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**UNDERSTANDING DIGITAL DATA ECOSYSTEMS ACROSS
MALAYSIA'S SURVEYING PROFESSIONS: A TWO ROUND DELPHI
STUDY**

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Abstract

This study investigates the digital data ecosystem across Malaysia's surveying professions using a two-round Delphi study involving experts from Building Surveying, Property Surveying, Geospatial and Land Surveying, and Quantity Surveying. The first round employed semi-structured interviews with ten experts to explore professional roles, project lifecycle involvement, digital information management, and data sharing practices. The interview data were analysed using thematic analysis, resulting in three themes comprising seven categories. The second round involved nine independent experts who validated the findings through a structured Delphi consensus process. A total of 65 of the 69 statements achieved the predefined consensus threshold of at least 80 percent agreement, demonstrating strong expert convergence. The validated framework identifies three interconnected dimensions, namely professional roles and lifecycle involvement, data types, organisation and digital tools, and data sharing practices and cross-disciplinary exchange. The findings demonstrate that an effective digital data ecosystem depends on the integration of professional responsibilities, structured information management, and collaborative data exchange throughout the built environment lifecycle. The study provides an empirically validated framework that supports digital transformation and interdisciplinary collaboration across Malaysia's surveying professions.

Keywords: Built environment; Delphi study; Digital data ecosystem; Malaysia; Surveying professions

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INTRODUCTION

Surveying professionals are among the principal producers and custodians of digital information throughout the built environment lifecycle. Construction projects generate substantial volumes of discipline-specific information, including spatial measurements, cost estimates, building condition assessments, and asset information (Niu et al., 2026; Yin, 2025). These data support technical, commercial, legal, and operational decision-making across the planning, design, construction, operation, and maintenance stages (Jacob et al., 2025; Ojiako et al., 2025). Although each surveying profession produces distinct datasets according to its professional responsibilities, these information resources collectively contribute to project delivery and require effective management throughout the project lifecycle (Cao et al., 2025; Li et al., 2025).

The increasing digitalisation of the construction industry has substantially expanded the volume, diversity, and complexity of surveying data. Digital technologies have transformed the ways in which professional information is generated, organised, stored, analysed, and exchanged (Cheng & Hu, 2026; Shakur et al., 2026). Consequently, understanding contemporary surveying practice requires consideration not only of individual technologies but also of the broader digital data ecosystem, which encompasses professional activities, information resources, digital platforms, data management processes, and interactions among surveying disciplines.

A digital data ecosystem provides a holistic perspective for examining how digital information supports professional practice (Berlato et al., 2025b). Rather than focusing solely on technology adoption, it considers the interrelationships among professional services, project lifecycle involvement, data types, digital platforms, data management practices, and information exchange activities that collectively shape the creation, management, and utilisation of digital information. Examining these interconnected components provides a more comprehensive understanding of digital information management across surveying professions.

In Malaysia, the four principal surveying professions, namely Quantity Surveying (QS), Property Surveying (PS), Geospatial and Land Surveying (GLS), and Building Surveying (BS), have increasingly adopted digital technologies within their respective areas of practice. Despite the important role of these professions in supporting the built environment, there remains limited empirical evidence that comprehensively describes the digital data ecosystem across Malaysia's surveying professions (Royal Institution of Surveyors Malaysia, 2021a, 2021b).

Previous research has primarily examined individual technologies or specific surveying disciplines, including Building Information Modelling (BIM), Geographic Information Systems (GIS), digital measurement technologies, and

cloud-based information management (Berlato et al., 2025a; Nashruddin et al., 2024; Radman et al., 2025). Although these studies have advanced understanding of technology adoption within professional contexts, they provide only a partial view of digital information management. Limited attention has been devoted to investigating the broader digital data ecosystem across multiple surveying disciplines. Thus, there is insufficient empirical evidence regarding the professional services performed, project lifecycle involvement, data generated, digital platforms utilised, data management practices, and interdisciplinary data sharing across Malaysia's surveying professions. Furthermore, expert consensus on these dimensions of digital practice has not been systematically established.

In this study, the term digital data ecosystem refers to the interconnected professional activities, digital information resources, platforms, management practices, and exchange processes across surveying disciplines. Data exchange refers specifically to the transfer and sharing of digital information between project participants, while cross-disciplinary collaboration refers to the professional interaction required to use and coordinate such information across surveying disciplines. These terms are used consistently throughout the study to distinguish the broader ecosystem from its specific exchange and collaborative processes. To address these gaps, this study employs a two-round Delphi study involving experts from the QS, PS, GLS, and BS professions in Malaysia. The first research objective explores the digital data ecosystem across Malaysia's surveying professions through semi-structured expert interviews. The second research objective establishes expert consensus on the identified components of the digital data ecosystem by evaluating the level of agreement among experts using the Delphi technique. The findings provide a comprehensive empirical understanding of the current digital data ecosystem across Malaysia's surveying professions and establish a baseline for future research on digital transformation within Malaysia's built environment.

RESEARCH METHODOLOGY

Round One: Semi-Structured Interviews

The first Delphi round comprised semi-structured interviews (Sunandar et al., 2025c; Sunandar, Karim, et al., 2026). Participants were selected through purposive sampling from members of the Royal Institution of Surveyors Malaysia (RISM) based on their professional experience and active involvement in digital surveying practice. Data saturation was achieved after interviewing ten experts. The expert panel consisted of three participants, each from BS, PS, and QS, together with one participant from GLS. The smaller representation of GLS was primarily due to the more limited accessibility of eligible GLS professionals with direct experience in digital surveying practice during the data collection period.

This constraint was considered when interpreting the findings, and the Delphi process was used to assess whether the themes identified from Round One were supported across the wider expert panel. All interviews were transcribed verbatim and analysed using thematic analysis to identify recurring patterns and themes (Sunandar, Abd Karim, et al., 2026; Sunandar et al., 2025a, 2025d). The analysis followed an iterative coding process comprising data familiarisation, initial coding, category development, and theme generation (Braun & Clarke, 2021; Saldana, 2021; Sunandar, Andriyanti, Karim, et al., 2026). The demographic profile of the Round One expert panel is presented in Table 1.

Table 1: Details of Experts Round One

Code	Surveying Discipline	Professional Status
A1	BS	Business Practice, Academic, Consultant
A2	BS	Academic, Consultant
A3	BS	Government Officer
A4	GLS	Consultant, Director
A5	PS	Academic, Government Officer
A6	PS	Business Practice
A7	PS	Business Practice, Consultant
A8	QS	Business Practice
A9	QS	Business Practice, Director
A10	QS	Business Practice

Source: Author's Own Creation (2026)

Round Two: Delphi Consensus

The second Delphi round was conducted to validate the findings from the semi-structured interviews and establish expert consensus. A separate panel of nine RISM members was purposively selected to provide an independent evaluation of the Round One finding. The Delphi statements were developed directly from the seven categories identified through the Round One thematic analysis. Interview codes and supporting participant statements were reviewed and consolidated into concise statements representing the recurring characteristics of each category. These statements were then organised under the three overarching themes and reviewed for clarity and conceptual alignment before being presented to the Round Two panel. This process resulted in 69 statements for Delphi evaluation. Using a different expert panel introduced an additional level of verification and strengthened the credibility and trustworthiness of the study (Sunandar, Andriyanti, Abd Karim, et al., 2026; Sunandar et al., 2025b). Consensus was evaluated using simple frequency analysis to determine the proportion of experts who agreed with each statement. Statements receiving more than 80 percent agreement were considered to have achieved a high level of consensus and were retained, whereas statements with agreement below 80 percent were excluded from the final consensus (Nasa et al., 2021; Zarghani et

al., 2024). This consensus threshold also strengthened methodological triangulation by demonstrating convergence of expert perspectives across different surveying disciplines and professional backgrounds. The demographic profile of the Round Two expert panel is presented in Table 2.

Table 2: Details of Experts Round 2

Code	Surveying Discipline	Professional Status
V1	BS	Academic/ Consultant
V2	BS	Academic/ Consultant
V3	BS	Academic/ Consultant
V4	PS	Business Practice
V5	PS	Business Practice
V6	PS	Business Practice
V7	QS	Academic/ Consultant
V8	QS	Government Service
V9	GLS	Business Practice

Source: Author's Own Creation (2026)

ANALYSIS AND DISCUSSION

Round One Analysis

The first Delphi round explored the digital data ecosystem across Malaysia's surveying professions through semi-structured interviews with ten experts. Thematic analysis identified recurring patterns describing professional roles, project lifecycle involvement, digital information management, and data sharing practices. The coding process resulted in three overarching themes comprising seven categories that collectively explain the digital data ecosystem across the four surveying professions. For example, interview statements concerning “building inspection”, “defect identification”, and “compliance checks” were initially coded as building condition assessment activities and subsequently grouped under the Professional Services category within Theme 1. Similarly, references to “project-based folders”, “cloud-based document management”, and “version control” were coded as digital information organisation and consolidated under Data Organisation and Storage within Theme 2. This iterative process ensured that the Delphi statements remained grounded in the interview evidence. The thematic structure derived from the interview analysis is presented in Table 3.

Table 3: Themes and Categories Identified from Round One Interviews

Theme	Category
Theme 1: Professional Roles and Lifecycle Involvement	Professional Services; Project Lifecycle Stages
Theme 2: Data Types, Organisation, and Digital Tools	Data Types; Data Organisation and Storage; Digital Tools and Platforms

Theme	Category
Theme 3: Data Sharing Practices and Cross Disciplinary Exchange	Data Sharing Practices; Cross Disciplinary Data Exchange

Source: Author's Own Creation (2026)

The first theme demonstrates that the digital data ecosystem is fundamentally shaped by the professional responsibilities of each surveying discipline and their involvement throughout the project lifecycle. Building Surveyors primarily focus on building inspection, defect assessment, compliance evaluation, and maintenance planning. For example, A1 explained that the profession is centred on “building inspection, including condition assessment, defect identification, compliance checks, and advisory services for building performance and safety,” while A3 highlighted responsibilities extending to “policy maker, building inspection, management.” GLS concentrated on spatial data preparation to support engineering design, with A4 stating, “I process field survey data and prepare survey drawings such as topographical plans.” Property Surveyors emphasised valuation, feasibility studies, and property management, whereas Quantity Surveyors focused on pre-contract and post-contract cost management, contract administration, and commercial control. Interview findings also revealed that surveying disciplines contribute at different project stages rather than participating uniformly throughout the lifecycle. Building Surveyors were involved from pre-construction condition surveys to post construction performance assessment, while Quantity Surveyors participated from project inception through construction and handover. A8 described this involvement as “inception to hand over to end user,” whereas A9 noted participation during the “design stage by providing cost information and tendering and construction.” Collectively, these findings indicate that professional roles determine not only the services delivered but also the timing and nature of digital information generated across the built environment lifecycle.

The second theme illustrates the diversity of digital information managed by surveying professionals, together with the digital infrastructure supporting information management. The interviews revealed considerable variation in data types according to disciplinary responsibilities. Building Surveyors generated inspection reports, photographic evidence, defect records, condition ratings, and maintenance information. A2 described these as “condition and pathology data,” “geometric and spatial data,” and “regulatory and compliance data.” GLS primarily managed “GNSS coordinate data, topographical and utility survey data, boundary information” (A4), while Property Surveyors handled legal, market, financial, planning, and valuation datasets. Quantity Surveyors managed commercial information, including “Bills of Quantities, interim valuations, variation records, cost reports, and final account

documentation” (A10). Despite these differences, participants consistently reported structured approaches to organising digital information using project-based folders, centralised servers, cloud storage, and standardised naming conventions. A2 explained that data are organised using “project-based folders” and “cloud-based document management systems to ensure version control,” while A6 described a “centralized digital storage” system supported by an internal “master list database” and documented quality assurance procedures. A1 additionally reported using “AI generative tools such as Gemini, and NotebookLM” to improve reporting efficiency, illustrating the gradual integration of emerging artificial intelligence technologies into surveying practice. Overall, the findings demonstrate that digital information management has evolved beyond simple document storage towards integrated digital environments combining specialised software, cloud infrastructure, and collaborative information systems.

The third theme highlights that digital information exchange remains essential for multidisciplinary project delivery but continues to rely heavily on conventional document-based communication. Participants consistently reported that information is shared through emails, cloud storage platforms, organisational servers, and formal documentation rather than interoperable digital databases. A1 explained that information is distributed through “hardcopy printed reports, email, and digital platforms such as Google Drive,” while A4 reported sharing “DWG and PDF formats through email or cloud storage.” Larger projects increasingly utilise common data environments, with A2 referring to “Viewpoint, Aconex, or Procore” for collaborative document exchange. Nevertheless, several participants acknowledged persistent fragmentation in cross-disciplinary information management. A6 observed that data sharing is “currently fragmented and largely manual” because “the raw data remains locked away, meaning stakeholders often have to recreate the data for their own systems.” The interviews further demonstrated that the types of exchanged information vary according to project stages. During planning and design, spatial surveys, feasibility studies, market information, and cost estimates are frequently exchanged. During construction, valuation reports, variation assessments, inspection records, and progress information support project coordination and contract administration. At project completion, as-built drawings, operation and maintenance documentation, final accounts, and asset information are transferred to facilitate operational management. These findings suggest that while multidisciplinary collaboration is well established, opportunities remain to improve interoperability and integrated digital data exchange across Malaysia's surveying professions.

Round Two Analysis

The second Delphi round was undertaken to validate the findings generated from the semi-structured interviews and to establish expert consensus regarding the components of the digital data ecosystem across Malaysia's surveying professions. Nine independent experts representing BS, PS, QS, and GLS evaluated the statements derived from the thematic analysis conducted in Round One. Following the predefined Delphi protocol, statements receiving at least 80 percent agreement were retained, whereas statements below the threshold were excluded from the final framework. The consensus results are summarised in Table 4.

Table 4

Statement 1 (Theme 1)	Statement 2 (Theme 2)	Statement 3 (Theme 3)
1.1.1 (89%)	2.1.1 (89%)	3.1.1 (89%)
1.1.2 (89%)	2.1.2 (100%)	3.1.2 (78%)
1.1.3 (89%)	2.1.3 (100%)	3.1.3 (89%)
1.1.4 (89%)	2.1.4 (100%)	3.1.4 (89%)
1.1.5 (89%)	2.1.5 (89%)	3.1.5 (89%)
1.1.6 (89%)	2.1.6 (100%)	3.1.6 (78%)
1.1.7 (100%)	2.1.7 (89%)	3.1.7 (89%)
1.1.8 (100%)	2.1.8 (89%)	3.1.8 (89%)
1.2.1 (100%)	2.1.9 (100%)	3.1.9 (89%)
1.2.2 (100%)	2.1.10 (100%)	3.2.1 (89%)
1.2.3 (100%)	2.2.1 (100%)	3.2.2 (100%)
1.2.4 (100%)	2.2.2 (89%)	3.2.3 (100%)
1.2.5 (100%)	2.2.3 (100%)	3.2.4 (89%)
1.2.6 (100%)	2.2.4 (100%)	3.2.5 (100%)
1.2.7 (100%)	2.2.5 (100%)	3.2.6 (89%)
1.2.8 (100%)	2.2.6 (89%)	3.2.7 (89%)
1.3.1 (89%)	2.2.7 (100%)	3.2.8 (89%)
1.3.2 (89%)	2.2.8 (100%)	3.3.1 (78%)
1.3.3 (100%)	2.2.9 (89%)	3.3.2 (78%)
1.3.4 (89%)	2.2.10 (89%)	3.3.3 (100%)
1.3.5 (100%)		3.3.4 (89%)
1.3.6 (100%)		3.3.5 (89%)
1.3.7 (100%)		3.3.6 (89%)
1.3.8 (100%)		3.3.7 (89%)
		3.3.8 (100%)

Source: Author's Own Creation (2026)

The findings demonstrate a high degree of agreement among the expert panel. Of the 69 statements evaluated, 65 achieved the required consensus level, with agreement ranging from 89 to 100 percent. Specifically, 27 statements received unanimous agreement from all experts, while 38 statements obtained 89 percent agreement. These findings indicate strong convergence of expert opinions

regarding the professional roles, project lifecycle involvement, digital information resources, digital platforms, data management practices, and interdisciplinary information exchange that collectively characterise the digital data ecosystem within Malaysia's surveying professions.

Only four statements failed to satisfy the predetermined consensus threshold, each obtaining 78 percent agreement. Two statements concerned technical challenges during information exchange, namely data loss and geometric inconsistencies during model exchange, while the other two concerned information loss associated with static document formats such as PDF documents. The remaining two statements concerned behavioural dimensions of collaboration, specifically low levels of trust among professionals and disciplinary silo mentalities. Although these issues were recognised by several experts during the interviews, their exclusion from the validated framework reflects the predefined 80 percent consensus criterion rather than indicating that they are absent from practice. They are therefore considered emerging issues that warrant further investigation, particularly because their occurrence may vary according to organisational context, project characteristics, and professional experience.

Final Consensus

The validated statements confirm the three thematic dimensions identified during Round One and establish the fundamental components of the digital data ecosystem across Malaysia's surveying professions. Theme 1, Professional Roles and Lifecycle Involvement, achieved consistently high levels of consensus, demonstrating that surveying practices are fundamentally shaped by discipline-specific responsibilities and participation throughout the built environment lifecycle. The findings confirm that BS, PS, GLS, and QS contribute distinct forms of professional expertise and digital information from project inception, through design and construction, to operation and maintenance stages. This finding supports previous studies emphasising that digital transformation in the built environment requires recognition of professional roles, information responsibilities, and lifecycle-based collaboration rather than technology adoption alone (Berlato et al., 2025b; Parece et al., 2025; Yin, 2025).

Theme 2, Data Types, Organisation, and Digital Tools, also achieved strong validation, indicating that digital surveying practices are characterised by diverse information resources supported by specialised software, cloud-based platforms, and structured data management approaches. The consensus demonstrates a transition from fragmented and isolated digital tools towards integrated information environments, where data quality, accessibility, consistency, and organisation directly influence decision-making throughout project delivery. This finding aligns with existing research on digital information

management, which identifies effective data structuring, information exchange, and interoperability as critical elements of successful digital transformation within the construction industry (Cheng & Hu, 2026; Swe Myat & Malla, 2026).

Theme 3, Data Sharing Practices and Cross-Disciplinary Exchange, was generally validated by the expert panel; however, several statements related to interoperability limitations, information loss, and professional collaboration challenges did not achieve consensus. This indicates that although digital information exchange is widely recognised as an essential component of contemporary surveying practice, the maturity of collaborative digital processes remains influenced by organisational capability, project requirements, regulatory conditions, and established professional workflows. Similar challenges have been identified in digital construction research, where fragmented information systems, limited interoperability, and organisational resistance continue to constrain the implementation of integrated information management practices (Abdeen et al., 2025; Binamungu & Kimaro, 2025; Zohourian et al., 2026).

Overall, the Delphi findings establish an empirically validated framework comprising three interconnected dimensions: professional responsibilities, digital information management, and interdisciplinary data exchange, as presented in Figure 1. From a practical perspective, the framework can support several stakeholder groups. For RISM, the three dimensions provide a basis for developing professional guidance on digital information management and interdisciplinary data exchange. Surveying firms can use the framework to review their internal data structures, platform use, and information-sharing workflows, while public agencies can consider these dimensions when developing digital project requirements and information governance arrangements. For BIM and GIS users, the framework highlights the importance of aligning discipline-specific information with shared project environments and exchange requirements. More broadly, the findings suggest that digital data governance should address not only technology and interoperability, but also professional responsibilities, information ownership, data quality, and cross-disciplinary workflows. The validated framework highlights that the effectiveness of a digital data ecosystem depends not only on technological capabilities but also on the alignment of professional roles, structured information practices, and collaborative mechanisms that facilitate reliable data exchange across surveying disciplines.

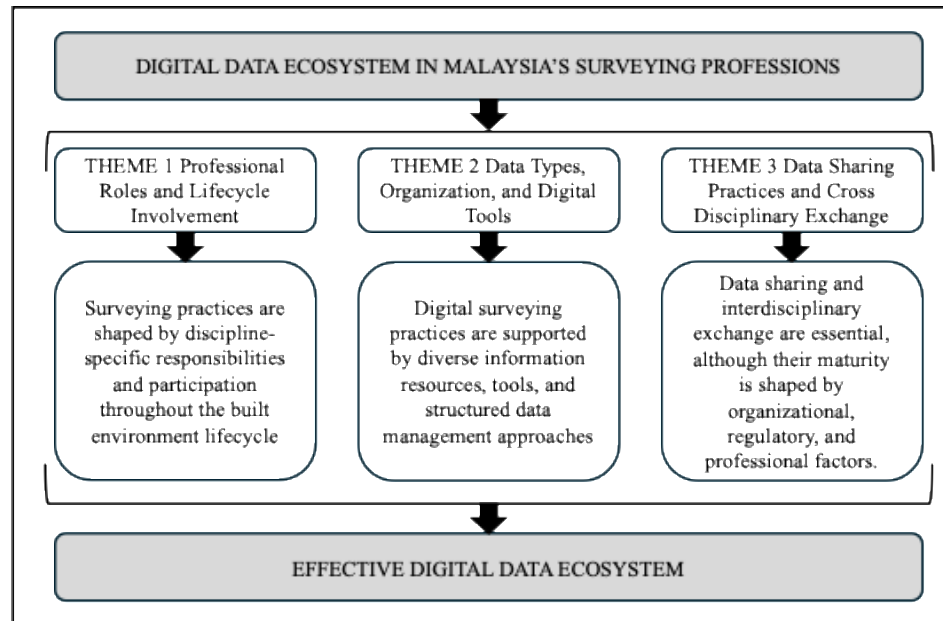


Figure 1: Final Consensus
 Source: Author's Own Creation (2026)

CONCLUSION

This study explored and validated the digital data ecosystem across Malaysia's surveying professions through a two-round Delphi study involving experts from BS, PS, GLS, and QS. The findings identified three interconnected dimensions, namely professional roles and lifecycle involvement, digital information management, and cross-disciplinary data sharing. The high level of expert consensus demonstrates that an effective digital data ecosystem extends beyond technology adoption and is fundamentally supported by the alignment of professional responsibilities, structured information management, and collaborative data exchange throughout the built environment lifecycle.

This study contributes to the literature by developing an empirically validated framework that conceptualises the digital data ecosystem across multiple surveying disciplines within the Malaysian context. The framework provides a holistic understanding of how professional functions, digital information resources, and collaborative practices collectively shape digital transformation in surveying services. The findings also offer practical implications for professional institutions, industry practitioners, and policy makers by identifying key elements that can strengthen interoperability, improve information management, and support the implementation of integrated digital practices across the surveying profession.

Several limitations should be acknowledged. The expert panel was confined to Malaysian surveying professionals and included limited representation from the GLS discipline. In addition, the findings are based on expert perspectives and therefore do not capture variations in organisational practices across different project settings. Future research should examine the applicability of the proposed framework in different national and organisational contexts through empirical case studies. Further investigation is also needed to examine governance arrangements, interoperability standards, and emerging technologies, including artificial intelligence and digital twins, to advance a multidisciplinary data ecosystem and strengthen digital collaboration within the built environment.

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DISCLOSURE

The authors declare that there is no conflict of interest associated with this research.

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