Integrating Business Process Modeling with Geospatial Data: Optimizing the Digital Cartographic Reference Data of the Walloon Region, Belgium (PICC)

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***Abstract*— The paper presents a comprehensive methodology for enhancing the "Projet Informatique de Cartographie Continue" (PICC), which serves as the digital cartographic reference for the Walloon Region, Belgium. Initiated in 1991, the PICC was chosen by the Service Public de Wallonie to serve as the foundation for an INSPIRE-compliant Georepository. It provides detailed coverage of the entire territory with a precision of less than 25 centimeters in the x, y, and z coordinates. The PICC supports various sectors through continuous updates and includes detailed features such as buildings, roads, and addresses, offering a comprehensive geospatial database for the region. This study applies Business Process Model and Notation (BPMN) to geospatial data management by modeling PICC update workflows and quality control processes. The development resulted in 36 detailed diagrams of seven key processes. By presenting example diagrams and corresponding workflow improvements, the results demonstrate that integrating BPMN into geospatial data management can significantly optimize process flows, strengthen quality controls, and improve data architecture. This study provides a framework that constitutes a valuable opportunity for similar geospatial data management projects, helping to improve geodata accuracy and efficiency.**

Keywords-geodata; process workflow; quality controls; BPMN.

I. INTRODUCTION

This paper presents an extended version of previous work on a methodology for documenting, updating, and quality control processes for the "Projet Informatique de Cartographie Continue" (PICC), the digital cartographic reference data of the Walloon Region, Belgium [1]. It significantly expands upon earlier findings and solutions, providing detailed examples and analyzing the outcomes of this methodology aimed at enhancing the PICC geodata update process. The initial study was first presented at the IARIA GEOProcessing 2024, the sixteenth international conference on advanced geographic information systems, applications, and services.

The PICC, also known as the Continuous Mapping Project, is a comprehensive cartographic representation of the Walloon Region in Belgium. Initiated by the Public Service of Wallonia (SPW) in 1991, this project encompasses the entire territory with high precision, ensuring homogeneity across all three dimensions and incorporating regular updates to reflect ongoing changes. The PICC includes all landscape components, from buildings and their addresses to roads, equipment, railway networks, hydrography, land use, relief elements, and road structures. The SPW aims to set up a Georepository in accordance with the INSPIRE directive [2], guaranteeing the quality of geodata. The PICC has been selected as the foundation for this development due to its role as a three-dimensional cartographic reference. With an accuracy of less than 25 cm in x, y, and z coordinates, the PICC is a dynamic geodatabase that continuously updates to reflect the constant evolution of the Walloon territory. Freely accessible through a Web Service via WalOnMap [3], it serves as a fundamental cartographic reference for the management of the region's territory, benefiting various professionals across a wide range of sectors, including network operators and surveyors. Moreover, it is employed as a basis for spatial analyses in combination with remote sensing technologies, supporting applications such as urban object-based classification [4], urban land-cover mapping [5], or roof materials mapping [6]. Similar cartographic projects have also emerged in other regions, such as the "Grootschalig Referentiebestand of Basiskaart" (GRB) in Flanders [7] and UrbIS in Brussels [8], as well as in other countries, including "Plan Corps de Rue Simplifié" (PCRS) in France [9].

In a first study [10], a comprehensive quality control methodology was proposed, focusing on three key geodata features: buildings, road axes, and point addresses. The latter addresses the requirements of the INSPIRE directive [2] regarding quality documentation and the revision of the initial data model. It provides a theoretical basis for validating geodata quality and offers a methodological framework for these processes. To complement this study, it became essential to model the flows involved in the PICC update process, along with the existing quality analysis processes. This is necessary to ensure compliance with current standards and to consolidate and improve these processes where needed. For this purpose, the internationally recognized methodology for business process modeling, known as "Business Process Model and Notation" (BPMN) [11], was employed.

By leveraging the strengths of BPMN, the research illustrates how geodatabases workflows can be optimized, ranging from identifying and removing unnecessary steps or bottlenecks to a complete reengineering of process flows, thereby encompassing the spatial and temporal dimensions of geodata. It also presents a comprehensive framework for representing, analyzing, and interpreting the logic of complex geodata workflows. Applied to the PICC, the cartographic reference in Wallonia, Belgium, it enables stakeholders to gain both a holistic and detailed understanding of the workflow. The overall objectives are multi-faceted: they include advancements in the application of BPMN in geospatial data processing, architectural improvements in the structure of the PICC update process, and practical implementation of these improvements.

This work represents a further step in the collaboration between geographical phenomenon-based and business-based modeling approaches. It aims to capture the complex interactions in real-world phenomena, thereby contributing to the advancement of geospatial data management practices.

The paper is organized into five main sections: The Background and related work section introduces the BPMN, first explaining its general applications and then focusing on its specific use for geospatial data. The Materials section presents the details and history of the PICC. The Methods section describes the BPMN notation and explains the methodologies for constructing and exploiting BPMN diagrams, detailing the steps and approaches applied to facilitate their analysis. The Results section comprises four parts: an explanation of the methodology's application to the PICC workflow, examples of BPMN diagrams with their interpretations, recommendations from the BPMN analysis to improve the PICC workflow and quality controls, and a presentation of implementation perspectives, followed by a final discussion. The last section, Conclusion and Future Work, summarizes the findings and outlines potential directions for future research.

II. Background and Related Work

BPMN is a standardized graphical notation that has become a reference for representing business processes in a highly expressive and graphical manner. It is designed to be comprehensible to all stakeholders in a business process, such as business analysts, technical developers, and managers, bridging the gap between business process design and implementation. The evolution of BPMN began with its inception in 2002 as a visual design layer for transactional workflow systems by BPMI.org, and was later adopted by the Object Management Group (OMG) in 2006 as BPMN 1.0, of which a 2.0 version was released in 2010 [11].

BPMN is one of the several standards in Business Process Modeling (BPM), among them the OASIS group's Business Process Execution Language (BPEL), and OMG's Unified Modeling Language (UML). BPEL is a standard executable language for defining business processes using web services, facilitating orchestration and automation [12]. UML serves the purpose of empowering system architects, software engineers, and developers with the necessary tools to analyze, design, and implement software-based systems, alongside modeling business processes [13].

Reference [14] suggests the advantage of BPMN models over UML models when it comes to addressing complex business-based approaches. In more general terms, the latest process modeling techniques offer a wide scope of coverage, especially due to their high degrees of completeness. In addition, [15] has observed that BPMN models are designed using a small subset of the notation elements, which indicates a focus on the most essential and widely applicable aspects of the notation, ensuring its accessibility and ease of use.

Furthermore, one of BPMN's main benefits is its ability to formalize existing processes, which often leads to the identification of spots needing improvements such as the elimination of unnecessary steps, automation of manual steps, or complete reengineering of the process flow [16]. This formalization is not only beneficial for analyzing current-state processes "as is" but also serves as a foundation for future-state process improvement ("to be") [17].

Besides the benefits, [18], in their review of the state of research on business process simulation, suggests that further research efforts are needed to advance knowledge on business process simulation and its applications.

Regarding the usage of BPMN, as it serves as a standard for graphically representing processes with high expressiveness, organizations predominantly apply it for documentation and for executing business processes, as noted by [17]. Reference [15] explores its application for the design of process collaboration, choreography, and conversation models. Additionally, [19] introduces an automated mapping technique to seamlessly convert BPMN diagrams into executable code. This approach facilitates the correct and fast transformation of the original concepts into software entities, which can then be readily deployed or adapted for business applications.

Geospatial data, characterized by its inherent spatial and temporal dimensions, presents unique challenges and opportunities in terms of modeling and analysis. Traditional approaches often struggle to capture this dynamic nature of geographic phenomena, which evolve over time and space. The utilization of Business Process Model and Notation (BPMN) in geodata processing represents a significant advancement in bridging business process management with the dynamic and complex nature of spatial phenomena. Indeed, its use addresses these challenges by offering a framework that merges spatio-temporal data with business processes at different levels (conceptual, logical, and physical). This provides a unique opportunity to accurately represent, understand, and explain the logic of changes occurring in space and time.

An important aspect highlighted by [20] is BPMN's role in fostering integration and data reuse in geospatial modeling. It promotes the separation between data and process modeling, thereby enhancing flexibility and adaptability as spatial requirements evolve, which is a novelty in the domain of geographical data. Additionally, it enables stakeholders to discuss the scientific conceptual approach underlying this modeling [21].

BPMN also plays a crucial role in standardizing and automating workflows in geodata management. Although current tools do not yet support reading BPMN notation and translating it into Geographic Information System (GIS) procedures [22][23], several studies have explored this area. For instance, [24] proposes a method to enhance the sharing and reproducibility of geospatial workflows. Reference [25] uses BPMN to outline the sequence and execution order of activities, leveraging an application programming interface (API) to identify BPMN tasks that represent geo-services within the workflow. Reference [26] focuses on developing software that employs BPMN for flexible service chaining, creating a reusable workflow toolbox for data qualification. Moreover, [27] applies BPMN notation for Web services orchestration, while [28] proposes a BPMN extension tailored for spatial concerns, and [21] utilizes self-contained BPMN files to provide easy access to metadata associated with geoprocessing.

The practical applications of BPMN in geodata processes encompass a wide range of uses. These include utilizing geodata for crime analysis, transportation, and land use planning [22], qualifying crowdsourced data for policymaking in biological monitoring [26], and developing standardized workflows for publishing cycling infrastructure data as Geospatial Linked Open Data [29]. In agriculture, BPMN has been integrated with OGC Web Processing Service (WPS) standards to streamline processes and enhance data interoperability [30].

An innovative use case highlighted by [31] involves the application of BPMN in online remote sensing analysis for post-disaster assessment. Here, BPMN was employed to structure collaborative workflows that facilitate the extraction and analysis of fire trace areas using remote sensing data. This standardized approach not only reduces errors but also enhances the reproducibility and scalability of collaborative remote sensing analyses.

These applications leverage BPMN's ability to model intricate workflows involving spatial data inputs and outputs, facilitating informed decision-making in spatial planning and policy formulation.

Despite these advancements, [22] notes a gap in tools that translate BPMN notation into GIS procedures, pointing to an area for future development. More broadly, challenges remain in the modeling and execution of business processes involving geospatial data. Reference [20] highlights the need for further collaboration between phenomena-based and business-based modeling approaches to capture the complex interactions in real-world phenomena. Furthermore, complex situations require conceptual frameworks that provide a clearer and more comprehensive description of the data when data needs to be exchanged and understood by different organizations. The PICC update process, a critical base for the Walloon Georepository, is one such complex situation involving several stages, different processes, and disparate data sets. This research aims to address this complexity by applying BPMN to model the PICC update process flows and existing quality analysis processes, focusing on the three main geodata features: buildings, road axes, and point addresses.

III. MATERIALS

The PICC is the detailed map of the Walloon territory. It was initiated by the public authority in 1991 and has since been a spatially continuous representation of the entire territory. The map includes all components of the landscape, such as buildings with their respective addresses, roads with names, axes, edges, and sidewalks, equipment like manhole covers, posts, pylons, and the railway network, hydrography, land use including trees, groves, sports fields, relief elements like embankments, and road structures. Figure 1 shows the elements of the PICC, focusing on significant features like buildings with addresses, roads with street names, and natural features. The complete legend can be accessed through the WalOnMap Web Service [3].

Figure 1. Example of the PICC features on aerial photography 2023.

In the early years, the project was created using photogrammetry. This method allowed for a detailed and accurate representation of the whole territory. The precision of the elements mapped by the project is around 10 to 25 cm, depending on the type of element, which is much higher than any other mapping of the territory. Updates have been carried out since 2008. Figure 2 illustrates the evolution of the PICC in an area of Namur, Belgium, where roads and buildings have undergone significant changes. The left image shows the pre-construction layout from 2015, while the right displays the updated situation in 2023, which

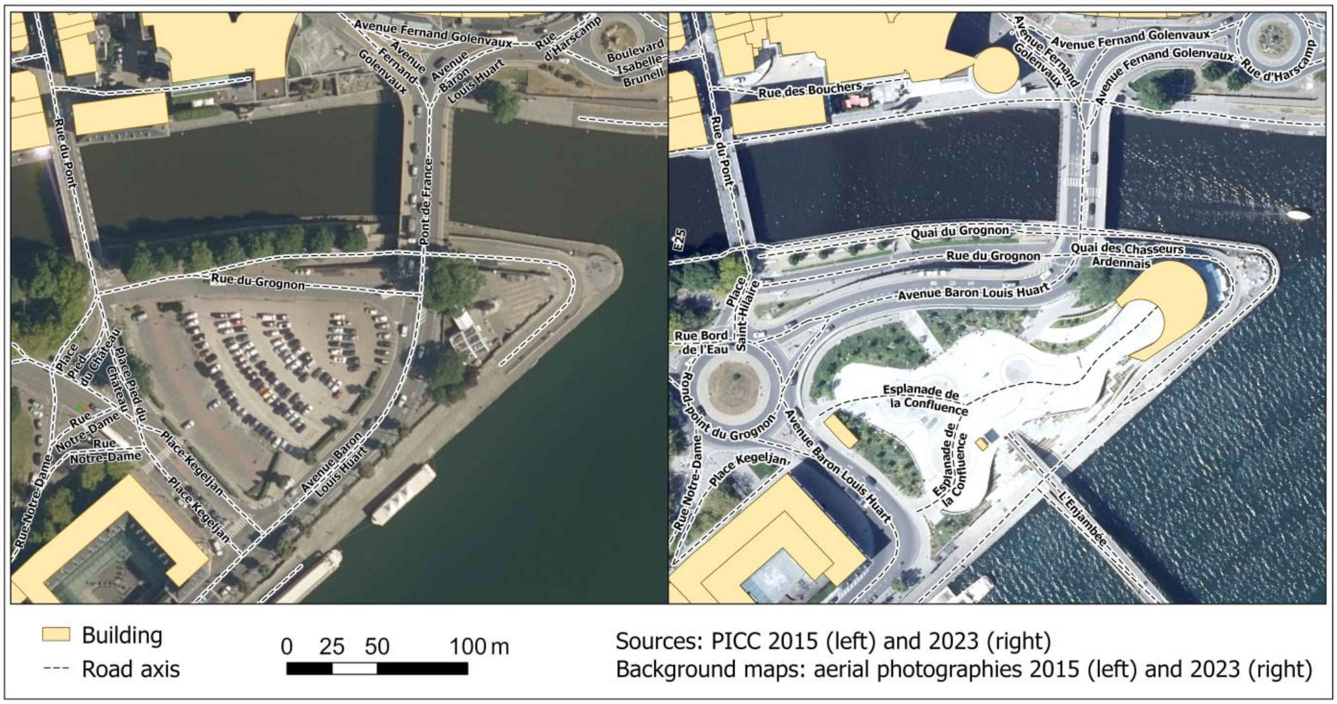

Figure 2. Exemple of changes in the PICC, for road and buildings features, between 2015 (left) and 2023 (right), in Namur, Belgium.

includes the addition of a new bridge and a roundabout, among other infrastructure improvements. This illustration thus demonstrates the results of a complete PICC update process, from the alert of a terrain modification, through field surveys, cartographic integration and distribution.

In 2015, a modernization of the project took place. On the one hand, to standardize topographic survey operations, a method was designed and implemented. This method, called WALTOPO [32], ensures uniform management of the different elements that surveyors and topographers are required to survey in the field. Thanks to this method, surveys contribute more easily to updating the project. On the other hand, a new data model was implemented. The latter, combined with WALTOPO, facilitated the initiation of the first comprehensive PICC data update cycle in 2018. These update cycles utilize annual aerial photography to identify areas requiring updates, which are then complemented by precise field surveys conducted by teams of topographers and surveyors. Additionally, the public authority finances and coordinates various public contracts for topographic, mobile mapping, and photogrammetry surveys, carried out by external providers to ensure complementary updates. Finally, the integration of all these surveys and the dissemination of the updated geodatabase require a structured sequence of steps, combining automated processes with essential manual interventions.

IV. Methodology

This section begins by introducing the BPMN notation and then explains the process of constructing BPMN diagrams and their exploitation for the optimization of geographic databases.

A. BPMN

Effective BPMN diagrams should be correct, clear, complete, and consistent [33]. Based on the diagram alone, the process logic must be clear and comprehensible to a business professional, yet semantically precise, as required by a developer for the underlying XML semantic model in executable BPMN. BPMN provides a complete map of all the paths from the triggering event to any defined end state, as opposed to simply documenting a single instance of the process. It is essential to emphasize that BPMN diagrams are not intended to describe the inner workings of the activities themselves, such as the methodologies.

BPMN notation comprises various elements that outline the process flow and interactions (Figure 3). First, an activity represents an action or a task, and it can be further detailed in a sub-process. A BPMN process is a sequence of activities that transitions from an initial state of the process instance to some defined end state. Moreover, there are different types of flows within BPMN: message, association, and sequence, with the latter describing possible flow paths. Gateways, along with their outgoing connectors, show conditional logic on the process diagram. Additionally, events can alter the flow when exceptions occur or external messages are received. Furthermore, BPMN includes swimlanes and pools, which typically represent the roles or organizational units performing the activities. Finally, artifacts provide additional information that, although informative, does not influence the process flow.

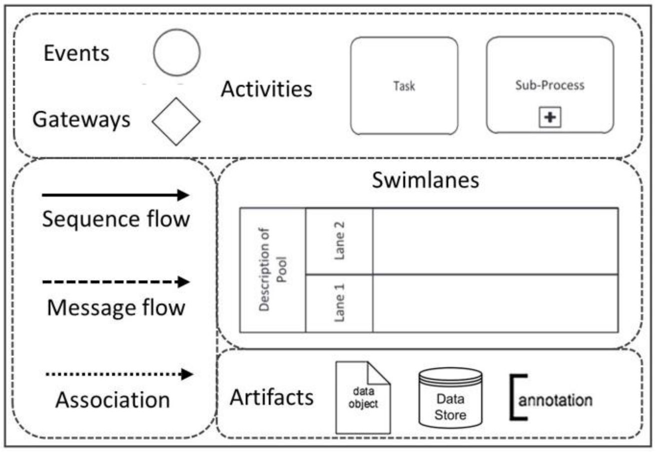

Figure 3. Basic elements in BPMN.

The methodology offers numerous advantages, particularly through its collaborative approach. Indeed, as [33] explains, documenting processes "as is" requires the collaboration of subject matter experts.

B. *BPMN modeling and exploitation*

The construction of BPMN diagrams, to model and analyze process workflows, requires a thorough initial collection of existing information on the processes in question. This data collection phase can be based on four main approaches: (1) conducting a detailed review of legal and regulatory documents to ensure compliance, (2) compiling key process documents and deliverables, (3) designing targeted questionnaires to explore specific activities, and (4) conducting interviews and workshops with relevant stakeholders. The latter are conducted only at a later stage, once sufficient familiarity with the subject matter has been gained. This ensures that discussions are well-informed, avoiding superficial engagement and preventing participants from feeling that their time is not used effectively.

Interviews not only deepen understanding of processes, but also engage different stakeholders, providing more nuanced insights into areas that function well or need improvement. They also allow for comparisons of practices among individuals performing similar tasks, detailing undocumented processes and procedures, and identifying best practices. To guide these interviews, a structured process analysis grid (Table I) can be used, ensuring comprehensive coverage of all relevant information. Specifically for the PICC, following the compilation and analysis of the regulatory and key documents, two phases of interviews were conducted with a total of 20 experts. The first phase provided an overview of the PICC and its updating process, while the second focused specifically on gathering detailed information on the PICC updating processes and procedures.

The information gathered on the relevant processes is then organized to facilitate analysis and modeling. Once the existing data has been compiled, BPMN diagrams are developed, often accompanied by textual descriptions. These diagrams are subsequently reviewed and validated in discussions with the interviewees and other stakeholders to ensure accuracy and prevent loss of veracity.

TABLE I. ANALYSIS GRID FOR STRUCTURED INTERVIEWS

Task framework	**Description**
Who	Name, job title, responsible for which tasks, how many people perform the same task
What	Result of the task, deliverable
Why	Purpose or reason for this task
When	Triggers (arrival of data, date...)
Input	What is needed for carrying out the task / producing the deliverable
How	Actions to be taken to carry out the task, decisions & why
How many times	Repetition & timing of the task
How long	Average processing time, volume (per year, month, day...)
Quality criteria	Completeness, accuracy, precision
Guidelines	Guidelines availability, theory vs practice
What if	Impact if the task is not performed
Problems	What? Cause? What works and what doesn't / sources of blockage (money, hierarchy,...)
Exceptional cases	Does exceptional cases occur
Suggestions for improvement	What? Why? How?

Once the BPMN diagrams are finalized, they are analyzed and strategically leveraged. A synthesized overview of findings and areas for improvement across different process levels, aligned with the evolving goals of geodatabase updates, is compiled. The methodology enables the prioritization of improvements, specifically emphasizing achievable "quick wins": immediate, low-cost improvements that reduce workload, establish short-term credibility, and enhance process comprehension.

This structured approach enables a balance between rapid adjustments and long-term strategic optimizations, ensuring sustained impact. The synthesized findings are then reviewed with stakeholders to facilitate the effective implementation of the recommended improvements.

V. RESULTS AND DISCUSSION

The results section begins by examining the application of BPMN to the PICC update process. Then three BPMN diagram examples are presented to analyze activities, interrelationships, and identify inefficiencies, such as bottlenecks, exceptions, and duplications. The next sub-section discusses the outcomes of a comprehensive analysis across all diagrams, offering recommendations to enhance the PICC update process. This is followed by a sub-section detailing the process of user adoption and implementation of these recommendations, concluding with a final discussion.

A. BPMN application to the PICC

An initial outline of the general update workflow was drawn up (Figure 4), as PICC is complex and involves several stages, different processes, and disparate data sets.

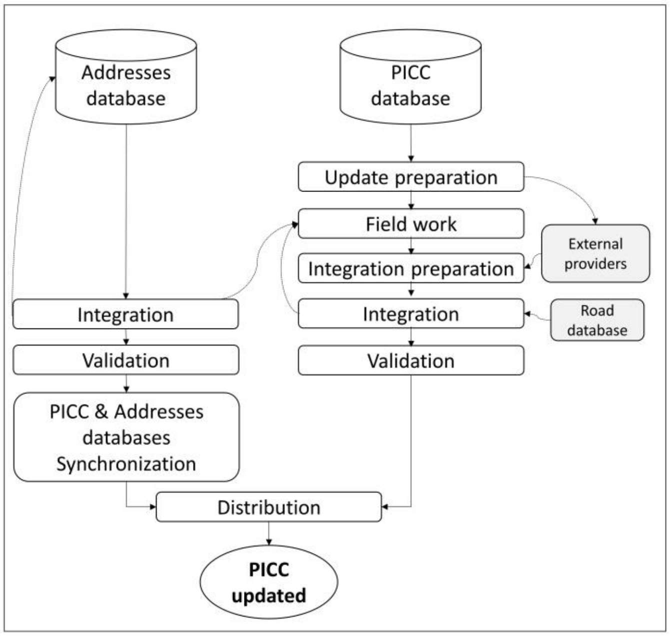

Figure 4. The PICC update workflow.

The workflow begins with two separate databases: the "PICC database" and the "Addresses database". This arrangement stems from the coexistence of the PICC database with an official database specially designed for address management. These databases thus serve as the starting points for the update process, with the two branches converging only at the final "Distribution" step.

The "Addresses database" branch involves several steps: "Integration", "Validation", and subsequent synchronization between the "Addresses database" and the "PICC database".

The "PICC database" branch involves a more complex series of steps, beginning with "Update Preparation", followed by "Field Work", and then "Integration Preparation". During the "Update Preparation" step, detailed specifications and necessary information are provided to external providers to conduct complementary topographic surveys. The data gathered from these surveys are later reintroduced during the "Integration Preparation" step. The "Integration" process itself incorporates data from the Road database. This is followed by a "Validation" step before progressing to the final stage, "Distribution," where the completed database is disseminated.

With the help of this workflow, the BPMN diagrams were then directly co-constructed with the experts to avoid any misinterpretation or errors. This collaborative approach not only enhances accuracy but also engages experts actively in the project, facilitating change management when necessary improvements are identified. "Bizagi Modeler" was used as it is open-source software for creating visual diagrams, modeling, and documenting business processes based on the BPMN standard.

The outcome of this analysis is a set of seven distinct processes, each further divided into sub-processes, for a total of 36 diagrams, as shown in Table II. These diagrams, when combined, offer a complete and detailed vision of the PICC update process, providing both a high-level overview and a deep dive into each step.

In addition, the diagrams are designed to highlight the processes and sub-processes in which quality controls are present. These are indicated in bold in Table II.

A first review of Table II reveals that quality control procedures are embedded in all processes except for the one associated with the addresses database. This absence of quality control measures in the addresses database processes represents a significant issue that will require further improvement.

B. BPMN exemples and interpretation

The analysis of BPMN diagrams themselves facilitates the determination of the steps following the completion of an activity. The primary objective is to systematically examine the various activities, their interrelationships, potential bottlenecks, exceptions, event-related behaviors, and possible omissions or duplicated activities. It should be noted that BPMN analysis focuses on the flow and structure of processes, rather than the internal methodologies of individual activities.

Figure 5 presents an example of one of these diagrams, where external data is used as input for the integration of changes in the PICC. Specifically, it presents the integration of the Road database into the "Integration" process of the PICC database branch from the PICC update workflow shown in Figure 4.

The diagram begins with an event labeled "Road database message received". This event marks the initiation of the process, triggered by a notification from an external source, specifically the road database team, which operates outside the organization responsible for the PICC. Typically, the notification includes images or drawings of the modifications that need to be implemented into the PICC. This event is followed by an activity titled "Prepare version", which is the work version for integration. This task is executed automatically after the manual launch. After the completion of this task, changes are manually entered into the work version database, entity by entity. Each evening, an automated reconciliation occurs with the main database. This sub-process is detailed in another BPMN diagram. Following the completion of the "Digitize in PICC db" task and the update of the work version, a secondary digitalization process is required in the road database, termed the "Digitize in Road db" task. The workflow then diverges into two paths at a parallel gateway. One path involves notifying the road database team of the completion of changes integration. Simultaneously, the other path results in a task that determines whether field data collection is necessary to ensure compliance with PICC updates. This last task leads to an exclusive gateway where a decision is made regarding the necessity of field work. If required, modifications are added

TABLE II. BPMN DIAGRAMS OF THE PICC UPDATE

Sources databases	**BPMN diagrams**		
	Main processes	***Sub-processes***	***Sub-processes***
Addresses database	Addresses database branch	Research missing data	
		Integrate	Integrate map
			Integrate addresses from digital plan
			Implement addresses
			Validate addresses
PICC database	Update preparation		
	Field work	Prepare field work	
		Conduct field surveys	Measure in the field
		Deliver field surveys	
		Receive field data	
		Control field data	
	Integration preparation	Receive data (field and external data)	
		Control data quality	**Control data quality details**
			Control entity quality
		Distribute field data	
	Integration	Prepare field data	**Control for integration**
		Implement field data	
		Reconcile automatically	
		Finalize implementation	
		Road database integration	
	Validation	**Control**	
		Reconcile	
		Finalize	**Reinject - Quality**
	Distribution	**Prepare PICC vDIFF and vTOPO**	**Control quality**

to the inventory of updates to be field measured. If not, or once the inventory is updated, the process concludes in the “Road db Integration ready for validation” end event. Subsequently, this event is linked to the “Validation” process as depicted in Figure 6.

The analysis of this BPMN diagram identifies areas requiring improvement. Specifically, it highlights redundant manual digitization processes for the PICC and road databases, nearly doubling the processing time and potentially resulting in discrepancies between the two databases.

Figure 6 shows another example of a diagram, the “Validation” process, which is divided into three sub-processes. The process commences with a start event labeled “Integration completed”, signifying the beginning of the process after the integration process. This leads to a “Control” sub-process, which is detailed in another BPMN diagram. This sub-process involves verifying whether errors were made in the integration process and correcting these errors if needed. After the “Control” activity, the process flow transitions to the “Reconcile” activity. Similar to the previous step, “Reconcile” is a sub-process, indicating that this stage involves additional processing. The aim of this sub-process is to ensure the absence of conflicts between the work version for integration and the main database. At this stage, the results of the "Road database integration" process (Figure 5) are incorporated. Following the “Reconcile” activity, the process flow reaches the last sub-process, labeled “Finalize”. Through this sub-process, the BPMN diagram concludes with two end events representing the two outcomes of the process: “Integration ready for distribution” event indicates that the geodata “Validate” process is complete and the data is ready for distribution, while “PICC

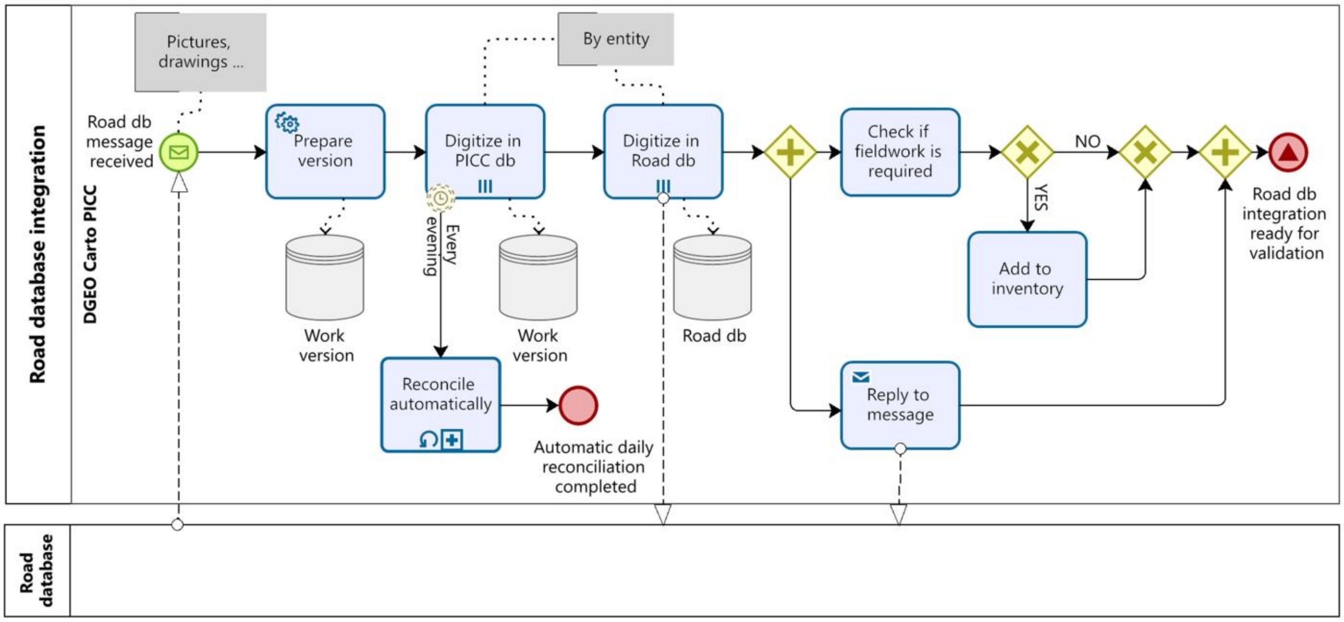

Figure 5. Diagram example: sub-processes of the PICC update "Integration" process.

age updated" represents a terminal point that does not transition to another process, as it constitutes the foundation of the overarching global process (Figure 4).

One key point this diagram illustrates is the interconnections between the various diagrams, with the start event of the second sub-process corresponding to the end event shown in Figure 5. The diagram analysis also highlights another key point: modifications related to the road database are exclusively assimilated during the reconciliation stage, thereby excluding any control over changes integrated into the PICC. This limitation needs to be improved and is the subject of one of the recommendations.

The last example concerns a sub-process of the "Distribution" process (Figure 7). It represents a sequence of fully automated activities, with no operator intervention, related to the preparation of the PICC geodata for distribution.

The first task is to read the main database, which was updated during the previous "Validation" process. This is followed by quality control, which is detailed in a sub-process and involves the geometry, attributes, and topology of modifications made to the main database. The model is then transformed, meaning that the main database must be adapted to match the PICC vDIFF and vTOPO models. An exclusive gateway, which depends on the type of object, allows two different paths.

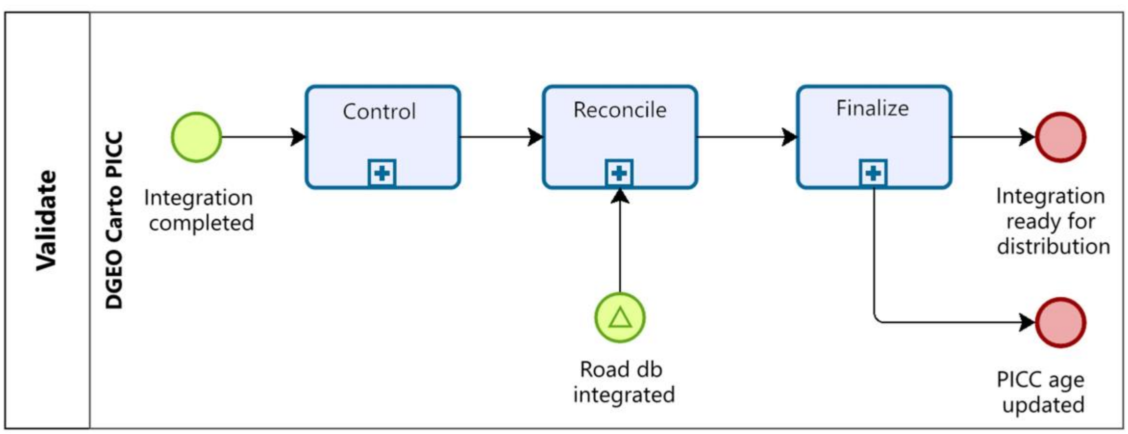

Figure 6. Diagram example: the PICC update "Validation" process.

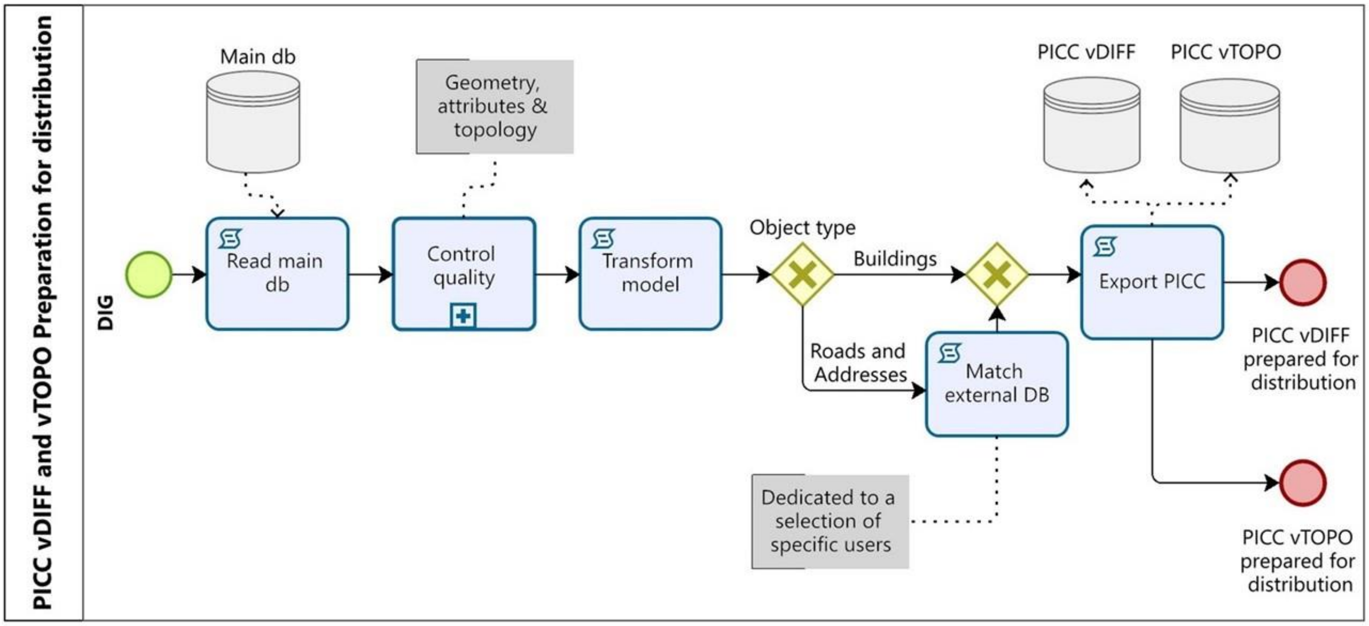

Figure 7. Diagram example: sub-processes of the PICC update "Distribution" process.

The BPMN examples shown above were selected for their clarity. In practice, many BPMN diagrams describing the PICC update process are much more complex, involving intricate workflows and detailed analyses to address the full scope of geospatial data management challenges.

C. PICC improvement recommendations

Analysis of all 36 diagrams, as shown in Section V B, facilitated optimization suggestions for PICC. As mentioned by [33], BPMN is particularly effective for representing exception handling and event-driven behavior. Recurring observations were identified across multiple processes and sub-processes, complemented by specific observations corresponding to particular processes or sub-processes and more general remarks.

Regarding quality control tasks, a list was first established. Then, a comparison was made with the proposed quality control methodology formulated by [10] to identify the missing, incomplete, or duplicate controls. This led to specific recommendations for improving the overall quality control process.

As a result, a set of 57 recommendations was compiled and consolidated into a comprehensive report accompanied by a detailed table. The table was designed to serve as a decision-making tool. For each recommendation, additional information was provided to the stakeholders to facilitate the prioritization of the necessary improvements. First, four levels of application were identified, each requiring varying degrees of modification of the PICC update workflow:

- Improvement of existing processes and sub-processes, without radical changes to activities;
- Radical changes to activities within existing processes, which may also change the sub-processes;
- New sub-process within current main processes;
- Redesign of a main process or the structure of the processes.

Detailed information was then provided on the following aspects of the recommendations:

- The geodata type: buildings, roads, and addresses;
- The specific process or processes among the seven listed that the recommendation relates to, or whether a new process is required. Some recommendations suggest a general redesign of the entire PICC update process;
- The detailed information about the recommendation;
- If the recommendation is linked to quality controls;
- Which stakeholder the recommendation concerns, and whether it involves external stakeholders;
- Whether new skills are required among the stakeholders;
- Whether the required budget ranges from low to high;
- The estimated timeframe required to implement the recommendation.

In the context of this decision-making tool, it is crucial to acknowledge that simultaneous implementation of all recommendations is neither desirable nor possible. Therefore, they need to be carefully selected and aligned to achieve the most feasible and effective improvements, while being attentive to the objective of improving the quality of the PICC update.

D. Technical Insights and User Adoption

The set of 57 recommendations suggesting improvements and innovations in the current PICC update is being analyzed by the production teams in a participative manner. Specifically, these recommendations have been divided into five working groups: processes linked to the addresses database branch, field survey, update preparation, integration-validation and distribution. Through participatory workshops, each recommendation is discussed and evaluated. Several elements are defined: current status, order of priority, resources required, implementation manager and team, deliverables, and timeframe. Dependencies between recommendations are also discussed. At the end of this process, a Go/No Go decision is specified for each recommendation, and regular monitoring of implementation is initiated.

By way of illustration, the first results of the participative approach applied to the "Distribution" working group, which has already started, can be examined. At the end of the first workshop, the recommendation to simplify the distributed products, namely the possibility of grouping the vDIFF and vTOPO models into a single output, was evaluated. This recommendation is consistent with the expectations of the distribution team. In this sense, a maximum priority was defined, the necessary resources were identified, and the time frame set, with an achievement objective set for mid-2025. Different actions were identified, the main one being to question users of the vTOPO model specifically in order to assess their needs and any constraints linked to the unification of the disseminated model. An online questionnaire has been set up and the results are expected very soon. Such a unification would lead to the modification of the BPMN presented in Figure 7, with the distribution of a single version of the geodatabase (a single output for this BPMN), improving the efficiency of the updating process and limiting the redundancy of the information distributed to different users.

This participatory approach will now be transposed to the other working groups. BPMN diagrams, as presented in Figures 5 and 6, offer a visual side useful for understanding observations and recommendations. All stakeholders involved in this particular process can thus easily understand the scope of the developments discussed, and define realistic solutions accepted by all.

A follow-up of all the recommendations has been established and will make it possible to obtain an improved version that meets the needs of as many users as possible of the PICC and its production and updating method.

E. Discussion

The use of BPMN in a geodatabase update process has highlighted the potential for significant improvements in both workflow optimization and the challenges inherent in adapting business-based modeling approaches to spatial data contexts. BPMN provides a structured, visual approach that is particularly effective for identifying and addressing inefficiencies within the complex, data-intensive workflows characteristic of geographic databases. Through the example of the PICC update process, BPMN has shown its ability to capture intricate workflows, facilitating not only process standardization but also the identification of inefficiencies and opportunities for automation. These capabilities make BPMN especially valuable in contexts where spatial data accuracy and update efficiency are critical.

A significant benefit of BPMN in geographic databases management is its versatility: BPMN diagrams serve as both documentation tools and actionable roadmaps, guiding stakeholders in implementing immediate "quick wins" as well as long-term optimizations. This structured approach is well-suited to the evolving needs of geodatabases, where continuous updates are necessary to reflect dynamic spatial information. Moreover, stakeholder engagement has proven crucial to BPMN's effectiveness. By involving users in different stages, from construction to validation and refinement of models, this methodology fosters a collaborative approach to process improvement, ensuring that the proposed adjustments are practical and aligned with user requirements. This participatory framework has broad applicability to other geographic databases, as user insights support sustainable improvements in data management practices.

Besides these advantages, using BPMN in geographic data workflows presents certain challenges. Although it is based on official documentation and stakeholder collaboration, manual BPMN modeling may introduce subjectivity, as models partly rely on user input that may not fully capture the complexities of spatial data workflows. In this context, combining BPMN with process mining techniques could enhance model accuracy by providing data-driven insights into actual workflows, thus offering a more objective foundation for model refinement and process improvements. This integration could further reinforce BPMN's effectiveness as a robust tool for managing geographic databases. To build on these findings, future work could also apply this framework to other geographic databases in order to assess the adaptability and broader applicability.

VI. Conclusion and Future Work

In conclusion, this paper has proposed an innovative integration of real-world phenomena with business-based modeling by using BPMN for geospatial data management. This approach addresses the critical need for more collaboration between phenomena-based and business-based modeling to effectively capture complex interactions, as highlighted by [20].

This study has documented the sequence of activities from the preparation of what needs to be in the PICC for its update, to the distribution of the updated version of the PICC, for a total of 36 diagrams representing seven processes and their sub-processes. It has enabled the identification of the quality control steps in order to improve them within the framework of the INSPIRE directive requirements.

Through the presentation of example diagrams, the study demonstrated that the application of BPMN has led to substantial recommendations for improving the entire PICC update workflow. Some of these recommendations have already been implemented, leading to a more efficient update process. Future work will focus on analyzing the remaining recommendations and their potential for implementation, and evaluating their effectiveness using the same BPMN methodology. This continuous process of evaluation and improvement underscores the dynamic nature of BPMN in geodata processes.

These findings have important implications for the field of geospatial data management, suggesting that BPMN can be a powerful tool for streamlining processes, strengthening quality controls, and optimizing data architecture. BPMN has offered, among other benefits, the advantage of providing an exhaustive vision, both globally and in-depth, of the processes.

The BPMN diagrams also served as a valuable tool for understanding, communicating, and improving complex geodata workflows, contributing to more efficient and effective geodata management practices and data quality. Understanding such diagrams is crucial for professionals involved in managing complex data workflows like those found in GIS, where accurate data handling can have significant real-world implications.

A potential direction for future research is the application of the lessons learned from this study to other geospatial data management projects. This could lead to the development of new best practices and standards in the field, contributing to the ongoing evolution of geospatial data management.

However, challenges remain and continuous efforts are needed to effectively merge phenomena-based and business-based modeling approaches, ensuring the full potential of BPMN in geodata processes is realized.

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