Approach

To explore the opportunities and barriers to sharing engineering data, the ODI undertook the following activities.

Interviews

The ODI met with 12 stakeholders from a range of disciplines, who were involved in projects relating to engineering. The unstructured interviews aimed to understand the challenges and best practices in accessing, using and sharing data within and between projects, and within and between sectors.

Workshop

The ODI convened a group of experts representing organisations from across the infrastructure value chain² in multiple sectors, to explore barriers and opportunities to data sharing. This workshop contributed towards building a network of data professionals focused on creating a resilient, safer and more innovative future where data works for everyone.

Public event and roundtables

Lloyd's Register Foundation, the Royal Academy of Engineering and the ODI, with the support of The Alan Turing Institute, the Health and Safety Executive (HSE) and Cambridge University Press, hosted a one-day event to start a wider conversation with the community around the challenges, opportunities and key enablers to help achieve this shared vision.

The free, public event was aimed at those working in and around the engineering, energy and infrastructure sectors who are interested in driving innovation and increasing safety through better use of data. The video of the talks from this event have been published online³.

Authors and contributors

Principal authors

Leigh Dodds

Open Data Institute

Deborah Yates

Open Data Institute

James Maddison

Open Data Institute

Pauline L'Henaff

Open Data Institute

Contributors to the report

Dr Helen Balmforth

Health and Safety Executive

Dr Jeni Tennison

Open Data Institute

Dr Ruth Boumphrey

Lloyd's Register Foundation

David Tranah

Cambridge University Press

Professor Richard Clegg

Lloyd's Register Foundation

Peter Wells

Open Data Institute

Dr Theo Damoulas

The Alan Turing Institute

Dr Philippa Westbury

Royal Academy of Engineering

Helena Quinn

The Alan Turing Institute

Sir Nigel Shadbolt

Open Data Institute

Jesus College, Oxford University

The authors would like to acknowledge the support from other individuals and organisations who joined the workshop, participated in our public event and interviews, and provided feedback on the manifesto and draft report.

Introduction

Safety is a global challenge. Our growing population worldwide has resulted in ever greater demand for housing, goods and services. This demand needs to be met while emissions are reduced, infrastructure is improved and funding is limited.

The climate crisis means we need to create more resilient cities, supply chains and food supplies. Critical infrastructure needs to evolve in order to cope with extreme weather conditions⁴. We need to maintain and develop the critical infrastructure that enables the supply of our water, food, power and communications, so it is safe, sustainable, reliable, resilient and secure.

As the Lloyd's Register Foundation's Insight report on global safety challenges⁵ highlights, of key concern is not only how we interact with the infrastructure operated today, but also the infrastructure that will be enabled by technology in the future.

We expect to be safe when travelling, in our public spaces, at home and in the workplace. But the increasing complexity and interconnectedness of infrastructure systems⁶, and the development and adoption of technologies like autonomous vehicles and robotics, mean we are dealing with a changing environment which raises new and existing safety challenges.

World Health Organization (WHO) figures show that some 1.35 million people die each year from road traffic accidents around the world⁷, highlighting the need to do more to increase safety on our roads. A lack of trust in the safety reporting around autonomous vehicles is raising further concerns, resulting in calls for increased transparency and data sharing from manufacturers^{8,9}.

Figures published in 2018 show that 1.4 million workers in the UK suffered an illness they believed was caused or made worse by their work. In the same period, 555,000 workers sustained a non-fatal injury at work and 144 people were killed at work¹⁰. The construction industry employs around 7% of the UK workforce. In the same year, approximately 82,000 construction workers suffered from work-related illness and injury and there were 38 work-related deaths¹¹.

We need to maintain and develop the critical infrastructure so it is safe, sustainable, reliable, resilient and secure

Worldwide, every 15 seconds, 151 workers have work-related accidents, and one death from a work related accident or disease occurs¹². The International Labour Organization (ILO) estimates 2.3 million deaths related to work a year, and the construction industry has a disproportionately high rate of recorded accidents¹³. The utilities sector in North America has a 32% serious injury and fatality exposure rate, which is 7% higher than the all-industry average. Employees in water companies are most at risk, with an exposure rate of 42%¹⁴.

Better use of data and new technologies has huge potential to increase safety and to address a variety of social, economic and environmental challenges.

Previously, measures for the prevention of accidents have been informed by lagging indicators, the identification of historical patterns to help change behaviour. But the increasing amount of data that is being collected across the public and private sectors brings new opportunities. Leading indicators can be used to help to predict faults and accidents. Data can also be used to identify trends, design better infrastructure, improve resilience, and create safer outcomes.

Roads, buildings, bridges and other features of the built environment are increasingly being fitted with sensors that can be used to provide real-time insight into how that asset is performing. The data from these sensors can be employed to create models of how our physical infrastructure is being used. These models or 'digital twins' can help to manage traffic flow to avoid or react to accidents as they occur, or help to plan maintenance schedules that respond to demands on the infrastructure¹⁵.

Continuous monitoring of infrastructure will enable reactive and timely maintenance across all infrastructure to help avoid component failures and system outages. Sharing data will contribute to better scenario planning, infrastructure modelling and operations. It will also enable systems-level planning and help to reduce vulnerabilities in the face of climate changes¹⁶.

The Data Spectrum

In order to unlock the value from data, it needs to be shared and published in ways that retain trust and ensure it is used ethically, legally and securely¹⁷.

To help achieve this, it is important to recognise that data exists on a spectrum¹⁸, from closed, to shared, to open. On the next page is a graphic of The Data Spectrum, produced by the ODI.

Open data is data that is available for anyone to access, use and share. It is published under an open licence that allows it to be used for any purpose.

A good example of this is transport data. Many transport companies and cities have made their data available as open data. This includes things like timetables and real-time data about buses that companies can use to build services for people to plan their journeys better.

Some data cannot be made open because it contains sensitive information about individuals or groups. It may still be possible to share that data with specific organisations, so long as there are appropriate safeguards in place.

Shared data is data that is only available to certain people or groups, such as researchers. Data that is shared will typically be made available for specific purposes that are defined by, for example, a data sharing agreement. There are many ways in which data can be made accessible, or 'shared', with others¹⁹.

Closed data is data that is held privately within an organisation, like employment contracts and policies, or sales reports.

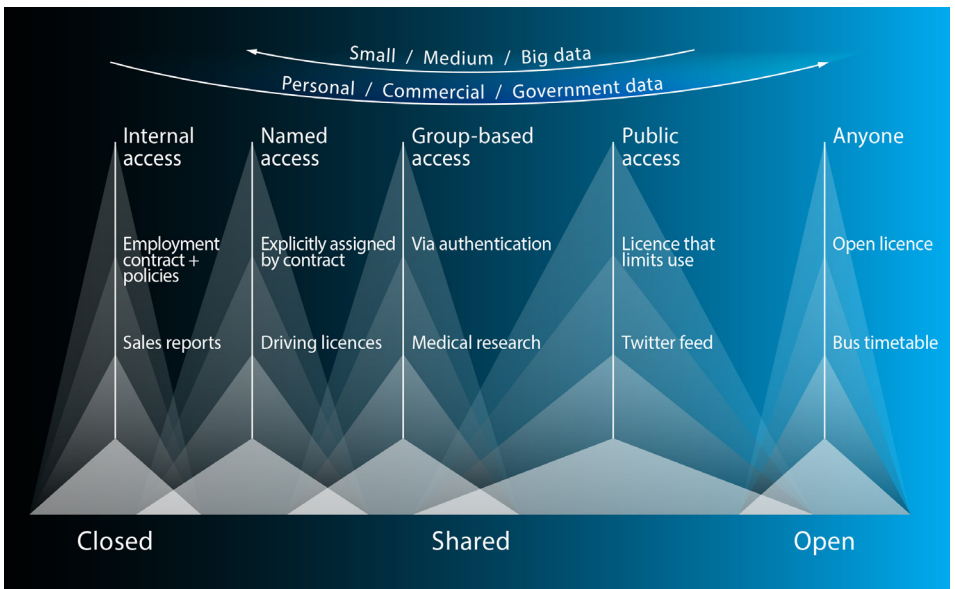


Figure 1: The Data Spectrum (theodi.org/data-spectrum)

By making data as open as possible – while protecting privacy, commercial confidentiality, and national security – we can unlock more value from it. Data that is as open as possible will be available to more people with fewer restrictions on how it can be used.

Through collaboration across the public and private sectors, and in partnership with academia, we can explore new ways to use that data to address the range of challenges. The following sections of this report (pages 19 to 26 and 30 to 34) highlight a number of projects that are beginning to deliver results.

Data infrastructure

In 2017, the UK's National Infrastructure Commission's Data for the public good report²⁰ highlighted that 'Data is part of infrastructure and needs maintenance in the same way that physical infrastructure needs maintenance. It must be updated, housed and made secure'.

To increase safety, and solve a range of economic and social challenges through research and open innovation, data access will need to be increased, and regional, national and international data infrastructure will need to be invested in and strengthened.

We must ensure that engineering data is at the right point on The Data Spectrum, and also supported by the data infrastructure that enables its use.

The ODI has defined data infrastructure²¹ as consisting of:

- data assets such as datasets, identifiers, and registers
- the standards and technologies used to curate and provide access to those data assets
- the guidance and policies that inform the use and management of data assets and the data infrastructure itself
- the organisations that govern the data infrastructure
- the communities involved in contributing to or maintaining it, and those who are impacted by decisions that are made using it.

The data that is part of a trustworthy data infrastructure will be sustainably funded and governed to maximise its value to meet society's needs. While using data for the public good is a cornerstone of the UK's strategy for the built environment, the same approach should be adopted across other sectors and internationally.

This insight report explores the findings of initial research into the benefits and challenges of sharing engineering data for the public good. To encourage further progress, the report includes a manifesto and recommendations that will support the engineering sector in working towards a more open future.



Data is part of infrastructure and needs maintenance in the same way that physical infrastructure needs maintenance. It must be updated, housed and made secure.

How can increasing access to data create value?

As a charity that helps to protect life and property, Lloyd's Register Foundation has a focus on using data to increase safety. The Foundation's Foresight review on global safety evidence²² describes how building a global 'safety evidence base' will generate insights to improve decision making around safety policies, practices and investments and ultimately inform the public's understanding of risk.

Increasing access to data across the engineering sector has the potential to create a range of additional benefits for society and for individual businesses. Better use of data can help to:

- increase safety by monitoring and improving working conditions, for example, across engineering, construction and manufacturing supply chains, or by optimising and improving the design, delivery and maintenance of infrastructure assets
- increase productivity in construction and engineering through better collaboration across the supply chain and asset life-cycle
- enable open innovation, for example by including more communities and organisations in the development of services, helping to create new technologies and insights or design new approaches to designing, building and maintaining aspects of the built environment
- driving economic growth by enabling new business models and cost savings across the engineering and construction sector
- reduce impact on the environment by reducing waste in construction or engineering processes, or through better management of energy and water resources.

In this section we draw on examples from a variety of sectors to illustrate how increasing access to data, and strengthening data infrastructure, is delivering a number of these benefits.

Increasing access to data across the engineering sector has the potential to create a range of benefits for society and for individual businesses

Maritime and offshore

By its nature, the maritime and offshore sector cuts across political and geographical borders, requiring more open, collaborative approaches to data sharing. Better access to data is necessary to increasing safety aboard ships.

Projects like EfficienSea2²³ have demonstrated how creating data infrastructure that provides better connectivity for ships can help to increase safety at sea through automated reporting on safety issues, weather conditions and smarter navigation²⁴.

The HiLo²⁵ (High Impact, Low Frequency) initiative aims to increase ship safety by enabling better modelling and prediction of the likelihood of more safety incidents. By enabling multiple organisations to share and combine their individual datasets, HiLo is able to develop better predictive models for asset failures and recommendations for improving onboard safety. The project already contributed to reducing risks related to lifeboat accidents by 72% on 900 ships (between August 2017 and June 2018²⁶).

The sharing of data across organisations through HiLo is essential to unlocking this value as no single organisation has the data necessary to develop models in isolation. The provision of accurate, timely information provides direct benefits for the individual organisation, by increasing safety of their vessels and crews.



Energy and utilities

Sharing of data across the energy and utilities sector is helping to reduce accidents and costs, empower local communities, and improve disaster planning and responses.

Following an explosion caused by construction workers piercing a gas main in Belgium in 2004²⁷, the Flanders region now requires all of its 300 utilities companies to provide access to digital representations of their infrastructure, using a common data model. That data is provided via a single repository of information to help ensure that building work is safe²⁸.

By modernising regulation to adapt to new technologies and uses of data, the region has not only seen a reduction in accidents – administrative costs have been reduced by 80% and project delivery times have been halved, from 15 to seven working days²⁹.

In Puerto Rico, following Hurricane Maria in 2017 – which devastated the island and caused a water crisis – a group of researchers developed new data infrastructure to support scientific investigation and data-driven decision-making following natural disasters³⁰. Researchers are now using the HydroShare data platform to share data, models and code, making these assets easily findable, accessible, reusable and interoperable³¹.

Sharing data via a common platform is creating opportunities for interdisciplinary research and enabling new research collaborations. The research team are training members of local communities to also share data via the system. Designing for community inclusion ensures the data will reflect and support the community it serves, helping them to understand water quality and make decisions that will ensure the provision of safe drinking water in their local areas.





Construction and the built environment

Every year in the UK, the construction sector witnesses around four times as many workplace fatalities as other similar industries¹¹. In addition to ensuring the health and safety of their workforce, construction companies have a duty to keep the general public safe.

The sector is modernising its approach to tackling safety and productivity challenges, by strengthening its data infrastructure through the adoption of open standards, embracing open innovation, new technologies and ways of working.

For example, individual companies like Arup are using data as a means to collaborate with startups, helping to inject new ideas and create new products and services³². While industry initiatives like the i3P³³ are funding innovative data-enabled projects like Safetibase making it easier for construction projects to identify, manage and communicate health and safety hazards³⁴.

Supported by the Centre for Digital Built Britain³⁵ via the UK BIM Programme³⁶, construction companies are adopting the Building Information Modelling (BIM) standard to support sharing data to increase productivity and reduce the safety risks commonly associated with large construction projects.

The HSE report, *Improving health and safety outcomes in construction*³⁷, provides a range of case studies where standardised sharing of data is helping to better coordinate and schedule works, reduce waste, avoid operational and logistical clashes, and mitigate health and safety risks.

Large infrastructure projects are often delivered by consortia, or groups of organisations, which creates technical and organisational challenges in sharing the operational data needed to improve health and safety. Existing procurement and contracting models also discourage more open ways of working and long-term stewardship of data.

But new approaches for delivering infrastructure, like Project 13, are emerging that place greater emphasis on collaboration and shared enterprise, enabled by standardised data sharing and digital transformation³⁸. This new approach is improving productivity, encouraging innovation, reducing waste, creating efficiencies and improving safety in the delivery of infrastructure projects.

The Data and Analytics Facility for National Infrastructure (DAFNI)³⁹ is building a platform, which will support the development of essential UK infrastructure by providing a central point for data, modelling and visualisation. Although this is a relatively new initiative, DAFNI is already collaborating with Oxfordshire County Council and the Science and Technology Facilities Council to help improve the way that transport is managed in the county⁴⁰.

In support of new approaches, and to help deliver on the recommendations from its report, *Data for the public good*²⁰, the National Infrastructure Commission has recommended that a digital framework should be created to help strengthen data infrastructure for the built environment.

The Centre for Digital Built Britain has set up a taskforce to bring together experts from industry, academia and government to lead the development of this framework⁴¹. Aiming to advise on how data, AI and machine learning can help us predict and meet the construction needs of the UK, one of the first steps has been to develop a set of principles that set the direction, known as The Gemini Principles¹.

Manufacturing

A resilient supply chain relies on good communication and access to the right information at the right time. As the climate warms, extreme weather and seismic activity can dramatically disrupt manufacturing.

Sharing data, insight and knowledge with global supply chain members can help identify and manage these risks in a quick and efficient way, reduce bottlenecks and maintain the production of goods. Projects like International Data Spaces⁴² are proving a means for organisations to address this⁴³.

The APROCONE (Advanced Product Concept Analysis Environment) project brings together companies in the aerospace industry to share design data for their mutual benefit. It focuses on methods for sharing data, via a central platform, to enable improved integrated aircraft design⁴⁴. Each company can design products more quickly and cost-effectively without compromising on quality. Ultimately, products are designed to better integrate with other components, which contributes to the aircraft being easier to operate and maintain and increased passenger safety.



Transport

Transport services are provided by both public- and private-sector providers. The UK's Transport for London (TfL) has been publishing open data about the transport network for over 10 years, which has led to a range of benefits for travellers, London and TfL. A recent report⁴⁵ suggests that use of the data is producing savings for commuters of up to £130 million per year, has created over 700 jobs, and delivers between £12-15 million of value per year to businesses using the data.

Collaboration across local authorities in the UK shows that access to data and information supports solution providers to design services which meet local requirements, demonstrating that pooling knowledge, insights and resources is an effective way to address common local transport challenges⁴⁶. Likewise, cross-sector projects centred around shared data to provide new services are playing an increasingly important role in efficient transport network utilisation, better infrastructure planning and reducing accidents⁴⁷.

In the cities of Malaga in Spain and Porto in Portugal, fleet operators have been using sensors in their vehicles to predict when mechanical failures are likely to occur. These sensors capture information, such as engine temperature and battery charge status, which is matched against historical data about mechanical failures to show the likelihood of a similar failure occurring. This data is combined with information about other variables that might affect the vehicle, including traffic situations and weather conditions, and transmitted through a secure server back to fleet operators. Sharing this data with operators provides insight to inform fleet maintenance strategies to reduce the likelihood of accidents⁴⁸.



Insights from shared data could identify gaps or biases that could have safety implications. For example, in the transport sector, people outside 'average' height and weight ranges – many of whom are women – have a higher chance of injury in road accidents⁴⁹. This is due to biases in the data that was used in vehicle safety design: crash test dummies were modelled on male bodies.

In 2019, Volvo announced it will be sharing insights from 40 years of data about car accidents with other car providers to help increase safety. Sharing this data gives car manufacturers more opportunity to understand and address biases and gaps in the data, and ultimately produce safer vehicles, suitable for all⁵⁰.

Robotics and autonomous systems

As the capabilities of robotics and autonomous systems (RAS) develop over time it is important that the integrity of these systems can be guaranteed.

The Assuring Autonomy International Programme⁵¹ focuses on the assurance and regulation of RAS by bringing together industry, regulators and researchers to work on challenges, via specific projects, research or training. The team is developing a body of knowledge⁵² in an attempt to collate and share existing data and information. This includes engineering data about machine development and data about accidents that have occurred in the environments in which autonomous systems will operate.

Connected autonomous vehicles collect large volumes of data from onboard cameras and other sensors. Camera and sensor data is combined with highly detailed maps to determine optimum routes and arrival times. Companies providing ride sharing services and developing autonomous vehicle technology rely on being able to access accurate and detailed mapping data. Transportation company Lyft is looking at ways to bridge the gap between collaboratively maintained openly available geospatial data and the high precision and mapping accuracy that the next generation of autonomous vehicles will need⁵³.



The algorithms that drive autonomous vehicles must be trained on large volumes of data to ensure the algorithms are well-tested in real-world conditions⁵⁴. Projects like ConVEx⁵⁵ and Berkeley Deep Drive⁵⁶ reduce duplication of efforts around data collection through sharing training data. They are helping companies to compete on quality of their models rather than their ability to collect data.

Common technical platforms, such as that offered by the OmniCAV project⁵⁷ and open source code from companies like Telenav⁵⁸, are also helping the industry to develop and test safer algorithms for use in connected vehicles.

Health and safety

As previous Lloyd's Register Foundation reports have highlighted, internationally there are often inconsistent approaches to collecting health and safety data, and variations in legal and regulatory requirements for collecting and reporting data²². This increases the challenge of improving safety around the world.

However, projects like the Discovering Safety programme⁵⁹ are working towards enabling better access to, and use of, health and safety data on a global scale. Using 40 years of accident and incident investigation data – combined with other health and safety data from industry, trade bodies and safety organisations – the UK's HSE is developing a safety knowledge base. This is being analysed to provide insights about why, and how, health and safety failures occur in local contexts around the world. The programme also brings together industry, trade groups, international networks, governments and academia to identify health and safety challenges and opportunities where deeper insights from data could make a significant impact.

The HSE have also been improving the prioritisation and delivery of health and safety interventions through its Regulatory Intelligence programme. Other regulators across government have shown an interest in this work and plans to create a cross-government Regulatory Intelligence Hub⁶⁰ have been proposed. The Regulatory Intelligence Hub would enable different regulators to share data with each other, allowing interventions to be more evidence-driven. It would also help to make departmental operations more cost-effective and make inspections easier on businesses that are compliant.

International organisations also play a role in bringing organisations together to share data, insights and knowledge. For example, the ILO provides comprehensive data on workplace health and safety from countries around the world⁶¹. This data is being used to develop indicators of risk, drawn from data on death and injuries, and is informing development of leading indicators to support preventative measures.

Where are the barriers to sharing data?

While the examples in the previous sections highlight some of the real benefits that can arise from increasing access to data, many organisations are still cautious about sharing data.

Many organisations are still cautious about sharing data

The ODI's research⁶² and that of the Royal Academy of Engineering⁶³ have highlighted a number of concerns around increasing access to data which touch on a range of cultural, commercial, legal and technical barriers. Some of these issues are briefly outlined in the following sections. In understanding these barriers it is hoped to achieve the goal of finding ways to overcome them.

Concerns over the risks of data sharing

Organisations, particularly those in the private sector, have a number of concerns relating to the risks of data sharing. These include:

- Commercial sensitivity. Organisations may rely on certain datasets to support their business model and funding decisions, and therefore be fearful of the impacts of sharing data.
- Dealing with personal data. Many organisations and sectors struggle with how to make effective legal use of personally-identifiable data⁶². Data publishers and decision makers may not understand how to anonymise data or feel insufficiently informed to design or make decisions about data sharing.
- Reputational impacts. Poor data quality or inconsistencies in the application of data are common reputational concerns.
- Misinterpretation or misuse. Stories of misuse and fear of misuse are common, especially if there is a risk that misuse can lead to an accident. Access to the datasets can be and have been revoked through this fear.
- National security risks. For example, providing the ability to identify the location of combustible energy sources in public buildings that are likely targets for attack, or where a malicious person could interfere with the supply of safe drinking water.



A lack of frameworks and standards for data

Organisations that publish and use data regularly highlight the problems that arise from inconsistent and incompatible approaches to publishing and sharing data.

A lack of standards for data increases friction when using data and also discourages data sharing as organisations are unsure how to best make data available for reuse. Adopting open standards for data can help to support the consistent collection, publication and use of data⁶⁴.

Confusion around data rights and licensing

Organisations often fail to share data because of a lack of clarity around their rights to do so. While organisations may hold data internally, it is often unclear whether their rights cover only limited internal uses or extend to sharing and using in other ways.

There is a complex set of overlapping rights that apply to the collection, use and sharing of data. These rights cover intellectual property, data protection, individual data access rights, government's rights to data to perform their democratic responsibilities and the freedom of information⁶⁵. These different rights support different purposes and are often overlapping or in conflict with one another.

A combination of a frequent lack of clarity around data licensing and rights in procurement and contracting means that organisations are often uncertain about their ability to share data more widely. Risk of significant legal costs means that organisations choose not to share data.

Uncertainty around the value of sharing data

Companies often do not understand the social, economic or environmental benefits of increasing access to data that they hold. A lack of understanding of new business models⁶² that can be enabled by data sharing, or the role of specific datasets in helping to address specific safety challenges, means that organisations are unsure of the benefits of sharing data, either for themselves or society more widely. Research to show the value of sharing data in the private sector may help to address this⁶⁶.

Attendees at the ODI workshop exploring data sharing across the data value chain felt that many companies were unable to see the long-term benefits of spending money on upgrading their data infrastructure and improving access to data. Many organisations are still struggling to see data as an asset that might have longer term value. There is often a focus on delivering short term benefits, for example, to fulfil a contract, rather than collaboration to build shared data assets.

Cultural attitudes to risk

Countries differ in the state of their physical and data infrastructure, in their laws and regulations and in their attitudes to sharing and using data.

The workshop participants described a variation in attitudes to sharing data around the world. For example, there was a feeling that companies in the United States, New Zealand and Australia were more comfortable with the concept of sharing data, whereas UK businesses were more reticent to share. The reasons for this may include maturity of business and governance structures, availability of data infrastructure to facilitate sharing or political appetite for openness.

Across Europe, attitudes to sharing of personal data with the private sector differ between countries, but generally, the public thinks that data is more useful when it contributes to their safety⁶⁷.

What can be learned from other sectors?

Every sector has its own unique context of regulation, competition, approaches to collaboration and pace of technological change. This means the drivers towards more open approaches to sharing data are different – for example, more heavily regulated sectors have different influences than those that are still emerging.

To help understand the range of approaches that might lead to a more open engineering sector, this section briefly describes how other sectors are exploring ways to increase access to data.

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Banking – using data to drive innovation

In the UK, the dominance of high-street banks in the banking sector has led to reduced competition, a subsequent reduction in innovation and ultimately inertia in the marketplace. Spurred on by regulatory changes, the sector is now beginning to benefit from the adoption of a new standard for open banking which is stimulating innovation through increasing access to data.

The approach

- The UK Treasury set up the Open Banking Working Group (OBWG) in 2015 to explore how data could be used to help people to transact, save, borrow, lend and invest their money, and thus improve their banking experience.
- The OBWG created a framework for developing the Open Banking Standard⁶⁸ which guides how banking data should be created, shared and used (rules, technologies and standards allowing customers to give companies permission to securely access their accounts).
- The Open Banking Implementation Entity (OBIE)⁶⁹ was set up to develop and implement the standard under the governance of a regulator, the Financial Conduct Authority (FCA).
- The sector has run challenges, such as the Open Up Challenge⁷⁰ and Open Banking for Good, creating incentives to develop products and services for different needs.

Outcome

The ability for a broader range of organisations to access data on banking products and customer transaction histories, is leading to more innovative products and services being created. By granting trusted third parties access to data, customers can more easily switch current accounts, gain access to personal finance dashboards, as well as more accurate loan and credit referencing decisions. Meanwhile, small- and medium-sized businesses are benefiting from better tax advice.

A recent review⁷¹ of the impact of Open Banking by the ODI and Fingleton Associates found that, while the initiative is still early in its development, it has evolved to add value to customers and service providers in broader financial management issues as well as delivering on its intended purpose: to stimulate innovation. The model initially adopted by the UK is now being replicated worldwide.

The approach illustrates the role of regulation in shaping data access arrangements within a sector, the speed of data innovation once the necessary data infrastructure is available, and the ability for innovative models to spread to other countries.

Physical activity – opening data to deliver policy goals

A lack of physical activity is one of the UK's biggest public health challenges, causing 37,000 deaths⁷² annually and costing £20 billion⁷³ a year. Much of the information about sport activities in England is hidden within websites, PDFs or printed flyers. Finding out which classes are nearby is difficult and reduces the chance of participation. To help get the population more active Sport England has been funding the OpenActive⁷⁴ initiative to encourage publication and use of open data across the sports and physical activity sectors in England.



The approach

The OpenActive programme was set up in 2016 by the ODI and Sport England to support the sector by:

- Building data literacy and skills – on data collection, sharing and use across the sector
- Increasing data availability and consistency – working with providers to openly publish data about where and when physical activity opportunities happen
- Encouraging innovation – running an accelerator programme to support companies to innovate and propose solutions using open data
- Developing open standards – using a cross-sector working group to create stronger data infrastructure in the sector
- Sharing experience across the sector – the OpenActive Champions⁷⁵ programme is a peer network supporting 10 advocates working to encourage the sector to adopt more open approaches.

Outcomes

The initiative has successfully been building momentum around publishing and using open data across the sector by engaging with a range of organisations including leisure providers, sports governing bodies, startups and other industry organisations. A number of the major leisure operators and platforms have adopted the OpenActive standards and are routinely publishing open data.

While the primary goal of the programme is to help create a healthier nation, many of the participating organisations are seeing the benefits because it creates opportunities to increase revenue, create new products and enable collaboration across the industry.

The programme highlights that change can be driven by more bottom-up approaches.

Open Contracting – increasing transparency to create fairer markets

Around the world government contracting is worth trillions of dollars per year⁷⁶. However, the lack of open processes around public spending means that there is often little transparency into how these funds are being used. This can lead to corruption, a lack of competitiveness and poor insight into how and where money is being spent.

The Open Contracting Partnership (OCP)⁷⁷ was set up in 2012 to use open data to help save governments money and time, deliver better services and create a better business environment for all.

The approach

- OCP have developed a data standard⁷⁸ and a set of supporting open source tools and guidance to help support the publication of data, and monitor the effectiveness of cities and governments in adopting the standard.
- A mixture of advocacy, implementation support and learning programmes helps to build capacity, across a wide community of data publishers and users, in using open data to drive reform and create impact.
- The use of peer networks to share knowledge and experience, and regular reflection on progress and impact, is creating a culture of working in the open across governments and in specific sectors.

Outcome

More than 20 countries around the world are implementing the standard and another 20 are currently working towards implementing reforms to adopt more open approaches⁷⁹.

The OCP have partnered with the Construction Sector Transparency Initiative to help drive improvements in investments in public infrastructure projects⁸⁰. Impact studies are showing how open procurement can help assess investment in flood management infrastructure in Taiwan⁸¹ and improve infrastructure procurement in Honduras⁸² and Colombia⁸³.

An important lesson for other sector programmes is how the OCP have worked to drive change by not just advocating for more open approaches but also by building capacity and motivation for change by creating a culture of measurement, learning and improvement. Working in the open is helping to embed systemic change to create longer term impact.



Agriculture – strengthening data infrastructure to improve food security

By 2030, the agricultural productivity and incomes of small-scale food producers need to double to achieve food security and promote sustainable agriculture⁸⁴. The rapidly increasing availability of data has huge potential to improve the agriculture sector and address food and nutrition challenges. Supported by government funding, a range of organisations across the agriculture, nutrition and digital sectors are collaborating to increase access to data to address food security and nutrition challenges.

The approach

GODAN Action⁸⁵ is a three-year project which began in 2017, to enable data producers, stewards and users to engage effectively with open data and maximise its potential to bring positive impact in the agriculture and nutrition sectors.

The project focuses on three key areas of work:

- standards – facilitating the use of standards to support the exchange and use of data
- impact – researching the impact of open data in the sector
- capacity building – helping stakeholders to engage with and use the open data.

Each partner organisation brings unique skills and experience to contribute to each workstream. For each area of work, a leader is appointed to drive efforts. The project team regularly meets to coordinate activities and ensure learning processes are put in place. Regularly engaging with target audiences via events⁸⁶, training sessions and workshops⁸⁷, the project team has been able to adapt content to achieve greater impact.

Outcomes

The project has engaged many different groups to improve understanding and use of open data – training over 1,000 data producers, stewards and users around the world. The project has created tools to facilitate discovery and use of standards for agricultural and geospatial data across diverse communities of practice. It has also made recommendations to improve the discovery, interoperability and use of data across the sector.

The GODAN Action project highlights how a range of organisations working in collaboration can help to drive change across an industry.

Discussion and recommendations

This report has discussed how increased access to data across the engineering sector can help us address significant challenges facing our economies and societies around the world. The way we design, build and maintain the built environment, supply chains, utility and transport networks must all adapt to respond to those challenges.

The report has identified existing projects that demonstrate the benefits of increased access to data across a range of sectors. The ODI's research and workshops also found barriers that discourage both the public and private sectors from sharing data.

Concerns over the risks of data sharing, usage rights, quality, standards and business models are not unique to the engineering sector. But some sectors are finding ways to navigate these issues, giving useful insights into how to enable the necessary changes to scale up projects to create sustainable, trustworthy data ecosystems, where a range of organisations can benefit from increased access to data.

In some areas existing regulation and oversight provides a strong lever to ensure that data is shared and opened in ways that bring about value. In other areas we need to look for other ways to drive change – such as through open innovation and collaboration – and explore new approaches to sharing and governing data that help solve problems. In all cases, identifying challenges that can be addressed with increased data access is a necessary first step.

This report has discussed how increased access to data across the engineering sector can help us address significant challenges

A manifesto for the public good

The manifesto in this report includes recommendations to help organisations across the engineering sector work towards a shared vision of engineering data being used for the public good.

Change requires intervention and collaboration between a range of organisations across the data ecosystem. Data stewards and users need to be supported by regulators, investors and funding bodies, academia, technology suppliers and professional bodies. Change requires coordinated action and leadership from all types of organisation.

The manifesto contains key principles that bring together existing thinking and experience from across the engineering and other sectors. It highlights the importance of treating data as infrastructure, of data stewardship and sharing, and of developing the skills and experience needed to solve important challenges.

Sixteen organisations have already endorsed this manifesto and others are encouraged to do the same. It is hoped the manifesto will drive positive change and convene a variety of organisations working to deliver on the promise of data for the public good. The manifesto should lead to useful collaboration and activity across the sector and it includes recommendations for a range of stakeholders to help achieve this.



Changing behaviour by enabling good practice

Sharing and using data for the public good will require organisations to change their behaviour: collecting, stewarding and using data in ways that build trust and respect privacy.

Recognising this, existing models of behaviour change can be used to help articulate how different activities can contribute to the creation of a trustworthy data ecosystem. The COM-B⁸⁸ framework for behaviour change highlights that change requires building capability, motivation and opportunity for the desired outcomes and behaviours to exist.

In the context of delivering on the manifesto, this can be interpreted as follows:

- **Capability** – does the engineering sector have the necessary capacity to access, use and share data in ways that create value for the public good?
 - The manifesto recommendations identify the need to provide training, develop skills and share knowledge and experience.
 - Capacity building will involve academia, research organisations, societies, professional associations and networks, among others.
- **Motivation** – does the engineering sector have the necessary motivation that will lead it to access, use and share data for the public good?
 - The manifesto highlights the role of regulation and procurement to require data sharing, the creation of incentive schemes to encourage wider collaboration and the importance of case studies to communicate the value of increasing access to data.
 - Increasing motivation will require activity from funders, regulators, policymakers.
- **Opportunity** – are there opportunities for organisations across the engineering sector to legally and ethically access, use and share data?
 - The manifesto highlights the importance of ensuring that regulations enable the safe publishing of data and the role of standards and codes of practice in ensuring data is shared in ways that maximise potential benefits while minimising harms. It also emphasises the importance of challenges and open innovation in encouraging organisations to explore the benefits of data sharing.
 - Creating opportunities for data sharing will involve standards development organisations, professional associations and societies, tools and platform providers, among other organisations.
 - Enabling businesses to legally share data will also require new technologies and tools to be applied, such as privacy-enhancing technologies that will allow organisations to safely share personal data.

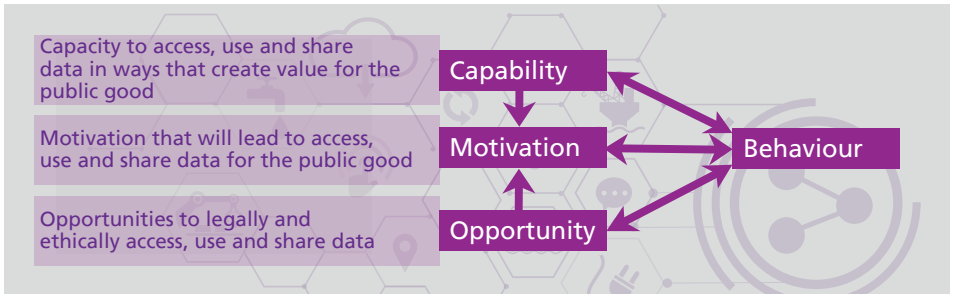


Figure 2: COM-B framework for behaviour change

Applying this COM-B framework can help to frame what problems are to be solved, and understand how existing projects and initiatives complement one another. For example:

- The Alan Turing Institute is bringing together academia and industry to undertake projects that will build capacity and motivation for data sharing by exploring data-centric engineering.
- The Discovering Safety programme⁵⁹ run by the HSE will eventually lead to the creation of new tools and technologies that will provide organisations and other regulators – nationally and internationally – with opportunities to use and share data more effectively.
- The Digital Framework Task Group⁴¹ has developed a roadmap for creating the information management framework that will support delivery of the UK national digital twin. The roadmap includes activities that will build capacity, motivation and opportunities to share data across the engineering sector.
- The Energy Data Task Force has proposed a series of recommendations⁸⁹ that will build capacity, motivation and opportunities for organisations in the energy sector to access, use and share data.
- The Royal Academy of Engineering Towards Trusted Data Sharing Project⁴⁴ has helped to increase motivation for sharing data by capturing case studies and advice from different sectors.
- Cambridge University Press have launched the open access *Data-centric Engineering*⁹⁰ journal to support publication of research, creating a more open research environment that will create opportunities and motivation for translational research and further collaboration across academia and industry.
- Accelerator programmes such as the Lloyd's Register Safety Accelerator⁹¹ and Data Pitch⁹² are motivating and supporting large organisations and startups to use data to collaborate on specific challenges.

Key areas of focus

Short term priorities will differ across specific sector programmes due to the needs of different communities and organisations. But a few themes are important to highlight.

Short term priorities will differ across specific sector programmes... But a few themes are important to highlight

Taking a challenge-led approach

First, change is best driven by a focus on outcomes. Bringing a set of stakeholders together to tackle a specific safety, productivity or environmental challenge has a number of benefits. In the ODI's experience this focus helps to build alignment, clarifies which data assets should be shared and used, and identifies the data stewards, innovators and influencers that can help address a specific problem. The process of collaboration helps to embed good practices, build relationships and identify new business models.

This challenge-led approach to change is the model used in the Lloyd's Register Safety Accelerator⁹¹ and initiatives like Data Pitch⁹². Accelerators and challenge programmes help to drive interest and funding towards problem focused approaches. However in some cases what is needed is stimulus funding to help organisations run a discovery project to help develop a better understanding of needs and scope further activity.

Strengthening and improving data infrastructure

Taking a purposeful approach to opening and sharing data has been adopted in other areas, for example in the open government movement⁹³. The focus on sharing and using specific data assets must be balanced by coordination, investment and support in building cross-cutting data infrastructure that will help to ensure that successful approaches are sustainable and can scale across regions and internationally.

Looking at how individual challenges are being addressed will help to highlight areas where strengthening data infrastructure, or increasing access to specific datasets, will have broader benefits to the wider engineering data ecosystem. For example, there may be a need to drive the adoption of new standards, increase access

to foundational datasets like weather and geospatial data, or a need for codes of practice or other guidance that will help ensure that data is being used legally and ethically.

We need to balance the need to drive innovation with investing in maintaining and improving the underlying data infrastructure that enables it. The Lloyd's Register Foundation's Foresight review of big data⁹⁴ highlights the role of certification of data in strengthening data infrastructure. As that report notes, the Foundation has a role to play here – as do governments, regulators and other investors.

Recognising the range of data access models

The ODI has been mapping the range of data access models^{19,95} that are being used to share data between organisations and across sectors. Each individual approach has its own strengths and weaknesses in supporting specific types of innovation, collaboration and transparency. We must use appropriate models to help address specific challenges and create new institutions where necessary.

The HiLo project²⁵ illustrates how the private sector is able and willing to share sensitive commercial data when there is both trust in how the data is being governed and used and there is a clear return on investment in building shared data infrastructure. Recent ODI research has shown that data trusts can provide a means for increasing access to data while building trust⁹⁶. Independent stewardship of data will be a part of building a sustainable, trustworthy data ecosystem.

Lloyd's Register Foundation, governments and other funders should use their investments to help the sector to explore a range of data access models.

Beyond open data

Delivering on the vision of using engineering data for the public good is not just about open data or shared data. Change will require a variety of collaborations and approaches to creating value.

Openness has multiple forms: open data, open standards, open access, open source. Sharing of data, code, models, guidance and insights is all necessary to maximising value of data for society. Lloyd's Register Foundation and other funders can accelerate this change by building requirements for open approaches into their policies and grantmaking. Government procurement provides another important lever.

Using the full range of open approaches will be necessary to create value for the public good and a world where data works for everyone.

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