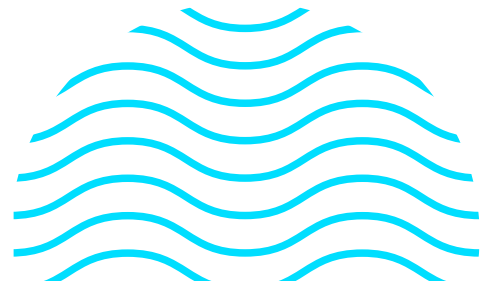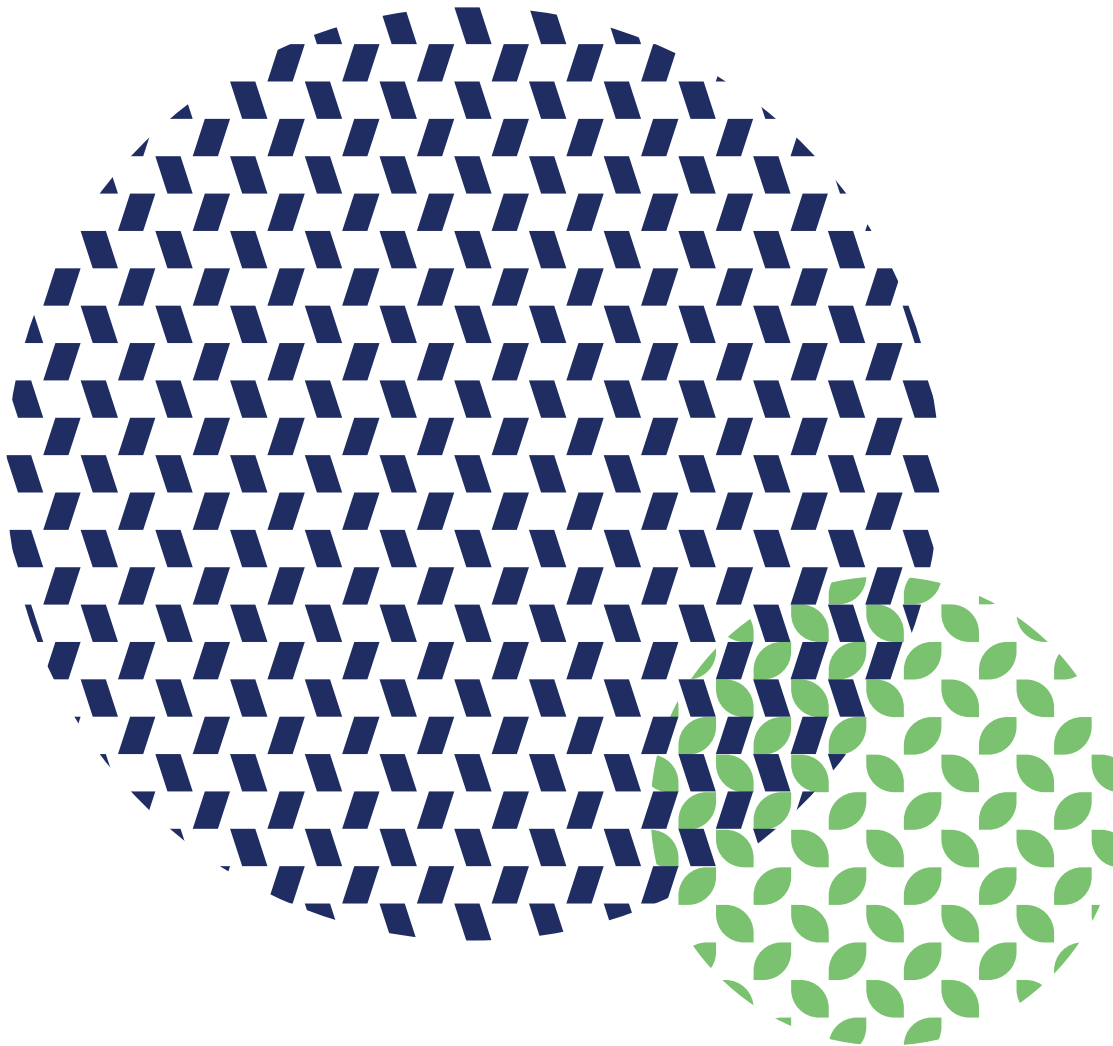# Pathway towards an Information Management Framework

Summary of Consultation Responses

Executive summary

The National Digital Twin programme (NDTp) was established by the Centre for Digital Built Britain (CDBB) to deliver the Information Management Framework (IMF) as recommended by the National Infrastructure Commission in the report Data for the Public Good.[1]

Information which is managed effectively and shared securely to form connected digital twins and enable people to make the best decisions has value which is becoming increasingly well understood (See Figure 1). The Gemini Principles set out the guiding values for the creation of a national resource for the connection of digital assets and CDBB is working across the infrastructure and built environment sectors, with industry, government and academia to progress the vision for the National Digital Twin. The Pathway Towards an Information Management Framework: A Commons for a Digital Built Britain (Hetherington and Matthews 2020)", hereafter called the
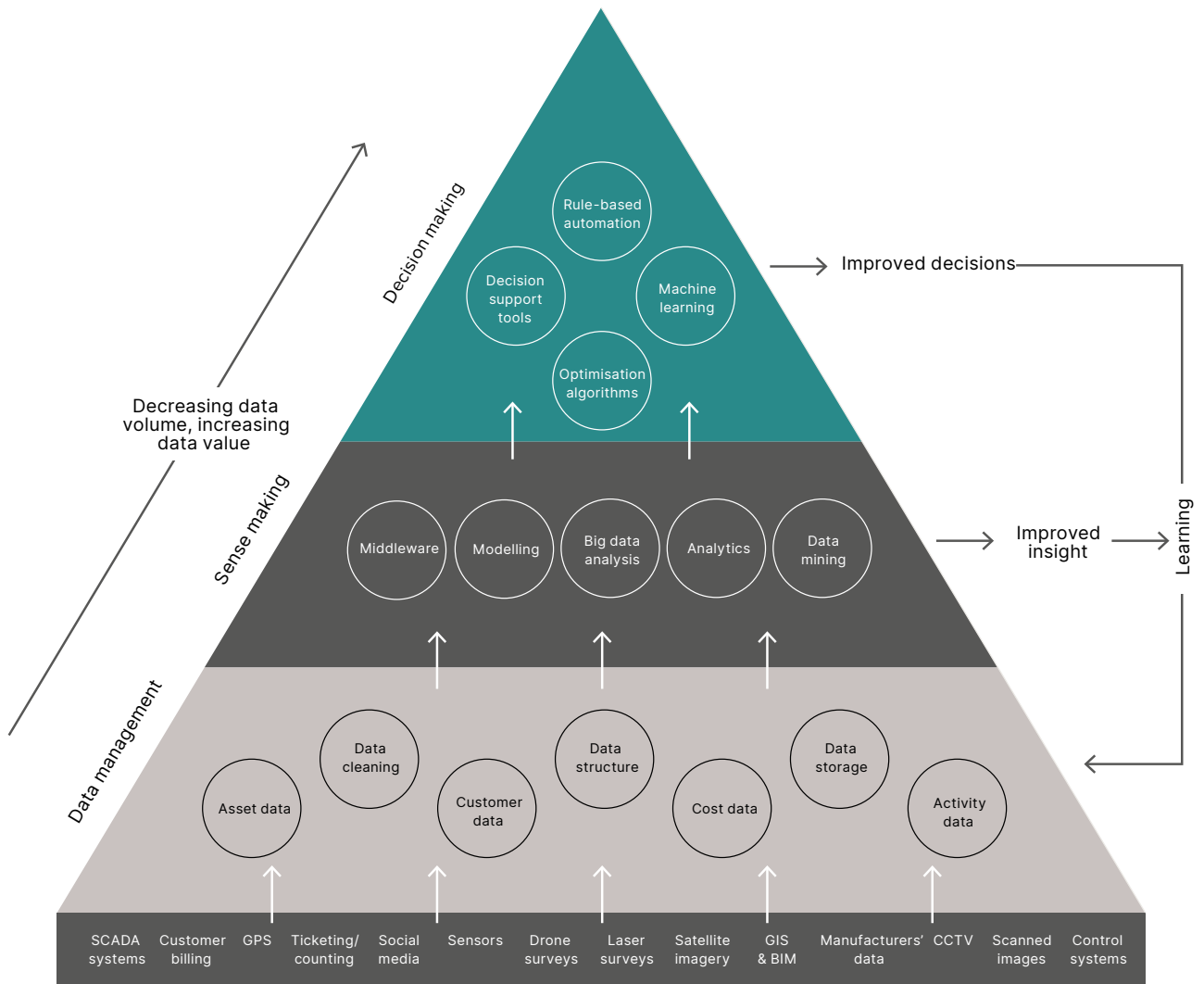
Figure 1: The Information value chain showing the connection between data and better decisions that lead to better outcomes taken from the Gemini Principles[3].

Pathway report, sets out the proposed approach to deliver the technical core of the IMF and enable the NDT.[2] The publication of the report was accompanied by an open consultation, the responses to which this report summarises.

According to the report, the technical core of the IMF that allows digital twins to connect, would comprise:

- the **Foundation Data Model (FDM)** – a consistent, clear understanding of what constitutes the world of digital twins;

- the **Reference Data Library (RDL)** – the particular set of classes and the properties we will want to use to describe our digital twins; and

- the **Integration Architecture (IA)** – the protocols that will enable the managed sharing of data.

This national resource, will enable competition on delivery of services to support real world and digital assets, encouraging innovation and development over time. A proposed approach to the creation of that resource was discussed in the Pathway report which was created by more than 100 information management experts from industry and academia working with NDTp.

The Pathway report was intentionally focused on the technical requirements of the IMF and did not attempt to describe

the wider socio-technical elements of change which would be required to ensure the successful creation and adoption of the IMF to enable a National Digital Twin. The whole programme is described in the NDTp roadmap, which includes but is not limited to security, data quality, ethics, legal and commercial considerations.

Overall, the responses received were positive about the programme and its progress, and many explored issues beyond the specific technical brief of the document. We welcome all feedback, positive and negative, which contributes to the ongoing development and adoption of the IMF. There were a small number of criticisms and several questions where greater clarity will significantly aid progress towards the creation of an NDT. Responses themes are summarised in the table below.

A number of use cases were identified which all support better decision making as described in the Gemini Principles (Figure 1, p.3), specifically through

- managing assets;
- decision support and assurance; and
- systems thinking.

The motivations for using the IMF to connect digital twins and create an NDT were explored in some depth by respondents who considered that the non-technical elements were as significant as the technical challenges. Whilst agreeing on the purpose of the programme, several noted the scale of the challenge in connecting the diversity of sectors, their existing systems, processes and approaches. They called for:

- recognition of the legal, commercial and regulatory challenges in the secure and resilient sharing of data to be tackled in parallel with technological development;
- demonstration of activity in connecting twins including benefits realisation and steps taken by practitioners; and
- plans to ensure adoption of the IMF outputs in a market where profit motivated offerings already exist and will continue to emerge.

The responses and suggestions received will inform the development of an updated document later in 2021.

Positive response themes	Nuanced response themes and questions	Critical response themes
The work is welcome and progress towards it is considered consistent with the Gemini Principles. The plans to build on existing work are particularly welcome.	Discussion of the technical challenge is valid but respondents called for human factors associated with change to be explored in parallel.	A small number of respondents rejected the approach as too "top down".
There was broad agreement that the IMF should consist of a FDM, RDL and IA.	Representatives from organisations often sought an indication for tangible next steps.	Some respondents stated that more than a single Integration Architecture is required.
The models and protocols described in the report were seen as comprehensive.	There were specific asks for advice on data quality, security, legal provenance and the securing of benefits from investment.	Several responses disputed the possibility and validity of a single FDM .

Process overview

The Pathway report was published early in 2020. It was directed at a technical audience who are interested in developing an IMF from The Gemini Principles to deliver public good and commercial benefits arising from a National Digital Twin. The 'Approach to Delivering a National Digital Twin for the United Kingdom'[4] was published alongside the Pathway report for a more general audience.

On publication of the Pathway report, the NDTp launched an open consultation, seeking feedback on the proposed approach to the development of the IMF. The consultation was promoted in a webinar with the authors of the paper and Dame Wendy Hall who wrote the foreward.

The consultation closed on 31 August 2020. The formal consultation received 24 responses and was supported with direct engagement with a range of stakeholders to refine and develop the approach to developing the IMF. As part of this engagement, the NDTp undertook a further nine interviews based on the questions in the consultation and the key themes that emerged in the formal consultation responses. The list of interviewees is listed in the Acknowledgements.

Response overview

This paper presents the Response overview from both waves of the consultation and outlines the proposed next steps for the NDTp. The paper is set out in three parts:
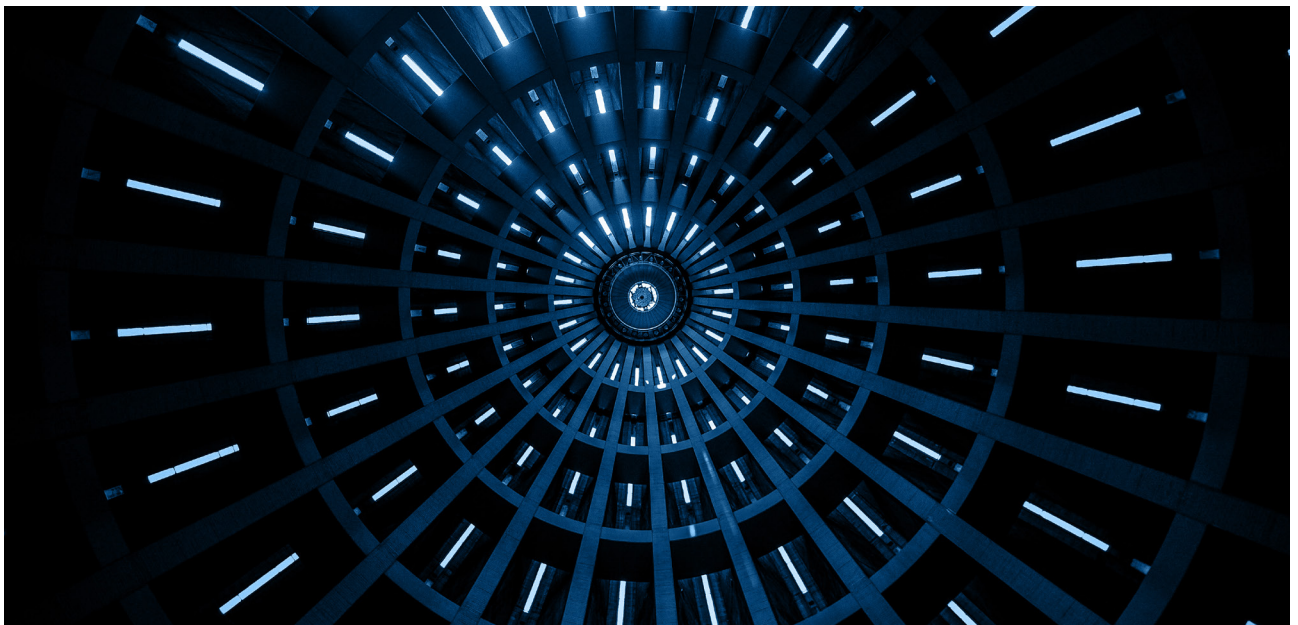
1. analysis of open consultation responses;

2. analysis of the direct engagement; and

3. next steps.

Analysis of open consultation responses

Overall, the responses to the Pathway towards an IMF document were positive and supportive of the initiative and the approach being taken. There were a small number with material and significant objections and the respondees often took a nuanced position when answering the questions.

The table below gives an indication of the nature and weighting of the responses, a number of respondents in interviews noted the clarity that this presentation brought, and we welcome feedback on this approach.

Blank cells in the table below represent no significant comment (Not all recipients answered all the questions with some referring to points made in other areas).

Question in original Consultation	Positive	Critical	Nuanced	Other
1. It has been proposed that the Information Management Framework (IMF) should essentially consist of a Foundation Data Model (FDM), a Reference Data Library (RDL) and an Integration Architecture (IA). Do you agree with this overall framework? In your view, are there any key elements missing from this framework?	16 of the 24 respondents welcomed the report and were very positive that progress is being made.	One of the respondents had fundamental objections to the methodology being deployed and the starting point.	A recurring theme throughout the consultation responses was a concern that a technical solution cannot be reached in isolation and, whilst welcoming the Pathway document, respondents could not fully evaluate it in the absence of legal, commercial and the social elements of change.	4 specific technical questions were raised.
2. In your view, is the proposed approach to the IMF consistent with the Gemini Principles? Are there any inconsistencies that should be addressed?	Six of the 16 respondents to this question responded positively.	Two respondents considered the approach too top down with the impact of locking down systems and preventing innovation.	Six of the 16 responded positively but called for wider factors to be considered.	There were 2 specific calls for security to be considered as well as requests to consider data quality and a need for examples.
3. Section 3.4 lists the models and protocols that would form part of the IMF. Is there anything that you would like to suggest to improve this list?	Five of the respondents to this question did not suggest additions.	One reiterated the point about the approach being too top down.		There were several calls for inclusions, most prominently: (3) meta data, (3) human layer (3), standards and definitions (2).
4. Section 3.5 describes key concepts of a Foundation Data Model. Is there anything that you would like to suggest to improve this description?		Responses were generally negative, questioning the possibility, viability and utility of a single FDM.	There was a call for clear guidance on regulation, data ownership and a stance on quality of inputs.	Respondents called for greater detail on steps to be taken towards an MVP.
5. Section 3.6 describes key concepts of the Reference Data Library. Is there anything that you would like to suggest to improve this description?	Four of the 24 respondents responded positively with no suggested additions.	One held the view that the approach was too top down.	A plethora of suggestions and recommendations including geospatial, non-physical, natural language interaction and the inclusion of standards and identifiers.	

Question in original Consultation	Positive	Critical	Nuanced	Other
6. Section 3.7 describes key concepts of an Integration Architecture. Is there anything that you would like to suggest to improve this description?			Most of the responses to this question suggested that there was more than a single IA and called for good governance. Concern was raised about the unforeseen and unforeseeable risks of combining data.	There were several specific technical questions, including security concerns.
7. Section 4 proposes a pathway for developing the IMF. Do you agree with the proposed overall approach? In your view, are there any key tasks missing from this pathway? Would you suggest any improvements to the order in which the tasks are undertaken to develop the IMF?	Three respondents were glad to see that existing work would be built upon.	One respondent noted the approach was too top down.	Most of the comments did not relate to the technical elements, rather they focused on the social elements of change. I.e. the need for a testing lab, business cases, benefits, procurement, governance, incentives and practical next steps.	
8. What do you see as the barriers to connecting digital twins within organisations and between different organisations/sectors? How can these barriers be overcome?			There were several answers to this question with a number of responses on notable themes. • Nine respondents noted theme on data quality, security, legal provenance. • Five respondents noted themes on opposition to change and an additional three respondents with technical change. • Three respondents noted themes on lack of direct and tangible benefit.	

9. In your experience what are the reasons why organisations invest in the creation of digital twins? Why would they invest in connecting digital twins?	The answers to this question are explored below.			
Question in original Consultation	**Positive**	**Critical**	**Nuanced**	**Other**
10. Do you have any other comments on the proposed approach to developing the information management framework?			Clear calls for use cases and not to get lost in standards	
11. What opportunities do you see arising in your business from being able to connect Digital Twins and share and integrate data across them?	The answers to this question are explored below			
12. Any other comments				Several requests to be involved

Question 9.
In your experience what are the reasons why organisations invest in the creation of digital twins? Why would they invest in connecting digital twins?

The respondents contributed a positive vision of digital twins and connected digital twins including the vision that; "The IMF delivers efficiency of shared infrastructure, less wasteful development of data models, standards, common reference data such as registers and vocabularies, visualisation software, predictive models".

The three broad areas of identified use cases correspond well with the work emerging in the Digital Twin Toolkit from the Gemini Programme on the Digital Twin Hub seeking to understand the use cases and business cases for digital twins.

1. Managing assets

- Improved facility and asset management over the whole lifecycle through improved insight
- Increased efficiency and quality, reduction in failure risk
- Autonomous operation and collaboration (in real time)
- Learning form similar assets or those in the same situations

2. Assurance and decision support

- Present more robust information in order to make better informed decisions more quickly (from long term policy choices to hour by hour load balancing trade-offs)
- Enabling co-creation; acceleration and reduction in the risks associated with or and de-risker of sustainable, innovation-led business expansion
- Building and consolidating corporate knowledge

3. Systems thinking (strategy and planning)

- Any system being twinned does not exist in isolation and is itself a part of a larger system. Many of the inputs required to twin the in-scope system are therefore difficult to obtain and result in a large number of assumptions being made, which connected twins would address.

- Balancing objectives on costs, safety, security and environmental sustainability and collaborating and building consensus to address cross sector challenges.

- Exploring what if scenarios, especially disaster planning.

- Avoid repetition of data across multiple locations which reduces the risk of inaccuracies and breaking down of silos and reducing the 30% of time spent finding and collating information ahead of using it.

- Understanding how infrastructure managed by different organisations functions as virtual networks (in the way citymapper has already done in a consumer facing application).

A different perspective

Early examples of digital twins most frequently refer to twins of assets[5] and the use cases and benefits described in this consultation reflect that experience. Respondents discussed using digital twins to improve the outcomes associated with

- the management of assets throughout their lifecycle;

- supporting decisions through the consolidation of information;

- systems level thinking, taking into account linkages with other networks.

In addition, a small number of respondents noted the potential for digital twins to deliver new sources of value and data-driven solutions for those providing or interrogating digital twins or digital twin services to multiple clients. Examples being "Proving and validating provenance in connected supply chains or value chains, delivering a competitive advantage." "Sharing and integrating data across assets and clients will increase the size of the addressable market and will contribute to the increased value of our digital products to our clients and wider society".

Question 11.
What opportunities do you see arising in your business from being able to connect Digital Twins and share and integrate data across them?

The answers in this section reflect the motivations for connecting digital twins. Further examples appeared in the answers to this question but have been added to question 9 above.

Wider public good

- To work within planetary constraints, to ultimately secure humanity's future and make more balanced and equitable decisions
- Addressing cross-sector challenges

Technology exploitation

- Obtaining value from the data derived from new and emerging technologies especially artificial intelligence and machine learning.

Efficiency

- Access data which are often hidden, locked or in unusable formats.
- Speed in early feasibility if existing data sets can be identified / accessed in lieu of having to commission surveys.

Specific examples given by respondents

- Managing energy usage in housing
- Locating water & telecoms underground assets
- Climate change monitoring
- Emergency scenario planning
- Transport network optimisation
- Source model for Golden Thread (Hackett)[6]
- Acoustic mapping
- Clean Air Zone: Air quality simulation
- Traffic Modelling
- CCTV monitoring
- Cultural space and activity: Belonging, Identity, Memory, Active Cities
- Planning Model (LVIA compliant?)
- Public Realm Design and Planning
- In the energy sector, bringing together generation, storage, transmission, distribution and use models into a more integrated model.

Analysis of direct engagement

Long form interviews were conducted with expert organisations in order to better understand the questionnaire responses and to gather focused feedback. As with the written responses, the interviewees welcomed the NDTp, its vision and ambition, and the Pathway report. All welcomed the Gemini Principles as an accessible descriptor of the vision and agreed that the IMF was a logical next step. Both the organisations and individuals themselves were keen to engage in order to ensure the success of the programme and broadly agreed with the positive nature of responses to the open consultation. The responses have been characterised in to programme level (general) and technical points about the IMF itself.

General

- As with the written responses, the interviewees welcomed the NDTp, its vision and ambition, and the Pathway report. All welcomed the Gemini Principles as an accessible descriptor of the vision and agreed that the IMF was a logical next step. They were keen to engage in order to ensure the success of the programme and broadly agreed with the positive nature of responses to the open consultation.

- The majority of respondents took the opportunity to comment on the breadth of the challenge in creating a NDT. Though rich in technical skills, these stakeholders, in common with those who had submitted written responses, noted that their ability to comment on the Pathway report was limited because of the lack of development on the human factors opposing change as well as other commercial barriers such as legal, including IP protection, regulatory and insurance regimes.

- Several noted that the gap between principles and actions was wide and the challenge of making technical decisions, linked to outcomes, translatable to multiple sectors was significant.

  - Despite these barriers to change, stakeholders welcomed the opportunity to support the programme and participate in demonstrations of the art of the possible and building momentum towards adoption.

  - Stakeholders asked what incentives might exist to take up NDTp outputs and what would be the minimum requirement for use?

    - Noting that the RDL and the FDM can be considered analogous with HTML and HTTP, one stakeholder noted that the reason that the languages had worked so well was

their simplicity to learn and the obvious advantages from doing so, such as publish your own page and selling your own goods and services.

- The risk was noted that any NDTp output may not be compatible with services offered at a later date by the large data and software entities, or that freely available interoperable services will become available in the future.

  - It is common practice for industry leaders to expect new entrants to ensure compliance and interoperability with existing solutions

  - However, some reflected that a mandate for use of NDTp outputs was unlikely to be successful and the correct balance of utility and incentives would need to be created to ensure adoption.

- The tasks for completing the development of the IMF was welcomed as an approach (See Figure 1, p.2). Of particular importance was the Gathering of the corpus (of evidence) of willing and able collaborators to examine more specific goals and to develop realistic case studies, expectations and prototypes for the NDTp.

There was a call for these to prototypes to include examples of the better decisions than can be made with linked, digital twin data, noting that simply making data available, may not address all the issues associated with making the best, evidence-based decisions.

- Stakeholders described use cases for connected digital twins as informing non-binary choices and enabling entities to make decisions without referring to consultants.

Specific technical points

1. As in the questionnaire responses, interview respondents questioned the practicality of implementing a single FDM. A commonly held view was that there was simply too much variation in the source and application of data and legacy technology to make relation to a single FDM a viable investment. There was comment that this project and attitudes to it reflected the tension between engineering and software approaches.

2. There was a question about the ability of any FDM meaningfully relating to non-semantic data. Specifically, triple graph, relational, topographic approaches point clouds or video feeds.
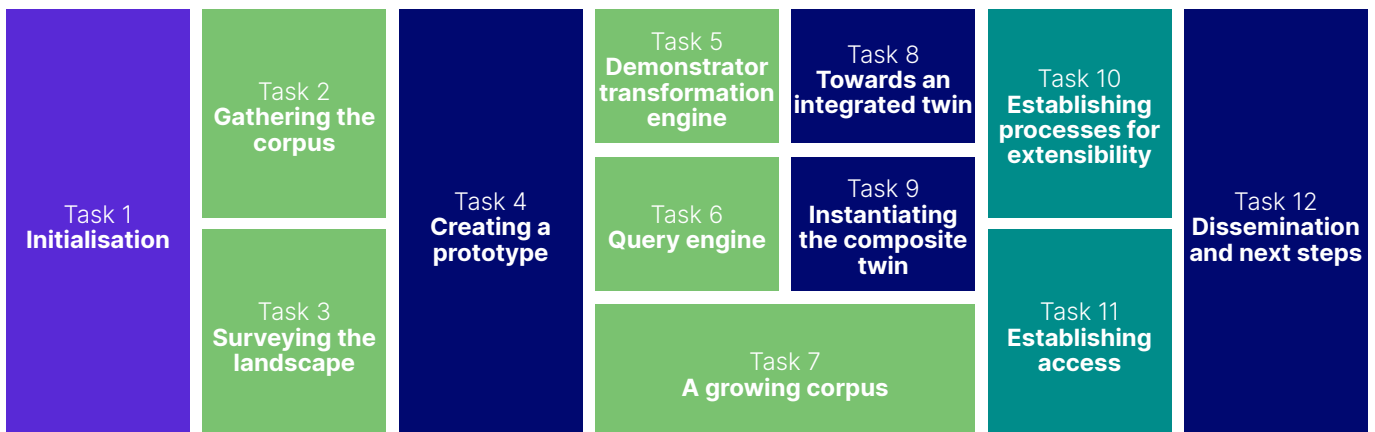

Figure 2: Tasks to be completed in the development of the Information Management Framework for the National Digital Twin taken from The Pathway Toward an Information Management Framework

3. Support for RDL's was consistent but there was confusion about the extent, nature and purpose of integration architecture.

4. Stakeholders noted that the document used the term "Model" in three different ways; simulation models, as a synonym for a data model, and as a descriptor for the NDT itself. A tighter definition would be welcome.

5. The security risk of data aggregation was commented on several times and also the significant developments which have been made to test approaches in this area.

Next steps
How to continue the conversation

Over 30 specific questions were asked in the responses to the Pathway paper consultation. These have been categorised and answered by the NDTp team and are available to view and comment on in the DT Hub. Further comments or perspectives are welcome.

The CDBB has published a survey document on Top Level Ontologies and continue to engage with practitioners through the DT Hub, the Gemini Programme and other activities to inform the development of the IMF. This work, together with the input received in this consultation will contribute to updating the Pathway report which is expected to be published in the coming months.

Acknowledgements

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