# Automating GIS-Derived Site Plans for Digital Building-Permit

Fatma Ahmad[1] and Ralf Becker[1]

[1]Chair of Computing in Civil Engineering and Geoinformation Systems and Geodetic Institute (gia), Aachen, Germany

E-mail(s): fatma.ahmad@gia.rwth-aachen.de, ralf.becker@gia.rwth-aachen.de

**Abstract:** This research presents an approach to automate the generation and validation of regulatory-compliant building site plans by integrating Geospatial Information Models (GIM) and Building Information Modeling (BIM). The methodology uses Industry Foundation Classes (IFC) and CityGML to turn authoritative cadastral and zoning information into semantically rich IFC models, then exports them as XBau-compliant XML for automated permit-data exchange and rule checking. The workflow relies on precise georeferencing and boundary representation (B-Rep) modeling to define permissible building volumes constrained by the building line (Baulinie), the building boundary line (Baugrenze), and the property-line (Grundstück). The prototype employs open-source tools like ifcopenshell and demonstrates potential violations through geometric analysis. This approach streamlines building permit approval processes, reduces manual effort and errors, and advances digital transformation goals within Germany's building sector.

*Keywords:* BIM, Digital Building Permit, Digital Building Application, GIM, IFC

DOI: 10.18154/RWTH-CONV-254927. Published in the conference proceedings of the 36. Forum Bauinformatik 2025, Aachen, Germany,


## 1 Introduction

In Germany, a building permit (*Baugenehmigung*) is required before constructing, modifying, or demolishing a structure; building application (*Bauantrag*) documents—architectural drawings, structural engineering checks, energy reports and the (official) site plan (*amtlicher Lageplan*)—are still submitted as paper or PDF bundles and manually checked against zoning (*Bauplanungsrecht*) and building code (*Bauordnungsrecht*), often prompting queries and resubmissions. In 2023, 260,100 permits were approved—the lowest since 2012—with processing times of 4–8 weeks for simple cases and several months for complex ones, and a federal reform now requires all states to adopt a three-month "deemed-approved" deadline (*Genehmigungsfiktion*) by 2026. To address delays, Fauth et al. [1] call for digital transformation; since 2017, XPlanung and XBau standards have enabled structured data exchange (fully rolled out by 2022), and Mecklenburg-Western Pomerania's 2021 *digitaler Bauantrag* under the "Einer für Alle" model integrates BIM/IFC models and cadastral data for automated, paperless permitting.

Long before an architect models a building, the site plan establishes the legal and physical framework for a project by capturing parcel boundaries, existing buildings, topography, access roads, easements, utility corridors, and the proposed footprint. Survey-grade coordinate geometry ensures boundary accuracy, exposes hidden constraints, and underpins compliance checks and risk assessments. However, submitting the site plan as a flat PDF breaks the digital workflow, as automated engines require explicit geometry, topology, and semantics to verify rules for eg. "minimum clearance 3m from the property line." By creating an open, semantically rich 3D model, this work unifies survey precision with BIM and GIS context, enabling automated compliance checking, seamless data integration, and practical application across all project stages, from site planning to city-level analysis. This paper's novelty lies in three main contributions. The integration of BIM and GIS into a standardized 3D site-plan model, machine-readable regulatory compliance verification, and practical validation through three real-world projects.

The remainder of this paper is structured as follows. Section 2 introduces the associated project overview followed by related work and technical background. Section 5 describes the methodology of the schema transformation between CityGML and IFC on a use case. Finally, Section 6 discusses the results and Section 7 concludes and discusses the outlook direction.

## 2 Project Overview: *"3D-LagePlan zum Baugesuch"*

To bridge the gap between survey-grade site plans and Germany's digital building permit workflow, the federally funded research project "3D-LagePlan zum Baugesuch" was launched within the *Zukunft Bau* programme. [2]. Over 24 months, a consortium coordinated by the *Bund der Öffentlich bestellten Vermessungsingenieure e. V. (BDVI)*—including KDS Köln, the Geodetic Institute & Chair of Computing in Civil Engineering & GIS at RWTH Aachen, the Chair of Geoinformatics at TU Munich, HHK Datentechnik, and the federal XPlanung/XBau Coordination Office will deliver Germany's first standardized, BIM-ready 3D site-plan model for seamless integration into digital building applications.

By unifying BIM and GIM data into a single information model and automating compliance checks, the project enables planners and authorities to exchange data effortlessly and verify against XBau standards. This end-to-end digital workflow reduces paperwork, minimizes errors, accelerates approvals, and lays the foundation for smarter cities and a more responsive construction sector.

To validate and refine its prototype software in practical settings, the consortium will apply the new digital processes to three real-world projects: a school, a housing block. Feedback will be gathered to ensure the system's robustness and versatility.

## 3 State of the Art

Digital permitting is advancing, but data silos, low automation, and non-machine-readable rules still hinder widespread adoption [3]. BIM–GIM integration supports zoning, yet semantic gaps and incomplete datasets persist [4], and existing rule checks often depend on manual georeferencing [5]. Recent reviews highlight the central role of georeferencing for reliable BIM–GIS integration [6], while new research stresses the need to formalize data requirements for digital permitting processes [7]. Semantic approaches for IFC–CityGML interoperability show promising results [8]. The 3-D "SitePlan ADE" demonstrates how cadastral detail can be incorporated [9]. However, a fully automated standard workflow is still missing. We therefore introduce a lightweight tool that georeferences BIM, exchanges data via XBau, and enables surveyor-certified, rule-compliant submissions.

# 4 Technical Background

### Geo-referencing

Geo-referencing BIM models is crucial because local coordinates in BIM tools often do not match real-world positions. IfcProjectedCRS defines the target projected coordinate system, and IfcMapConversion handles scaling, rotation, and translation from local coordinates. The transformation can be expressed as a 2D Helmert equation for horizontal coordinates:

$$\begin{bmatrix} X_{\text{UTM}} \\ Y_{\text{UTM}} \end{bmatrix} = s \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix} \begin{bmatrix} X_{\text{local}} \\ Y_{\text{local}} \end{bmatrix} + \begin{bmatrix} t_x \\ t_y \end{bmatrix}, \quad Z_{\text{UTM}} = Z_{\text{local}} + t_z \tag{1}$$

where $s$ is the horizontal scale, $\theta$ the rotation angle, and $t_x, t_y$ the translations. In equation (1), $s$ vary based on the distance of the location from the central meridian, potentially affecting parcel boundaries or zoning compliance. In Revit, this is set via the Project Base Point and exported as IfcMapConversion and IfcProjectedCRS in IFC4+. IFC export for geo-referencing:

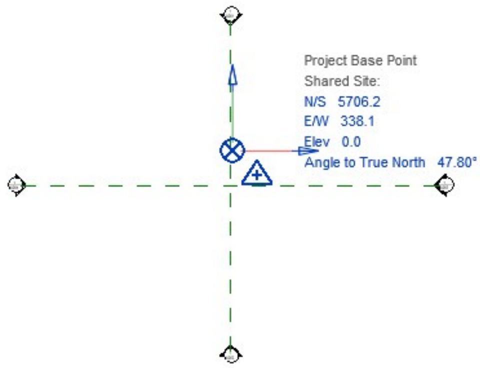


Figure 1: View aligned to Project North

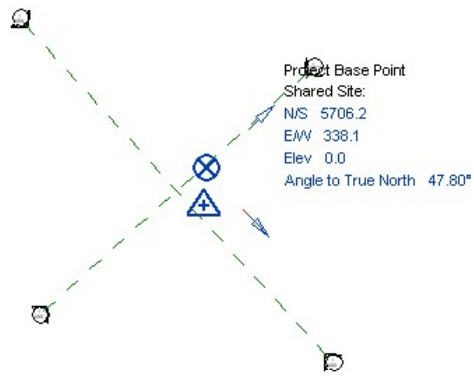


Figure 2: View aligned to True North (Revit)

```
#27 = IFCPROJECTEDCRS('EPSG:25832','ETRS89',,,,#SI_UNIT_METRE);
#28 = IFCMAPCONVERSION(#22,#27, 338.1, 5706.2, 0.0,
                        0.672708, -0.739911, 1.0);
```

Here, the rotation angle $\theta$ is encoded via its cosine and sine values: $\cos\theta = 0.672708, \sin\theta = -0.739911$. If the angle is given in degrees, it is first converted to radians before computing these values. The scale is 1.0 due to Revit export limitations.

# 5 Methodology

## 5.1 Requirement Analysis

Developing a prototype begins with a data-independent model that captures all inputs required for an official building application. Müller [10], in his master's thesis, analyzes the 3D requirements for the official site plan (*amtlicher Lageplan*) based on *BauPrüfVO NRW* §3 (24.07.2020). He categorizes object types, data sources (e.g., cadastral data (ALKIS), CityGML building models, surveyor on-site captured data), and distinguishes between existing/planned and topographic/conceptual data—forming a solid foundation for defining 3D Lageplan inputs.

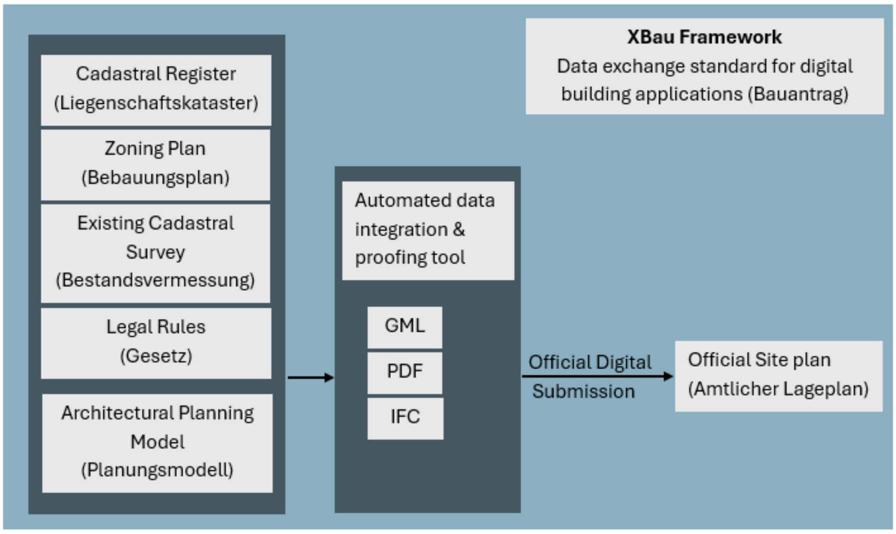


Figure 3: Processing pipeline for generating an official digital site plan.

This research focuses on the geometrical components of the application. Key elements from the site plan include: building lines, building boundary lines, property-line, and LOD2 (Level of Detail 2 ) CityGML building models with terrain.

These data are standardized through Germany's cadastral and planning systems. The AAA model (AFIS-ALKIS-ATKIS) provides legal and topographic baselines—especially ALKIS for parcels and boundaries. Planning data such as building lines are delivered via the national *XPlanung* standard, used for digital land-use and development plans (*Bebauungspläne*). LOD2 CityGML data is obtained from *Geobasis NRW*, the authoritative agency in North Rhine-Westphalia.

## 5.2 Geo-referencing of the IFC Model

To ensure compatibility with official datasets (e.g., ALKIS, CityGML), the IFC model is geo-referenced to German standard systems: ETRS89 / UTM Zone 33N (EPSG:25833) for horizontal and DHHN2016 for vertical reference. Using the `IfcMapConversion` class ( IFC4+; see Section 4), the model's local coordinate reference system is mapped to the projected CRS through translation, rotation, and scaling. This enables spatial alignment with authoritative geodata while preserving the model's internal coordinate logic.

## 5.3 Schema Transformation between CityGML and IFC Data Models

### 1. Input Data Acquisition and Preprocessing

Official site information—parcel (GML coordinates), cadastral attributes (ALKIS IDs), and regulatory lines (building line, building boundary line) geometry are extracted using GML parsers, validated for topological correctness, and stored as intermediate geometric primitives like Cartesian points. See figure 4.

**Data Mapping and Semantic Annotation**

CityGML features are converted into IFC by mapping property-lines to `IfcSite` (using its `IfcSite.Representation`) encoding zoning attributes derived from XPlanung into `IfcPropertySetDefinition`, and representing regulatory constraints as surface geometry under `IfcProxyElement`. See figure 5. (Figure 4 and 5 are made with QGIS)

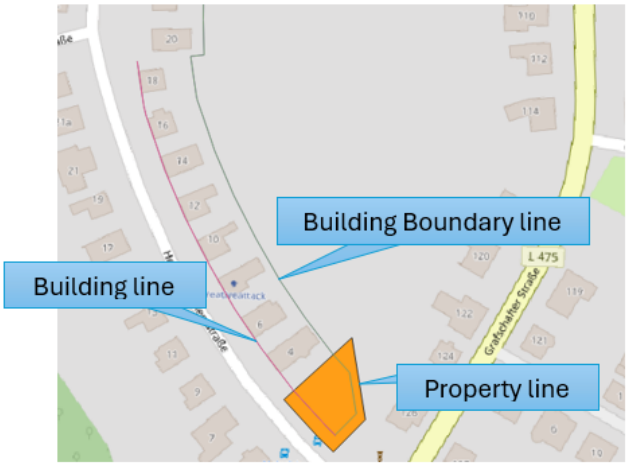


Figure 4: Site plan constraints in GIS data model

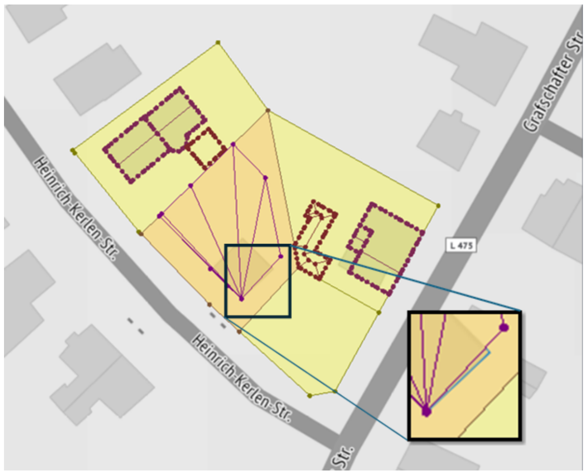


Figure 5: Parcels and buildings in IFC data-model.

**3. Addressing Linear Constraints in IFC**

Instance classes such as `IfcExtrudedAreaSolid` and `IfcSweptSolid` is challenging because they require closed planar profiles with thickness. Since linear constraints lack area or volume, they cannot be modeled directly without introducing artificial thickness, which in turn leads to approximation errors and a reduction in buildable volume.

**4. Boundary Representation (BRep) Implementation**

To accurately preserve regulatory constraints (Planzeichnungsverordnung § 3)[11], a pure Boundary Representation (BRep) approach is implemented using `IfcFacetedBrep`; see Algorithm 1 [12]. The final buildable volume, which serves as a spatial envelope for architectural design, is computed by applying constraints such as the building line, building boundary line and property-line boundaries. Additional parameters, including building height limits and setbacks from existing structures, can be incorporated in future developments of the model. A visual representation of the resulting buildable volume is shown in figure 6.

### 5.4 Validation of Models Against XPlanung Requirements

The resulting IFC model includes accurately defined B-Rep volumes that represent the permissible building envelopes. Automated scripts can traverse these volumes to extract dimensional parameters such as maximum allowed heights and buildable volumes and perform compliance checks based on spatial planning constraints derived from XPlanung data (see Section 5.1).

Geometric inconsistencies, such as elements extending beyond the defined regulatory B-Rep constraints, are flagged for revision. As shown in figures 7 and 8, the modeled geometry complies with

**Algorithm 1** Boundary Representation in IFC for allowed buildable Volume

**Geometric inputs:** building line, building boundary line, and property-line
**Output:** IFC-compliant volumetric representation using `IfcFacetedBrep`
**Profile Construction:**
  Concatenate building line, building boundary line, and property-line
  Form a closed planar loop of 3D Cartesian points
**Shell Topology Definition:**
**for** each looped surface **do**
  Create `IfcFaceOuterBound` or `IfcFaceBound`
  Define the face as an `IfcFace` instance
  Apply geo-referencing using 2D Helmert transformation.
**end for**
**Solid Assembly:**
Aggregate all faces into an `IfcClosedShell`
Instantiate `IfcFacetedBrep` using the shell.
**Integration:**
Insert the `IfcFacetedBrep` into an `IfcProxyElement`
Link the proxy to the `IfcSite` using `IfcRelContainedInSpatialStructure`, as per IFC standard.

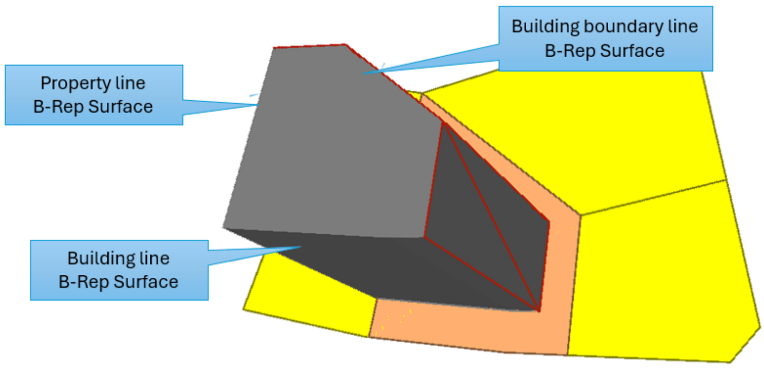


Figure 6: Buildable volume formed by regulatory constraints as surfaces, modeled into B-Rep solid.

the respective building line and property-line constraints. However, figures 5 and 9 indicate that the building boundary constraint has been violated.

Such validations can be automated using the `IfcOpenShell` library, which enables geometric analysis on IFC models. For advanced rule-based checking and regulatory validation, tools like Solibri Model Checker can be used to perform XPlanung-compliant spatial checks and generate comprehensive reports.

## 6 Results

The workflow converts CityGML-based parcel and zoning data into IFC proxy elements, modeling regulatory constraints as `IfcFacetedBrep` surfaces. This B-Rep approach preserves geometric accuracy and ensures alignment with legal envelopes. Geo-referencing via `IfcMapConversion` anchors the model in projected coordinates for integration with cadastral and topographic data. Automated

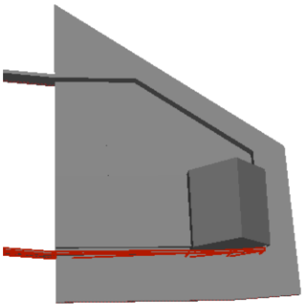

Figure 7: Building line

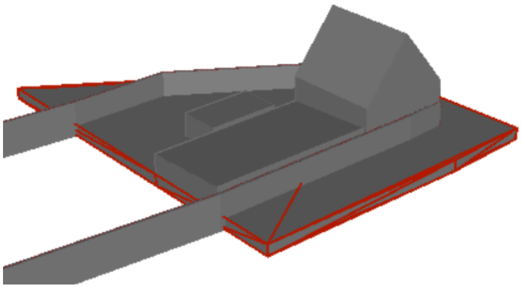

Figure 8: Property-line

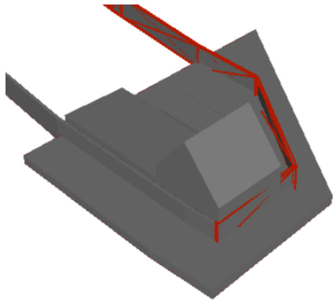

Figure 9: Building boundary line

checks using `IfcOpenShell` extract height and volume metrics, confirming compliance with building lines and parcel boundaries, while detecting violations such as building boundary line overreach. These results demonstrate the method's effectiveness for precise, rule-based validation within the IFC schema.

## 7 Conclusion and Outlook

The proposed method improves the accuracy and efficiency of digital permitting by enabling precise IFC modeling and automated constraint validation. It supports seamless integration of authoritative planning data (XPlanung) into BIM, and provides a XBau communication and data exchange standard ready 3D site plan.

However, several limitations remain. Different municipalities may interpret zoning regulations differently, which can complicate standardized rule checking. Current checks focus on basic constraints such as building lines, parcel boundaries, and height limits, while other rules required for building permits. Such as usage restrictions, protected or heritage areas, and public infrastructure constraints, are not yet fully integrated. In the scope of this research, Machine-readable interpretation of legal texts is still limited. Future work will implement the CityGML 3.0 model capabilities to extend validation to cover additional rules, such as height limits and setback requirements. Integration with commercial platforms like Solibri could enhance compliance reporting. This approach marks a step toward fully automated permitting, advancing Germany's digital transformation in construction.

## Acknowledgements

The authors express their gratitude to our project partners: Bund der Öffentlich bestellten Vermessungsingenieure (BDVI), Vermessungsbüro KDS – Semler · Schult Öffentlich bestellte Vermessungsingenieure (ÖbVI) and the Technical University of Munich (TUM) for their contributions. This research was supported by funding from the German Federal Institute for Research on Building, Urban Affairs and Spatial Development (grant number 10.08.18.7-24.23.3).

## References

[1] J. Fauth and L. Soibelman, "Conceptual framework for building permit process modeling: Lessons learned from a comparison between germany and the united states regarding the as-is building

permit processes", *Buildings*, vol. 12, no. 5, 2022. DOI: 10.3390/buildings12050638 [Online]. Available: https://www.mdpi.com/2075-5309/12/5/638

[2] Bundesinstitut für Bau-, Stadt- und Raumforschung, *Förderprogramm „Zukunft Bau" – Projekt 3D-Lageplan zum Baugesuch*, Projektsteckbrief, BBSR, 2024. [Online]. Available: https://www.3d-lageplan.org/zukunft-bau-forschungsprojekt

[3] M. Ataide, O. Braholli, and D. Siegele, "Digital transformation of building permits: Current status, maturity, and future prospects", *Buildings*, vol. 13, no. 10, 2023. DOI: 10.3390/buildings13102554 [Online]. Available: https://www.mdpi.com/2075-5309/13/10/2554

[4] Y. D. Altıntaş and M. E. İlal, "Integrating building and context information for automated zoning code checking: A review", *Journal of Information Technology in Construction (ITcon)*, vol. 27, pp. 548–570, 2022. DOI: 10.36680/j.itcon.2022.027 [Online]. Available: https://doi.org/10.36680/j.itcon.2022.027

[5] F. Noardo, T. Wu, K. A. Ohori, T. Krijnen, and J. Stoter, "Ifc models for semi-automating common planning checks for building permits", *Automation in Construction*, vol. 134, p. 104 097, 2022. DOI: 10.1016/j.autcon.2021.104097 [Online]. Available: https://doi.org/10.1016/j.autcon.2021.104097

[6] P. Azari, S. Li, A. Shaker, and S. Sattar, "Georeferencing building information models for bim/gis integration: A review of methods and tools", *ISPRS International Journal of Geo-Information*, vol. 14, no. 5, 2025. DOI: 10.3390/ijgi14050180 [Online]. Available: https://www.mdpi.com/2220-9964/14/5/180

[7] S. Comai, S. Mastrolembo Ventura, F. Noardo, K. Raja, and A. L. C. Ciribini, "Definition of bim and 3d city model information requirements for digital building permits", in *Proceedings of the Digital Building Permit Conference 2024*, Barcelona, 2024, pp. 193–199. [Online]. Available: https://iris.unibs.it/retrieve/8ef85646-a23b-4826-a14f-2491c4cb5cee/2024_Comai%20et%20al_DBP24.pdf

[8] H. Tauscher, N. E. Krieger, and F. Boochs, "A modular graph transformation rule set for ifc-to-citygml conversion", *Transactions in GIS*, vol. 25, no. 1, pp. 79–109, 2021. DOI: 10.1111/tgis.12723 [Online]. Available: https://onlinelibrary.wiley.com/doi/10.1111/tgis.12723

[9] A. Rose, R. Becker, and A. Donaubauer, "3D-Lageplan zum Baugesuch", in *Leitfaden Geodäsie und BIM*, ser. DVW-Merkblatt 11-2021, R. Kaden et al., editors, Augsburg: Wißner Verlag, 2021, pp. 103–111. [Online]. Available: https://dvw.de/BIM-Leitfaden.pdf

[10] F. Müller, "Entwicklung einer citygml application domain extension: Der amtliche lageplan in 3d", Master's thesis, Technische Universität München, Munich, Germany, Jan. 2021.

[11] Bundesministerium des Innern, für Bau und Heimat. "Verordnung über die zur durchführung der bauleitplanung erforderlichen unterlagen (planzeichenverordnung – planzv)", Accessed: Jun. 25, 2025. [Online]. Available: https://www.gesetze-im-internet.de/planzv_90/BJNR000580991.html

[12] F. Ahmad, *Building permit application algorithm 1: Boundary representation in ifc*, https://github.com/tofatma/BuildingPermitapplication, 2025.