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Heritage in Action: From the Field to the Future

Closing the Documentation Gap: A Human-Centred Interface Approach to Scientific Virtual Reconstructions

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Abstract

Introduction
The number of virtual reconstructions of historical architecture is growing, yet their scientific value remains difficult to verify. The London Charter (2009) and the Seville Principles (2011) established paradata as a mechanism for documenting interpretive decisions, but systematic adoption remains the exception. The reason is structural, not motivational. Documentation is no longer part of project logic, it is not funded, rarely counts as a research output, and is not integrated into the tools people actually use. As Bajena and Kuroczyński (2023) have shown, without transparent documentation of decision-making processes, there is a risk of losing both the knowledge embedded in reconstructions and their scientific value, as well as the risk that publicly funded work must be repeated from scratch with each update. The solution lies not in better standards or renewed appeals to scholarly rigour, but in the interface itself: a well-designed tool can make documentation a natural part of the reconstruction workflow.

Material and Data

Our work draws on three sources: (1) the project documentation of IDOVIR, an initiative that explicitly identifies the undocumented middle of the research lifecycle, between source retrieval and archiving, as the critical gap; (2) a systematic analysis of thirteen documentation standards currently deployed in European cultural heritage infrastructure, including the DFG 3D Viewer Metadata Recommendation, the W3C Web Annotation Data Model, and CRMdig; and (3) a taxonomy of six uncertainty types, developed by Ehlers as part of an ongoing doctoral project and already applied in Ehlers, Barsch and Jetter (2025) and Ehlers and Uesbeck (2026). This framework further builds on Boukhelifa et al. (2017), who characterise uncertainty as incompleteness, ambiguity, or variability in data, models, and analytical processes, as well as on Panagiotidou et al. (2023), who emphasise the inherent uncertainty of knowledge production in the humanities.

Methodology

The methodological approach follows Human-Centred Design principles according to ISO 9241-210 (2019) and adopts a requirements engineering process in which needs analysis precedes task specification, and task specification precedes formalised interface requirements. Three structural problems are derived from the IDOVIR documentation, the standards analysis, and the FAIR principles, and translated into concrete design criteria. The methodological framing follows Bajena and Kuroczyński (2023), who establish that a shared metadata and paradata infrastructure is the necessary precondition for comparability across reconstruction projects.

Results and Conclusions

Three structural problems frame the analysis:

1. Documentation burden: Grellert and Pfarr-Harfst (2019) identified the absence of user-friendly documentation standards as the central obstacle and proposed the Reconstruction Argumentation Method as a minimal starting point. The interface proposed here builds on this foundation by reducing the effort required rather than increasing it. Type-sensitive input assistance proposes relevant fields and controlled vocabularies as soon as an uncertainty type is selected. AI-supported autocomplete reduces typing effort. Checkboxes cover frequent responses. A learning system converts repeated free-text entries into reusable options. Source metadata are always required, other fields optional, minimal documentation is always valid, complete documentation always possible.
2. Insufficient uncertainty classifications: Different uncertainty types require structurally different modelling, and classification by medium does not achieve this. As Apollonio (2016) has shown, existing schemes classify uncertainty by medium, geometry, texture, colour. This describes only where uncertainty becomes visible, not where it

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originates. Within the same medium, uncertainties can occur that differ fundamentally in source, remediability, and impact on scientific validity. Documenting only the medium documents the symptom, not the epistemic situation, and produces false comparability between reconstructions. The six-type taxonomy of Ehlers and Uesbeck (2026) classifies by epistemic source instead, covering source gaps, documentation decisions, algorithmic assumptions, visual mapping, interpretive reading, and purpose ambiguity. Type-differentiated documentation is not merely more precise than undifferentiated documentation: it is categorically different, because it makes explicit what kind of claim is being made and how different uncertainty types can be handled scientifically.
3. Confidence decay: Knowledge is a snapshot, and without paradata recording the author, date, and epistemic context of each decision, information becomes nearly unusable within a few years (Ehlers and Uesbeck, 2026). Structured, agent-attributed paradata at the level of individual decisions are therefore, as Kuroczyński (2017) shows, a precondition for interoperability and reusability. CIDOC CRM E13 Attribute Assignment is the most complete existing model for this purpose, but is implemented by no current reconstruction interface, a gap confirmed at the aggregation level by Isaac et al. (2024) and Bajena and Kuroczyński (2023). Epistemic status is not machine-readable and therefore cannot function as a cross-platform quality filter. The existing standards stack reliably performs identification, description, preservation, and aggregation, but does not provide workflow-integrated epistemic documentation at the level of individual decisions.

Discussion

We propose a plugin concept as a first step towards a solution that can be developed iteratively, in its early stages encompassing needs and requirements analysis, derived tasks, and initial sketches. The plugin responds to uncertainty type selection with type-specific fields, vocabularies, and examples. A learning mechanism converts repeated entries into reusable options so the interface grows with practice. Crucially, selecting an uncertainty type makes the epistemic structure of a decision visible in ways that unstructured notes do not. Paradata generate not only documentation but scholarly connection: researchers working on related objects can find one another through shared documentation structures.The time cost of documentation is a well-known structural problem, but incomplete or incorrect data are deferred costs. As Münster et al. (2015) argue, the absence of structured documentation is precisely what prevents reconstruction knowledge from being reused. Human-centredness and usability are not soft goals here, but the methodological foundation.

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