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# Paradata: The Digital Prometheus

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**Abstract.** Paradata [ˈpær.ə ˈdeɪ.tə] Mass noun: From Ancient Greek παρά (pará) "beside" and the Classical Latin datum "that which is given". Paradata is a word that has become synonymous with good practice in the field of Digital Cultural Heritage over the past few years, but where did the concept of Paradata within cultural heritage come from, what is its significance, how has it evolved, and why is it relevant to our field today? This paper aims to answer some of those questions through the author's personal reflections on their relationship with developing Paradata as a concept and its use in current research practice.

**Keywords:** Paradata · Digital Cultural Heritage · 3D Visualisation

## 1 Introduction

Within Digital Cultural Heritage circles, Paradata has gained significant traction over the past few years; indeed, it is now considered by many to be an essential part of 3D digitisation along with a digital asset's metadata and the data describing the geometry of the analogue object digitised. The concept of 3D Paradata is not new and was formulated during the Arts and Humanities Research Council (UK)-funded project "Making Space" in 2005–2007 under the auspices of King's Visualisation Lab, King's College London. The Making Space project aimed to investigate a methodology for tracking and documenting the cognitive process in 3D visualisation-based research, and its results, including 3D Paradata, formed the basis of The London Charter for the computer-based visualisation of cultural heritage [6].

A key outcome of the project was the identification and acknowledgement that the creation of a digital 3D asset—that is, a data-enriched digital or virtual object typically representing an artefact, monument, or site—generated a significant amount of additional data during the process of research that informed the final form and content of the asset. Moreover, the project highlighted that a great deal of this data constituted information essential for the understanding, and evaluation of 3D assets, their method of creation, and the impact outcomes; further, this data was seldom documented or accessible from the finalised asset, making the creation process opaque. This lack of intellectual transparency, the project concluded, would hinder innovation in 3D visualisation-based research and result in an under-exploitation of created assets and a loss of intellectual capital if not addressed. The project proposed a solution to this: a new data-type called "paradata".

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## 2 The Historical Context

To understand the need for this new data type, it is necessary to revisit the context and state of the art in 3D representation from which it arose circa 1994–2004. The use of computer-generated imagery (CGI) in the film industry had been well established by the 1990s, but with big budgets. It was not until the end of the decade that computer hardware and software became sufficiently powerful and affordable for more modestly funded institutions and individuals to create visually compelling images, graphics, and increasingly virtual worlds—the specific area of interest for the Making Space project.

In academia and especially in cultural heritage, this opened new and promising avenues of investigation; however, this presented several challenges to those working at the intersection between traditional research and this new digital frontier:

As a point of disambiguation, it is important to acknowledge that the term "paradata" pre-existed the Making Space project's definition and use of paradata. This can be attributed to Mick P. Couper 1998/2000 to describe the recording of "by-products" of automatic computer-assisted statistical survey systems. To quote Couper, "*I term these sources of information 'paradata' (auxiliary data describing the process) to distinguish them from metadata (describing the data).*" [2]. Paradata in the context of 3D documentation is *not* the same as that proposed by Couper, although there are similarities (Couper's own account of paradata within statistical surveys is an interesting read in its own right) [3]. Retrospectively, this inadvertent duplication of nomenclature may have put more emphasis on recording the quantitative aspects of digitisation rather than the qualitative than had been originally intended, although both are important.

### 2.1 Intent vs Illustration

Traditionally, representations of heritage had been purely illustrative, generally falling into one of three categories: diagrammatic or simplified technical drawings, artistic impressions, or photographic documentation. CGI was still widely viewed as an illustrative medium. With advances in computing, the ability to interactively explore 3D assets had become an area of increasing cultural heritage research. The use of the same or similar tools, methods, and terminologies, however, blurred the boundaries between illustrative and experimental or experiential research use of 3D assets and environments. To some extent, this was a misunderstanding or mis-implementation of the technological affordances of the new medium. As the primary interface with the data was visual, it was natural to present research visually, but the visual output of a project was not necessarily the intent or purpose of the study undertaken.

There was a perception that as the digital is infinitely mailable, changes can be made easily over their analogue counterparts (physical drawings, maquette models, etc.). This is partially true; the flexibility of the digital medium to change aspects of an asset is a clear advantage and allows the manipulation of the digital to explore assets through interaction and experimental experimentation. However, the digital asset, just like the analogue, still has to be defined and created, and depending on why and how the asset is developed, the ability to repurpose the visual output may or may not be 'easy'. Nothing spontaneously exists in the digital domain; the computer does not "create" the asset (even programmatically generated assets still need to be encoded); therefore, as much diligence is required in recording the process of creating digital assets as archaeologists take in recording the destructive process of excavation.

It was observed that the majority of these changes were made towards the end of the research, where the asset, having served its purpose, was being repurposed for dissemination. The nature of changes varied from changes in lighting to the addition of effects to make assets look more “realistic” and additional incidental props to “complete the scene.” Unless the asset had been created in such a way that allowed or anticipated such changes—now commonly called reuse—it ran the risk of introducing unintentional errors or misrepresenting the purpose of the research objectives through ‘gilding the lily,’ detracting or distracting from the actual results.

Moreover, due to the time of introduction, such changes were frequently undocumented and insufficiently researched, and while only ever intended to be indicative, were presented (or worse, incorporated into the 3D data of the asset) as a *de facto* truth, bringing the underlying scholarship into question.

## 2.2 Research Innovation vs. Technological Fetishism

Closely aligned with the above was the pressure within academia, especially in the humanities, to demonstrate ‘innovation’ and ‘cutting edge’ research by exploiting new digital technologies to secure funding and show impact. While undoubtedly pushing the state of the art forward, the rapidity of technological change created an environment that promoted “wow moments” and proof-of-concept demonstrations rather than a more considered investigation into understanding the potential use of the new digital medium and its implications for scholarship and dissemination.

By definition, research into how the digital domain could enhance scholarship and research depended on a stable technological infrastructure available to be studied. At a time of high technological innovation, research constantly had to readjust and adapt to be seen as cutting-edge and, therefore, relevant. Arguably, the result was a culture of creating products showcasing technology using Cultural Heritage scholarship rather than showing how cultural heritage research could be enhanced through technology.

This does not imply that the scholarship produced at this time was somehow superficial, but that research was often judged on the technology *de jour* rather than its intellectual merits. Good results could be achieved but at the cost of understanding the medium and sustainability. Documentation of assets, if it happened at all, was seen as something done at the end of the development cycle, in much the same way as one might write a user manual for a computer programme, and tended to focus on specific implementations rather than developing best practices.

The rapidity of change in the technological infrastructure and the lack of documentation of both assets and practices meant that with almost every new project, a new piece of software or hardware would need to be implemented, compatibility with previously developed assets could not be guaranteed, skills and methods were not transferable, and research projects ran the risk of investing in technological dead ends.

## 2.3 The Transition from Paper to Screen

Again, it is important to stress the historical context here. In a pre-Web 2.0 world, in the middle of the first great digital transition, the uptake of new media presented new challenges to disseminating digital 3D results in an academic infrastructure that was primarily still geared towards paper publications.

CD-ROMs were frequent companions to publications, although seldom distributed with conference proceedings. Programmes were frequently bespoke applications or source code to be compiled to allow assets to be shown, but one could not guarantee the same hardware and software combinations needed to use assets at their point of delivery. The World Wide Web had been publicly available since 1993, but access to the Internet was neither ubiquitous nor fast, even within educational institutions. Producing a manifest of software-hardware specifications and setups, workarounds, and settings lists became an expectation.

Further, online dissemination of heritage assets via the internet highlighted issues surrounding sustainability, preservation, and concerns about the intellectual property rights of digitised objects. Asset manifests became outdated, software applications discontinued, links became broken, software discontinued, and key files (sometimes entire sites) were reorganised, moved, archived, or just deleted as space, and a more institutional approach to digital resource management became necessary.

A significant milestone occurred between 1994 and 1998 when a standard for the exchange and viewing of 3D assets, the Virtual Reality Modelling Language (VRML), was published (ISO/IEC 14772–1:1997). A plain text format that was both machine and human-readable, allowing in-line annotation and hyperlinking of data, providing control over the level of detail, and offering redundancy through the distribution of components addressed some of the challenges of documentation of 3D assets.

While VRML had potential and found favour in academic circles, it was ultimately surpassed but did provide a period of relative stability where serious research into 3D digitisation, virtual representation, and understanding of the medium could take place.

## 2.4 Citation, Referencing, and Acknowledgement

Perhaps the most pressing concern for researchers working in this emerging field of 3D Digital Cultural Heritage was how a 3D asset could be cited. It might take several months to research, develop, test, and review an asset for scholarly integrity, but ultimately, if the results were only ever perceived as being illustrative, supporting traditional publications, why invest time if the work could not be cited, referenced, and acknowledged as key performance indicators in a researcher's career?

Without the infrastructure to ensure that an asset could be found, reviewed, and evaluated by peers, bad scholarship would go unchallenged. This not only ran the risk of misrepresenting cultural heritage and propagating falsehood but also prejudiced good scholarship. If the power of the digital medium to be responsive and flexible in testing and incorporating new data was seen as being ephemeral (both in terms of documenting results and being able to find and build upon those results), then the implication was that 'digital was disposable' and needed to be recreated by each project, casting doubt on the justification of the cost of production and return on investment.

Without being able to show the logic and progression of an asset's development through documentation or publication records, researchers were vulnerable to criticism, especially as outputs often challenged established mental models held by colleagues in the academy. Months of work could be undone in an instant by an expert pointing out a visual error unrelated to the subject matter, while scholarly output was frequently dismissed as being of 'poor quality' when compared to large-budget commercial offerings like film animation and video games.

If the transdisciplinary skills, research, and development needed to leverage the potential of 3D visualisation of cultural heritage were to be realised, if 3D assets were to be more than just a form of 3D photocopying, and if the communication of the scholarship and research was to be more than a Barnumesque "dog and pony show" and make a meaningful contribution to understanding the past, things would have to change.

## 3 The Paradata Model of Data Metamorphosis

As a concept, paradata can be seen as tracking the progression of understanding through the stages of data metamorphosis. This model followed the 'classic' Data-Information-Knowledge-Wisdom (DIKW) model proposed by Ackoff [1], with paradata being recorded at key transitional points during the research process.

- Data that is structured becomes information through contextualisation.
- Information that is interpreted becomes knowledge through hypothesis.
- Knowledge that provides insight becomes Wisdom (or Foresight) through understanding.

While the DIKW model is traditionally depicted as a pyramid with a large baseline of data refined to a pinnacle of wisdom through a linear progression, the paradata concept considers data metamorphosis as part of the development cycle with a non-linear progression. This cycle is intentionally collaborative, with lines of investigation being suspended, queried, or bifurcated due to deviation. Data metamorphosis within the paradata concept can therefore be conceptualised as an onion diagram with the core (data) at the innermost circle positioned at the base of the concentric rings (see Fig. 1).

The development of an asset will start somewhere within the innermost circle of the Data section and progress through the processes of data structuring (including metadata) and contextualisation until it metamorphoses into information. This transition—and other transitions—is not a predetermined barrier but is characterised by the point at which data items can be combined, analysed, and compared, i.e., interpreted, the process that paradata aims to capture. It also marks the point at which the data/information may be rejected or included during the interpretation stage; another process paradata aims to capture along with the details of how the conclusion was reached (including methods used). As the asset is developed, each boundary provides similar opportunities to record the research methods, process, and rationale for progressing, increasing the 'data load' of the asset and providing points where deviation can occur.

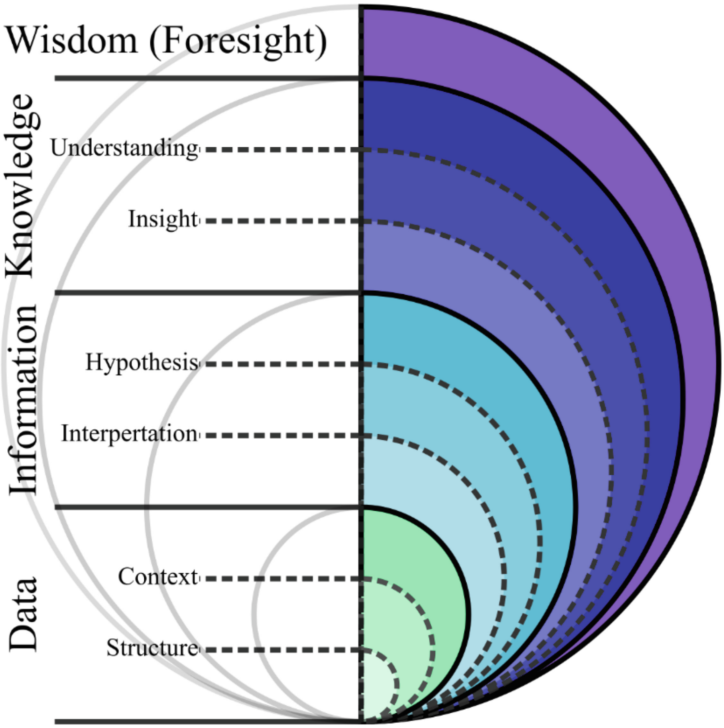


**Fig. 1.** The Paradata Conceptual Model of Data Metamorphosis

## 4 The Paradata Concept

As noted in the introduction, the objective of the Making Space project had a specific focus on 3D representations of cultural heritage within virtual worlds; however, as those worlds consisted of multiple individual 3D assets, the observations made during the project were still considered valid whether the digital representation was a single discrete object or part of a portmanteau scene.

The project concluded that a new type of data arose out of the digitisation of cultural heritage. This was not strictly metadata, as it was not information about the asset per se, but rather it was information about the development of the raw data from data capture, refinements, and enrichment, including vital information regarding the interpretation and selection of sources and deductive/inductive reasoning arising from the process of 3D modelling itself. This data fuelled the research and development of an asset while informing and, in turn, being assessed, validated, or rejected through experimentation. As such, the term “paradata” was used to describe this dynamic dialogue between source data sets and their digital manifestation.

Before we progress further, it is important to note one further point of language. The Paradata concept rejects the idea of digital or virtual “reconstruction” of cultural heritage but uses the term visualisation to distinguish the processes and outputs of digitisation. This is a subtle distinction, but fundamental to the paradata concept.

- Reconstruction is a process of rebuilding, repairing, or restoring something, the implication being that it is a faithful facsimile of the original, i.e., representing *the* truth.
- Visualisation, however, is the representation of the available data set to create a hypothetical version of the subject based on an identified and traceable decision-making process used to create the asset, in other words, *a possible* truth constructed on evidence. Visualisation communicates message and meaning not just imagery.

This shift in perspective is essential in representing cultural heritage where evidence may be missing, conflicting, unclear, its provenance is in question, or any form of interpretation as it changes the nature of the data. Even data acquired through high-precision data techniques cannot guarantee a faithful digital facsimile of an object. A multitude of factors may influence the recording process, and once raw data is compiled, errors can be included and proliferated. In contemporary parlance, visualisation is more aligned with the concept of a Memory Twin than that of a Digital Twin.

The principle of paradata was, therefore, not to simply record, define, and quantify cultural heritage through digitisation but to understand the context and significance of the object, including insights into the original creation process through digital affordances. One can measure, weigh, chemically analyse, and even grind down the Parthenon Marbles to understand their physical nature but will never find a single atom of the artistry, impact, meaning, or significance of their creation and how those innately human characteristics are still meaningful today.

This does not dismiss the quantifiable as that data is an intrinsic part of the Parthenon Marbles; but Cultural Heritage is not empirically based antiquarianism; it is the study of intellectual achievements and ideas, customs, and social behaviour of a particular people or society that exist from the past and their continued importance, impact and relevance to modern society.

In its simplest form, recording paradata echoes the schoolmaster's cry to "*Show your working out.*", perhaps a better analogy would be Karl Popper's statement, "*Those among us who are unwilling to expose their ideas to the hazard of refutation do not take part in the game* [of science]." [3]. While it is arguably impossible to apply the objective empirical-based scientific method to the subjective humanities, paradata offered a way to show the intellectual and creative narrative, which supported the development of a visual hypothesis presenting the results not as 'fact' but as 'possibility'.

Paradata would therefore introduce the possibility of falsification of the visual hypothesis presented, demanding a rigorous approach to the research employed in its creation and crucially providing information to allow meaningful scholarly debate surrounding conclusions by providing clear evidence of which elements of the visualisation were relevant and which were ancillary (but necessary) within the scene. The intent was to address five particular concerns:

### 4.1 Recording the Research Process

It was noted that little information was recorded about the processes undertaken in creating a visualisation. By this, we are not referring to data sources that form part of the research rationale but rather the variables that constitute the research process. Recording variables and constraints such as equipment and software used, personnel engaged in the development, methods employed, and purpose of the visualisation paradata would provide a clear *mise en scène* of the research process. This record would allow the visualisation context to be understood; for example, providing details of hardware and software would identify constraints (and potential issues) that may impact the results of digitisation, while stating the intent of a visualisation is to understand connectivity within an archaeological site allows the work to be judged on spatial representation rather than visual presentation.

### 4.2 Documenting Research Rationale and Logic

As a visualisation is an intentional creation, nothing exists within it without purpose. By recording the reason for a data object's inclusion within a visualisation, the rationale and logic of the research and creation processes become transparent. This documentation provides multiple services within the paradata concept:

- If an asset cannot be justified, it is superfluous to the needs of the visualisation and can be removed, increasing the communicative value and focus of the visualisation.[1]
- If everything can be justified, then the purpose of the visualisation is more understandable, defendable, with a higher potential for reuse as its confidence is increased.
- If the rationale and logic behind a visualisation are exposed and understandable—including alternative sources considered but rejected—the scholarly value of the visualisation (and its assets) is increased due to the inherent intellectual transparency.

Consider the case of digitising an example of standing archaeology; scanning provides state documentation; nothing more, nothing less. If digitisation intends to provide such a record, this can be stated within the paradata with details of the processes undertaken to produce that record. Future scholars can understand the intent and process through the paradata record assessing the digital record against their research criteria.

However, if the purpose is to provide a basis for interpretation, the digital scan is just one of multiple data sources required to construct a visual hypothesis. Indeed, such a scan may not be indicative of the structure in the past and may itself have been interpreted through physical reconstruction or interventions. Other sources—excavation reports, photographs, and testimonies—must be considered to prepare the visualisation. In the case of a room, the visualisation may need to consider the interpretation of walls and ceilings (possibly floors) that no longer remain; there may be doors, windows, or other features for which there is evidence but no longer exists or at least exists in situ.

### 4.3 Providing Mechanisms for Review of 3D Digital Assets

The reliance on traditional review methods of research was not considered robust enough to allow peer review of 3D visualisations, especially where the presented hypotheses

[1] It should be noted that this justification may be as simple as "required to complete the scene"—the point here was to encourage structured, thoughtful practice into asset creation and visualisation of cultural heritage.

involved multiple dimensions (spatial, temporal, and probabilistic). Paradata would provide the basis for a framework where visualisation-based research could be audited and assessed for scholarly integrity based on the documentation of the research rationale and process. Through such a mechanism, a reviewer would be able to follow the development of the research argument, the hypothesis made, and the resulting conclusions drawn without being distracted by any ancillary (but justified) elements needed to create a cohesive representation.

For example, a visualisation of a room for which there is strong evidence of a door but for which physical evidence does not exist will inform aspects of the visualisation of the room, such as minimum ceiling height, direction of ingress, illumination, etc. Acknowledging the existence of the door and its possible impact and effect on the hypothesis is a factor of review, not necessarily the appearance, materials, or construction of the door itself.

### 4.4 Support for Citation of 3D Digital Assets

Paradata was intended to show that the visible output of a visualisation was only a fraction of the research that contributed to the process. Without such recognition, it was considered (and arguably still is) that the serious scholarship required to create visualisations is ignored or less relevant than the (primarily) visual output.

As a new medium for scholarly investigation of cultural heritage (and other disciplines), a method that allows the citation of visualisations is critical to developing a sustainable career path for researchers using visualisation as part of digital scholarship. Paradata was seen as part of that solution, along with the review provision.

Without being able to cite visualisations and constituent assets, researchers would not receive the academic recognition vital for a sustainable career within the academy. Without such recognition, this new medium for scholarly investigation of cultural heritage would bifurcate: on the one hand, academics who would only consume or commission visualisations—repeating the illustration fallacy—and on the other, technically adept developers who would lack the necessary background for robust intellectual enquiry in the cultural heritage domain. Worse, those able to maintain a career in Cultural Heritage visualisation would be perceived as dilettantes, being neither one nor the other.

### 4.5 Accelerate the Research and Development Process

The final point paradata sought to address was the long development times for visualisations. The paradata concept, significantly influenced by The Berlin Declaration [4], took a two-fold strategy in tackling this issue: first the disciplined creation of visualisations and second the reusability of assets through open access.

The paradata concept's requirement for documentation and justification of assets and visualisation placed a quantifiable cost/benefit on development through the triple constraint 'iron triangle' principle of "*good, quick, cheap—pick two.*" The intent was to focus development on implementing clear research agendas but not restricting intellectual curiosity. Understanding that deviation from the core research statement, would need to be documented would have implications for resource allocation, acting as a deterrent to 'additional extras'. However, by requiring the recording the development process (both intellectual and creative), high-quality assets based on sound reasoning would be created. The return on investment would be twofold:

First the paradata record would provide an audit trail to understand the point of deviation between the requirements of researchers.

- Researcher B could either accept Researcher A's work by assessing and agreeing with their conclusions manifested in the asset and include it within their visualisations (with appropriate citation). Increasing the confidence or value of the asset.
- Or B could create a version of A's asset and produce an alternative view based on the paradata record. Researcher B would only need to work from the point of deviation saving time and effort. This would stimulate scholarly debate.
- If B rejected A's research *in toto*, a new asset would need to be produced by B. This would be available for review and, therefore, the scrutiny of other scholars, reducing digital plagiarism. This would help prevent ersatz assets and research.

Critically, the paradata for an asset would not change but be expanded by revisions, only the manifestation of the asset; geometry, textures, behavioural scripts, etc. This would permit researchers to draw on a common research pool and present alternatives of the asset (including lower graphical or polygon count versions).

Secondly, the lacunae in the research corpus or those paths not investigated would be exposed and exploited by future research. Again, this provision offered the potential for accelerating and expanding research, not only through the addition of new material but also through establishing a record of the process that documents the approaches taken and methods employed that could be reassessed as technology advanced and new research paradigms emerged.

This second benefit was considered instrumental in opening up intellectual transparency in digital cultural heritage research to a wider audience. The multi-disciplinary nature of the field implicitly requires cooperation and collaboration from the inception of a project until its conclusion (and preparation for its future accessibility and use beyond). The implication is that the research data, processes, and methods documented in paradata offer other uses cross-domain. Understanding which structures survived (and why) on a site may be of interest to civil engineers in assessing the durability of materials, but only if they are confident that the structures are contemporary with the timespan they are investigating, not earlier or later (or modern interventions).

## 5 Conclusion and Reflection

While paradata was adopted into the London Charter as part of its principles, the ideals of the concept were never fully realised. Astute readers will have noted that some of the proposals within the paradata concept bear similarities to existing methods; DOI 2000, Dublin Core ISO standard in 2003, Linked Data 2006, GitHub branching 2008, FAIR Data Principles 2016 etc. Many of these innovations were in their infancy when the paradata concept was being formulated contributing to the technological zeitgeist.

Despite initial interest, failure to capitalise on these nascent technologies severely retarded the progression of the concept as a whole. That is not to say that paradata research and development has not been undertaken in the two decades elapsed as witnessed by the contributors to this volume; however, the full potential of paradata has yet to be realised as it was originally conceived. One criticism of the paradata concept was that it was 'too forward thinking'—a solution looking for a problem—but time moves on and the demand for the digitalisation of cultural heritage has only increased.

As we move into the second quarter of the twenty-first century, cultural heritage is increasingly under threat, not only from the climate crisis, natural disasters, and destruction through conflict and ideology but also through authenticity and misappropriation. In his book, 1984, George Orwell wrote, "*Who controls the past controls the future. Who controls the present controls the past*." If the democratisation of access, understanding, and memory of our shared past is the aim of cultural heritage's drive for 'digital transformation', then we have a moral obligation to undertake digitalisation with diligence, intellectual integrity, and transparency to facilitate democratisation.

Ultimately, however it is described, realised, implemented, branded, or renamed, the concept behind paradata, intellectual integrity, transparency and responsibility in digitising Cultural Heritage remains. It is part of the process and part of the solution—a Promethean spark with the potential to ignite novel scholarship in the digital data space.

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