Information Technology Management

Chapter 14

National statistical offices (NSOs) and other producers of official statistics can expect a continued and accelerating rate of change in the years to come with further advances in Artificial Intelligence, machine learning, smart data and the "Internet of Things". These developments, combined with changing work practices, increased user expectations, competition from other data providers and a constant drive for modernisation and increased efficiency, provide an ongoing challenge for national statistical systems. This Chapter reflects current IT trends that modern NSOs and other producers of official statistics require, including cloud technology, big data, data visualization techniques, new methods of data collection and dissemination, and data integration.

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14.1 Introduction

Information Technology (IT) continues to play an essential role in all aspects of statistical processing throughout the entire production life cycle from data collection through to dissemination. This is a fast-moving and rapidly changing environment with new innovations being developed at a breath-taking rate. Since the publication of the last handbook in 2003, the IT landscape has changed almost beyond recognition - at that time many national statistical office s (NSOs) were just emerging from the mainframe era and have since evolved through the phases of personal computers, distributed databases, the explosion of the internet, smartphones and tablets, cloud technology and new data sources. An NSO can expect a continued and accelerating rate of change in the years to come with further advances in Artificial Intelligence, machine learning, increased computing power, smart data and the “Internet of Things”. These developments, combined with changing work practices, increased user expectations, competition from other data providers and a constant drive for modernisation and increased efficiency provide an ongoing challenge for an NSO. Harnessing the power of IT by innovating in new products and processes can help NSOs meet the challenges of the rapidly changing environment.

The ability to harness IT, of course, depends on capacity level – different approaches are required for different countries. This chapter will describe changes in the IT landscape since the last handbook, review emerging and existing standards, and look at the technology infrastructure required by a modern NSO.

14.2 Review of changes since last edition and current trends

14.2.1 User expectations for IT services in an NSO

It is a question of survival for NSOs the world over to modernise their statistical information systems in order that official statistics can stay relevant amid competition from other data sources, increasing demands from users and stakeholders combined with financial constraints.

NSOs are under constant pressure to do more with less in a continued climate of financial constraint. The levels of expectations from users are rising from all levels of government, policymakers, civil society, academia, research bodies and the general public – who demand high-quality statistics ever more rapidly – today’s users expect data immediately and are no longer prepared to wait weeks or months for information to

be made available by an NSO. In addition, an NSO is expected to access and make use of new sources of data, adding value and statistical know-how before making them available. Users now expect easy access on all platforms, telephones and tablets as well as via computers. Traditional users of official statistics expect secure, high performance, stable and modern applications to deliver data to meet the needs of decision-makers – and this is especially important in the context of the SDGs. The recent generation of millennials and digital natives expect immediate free access to data and interactive visualisations.

NSOs are now also in competition from other non-official providers of data - data is no longer the monopoly of the NSO – and users are no longer willing to wait months for official data to be released when unofficial alternative without the same constraints of ensuring quality can be available much more quickly.

14.2.2 Changes in the way of working

Collaboration between organizations

In this time of constant change, an agile and adaptive approach to working is needed. One way in which NSOs have responded to deal with these challenges and increased expectations is to work together to solve common problems.

Recent years have seen an increase in collaboration between organizations working on projects and sharing software having recognised the need to work together to modernise statistical systems, standardise processes and industrialise statistics production in the face of shrinking budgets so as to stay relevant in the face of alternative non-official sources of information. The model of developing in isolation is inefficient and obsolete: the future is in collaborating.

At the time of the last handbook, there were only a handful of collaborative projects between NSOs and International Organizations – today, this way of working is becoming mainstream**.** There are different modes of collaboration: An NSO can share its own software with other organizations, they can reuse existing software made available by another organization, or they can collaborate together with one or more other NSOs to develop tools for their common use that can then, in turn, be made available to others in the statistical community**.**

Recent years have seen the formation of international groups and communities to facilitate this process and organizations are now collaborating within formal frameworks. Such collaborations are not only a very important development for an NSO

in saving costs, but it also sends a positive message to stakeholders that they are getting value for money by not wasting resources reinventing the wheel.

Working collaboratively does require investment, it can be complex, and staff will need to adapt to new ways of working and new methods of project management, but it is the most efficient way of working for an NSO in the long run.

Reusing software

An NSO should always seek to gain advantage of the tools available from the international statistics community rather than develop software for their own use.

The move is away from in-house development towards collaboration and the first instinct of the NSO when there is a need to upgrade their processes should be to inspect the various inventories of software maintained by international and regional bodies such as the High-Level Group for the Modernisation of Official Statistics (HLG-MOS), the Common Statistical Production Architecture (CSPA), the Statistical Information System Collaboration Community (SIS-CC) and the Statistical Data and Metadata Exchange (SDMX) Toolkit.

Regional agencies have an important role to play in offering guidance and impartial advice on which tools would best meet the requirements of the NSO and to act as centres of expertise and training. This is of particular importance for countries with low capacity and limited infrastructure in order to avoid being overburdened with software from specialist agencies that does not meet precise needs and is complex to maintain.

This is especially relevant in the context of the SDG and the urgent need to provide indicators on development goals in a timely manner using standard interchangeable format. Common tools encourage the use of standards such as SDMX for improving data exchange processes.

If, however, an NSO does need to develop a specific software tool in the future, it should be developed with a view to future reuse by other organizations according to CSPA principles of being component-based and ‘plug and play’ ready.

Links to guidelines, best practices and examples:

- The UNECE High-Level Group for the Modernisation of Official Statistics (HLG-MOS) is a group of chief statisticians discussing the modernisation of

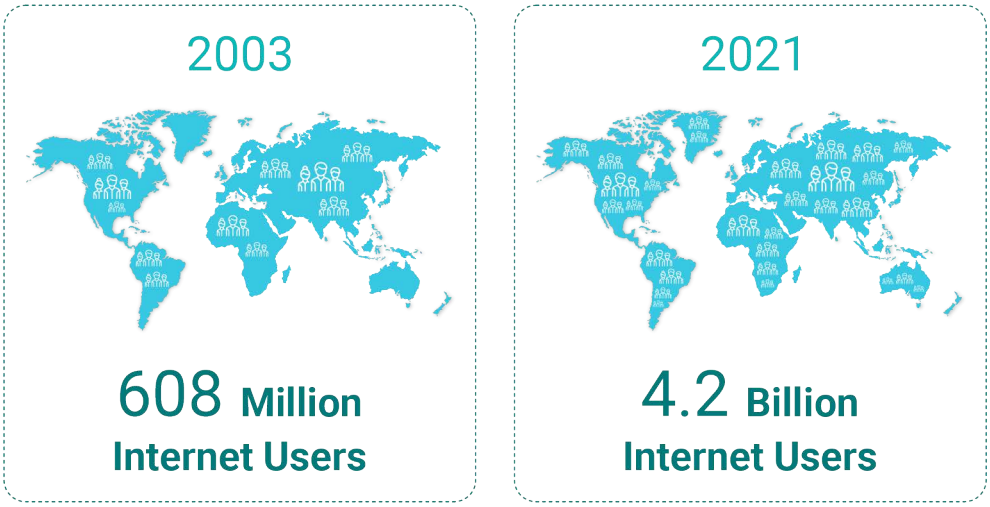
statistical organizations. Their mission is to work collaboratively to identify trends, threats, and opportunities in modernising statistical organizations. Modernisation groups cover Supporting Standards, Sharing Tools, Organizational Resilience and “Blue Skies Thinking” Network.

- The OECD Statistical Information System Collaboration Community (SIS-CC) is a community of dissemination software (“*.Stat*”) users which was set up so that participating members could benefit from a broad collaboration, sharing experiences, knowledge and best practices, and to enable cost-effective innovation.

14.2.3 Increase in use of web

Implications for an NSO of increased internet use

The massive increase in access to and use of the internet has, of course, had a huge impact on the NSO.



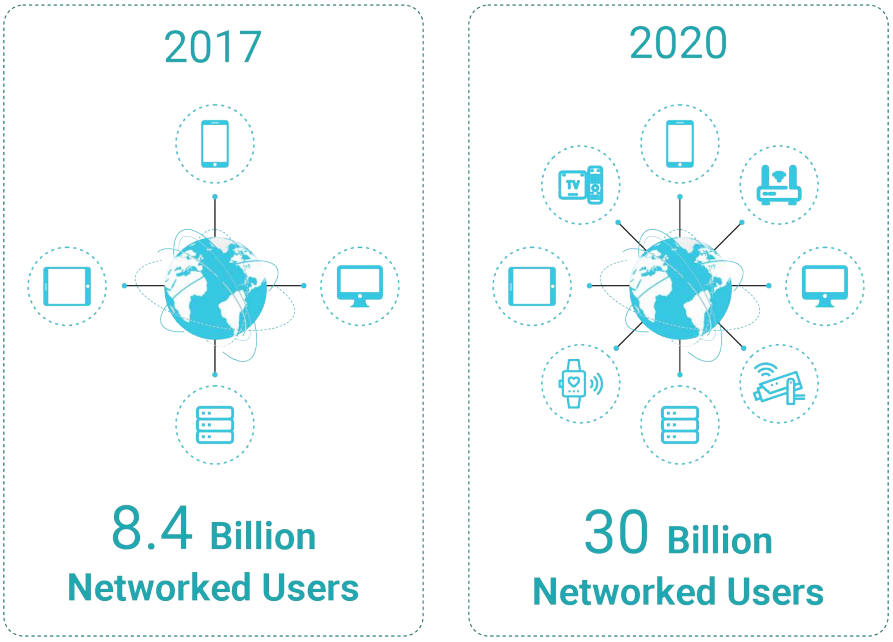
Since the publication of the last handbook in 2003, internet usage has increased from 608 million users to over 4.2 billion at the time of writing.

This figure is expected to rise further in the years to come as coverage expands even further and costs of access continue to drop. This obviously has had and will continue to have, a profound effect on the way statistics are accessed. Access to data via the internet has evolved from basic static pdf downloads through to interactive browsers and machine-to-machine connections. The internet affects how an NSO communicates, especially via social media and increased usage, in turn, raises the bar for expectations. The internet permits the merging of data sources between official statistics and other data sources to produce ‘mashups’ whose content are not in the control of an NSO. This

is both an opportunity and a challenge as while it can increase access to data, it also carries the risk of data being misused for political or other purposes.

The 'Internet of Things'

In addition to the vast increase in the use of the web, the "Internet of Things" (IoT) is emerging as one of the next technology mega-trends. IoT consists of the networked connection of billions of devices to the internet covering such diverse objects as household appliances, motor vehicles, planes and industrial equipment. By connecting these devices to the Internet, they generate further huge quantities of data available for analysing how we live.



The number of networked devices was 8.4 billion in 2017, and it is estimated to reach 30 billion objects by 2020.

In this way, IoT will open up new opportunities (and challenges) for additional data sources for an NSO as it integrates the physical world into new data sources. Tools for analysing IoT data sets are already available via commercial service providers such as Amazon Web Services.

There are both opportunities and challenges for an NSO as to how it can most effectively access and utilise this data. It could have an impact in the future on data collection and offer the possibility of real-time data on a number of sectors such as energy use, transportation, household consumption and industrial output.

The challenges posed will be the same as those for other Big Data (see *Chapter 8.5 — Big Data*) sources on how an NSO should adapt to new technologies required to store and use this data, how to gain access to this data, to integrate and mix it with traditional official data sources to compile new products.

Links to guidelines, best practices and examples:

- An article *"The Internet of Things Explained: Making sense of the next mega-trend"* (🔗) providing an explanation and facts and figures concerning the IoT.

14.2.4 Cloud technology

Increase in use of cloud technology

The "Cloud" is another growing web-based technology trend.

Cloud technology is computing power made available as a utility that can be tapped on demand. In this way, services such as servers, storage, and application software are delivered to a user via the internet enabling rapid access to shared networks of system resources.

Cloud computing barely existed as a service at the time of the last handbook. Its use was initially driven by the private sector, but it is now making significant inroads in NSOs. There, it is widely used for storage and communication such as web-based email and calendars and the sharing of documents. The next phase will be to use Software as a Service (SaaS) for data processing and Big Data analytics.

Pros and cons of cloud technology for an NSO

Cloud computing offers solutions to an NSO irrespective of capacity level but is especially useful for allowing countries with weak infrastructure to access more advanced computing technology. As the cloud requires only reliable internet access, it can eliminate high upfront costs of installing hardware and software infrastructure and reduce the resources needed for ongoing maintenance.

Cloud technology is scalable and can enable IT teams to more rapidly tailor resources to meet fluctuating and unpredictable demand and can remove the layers of complexity in setting up infrastructure. It can enable the sharing of software as applications can be saved on the cloud by one organization and used by other NSOs as needed.

The inherent security capabilities of large-scale Cloud computing services can guarantee a higher level of security for some lower capacity NSOs than their own infrastructure.

For some NSOs problems could be related to confidentiality as data on citizens is not stored on-site, which may go against the national legislation.

Links to guidelines, best practices and examples:

- An article from the Statista Statistics portal "*Cloud Computing - Statistics & Facts*" (🔗).
- Examples of local governments using cloud computing (🔗).
- An example from the OECD Statistical Information System Collaboration Community (SIS-CC) where cloud computing is proposed as a solution for countries with weak infrastructure (🔗).

14.2.5 Smartphones and tablets

Increase in use of smartphones and tablets

The most visible and unavoidable technology trend in recent years has been the massive increase in the use of smartphones and tablets. The ubiquity of these devices has had an impact on the NSO as in every other aspect of modern life. Smartphones have advanced computing capabilities and connectivity, and at the time of writing over a third of the world's population is projected to own a smartphone, an estimated total of almost 2.5 billion.

Implications for an NSO of smartphones and tablets

Due to the increasing functionalities and decreasing costs of mobile phones, they have been employed in a variety of ways by NSOs for both data collection and dissemination throughout the world.

Data collection using these devices can improve the quality of data by incorporating editing and validation rules in phone apps. The timeliness can be also be improved as data can be used to update a central database in real-time via the device if there is sufficient network coverage. If there is no coverage in a remote area, data can be stored on the device and used to update the database later.

Smartphones can have interactive survey questions sent directly to respondents to input and transmit data in structured ways. Simpler basic low-end 'dumbphones can use simple text messaging or voice to send out short queries by phone to a list of phone numbers, prompting users to reply with a short response.

For an NSO, the use of smartphones in data collection has the advantages of increased speed of data transmission, higher quality and accuracy. It also allows for the inclusion of additional geolocation information and images.

Links to guidelines, best practices and examples:

- UN Global Pulse and MobileActive.org inventory of mobile phone-based data collection projects (🔗).
- UN Big Data, Task Team on Mobile Phone Data (🔗).

14.2.6 Data visualisation software

The importance of data visualisation

Visualisation tools play a key role in making complex data understandable and accessible to a wide audience. It can support and underscore messages to influence policy and evidence-based decision making. Visualisations can also reveal compelling stories from complex underlying data and have become an important element of communication strategies. Data visualisations increase users' knowledge of statistics to help make better decisions – and easily understandable statistics are a public good - which will help ensure that data is being used more often, thereby increasing their value.

As with other technology fields, there has been an explosion in data visualisation technology and used in recent years. Until fairly recently data visualisations used by NSOs were mainly static images and simple graphics; advances in technology have led to a wide range of visualisation methods and sophisticated graphics that border on artistic design that can be reused, linked to datasets and embedded in websites and via apps in social media.

Good visualisations capture users' attention. This is a scarce commodity, and there is intense competition for this attention from information from many other sources. Data visualisation has a role in data analysis for finding patterns and correlations in different data sources, in particular in the spheres of Big Data analytics and data science.

Data visualisation brings together the skills of statisticians, analysts, IT experts, graphic designers and psychologists into one single domain. There is a challenge to recruit staff of the correct profile to undertake this kind of work. While there are expanding options for data visualization tools that do not require specialization, it is important that NSOs identify the technical and human constraints for their identified visualization objectives

Types of data visualisation

A number of tools are available for an NSO to visualise data. The most basic type is a **simple chart** derived from data and includes all the standard graphics such as line charts, bar charts, pie charts, scatter plots, etc. These can be generated from the data using office software such as Excel and then saved as static images to be posted in a document or website.

Other tools allow data to be **dynamically linked to visualisations on a web site** using third party graphical plug-ins. Using this method, an end-user can create and save their own visualisations that will also show the latest available data according to their own specifications.

Pre-prepared animated graphics can be used as 'storytelling' devices. In this way, a set of data can be used to illustrate a phenomenon with the graphic moving over a timeline accompanied by text describing events at each stage. These graphics can be used to explain complex topics in a visually appealing and more easily understandable way for wider audiences.

Interactive visualisations allow users to enter their own data into an online graphic to observe different scenarios or add their own criteria.

The increase in use of data visualisations by NSOs

Today, almost all NSOs use data visualisations on their websites or included in phone apps. They are often the most appealing part of a web site and can improve an NSO's communication with users. Data visualizations are essential for understanding and accessibility of complex data for a broad audience. They can be particularly appealing to the younger audience in the form of interactive visualisations that have an educative role, or for storytelling purposes.

Data Visualization Principles and Best Practices

When deciding how to offer data and information to audiences, visual formats tend to engage audiences more effectively when compared to just numbers and text. With half of the human brain devoted directly or indirectly to vision[1] and the ability to process an

image in just 13 milliseconds[2], providing complex information and data visually can help audiences better grasp the data and stories behind the numbers.

As statisticians and data analysts, this creates an opportunity to tell compelling stories with the data so that the information created has an impact and offers insight. Overall, the goal remains to provide audiences with accurate, insightful data and information in a way they can understand and connect with- where they can see themselves in the data. Visualization should therefore be grounded in ensuring it does not mislead the audience and that the data and information provided is accurate and truthful. To do this, it is important to:

- Be clear on the who, what, why of the data by exploring the data to understand different facets and facts.
- Identify and understand the target audience and their statistical literacy, keeping things simple and understandable.
- Understand, develop and articulate the key messages from the data.
- Identify visualization objectives, technical and human constraints, style guidelines and preferred visualization tools.

Effective data visualization, where audiences can easily digest the messages and relationships in the data, can be developed in myriad ways. Still, the following best practice steps are helpful when getting started:

1.See MIT News: https://news.mit.edu/1996/visualprocessing
2.See MIT News: https://news.mit.edu/2014/in-the-blink-of-an-eye-0116

- **Explore and understand the data:** This process begins by tidying or cleaning the data to explore it easily and identify anomalies or inaccuracies. Exploring the data leads to discovering trends, changes over time, patterns and correlations, etc., and helps identify the facts that should be highlighted in the data. This exploration helps to clarify the 'what', so that the data visualization and storytelling can provide the 'why' and the 'so- what'.
- **Understand your audience:** NSOs have a broad audience for the dissemination of statistics, ranging from the general public, government agencies, policymakers, academia and other stakeholders as well as the media[3]. It is essential to understand the target audience for the data visualization, along with their statistical literacy and their information needs to tailor the information accordingly.
- **Develop key messages:** The most challenging aspect of developing good data visualization is creating key messages from the data-- the main points or context you want the audience to hear, understand and remember. These messages should be data-driven and evidence-based as well as clear, concise and tailored to your audience. They also aim to provide essential information and show the meaning of the data.

3.See: User personas – Style.ONS

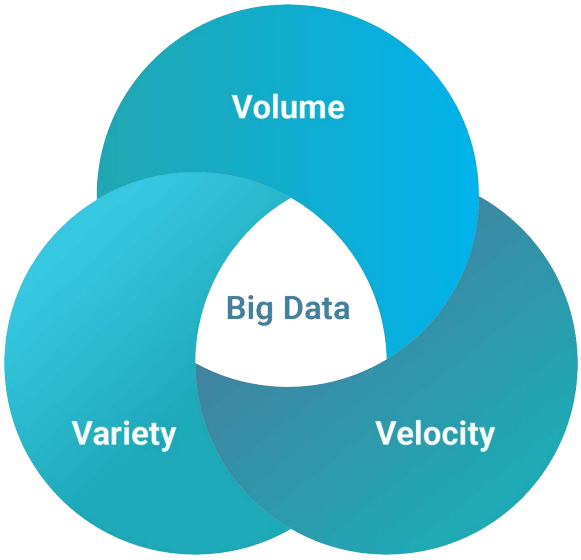
- **Choose the best visuals:** More is not necessarily better for visuals in data visualization, and finding the best chart or graph is very context-specific. It is important to strike a balance between simplicity and not losing the story behind the data. Luckily, many different chart and graph types can help to highlight the facts, key messages and context in the data.
  - **Charts**: depending on what message or data should be highlighted, choosing a chart depends on many different factors. See: Chart Chooser (🔗); Data to Viz (🔗); One Chart at a Time video series (🔗).
  - **Icons**: often used for infographics, icons communicate information without the need for words and are a strong tool for conveying messages and grabbing users' attention. See: UNSD SDG & COVID-19 Data Visualization Toolkit (icons) (🔗).
  - **Colours**: used to help differentiate and represent information, colour palettes and combinations should also be considered in any data visualization. See: Overview articles (1) and (2); Adobe Color (🔗); Data Color Picker (🔗).
  - **Clean design *(labels, visual hierarchy)***: follow a visual hierarchy and ensure titles, labels, axis, etc. are clear, correct and take the guesswork out for the user.
- **Get feedback and review/revise**: sharing the data visualization with colleagues and even testing it with your target audience can help to ensure it clearly conveys the data and data story in a concise and understandable way.

Links to guidelines, best practices and examples:

- *United Nations Economic Commission for Europe (UNECE) guidelines part 1 and part 2* or using data visualisation to make data more meaningful.
- Environmental Systems Research Institute (ESRI) geographic information system (GIS) software visualisations (🔗).
- UK Office for National Statistics (ONS) data visualisation guidelines for creating charts and tables (🔗).
- *Statistics Netherlands (CBS) guidelines for data visualisation* (🔗).
- *UK Government guidelines for effective tables and graphs in official statistics* (🔗).
- Top 10 Data Visualization Best Practices (visme.co).
- Chartio: 5 Data Visualization Best Practices: The Secrets Behind Easily Digestible Visualizations.

- GoodData: 5 Data Visualization Best Practices.
- Data Visualization – Best Practices and Foundations (🔗).
- Data visualization: basic principles (🔗).

14.2.7 Big Data



The growth of Big Data

The term Big Data was coined in recent years - the term has several definitions but refers in general to the huge proliferation of data generated by business transactions, social media, phone logs, communication devices, web scraping, sensors etc. Perhaps the most well-known definition of Big Data is data of “increasing volume, velocity and variety”.

Big data is often unstructured as such data sources have no pre-defined data model and often does not fit well into conventional relational databases.

A huge amount of hype has been generated around the topic which has generated pressure on the NSO to use Big Data to create new products and to complement or replace existing data outputs at low cost and in a more timely manner, particularly in the context of the so-called “Data Revolution” for using new data sources to fill some of the most critical data gaps, particularly in development.

Despite the high expectations for using Big Data, the reality is currently proving to be that while the technology needed to process these huge data sets is available and maturing, the biggest obstacle for an NSO is to actually gain access to the data. This lack of

access can be due to reluctance of a business to release their data, legal obstacles or concerns about privacy (see also *Chapter 8.5 — Big Data*).

Implications of Big Data for an NSO IT infrastructure and skill requirements

At the time of writing, there are very few cases of using Big Data in NSO production processes apart from geolocation data. This type of data has the advantage of being both relatively simple to access and also structured in a standardised way that allows integration with traditional datasets to provide additional and more granular information on location.

There has been much discussion on what the position of an NSO should be vis-à-vis Big Data – scenarios include the NSO developing a role as a 'broker' of Big Data which has been integrated by a third party, or simply providing a stamp of official quality to such datasets once they have validated its content and methodologies.

In order to make use of Big Data, an NSO will require access to High-Performance Computing resources and staff with new skills. The processing of increasingly high-volume data sets for official statistics requires staff with statistical skills and an analytical mindset, strong IT skills and a nose for extracting valuable new insights from data – often referred to as "Data miners" or "Data scientists" (see *Chapter 14.2.16 — Data science*).

An NSO needs to develop these new analytical capabilities through specialised training. Skills will include how to adapt existing systems to integrate Big Data into existing datasets and processes (ref para.) using specific technology skills as Massively Parallel Processing (MPP), Hadoop, R, Elastic Map Reduce, Visualisation methods and text mining.

Links to guidelines, best practices and examples:

- *UNECE Guidelines for the establishment and use of partnerships in Big Data Projects for Official Statistics* (🔗).
- Asia-Pacific Guidelines to Data Integration for Official Statistics (🔗).
- ESCAP Working Paper Series: Big Data for SDGs (🔗).
- ESCAP Working Paper Series: Big Data for Environment and Agriculture Statistics (🔗).

- ESCAP Stats Brief: Big Data for Economic Statistics (🔗).
- ESCAP Stats Brief: Big Data for Population and Social Statistics (🔗).
- UNSD paper on uses of *Big Data for Official Statistics: Privacy, Incentives, Statistical Challenges, and Other Issues* (🔗).
- European Statistical System Big Data project (🔗).
- Paper on *"Big Data: What Can Official Statistics Expect?"* (🔗)
- OECD *'Smart Data Framework'* (🔗) – 4 steps to create new evidence for policy, source new data, develop a smart data platform, and to cultivate new data ecosystems.
- UN Data Revolution Group (🔗).
- UNECE classification of Big Data types (🔗).
- Example of ONS Big Data project (🔗) - How alternative sources of data and data science methods will affect our processes and outputs.
- The HLG-MOS Big Data sandbox project (🔗).

14.2.8 Open data initiatives

The growth of the open data movement

The first Fundamental Principle of official statistics states that data should "made available on an impartial basis by official statistical agencies…." and recognises the "citizen's entitlement to public information," (see *Chapter 10.9 — Open data movement*). This is a strong statement for an NSO to provide open access to all information produced by the national statistical system.

> The term Open Data means that data and content can be freely used, modified, and shared by anyone for any purpose.

However today open access to the data produced by NSOs remains limited. According to the Open Data Barometer that monitors open data initiatives around the world, in 2020, only 11% of dataset entries in the index currently meet the criteria for the data to be considered open.

The criteria for an NSO to make its data open are: that data should be available in a machine-readable format (not PDF files or images); be in non-proprietary formats such

as comma-separated values (CSV), text, or Extensible Mark-up Language (XML); provide options for selecting data and for bulk download; and, include any related metadata.

The NSO should make its full range of statistics available via its website, be simple to locate and at the most granular level possible while considering privacy issues. Open data sets should be regularly updated, and an updating schedule published. They should use recognised international standards and definitions for the compilation and documentation of statistics should be used and be fully documented. They should include metadata describing the relevant characteristics (including standards and definitions) of the data, should be readily available with the data and be free of political considerations. The terms under which the data may be used or reused should be non-discriminatory, and the license permit the use and reuse of data without restriction. The data should be interoperable, allowing diverse systems and organizations to work together. In this case, it is the ability to interoperate and intermix different datasets ("Mashups").

Implications of open data for an NSO IT infrastructure and skill requirements

NSO open data sets should be as accessible as possible, and there should be no barriers such as completing forms or submitting requests or having to use specific browser-oriented technologies (e.g., Flash, JavaScript, cookies or Java applets). An NSO should provide a published Application Programming Interface (API) to facilitate access to data by other systems (also known as Machine-to-Machine access).

Information should be stored in widely-used file formats that easily lend themselves to machine processing and accompanied by documentation related to the format explaining how to use it in relation to the data.

Open Data principles state that data should remain online with appropriate archiving over time and that all data should be available free of charge.

Links to guidelines, best practices and examples:

- Data Barometer (🔗) / World Wide Web Foundation global measure of how governments are publishing and using open data for accountability, innovation and social impact. The table shows the ranking of countries by the number of open data sets.

- The Global Open Data Index (GODI) is the annual global benchmark for publication of open government data, run by the Open Knowledge Network. Our crowdsourced survey measures the openness of government data.
- The 5-star deployment scheme for Open Data (🔗) with examples for each step of the star rating and explanations of the associated costs and benefits.
- The Open Data Handbook (🔗) which includes guides, case studies and resources for government & civil society, on the "what, why & how" of open data.
- The European Data Portal workshop on official statistics as Open Data (🔗).
- Open Data Watch (🔗) is an international, non-profit, NGO that monitors open data policies and offers strategic advice and practical assistance to national governments, international organizations, and other NGOs.

14.2.9 Open-source software

The term Open-source refers to software that has its source code made available by use of a license in which the copyright holder provides the rights to change and distribute the software freely to anyone and for any purpose. Open-source software is frequently developed in a collaborative public manner.

In recent years, the adoption of open-source technologies has increased in NSOs to replace commercial software products. These technologies range from Operating systems (Linux), database management systems (MySQL) and programming languages (PHP, “R”).

Most programming languages in use today have a free software implementation available.

There are two main Open-Source models. The first is known as “Cathedral” where the source code is originally developed by a small group of developers who subsequently distribute each release free of charge – an example is the “R” language. The second is termed the “Bazaar” where source code is developed in public over the internet by a wider group of volunteer developers –examples of this are Linux and Apache. These models benefit from distributed peer review and the transparency of process. Advantages for an NSO include avoiding being locked into using a specific commercial product, flexibility and lower costs.

Links to guidelines, best practices and examples:

- *EU Guidelines on Open-Source Software for Official Statistics* (🔗).
- *UK Government paper "Open-Source Software Options for Government"* (🔗).
- *Canadian Government guidelines on the use of Open Source Software* (🔗).
- The Open-Source Initiative (OSI) protects and promotes open-source software, development and communities.
- Blog guide to Open-Source Software (🔗).

14.2.10 New methods of dissemination, M2M, web services etc.

New methods of dissemination

Disseminating data is one of the main activities of an NSO, and constant technological advance has to be taken into account. In recent memory, the majority of statistical systems produced paper publications as the main output. This progressed to the production of diskettes and CD-ROMs with the data in simple tables. The growth of the web meant that these files could be made available as downloadable files, and subsequently, data could be accessed interactively via online dissemination systems (see *Chapter 10 - Dissemination of Official Statistics*).

The current trend is towards machine-to-machine (M2M) access where computer systems access data directly using Application Programming Interfaces (APIs) and web services.

This allows for automated transmission of data between systems in a standard format without human intervention. Using such APIs and standard data formats allows end-users to create new outputs using multiple data sources (known as 'mashups'). While such mashups have great potential for combining data to find new insights, a concern for an NSO is the lack of control they have over the end uses of their own data in these outputs, and misunderstandings and misinterpretations could arise without clear documentation explaining the data sources and methodologies used in their compilation.

Implications of new dissemination methods for an NSO IT infrastructure and skill requirements

Modern dissemination methods require the appropriate technology infrastructure and skillsets. Staff with the necessary skills to develop the web services and APIs are needed as well as institutional knowledge of the data exchange standards such as SDMX (see *Chapter 14.4.5 — Statistical Data and Metadata Exchange (SDMX)*). These rapid, automated data dissemination techniques are crucial in the SDG context as they provide the means for countries to deliver high-quality development indicators in a rapid and efficient manner.

! Links to guidelines, best practices and examples:

- The African Information Highway (🔗) is a network of live open data platforms (ODPs) electronically linking all African countries and 16 regional organizations to increase public access to official and other statistics across Africa.
- The SIS-CC.Stat is an SDMX (ref para) based modular platform covering the complete end-to-end data lifecycle (GSBPM) from collection through to dissemination.
- Australia Bureau of Statistics (ABS) data portal (🔗).
- Italian Statistics Office (ISTAT) data portal (🔗).
- The ESRI Data Hub for the Sustainable Development Goals (🔗) combines geospatial and statistical information to visualize patterns to monitor, and report their progress on achieving the SDGs within a geographic context.
- Ireland's official boundary data (🔗) as part of a collaborative project between the Central Statistics Office (CSO) and Ordnance Survey Ireland (OSi) to link geography and statistics.
- Kenya Open Data (🔗).

14.2.11 Linked data

The growth of linked data

The term Linked Data refers to the method of publishing structured data so that it can be interlinked through semantic queries, connecting related data that weren't formerly related. It is defined as "a term used to describe a recommended best practice for exposing, sharing, and connecting pieces of data, information, and knowledge on the Semantic Web".

In practice, Linked Data builds upon standard Web technologies such as HTTP, the Resource Description Framework (RDF) and Uniform Resource Identifiers (URI), but instead of using them to generate standard web content as pages to be read by users, it extends them to connect information in a way that can be read automatically by computers.

In this way, data is linked to other data, fully exploiting these connections so its value increases exponentially. Thus, data becomes discoverable from other sources and is given a context through links to textual information via glossaries, dictionaries and other vocabularies.

Uses of linked data for an NSO

There are a number of examples of NSOs using Linked data that can be interlinked and become more useful. The process is lengthy and requires significant investment.

Links to guidelines, best practices and examples:

- LinkedSDGs showcases the usefulness of adopting semantic web technologies and Linked Open Data (LOD) principles for extracting SDG related metadata from documents and establishing the connections among various SDGs (🔗).
- *SpringerLink Methodological Guidelines for Publishing Government Linked Data* (🔗).
- The World Wide Web Consortium (W3C) open standards community best practices for publishing statistical Data in Linked Data format (🔗).
- UK ONS examples of Linked Data products (🔗).
- *IStat paper on data innovation in Official Statistics - the leading role of Linked Open Data* (🔗).
- The Joint Research Centre (JRC) of the European Commission draft guidelines and pilots on Linked Data and Open Data Portals (🔗).
- Australian government guidelines for publishing linked datasets (🔗).

14.2.12 Common Statistical Production Architecture (CSPA)

The growth in use of CSPA by NSOs

The *Common Statistical Production Architecture (CSPA)* is a framework for developing statistical processing components that are reusable across projects, platforms and

organizations - it is often referred to as ‘plug and play’. CSPA has been developed in recent years by the international statistical community under the auspices of the High-Level Group for the Modernisation of Official Statistics (HLG-MOS).

CSPA is an enabler of collaboration and modernisation and has potentially enormous advantages for NSOs of all capacity levels. It aims to align the enterprise architectures of different organizations to create an “industry architecture” for the whole “official statistics industry”.

CSPA provides guidance for building software services that can be shared and reused within and across statistical organizations and enables international collaboration initiatives for the development of common infrastructures and services.

In addition, it encourages alignment with other statistical industry standards such as the Generic Statistical Business Process Model (GSBPM) and the Generic Statistical Information Model (GSIM).

CSPA components focus on statistical production processes as defined by GSBPM and are based on the Service Oriented Architecture (SOA) approach wherein the components (Services) are self-contained and can be reused by a number of business processes either within or across statistical organizations without imposing a technology environment in terms of specific software platforms.

Potential advantages of CSPA for an NSO

There are great potential advantages for an NSO in using CSPA. Its goal is eventually to have components covering all processes and sub-processes covered by GSBPM. This is important for countries of all capacity levels. GSBPM is especially useful for countries of low capacity with weak infrastructure as it can, in theory, allow any country to take advantage of developments by the international statistics community. In this way, an NSO could assemble a complete statistical information system component by component according to their specific needs.

Links to guidelines, best practices and examples:

- *Common Statistical Production Architecture – the Logical Information Model (LIM).*
- *Common Statistical Production Architecture - the Global Artefacts Catalogue* (🔗).

- *Common Statistical Production Architecture – list of CSPA-compliant services developed and under preparation* (🔗).
- Software available via CSPA inventory (🔗).

14.2.13 Common Statistical Data Architecture

Data architecture consists of the rules put in place for the collection and storage of data in an organization. The Common Statistical Data Architecture (CSDA) project has been set up to define a reference architecture and guidance for the modernisation of statistical processes and systems.

14.2.14 Data integration / data linkage

The importance of data integration and data linkage for an NSO

As new data sources are becoming available, an NSOs faces the challenge of finding ways to integrate changeable and often unstructured data with traditional data maintained by the NSO in order to produce new and reliable outputs.

Data integration provides the potential to augment existing datasets with new data sources, and produce timelier, more disaggregated statistics at higher frequencies than traditional approaches alone.

New and emerging technologies are available to support data integration, and an NSO needs to ensure that staff have the necessary new skills, in particular, the need for data scientists - new skills, new methods and new information technology approaches, designing new concepts or aligning existing statistical concepts to the concepts in new data sources.

Examples of data integration and data linkage

There are many possible types of data integration which include using administrative sources with survey and other traditional data; new data sources (such as Big Data) with traditional data sources; geospatial data with statistical information; micro-level data with data at the macro level; and validating data from official sources with data from other sources.

Links to guidelines, best practices and examples:

- *Modernstats Guide to Data Integration for Official Statistics* (🔗).
- Statistics New Zealand Data Integration guidelines (🔗) and manual (🔗).
- *HLG-MOS Review paper on Data Integration* (🔗).

14.2.15 Artificial Intelligence

Artificial Intelligence (AI) is the development and application of computer systems that can perform tasks normally requiring human intelligence. These tasks include visual perception, speech recognition, decision-making, and translation between languages. The growth in AI has major potential for an NSO.

A main component of AI is Machine Learning which is the way the computer can learn without being explicitly programmed. The goal of machine learning is to build computer systems that can adapt and learn from their experience. It is an application of AI that provides the system with the ability to automatically learn and improve from experience. Machine Learning, at its most basic, is the practice of using algorithms to examine data, learn from it, and then make a judgement or prediction on a particular question. Thus, rather than hand-coding software routines with a specific set of instructions to accomplish a particular task, the machine is “trained” using large amounts of data and algorithms that give it the ability to learn how to perform the task.

An NSO using AI will need to engage staff with a number of new skills, including the various methods of Machine Learning such as Supervised Learning, Unsupervised Learning, Reinforcement Learning and Deep Learning.

There is a strong relationship between AI and Big Data - Machine Learning needs a vast amount of data to learn, whereas Big Data uses AI techniques to extract value from Big Data sets.

AI-based applications can replace or augment certain tasks allowing staff resources to be freed up to do other work, with people having time to focus on creative projects and deal directly with clients and customers. A careful communication strategy will be required for such a game-changing technological transformation.

Links to guidelines, best practices and examples:

- *EU Paper on Artificial Intelligence, Robotics, Privacy and Data Protection* (🔗).
- *Eurostat paper on AI and data mining* (🔗).
- *Paper: How much time and money can AI save government?* (🔗).

14.2.16 Data science

The job title of 'Data scientist' has emerged in recent years in parallel with the growth of Big Data. The two fields go hand in hand in the pursuit of extracting knowledge and insights from new data collections in various forms, both huge structured datasets and unstructured alternative data sources.

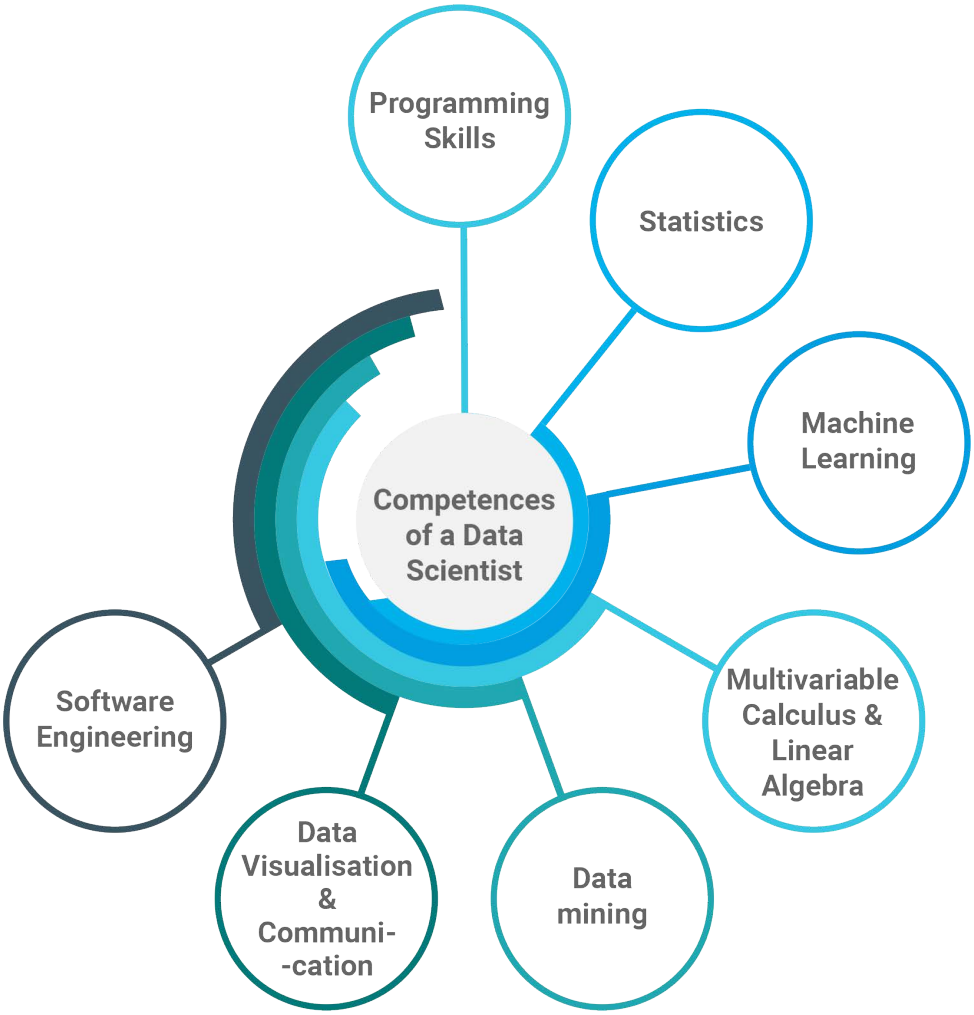
Data science requires a mix of expertise. Technology skills are required to manipulate Big Data using techniques such as massive parallel processing to analyse volatile unstructured data, perform data cleansing and then distilling it into a format suitable for analysis. Mathematical skills are needed to write the complex algorithms used in analysing these data. Statistical skills are needed to investigate the data and to respond to questions and derive insights from them. Other skills, like Machine Learning (🔗) and Deep Learning (🔗), may also be required.

Data Scientist candidates are consequently a highly sought-after species, and many universities now offer data science courses.

Given the range of skills involved in data science, the reality is that such tasks are carried out by a team rather than a single individual.

Such teams consist of a data engineer who would access the primary data source and render it into a structured format, a software developer to write the routines to clean and aggregate the data and the data scientist who would create algorithms and use statistical techniques to gain insights from the data.

A typical list of the required competences for a Data Science position would include:



! Links to guidelines, best practices and examples:

- *UK Government Data Science Ethical Framework* (🔗).

14.2.17 Data security

Data security is of paramount importance for an NSO. Confidentiality and privacy are, therefore, one of the most important of the Fundamental principles (*Chapter 3.2.6 — Principle 6 - Confidentiality*) and a major concern for citizens. Maintaining data security is vital for the good reputation of an NSO.

National statistics are aggregated from individual records and often contain personal or commercial information - thus security measures must be designed to preserve data confidentiality and ensure data is accessible only by authorised people and only on as-needed basis.

Alongside public concerns with data confidentiality and privacy, there is a growing demand for researchers to access microdata – and this access is often limited by the fear that confidentiality protection cannot be guaranteed.

There are a number of ways an NSO can address data security. Security measures can be implemented at the level of the data by using anonymisation techniques so that individual records in a microdata set have personal details removed so that identification of individuals is highly unlikely.

Security measures can be put in place at the physical level by restricting access to where the data is stored and implementing strict data controls. Many NSOs have set up Data Laboratories where on-site access to microdata is under NSO supervision with strict audit trails and supervision to ensure no confidential data leaves the premises.

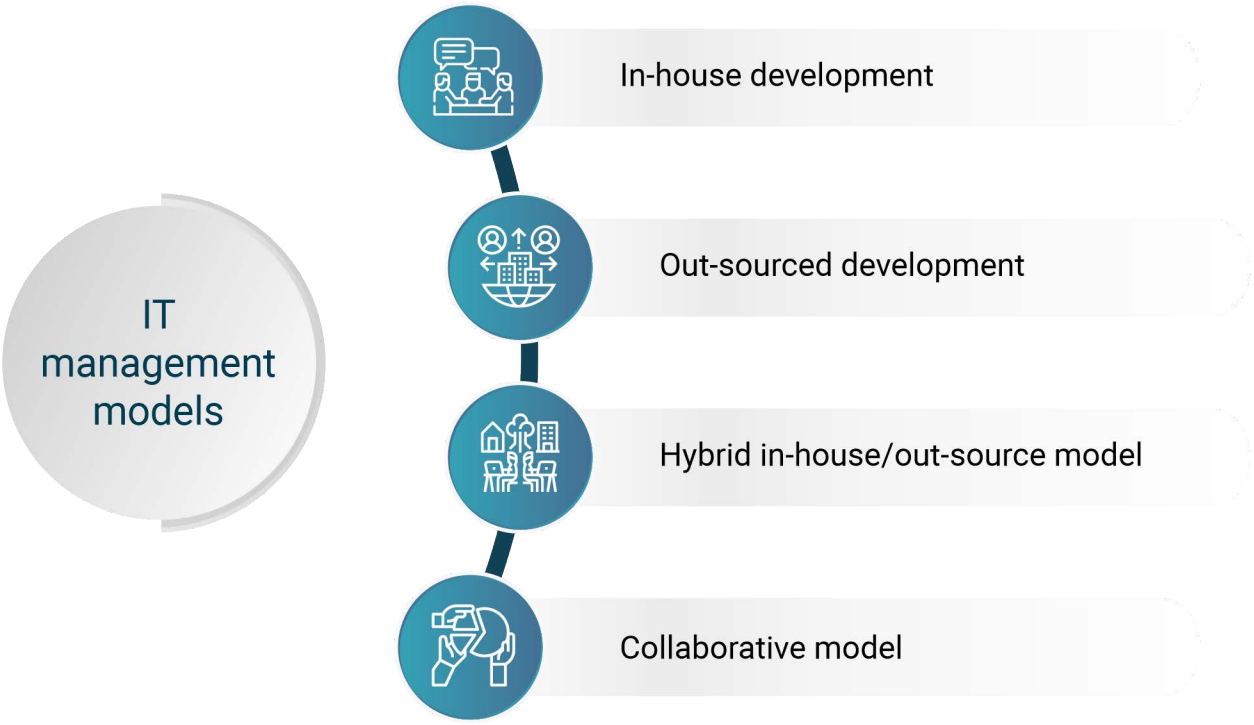
An alternative to Data Laboratories is Remote Access Facilities (RAFs). RAFs are becoming increasingly important as a way of facilitating secure access to microdata in order that researchers do not have to suffer the inconvenience of having to go to the NSO premises but can rather launch algorithms for microdata remotely via the internet. The job is then run by the NSO and results returned to the researcher while the microdata does not actually leave the NSO.

Procedural measures include vetting processes to approve requests for an individual researcher to access microdata and the signing of contractual agreements with these researchers that include penalties if security rules are breached.

Links to guidelines, best practices and examples:

- *UNSC Principles and Guidelines for Managing Statistical Confidentiality and Microdata Access* (🔗).
- *European Statistical System Handbook on Statistical Disclosure Control* (🔗).
- *International Household Survey Network – guidelines on Microdata anonymisation* (🔗).

14.3 IT management models



There are a number of models for managing IT staff and resources in an NSO. These range from in-house development, out-sourcing and off-shoring IT work to external companies, a hybrid in-house/out-sourced approach, and more recently, a collaborative approach to development. There has been a continuous cycle of changing approaches to management over the years – these depend on a number of factors: the size of the organization; government policy; budgetary issues; general management attitude toward managed IT or IT support models; overall staff resources; and global IT trends.

Insufficient resources for IT functions will create problems for the entire organization so it is vital to understand which support model is best to run an organization effectively. Each different approach has its advantages and challenges which are discussed below.

14.3.1 In-house development

The In-house model is the case where all software development and maintenance are carried out within the NSO by the staff of the IT department. This model was quite common in the past but is much less so today as IT and other support services are wholly or partially outsourced to external companies or individual freelance IT experts.

Statistical processing is a niche market for software vendors and very few 'off the shelf' products exist for managing the statistics processing life cycle. Consequently, an NSO

may have a legacy of internally developed statistical software (unlike, say Human Resources or budget planning which have a large range of commercial software solutions). This can make maintenance and evolution more complex as upgrades have to be coded rather than being provided by vendors.

An advantage of the in-house model is the autonomy of development, and the stability of teams can ensure the technical know-how of often complex processes is retained by the NSO.

A common challenge with this approach is the difficulty of attracting and retaining IT staff, as salaries in the NSO are often not competitive with those in the private sector, particularly in developing countries. This can result in a high turnover as staff leave once, they have been trained in the IT skills which are in high demand in the marketplace.

In-house IT development can be more costly than the out-sourced model given the necessary investment in time, training, employee salaries and benefits, and management.

14.3.2 Out-sourced development

With an Out-source IT management model, the main part of development and support is carried out by external resources. External resources can be onsite and come from local suppliers, be offshore and coordinated remotely, or a mixture of the two.

Using external resources has the advantage of flexibility in that resources are used only when needed for specific tasks which can save costs.

Points to take into consideration when using external resources include the loss of institutional knowledge when a consultant leaves and the lack of continuity in a project when an out-source provider changes personnel due to their own priorities. This is a particular risk for low-capacity countries when external staff are brought in, often by a donor agency, to implement a system – once the work is completed and the consultants leave there is inadequate internal capacity to maintain and use the system.

One should also consider vendor incentives as it can be in the interest of external staff to extend a task as long as possible and create a dependency for maintenance and further development of a software product, so it is important to ensure a transparent and ethical relationship with vendors and close monitoring of projects.

This also applies to low-capacity countries where donor aid can be linked to adopting a particular software package implemented by external consultants that the NSO is then unable to maintain themselves once the consultants leave. Cases exist where countries have been left with multiple tools meeting similar needs, particularly in the domain of dissemination software.

Outsourcing is typically a less expensive option than in-house development, as there are minimal training and time involved with IT management. Outsourcing typically converts fixed IT costs into variable costs which allow for effective budgeting as services are only paid for as they are needed.

14.3.3 Hybrid in-house/out-source model

In the hybrid In-house/Out-source model, the NSO uses both its own staff and also external staff. A hybrid IT model requires internal and external IT professionals to support the business capabilities of the enterprise. With this model, in some cases, only the IT managers are NSO staff members while all development and support are carried out by external staff. Other cases can include more of a mix of both managers and IT experts.

This model is widely adopted in NSOs and is the most common approach because it reflects the realities of the IT market - high mobility of staff with the latest skills are highly mobile and difficult to retain.

This approach typically allows an organization to maintain a centralised approach to IT governance, while using experts to deal with the functionality that is beyond the capabilities of the organization’s IT staff.

14.3.4 Collaborative model

The collaborative model of NSOs working together on IT projects is a trend that is increasing considerably in recent years. Collaborations can take the form of several organizations working together to develop a software that they will then all use; it can be a single organization developing a software tool that is then adopted and, possibly, further developed by other NSOs.

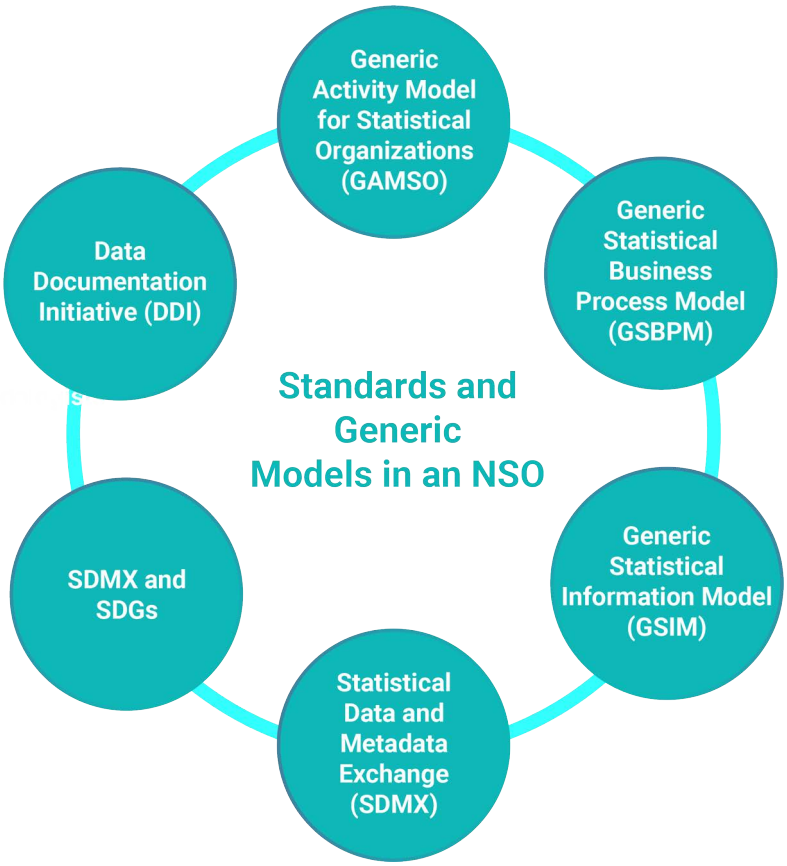
In the past, most of the statistical software used by an NSO would have been developed within an NSO for use only by that NSO. Today, the trend is for there to be a mix of the older legacy software and common shareable tools.

The obvious advantages of the collaborative approach for an NSO include sharing the software development burden and also sharing experiences, knowledge and best practices through multilateral collaboration and help build collective capacity.

It also reduces the risk for new developments through additional scrutiny and testing according to open-source principles with all members benefiting from each other in terms of ideas and methods.

Collaborating on projects does, of course, have its own challenges for an NSO – particularly in determining how to balance development priorities between the different partner organizations and the increased complexity of project management in the context of multiple-partner collaboration. To achieve this model, partnership management capabilities will need to be developed in an NSO (see *Chapter 12 - Human Resources Management and Development*).

14.4 Use of standards and generic models in an NSO



14.4.1 The importance of standards

Standards are enablers of modernisation - by using common standards, statistical systems can be modernised and “industrialised” allowing internationally comparable statistics to be produced more efficiently. Standards facilitate the sharing of data and technology in the development of internationally shared solutions which generate economies of scale.

Standards are expected to provide benefits in the following areas:

- **Efficiency:** Standards offer per definition re-usable solution patterns, they are a means to capture knowledge and promote best practices, allowing interested parties to re-use solutions without having to support a full investment.
- **Quality and trust:** Standards help to build trust by providing widely validated and accepted solutions to common problems.
- **Collaboration and competition:** Standards often provide a common language which can support collaboration among organizations and at the same time stimulate competition among service providers by reducing dependency and vendor lock-in that may be associated with particular solutions.
- **Innovation:** Standards foster innovation as they offer a solid basis for developments of all nature by formalising knowledge and best practices.

A number of major statistical standards are in use today, while others are emerging and maturing.

14.4.2 Generic Activity Model for Statistical Organizations (GAMSO)

The Generic Activity Model for Statistical Organizations (GAMSO) covers activities at the highest level of the statistics organization. It describes and defines the activities that take place within a typical organization that produces official statistics. GAMSO was launched in 2015 and extends and complements the Generic Statistical Business Process Model (GSBPM) by adding additional activities beyond business processes that are needed to support statistical production. GAMSO is also described in more detail in *Chapter 5.5.4 — The Generic Activity Model for Statistical Organizations*.

The GAMSO activities specifically concerned with IT management cover coordination and management of information and technology resources and solutions. They include the management of the physical security of data and shared infrastructures:

- Manage IT assets and services;

- Manage IT security;
- Manage technological change.

Links to guidelines, best practices and examples:

- *Modernstats – the Generic Activity Model for Statistical Organizations* (🔗).

14.4.3 Generic Statistical Business Process Model (GSBPM)

The Generic Statistical Business Process Model (GSBPM) is a statistical model that provides a standard terminology for describing the different steps involved in the production of official statistics. GSBPM can be considered the "Production" part of GAMSO. Since its launch in 2009, it has become widely adopted in NSOs and other statistical organizations. GSBPM allows an NSO to define, describe and map statistical processes in a coherent way, thereby making it easier to share expertise. GSBPM is part of a wider trend towards a process-oriented approach rather than one focused on a particular subject-matter topic. GSBPM is applicable to all activities undertaken by statistical organizations which lead to statistical output. It accommodates data sources such as administrative data, register-based statistics, and also Census and mixed sources.

GSBPM covers the processes that cover specifying needs, survey design, building products, data collection, data processing, analysis, dissemination, and evaluation. Within each process, there are a number of sub-processes. These are described in detail in *Chapter 5.5.5 — Definition of an integrated production system* and in *Chapter 14.4.3 — Generic Statistical Business Process Model (GSBPM)*.

GSBPM can play an important role in the modernisation of the statistical system, especially concerning the statistical project cycle, and can accommodate emerging issues in data collection such as the introduction of mobile data collection and Big Data.

Links to guidelines, best practices and examples:

- *Modernstats – the Generic Statistical Business Process Model* (🔗).
- *Modernstats – the GSBPM resources repository* (🔗).

14.4.4 Generic Statistical Information Model (GSIM)

The Generic Statistical Information Model (GSIM) standard was launched in 2012 and describes the information objects and flows within a statistical business process. GSIM is complementary to GSBPM, and the framework enables descriptions of the definition, management and use of data and metadata throughout the statistical information process.

GSIM is a conceptual model, and the information objects are grouped into four broad categories: Business; Production; Structures; and Concepts. It provides a set of standardized information objects, inputs and outputs in the design and production of statistics, regardless of the subject matter. By using GSIM, an NSO is able to analyse how their business could be more efficiently organized.

As with the other standards, GSIM helps improve communication by providing a common vocabulary for conversations between different business and IT roles, between different subject matter domains and between NSOs at national and international levels. This common vocabulary contributes towards the creation of an environment for reuse and sharing of methods, components and processes and the development of common tools. GSIM also allows an NSO to understand and map common statistical information and processes and the roles and relationships between other standards such as SDMX and DDI.

Links to guidelines, best practices and examples:

- *Modernstats – the Generic Statistical Information Model* (🔗).
- *Statistics Finland Project to adopt the GSIM Classification model* (🔗).
- *Statistics Sweden project to incorporate GSIM in the information architecture and the information models* (🔗).

14.4.5 Statistical Data and Metadata Exchange (SDMX)

The Statistical Data and Metadata Exchange (SDMX) standard for statistical data and metadata access and exchange was established in 2000 under the sponsorship of seven international organizations (IMF, World Bank, UNSD, Eurostat, BIS, ECB and OECD).

The importance of a standard for statistical data exchange is well known and cannot be underestimated. The labour-intensive nature of data collection and dissemination

mapping to different formats is a problem well known to an NSO, and in the context of the timely transmission of SDG indicators, it has become even more vital.

SDMX is a standard for both content and technology that standardises statistical data and metadata content and structure. SDMX facilitates data and metadata exchange between an NSO and international organizations – and also within a national statistical system. SDMX aims to reduce the reporting burden for data providers and provide faster and more reliable data and metadata sharing. Using SDMX facilitates the standardisation of IT applications and infrastructure and can improve the harmonisation of statistical business processes. There is much reusable software available to implement SDMX in an NSO which can reduce development and maintenance costs with shared technology and know-how.

SDMX ensures data quality as it incorporates data validation into its data structures and validation rules as well as with the many tools made freely available with the standard as part of its open-source approach. SDMX is an ISO standard[4] and has been adopted by the UNSC as the preferred standard for data exchange.

Thanks to its provision of a common Information Model, SDMX greatly facilitates reuse of software products and components. Software products such as SDMX Reference Infrastructure have made it possible to establish SDMX APIs by connecting to dissemination databases and mapping their structures to DSDs. This enables an NSO and international agencies to establish standards-based APIs without any software development involved, thus greatly lowering the barrier to entry. Furthermore, tools exist and are widely used that enable implementation of SDMX for data sharing without any dissemination infrastructure in place, by utilizing, e.g., Microsoft Excel or CSV files. This has greatly sped up the adoption of standards-based data sharing by statistical offices.

SDMX tools are not limited to data exchange or dissemination, and as they mature, are increasingly used to automate various business processes along the statistical production chain in conjunction with other standards such as CSPA and DDI.

14.4.6 SDMX and SDGs

A specific SDG indicator data structure (Data Structure Definition) will be used to report and disseminate the indicators at national and international levels. SDMX compliance has been built into a number of internationally used dissemination platforms such as the African Information Highway, the IMF web service and the OECD.*Stat* platform to ensure efficient transmission of SDG Indicator data and metadata.

4. ISO standard 17369 :2013 – Statistical data and metadata exchange (SDMX): https://www.iso.org/standard/52500.html.

Links to guidelines, best practices and examples:

- SDMX official website (🔗).
- The SDMX Content-Oriented Guidelines (COG) recommend practices for creating interoperable data and metadata sets using the SDMX technical standards. The guidelines are applicable to all statistical domains and focus on harmonising concepts and terminology that are common to a large number of statistical domains.
- Inventory of software tools for SDMX (🔗) implementers and developers which have been developed by organizations involved in the SDMX initiative and external actors.
- Eurostat main SDMX page (🔗).
- European Statistical System's SDMX standards for metadata reporting (🔗).
- Guidelines for managing an SDMX design project (🔗).
- The SDMX Global Registry (🔗) is the technical infrastructure containing publicly available metadata material, data structure definitions (DSD), and related artefacts (concept schemes, metadata structure definitions, code lists, etc.).
- The SDMX Starter Kit (🔗) - a resource for an NSO wishing to implement the SDMX technical standards and content-oriented guidelines for the exchange and dissemination of aggregate data and metadata.
- The African Development Bank Open Data for Africa (🔗) project.
- The IMF SDMX Central (🔗) project allows users to Validate, Convert, Tabulate, and Publish data to the IMF SDMX Central.

14.4.7 Data Documentation Initiative (DDI)

The Data Documentation Initiative (DDI) is an international standard for describing metadata from surveys, questionnaires, statistical data files, and social sciences study-level information. DDI focuses on microdata and tabulation of aggregates/indicators.

DDI is a membership-based alliance of NSOs, international organizations, academia and research bodies. The DDI specification provides a format for content, exchange, and preservation of questionnaire and data file information. It fills a need related to the challenge of storing and distributing social science metadata, creating an international standard for the design of metadata about a dataset.

In many NSOs, the exact processing in the production of aggregate data products is not well documented. DDI can be used to describe the processing of data in a detailed way to document each step of a process. In this way DDI can be used not just as documentation but can help use metadata to automate throughout the entire process, thus creating “metadata-driven” systems. In this way, DDI can also act as the institutional memory of an NSO.

DDI is a standard that promotes greater process efficiency in the “industrialised” production of statistics. DDI can be also be used for facilitating microdata access as well as for register data.

! Links to guidelines, best practices and examples:

- DDI Specifications (🔗).
- *Paper - DDI and SDMX are complementary, not competing, standards* (🔗).
- Guidelines on Mapping Metadata between SDMX and DDI (🔗).

14.5 Enterprise architecture

Enterprise architecture (EA) is a conceptual blueprint that defines the structure and operation of an organization whose role is to determine how the organization can most effectively achieve its current and future objectives.

EA maps the goals and priorities of an organization to Information Technology that is fit to support those goals as far as it can by managing information and delivering it accurately and in time where and when it is needed, and in a way that is cost-effective for the business. It seeks to guide the process of planning and designing the IT capabilities of an organization in order to guide them through the business, information, process, and technology changes necessary to meet desired organizational objectives.

EA helps enforce discipline and standardisation of business processes, and enable process consolidation, reuse, and integration. EA is basically designed for the whole system of systems across the "enterprise" - and like any design, it has to start from the business requirements and specify the best fit IT solutions. The IT part of EA is split into systems and data and finally infrastructure such as servers and networks.

There is an emerging trend of organizations using storage repositories that hold vast amounts of raw data in native format (‘Data Lakes’) from disparate sources. These data

lakes are used to respond to business questions by linking and querying relevant data and thus require a new type of EA to manage such linked datasets.

Benefits to the NSO of a well-designed EA include achieving better business performance as per the business goals, reducing investment risk in IT. EA also facilitates a more agile enterprise by making the IT architecture more flexible to transform business models. Agile Architecture practices support the evolution of the design and architecture of a system while implementing new system capabilities thus allowing the architecture of a system to evolve incrementally over time while simultaneously supporting the needs of current users.

Links to guidelines, best practices and examples:

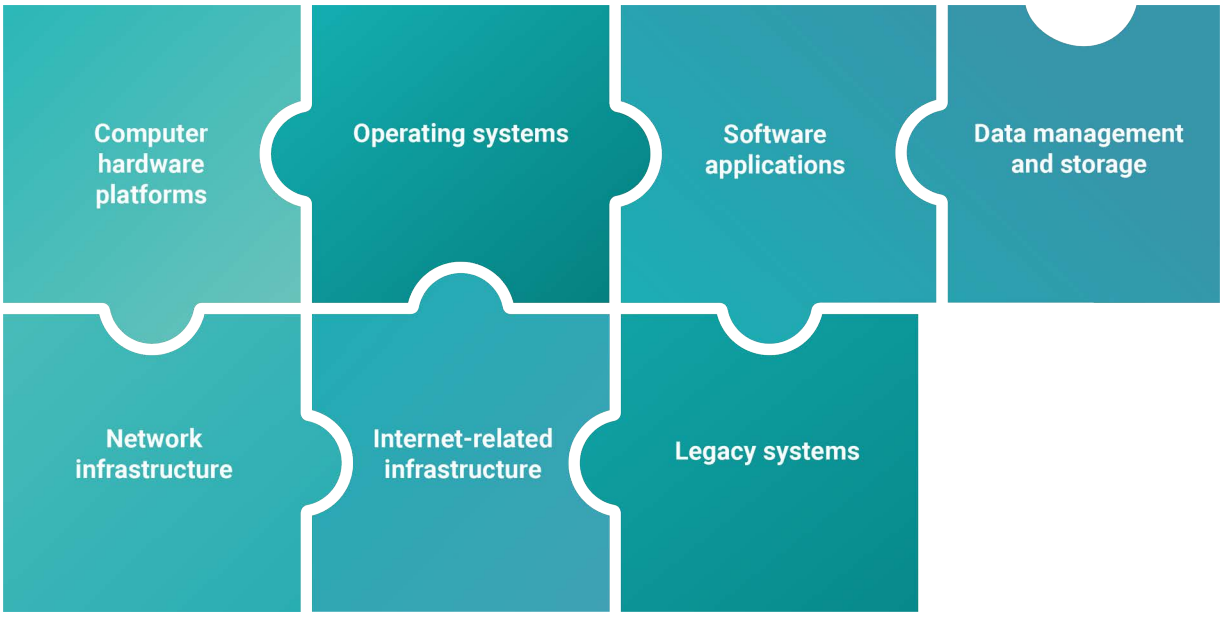
- European Statistical System (ESS) Enterprise Architecture Reference Framework (🔗).
- *ISTAT project - Business Architecture model within an official statistical context* (🔗).
- *Statistics Korea project - Building an Enterprise Architecture* (🔗).
- *Statistics Poland project - Introducing Enterprise Architecture Framework* (🔗).

14.6 Basic IT infrastructure needs and skill requirements

There are a number of technology infrastructure components and skill requirements that are essential for an NSO to be able to manage its statistical life cycle processing. These requirements are not uniform and will, of course, depend on the capacity of the NSO. A small, low-capacity NSO in a developing country will operate under a very different set of conditions than an NSO in a medium-capacity country and even more so than a developed, high-capacity country. However, there are certain technologies that are common for all NSOs in order to efficiently collect, process and disseminate quality statistics in a timely manner.

The term IT infrastructure is defined in the Information Technology Infrastructure Library (ITIL) version 3 as a combined set of hardware, software, networks and related facilities, used to develop, test, deliver, monitor, control or support IT services. People, processes and documentation are not considered part of IT Infrastructure.

The key infrastructure components are outlined below.



- **Computer hardware platforms** consist of client and server machines and in some cases, mainframes. A server is a computer that is dedicated to managing network resources dedicated to a particular task. These specialist server roles include print servers, file servers, network servers, database servers and web servers.

  Skills required: Software Engineer (Hardware specialist).

- **Operating systems (OS)** are software that manage the resources and activities of the computer and act as an interface for the user. The best-known client OS is Windows operating systems. Server OS are dominated by the various forms of the UNIX operating system or Linux.

  Skills required: Software Engineer (OS specialist).

- **Software applications** are the IT tools used to manage production activities in an NSO from data collection to dissemination as covered by the main processes and sub-processes in GSBPM. These applications can be developed by the NSO, commercial tools, generic software developed collaboratively, or software developed by another statistical organization.

  Skills required: Systems analyst, Software developer.

- **Data management and storage** is handled by database management systems (DBMS). DBMS is a collection of programs that manages the database structure and controls access to the data stored in the database. A relational database management system (RDBMS) is used for creating, storing and connecting structured data and then rapidly retrieving via a query language. Rules can be

applied for data security, connecting data and enforcing referential integrity. This is vital for an NSO to ensure data quality which cannot be guaranteed using unmanaged data stores such as Excel. The most widely used commercial DBMS are Microsoft SQL Server, Oracle, Sybase and IBM. A number of open-source examples are also available including MySQL, MariaDB, MongoDB and PostgreSQL.

Skills required: Database Administrator, Database Architect, Data Modeller.

- **Network infrastructure** consists of the hardware and software resources that enable network connectivity and communications. It provides the communication path and services between users, processes, applications, services and external networks and the internet. The most widely used networking and telecommunications platforms include Windows server operating systems, Novell, Linux, and UNIX. A network firewall protects a computer network from unauthorized access.

  Skills needed: Network administrator.

- **Internet-related infrastructure** includes the hardware, software and services to maintain corporate web sites, intranets, and extranets, as well as web hosting services and web software application development tools.

  Skills required: Webmaster, web developer.

- **Legacy systems** are generally older transaction processing systems created for mainframe computers that continue to be used to avoid the high cost of replacing or redesigning them.

  Skills required: System Analyst, Software developer.

Links to guidelines, best practices and examples:

- Information Technology Infrastructure Library (ITIL), a globally recognized collection of best practices for managing information technology.
- ICT plan for Laos Statistics Bureau is covering all aspects of the information & communication technology (🔗).
- Standard architecture implemented in the Tunisian Statistical Institute (INS).

14.7 Specialist statistical processing/analytical software

A number of specialist statistical and econometric processing and analytical software packages are available for use in an NSO, both on a commercial and open-source basis. Some of the more widely used products are described below.

	Analytica is a visual software package for creating, analysing and communicating quantitative decision models. It combines hierarchical influence diagrams for visual creation and view of models, intelligent arrays for working with multidimensional data, Monte Carlo simulation for analysing risk and uncertainty, and optimization, including linear and nonlinear programming.
	EViews is a statistical package used mainly for time-series oriented econometric analysis. EViews can be used for general statistical analysis and econometric analyses, such as cross-section and panel data analysis and time series estimation and forecasting.
	MATLAB Matrix laboratory is a programming language that allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages.
	Minitab is a statistics package developed at the Pennsylvania State University. It is a general-purpose statistical software package used as a primary tool for analysing research data.

	Wolfram Mathematica is a system whose programming language and capabilities cover neural networks, machine learning, image processing, geometry, data science, visualizations, and others.
	SPSS is a program for statistical analysis in social science.
	SAS is a software suite that can mine, alter, manage and retrieve data from a variety of sources and perform statistical analysis on it.
	Stata is a general-purpose statistical software package whose capabilities include data management, statistical analysis, graphics, simulations, regression, and custom programming.
	"R" open-source R is a programming language and free software environment for statistical computing and graphics. The R language is widely used among statisticians and data miners for developing statistical software and data analysis.

	CSPro The Census and Survey Processing System is a public domain data processing software package. The main purpose of this software framework is to design application for data collection and processing.

14.8 Questionnaire design tools

There are many questionnaire-design tools available commercially or developed by international statistical organizations and NSOs. A number of the more widely used ones are described below.

BLAISE is a software system developed by Statistics Netherlands used for statistical and scientific research. It is used for creating and processing computer-assisted surveys of varying size and complexity and supports questionnaire design and all types of computer-assisted data collection. It can be used to create small and simple questionnaires and large, complex and hierarchically structured questionnaire models and to link them to available external data files. In addition to questionnaire design, Blaise provides data entry facilities for all the various interview modes; namely, computer-assisted personal interview (CAPI), computer-assisted telephone interview (CATI), computer-assisted self-interview (CASI), computer-assisted web interview (CAWI), all of which can be combined within a survey. For telephone interviewing (CATI), a complete management system is available to schedule calls to respondents automatically, and follow-up calls after busy or no-answer responses. System developers can customize or expand the functionality of Blaise applications to use in their own applications.

Survey Solutions is free software developed by the World Bank. It supports questionnaire design with a full range of standard questions, nesting, cascading and linked questions. It supports validation of answers and direction of interview flow using .Net; use macros, calculated variables and lookup tables to construct sophisticated data validation algorithms. It enables collection of data offline on tablets (CAPI), online using web-interface (CAWI), from phone interviews (CATI), and conduct of mixed-mode surveys. It can scan barcodes, capture pictures and audio, and record information from external sensors. It facilitates collection of detailed GIS information on

locations, distances, and areas, application of geofencing and guidance of interviewers to the point of interview offline using high-resolution satellite images and built-in GPS receivers.

EUSurvey is an open-source online survey management system developed by the European Union for creating questionnaires and other forms and using them to collect data through the Internet. While its main purpose is to create official surveys of public opinion and forms for internal communication and staff management (for example, staff opinion surveys, evaluation forms, and registration forms), it can support the design of any type of web-based questionnaire. It provides a wide variety of elements used in questionnaires, ranging from the simple (such as text questions and multiple-choice questions) to the advanced (such as editable spreadsheets and multimedia elements).

Google Forms is a free software tool that can support an unlimited number of surveys, each with an unlimited number of respondents. It allows the addition of custom logos, images and videos. It enables simple skip logic and page branching. The survey can be delivered by a link to a website or by e-mail. Survey answers and data are automatically collected in Google Spreadsheets. The tool is appropriate for an NSO with very limited resources wishing to conduct a simple survey.

SurveyMonkey is similar to Google Forms in that it supports any kind of online survey. The free version supports only a very small number of respondents. The paid version has no such limitations.

Links to guidelines, best practices and examples:

- Comprehensive list of statistical packages (Wikipedia).

14.9 Dissemination tools

A number of data dissemination tools are available for use by an NSO (see *Chapter 10.7.1 — Dissemination by websites and data portals*).

Links to guidelines, best practices and examples:

- CountrySTAT is a collection of software tools, methods, and standards for the analysis of data coming from different sources. Data can be manipulated and visualized directly online, and various types of charts allow users to perform further analysis.
- Example of CountrySTAT implementation in Uganda (🔗).
- The Integrated Multi Information System (IMIS) is an integrated system providing users with access to national socio-demographic and economic data.
- The NADA dissemination platform provides access to the International Household Survey Network (IHSN) microdata.
- The OECD.Stat system allows users to search for and extract data from OECD databases. The platform is used by a number of other NSOs and International Organizations.
- Knoema is a subscription-based dissemination platform that provides access and visualisation tools for use with national databases.
- PC-Axis is a consortium led by Statistics Sweden that has developed a number of programs used to present statistical information for a number of NSOs.
- SDMX Reference Infrastructure (SDMX-RI) is a software suite produced by Eurostat, available as open-source, that enables the establishment of APIs for SDMX data dissemination and exchange directly from dissemination databases, without any software development required.
- Fusion Registry (🔗) is an integrated statistical data and metadata solution developed by Metadata Technology that facilitates data collection, integration, exchange, reporting, dissemination using SDMX standard. The basic Community Edition is available as a free download, while the full-featured Enterprise Edition is commercial software.
- StatKit is a free and open-source toolkit allowing a statistical organization to facilitate the standardization and industrialization of statistical dissemination and reporting.

14.10 Other current IT issues

The continuously evolving IT environment means that an NSO has to be permanently alert to the constant flow of new products becoming available from technology companies and from the international statistics community.

In the quest to modernise statistical systems in order to provide even more high-quality data more rapidly to meet increasing demands, an NSO needs to be aware of new developments and to learn from the experience of others within the community. For this to happen, an NSO will need to engage with the numerous collaborative bodies such as HLG-MOS and the SDMX community coordinated by regional institutions and international standards communities.

Of course, a balance needs to be struck between maintaining stable and reliable systems and the continual implementation of changes in order to keep up with the latest technology. Assessments of needs and risks must be built into the strategy and planning of an NSO as an ongoing process.