[DC-06-009] Field Data Capture Technologies

Abstract

Field data capture technologies are a foundational component of geographic information science and technology (GIST), enabling the systematic collection of spatial, attribute, and temporal data. This entry provides an overview of the preparation, tools, workflows, and data structures involved in field data collection. It begins with a reflection on the logistics and planning needed to organise field campaigns, including training, task allocation, and field offices. It then reviews key technologies in the mobile GIS ensemble, ranging from GNSS receivers and laser rangefinders to mobile apps and hand-held computing devices, and assesses their functionality within different field contexts. The entry also considers the integration of sensor networks, positioning techniques, and app-based interfaces such as Esri's Field Maps, QuickCapture, and Survey123. Whilst grounded in the technical requirements of data capture, it takes care to foreground the socio-technical and epistemological dimensions of field praxis, emphasising that spatial data collection is shaped as much by representational choices and logistical constraints as by technical precision and accuracy. Field data capture is presented as a contingent, embodied, and interpretive process linking the world to its digital representation.

Keywords: decision-making, field data collection, mobile GIS, sensor networks, sensors

Author & citation

Lerner, L. (2025). Field Data Capture Technologies. The Geographic Information Science & Technology Body of Knowledge (Issue 2, 2025 Edition), John P. Wilson (ed.).
DOI: 10.22224/gistbok/2025.2.16.

Explanation

1. Introduction
2. Preparing the Situating the Fieldwork
3. Assembling the Mobile GIS
4. Measuring Where, What, and When in the Field
5. Conclusion

1. Introduction

Field data capture technologies are foundational to the practice of geographic information science. They constitute one interface between the lived, material conditions of the world and the contingent spatial models used to represent them. Whether for infrastructure maintenance, biodiversity monitoring, or disaster response, field data capture is more than a technical task, it is a social and spatial practice. The platforms and technologies involved lie at the intersection of mobile computing, sensor networks, real-time positioning systems, and the decision-making needs of professionals working beyond the office. In the field, assumptions are tested, gaps in the models exposed, and participant and practitioner knowledge integrated. Field data capture is thus central to the production, maintenance, and contested praxes of geographic information science and technology (GIST).

Understanding the tools, methods, and infrastructures that enable this work is essential for the spatial sciences (see Pickles, 1997).

Despite assumptions of constant connectivity, real-world field conditions often challenge the seamless digital experience familiar to the Cartesian dimensions of a digital GIS, experienced removed from the field in a university library or at an office desk. Access to data and systems can be fragmented across devices, operating systems, user roles, or organisational and administrative boundaries. As a result, a field GIS is typically a pared-down, bespoke subset of an institution's broader geospatial infrastructure, configured for the constraints of mobile hardware, limited storage, potentially intermittent connectivity, and task-specific interaction. Preparing data for the field involves decisions about what is fundamentally relevant, as well as what can be considered usable and operational under unpredictable and demanding conditions.

Foundationally, the concept of "the field" varies across the various disciplines and social contexts associated with GIS. The taken-for-granted understanding of fieldwork, fomented from the colonial origins of geography and anthropology, posits the field as a place *out there*, to which a researcher travels in order to have an authentic empirical encounter with (a part of) the world. In contemporary GIS education, a period of fieldwork is maintained as a – usually mandatory – disciplinary rite of passage. In some cases, this is a one-time visit to gather observational data or conduct inspections, whilst others, particularly in earth and environmental sciences, agriculture, construction, and resource management, the field has become a primary workspace.

As a result, the field now poses in its various guises, the following propositions:

- A space of danger
- A site for simultaneous bodily and mental discipline
- A guarantor of understanding and legitimacy
- Opportunities for expertise and instrumentation
- A source of data
- An exotic, unfamiliar, other
- A chance to survey and master *terrae incognitae*
- Gendered divisions of labour
- A continued science of empire

Clearly, the idea of the field is a complex one, pivotal on its union of a spatial metaphor and the associated epistemological assumptions (Massey, 2003). The representation in a GIS of something *out there* is contingent on subject-object relations, and a gap: between representation and reality; between the field and the lab; the study and the paper; the geography and the map. In other disciplines, these two realms have become ontologically distinct, but GIST offers a strong contention to the contrary. The exchanges set in motion by a field data capture endeavour encompass a wide range of workflows including new data collection, validation, inspection, monitoring, and awareness tasks, and whilst each has its own epistemological and logistical demands, none seem to separate the two realms of representation and reality as neatly as they were once supposed.

The only way to understand the reality of this is to pay close attention to the details of fieldwork practice within GIST. Once this practice is described, the question can be raised: how do we pack the world into a GIS? Technologies used in the field: mobile phones;

ruggedised tablets; drones; sensor-integrated smart devices; offer increasingly powerful affordances, allowing users to capture complex phenomena with greater precision and automation. It is now possible to record multiple feature types simultaneously, populate attributes with any number of values, and integrate accessory inputs such as visual materials or environmental readings on the fly. Yet, as advances as these tools are, the process of encoding field observations into a digital format remains deeply situated. It is shaped by user experience, field conditions, data models, and institutional constraints. Every research design decision, from which fields are mandatory to whether a user can edit existing records, shapes what gets represented and what is left out.

Understanding this process demands an appreciation of field data capture as a more-than-technical operation. It is a practice of translation: of embodied, often place-based knowledge into structured, spatialised form. Whether the goal is documenting cultural heritage, assessing environmental impact, or maintaining infrastructure, the GIS becomes a site where interpretation, negotiation, and judgment are constantly under tension. And these judgments are not made in isolation. They are informed by organisational goals, regulatory requirements, historical data legacies, and the lived expertise of fieldworkers themselves. Field data capture technologies must be understood not simply as tools for a neutral process of data collection, but as instruments which mediate between lived environments and digital representations. They structure possibilities for knowing, deciding, and acting in space. They also carry with them implicit models of the world, which may align, or conflict, with what is found on the ground.

2. Preparing and Situating the Fieldwork

Before data can be captured in the field, there needs to be a considered period of framing, planning and provisioning. This stage is often demoted to logistical minutiae, swept up in excitement or anticipation before leaving for the field, but forms a key part of research design, and deserves close attention (Randall et al., 2007). The representational outcome of a GIS is embedded within the epistemic commitments which structure fieldwork: how the field is imagined; who is tasked with encountering it; and what technologies will mediate the encounter.

A pilot study is often the first tangible enactment. Beyond a trial of hardware functionality and workflow feasibility, it informs the rest of the project as an epistemological rehearsal; a first chance to bring desk-based assumptions into contact with the material world, and in doing so, reconfigure what is possible. Rather than viewing this as a confirmatory step, the pilot should produce new versions and iterations of the problem. The initially experienced frictions: routes are inaccessible; informants do not turn up where they were expected; the variables fall outside of the expected range, these are frays of the model in the face of the social world, surfacing the friction between the universal and the local. This is a crucial step to introduce an opportunity – often missed – for reflexive recalibration.

Once the fieldwork is deemed feasible, it can be taken to the field office. This may be a rented room or the boot of a car, or a more *ad hoc*, transient space, like a coffee shop with Wi-Fi, or a fold-out table under a tree. Wherever the data capture is staged, it inheres a liminal zone between the before-held institutional representation and the on-the-ground realities. Risk assessments and ethics reviews are cross-checked in real-time against

current conditions, devices are charged, and the practicalities of data stewardship, like syncing and backups, create a key node in the chain of translations between the field and the lab.

There are two further key tasks which must take place here. First is the training and preparation of fieldworkers. This should go beyond a simplified instruction in technical fluency, taking steps to decode assumptions about what to observe, how to interpret, and how to fit the data into a predefined schema. Of course, this demands reflection on who is trained and who is performing the training, raising questions about authority and the representation and re-representations of power. At a granular level, differences in understanding in the field, for example in the categorising of land-use classification, soil cover, or occupancy status, may create inconsistencies (often termed “inter-rater reliability”) which are later treated as noise, rather than as indicators of competing ground truths.

Secondly is the division and allocation of tasks in the field. These are often driven by practical or cost constraints, but like every other decision, may carry substantial epistemological weight. Who will walk which transects? Who takes photos? Who carries the tablet and who asks the questions? Who is the backup fieldworker? Such choices are embedded in an uneven distribution of expertise, physical ability, language, and institutional trust. They may reflect a path dependent division of labour as gendered, racialised, and class-based, which continue to shape fieldwork in subtle and not-so-subtle ways.

From this ensemble of preparatory work and decision-making, the framework for field data capture is set into motion. The seemingly neat analytical breakdown of core workflows like tracking objects or managing assets, whereby location is the measured dimension, time provides a frame, and attributes are determined through schema design, rests on a scaffold of prior choices. These choices are not merely technical but are reflected more intently in the power relations and representational commitments which underwrite spatial knowledge production.

3. Assembling the Mobile GIS

The fieldworker is not a standalone observer, but an actor within a complex assemblage of technologies and practices. The equipment they carry is more than a tool; it is a site of mediation between spatial phenomena and its inscription into a GIS. Choices made about what to bring into the field shape not only what can be recorded, but also how the world is experienced and interpreted. The mobile GIS ensemble, therefore, is a socio-technical infrastructure tuned to a particular task, environment, and institutional context (Hein et al, 2008).

Field technologies vary greatly depending on the needs of the project, the resources available, and the imagined user. A team conducting a biodiversity survey in a remote area may prioritise lightweight gear with long battery life and reliable offline functionality, whereas an urban infrastructure audit might rely on real-time connectivity for integration with cloud-hosted databases. The variations reflect epistemological demands: what kind of knowledge counts; how is it verified, and how is it stored and shared?

At the heart of most fieldwork technologies is a mobile device. Rugged tablets, smartphones, and handheld GNSS receivers offer different trade-offs in terms of durability, precision, and usability, although these are increasingly convergent with the latest (and most expensive) iterations. Most modern tablets pair with external high-accuracy GNSS units via Bluetooth, extending the capabilities of otherwise generic hardware, bringing them into a field data capture technology “ecosystem”.

One example of this kind of ecosystem is produced by Trimble, an American company providing an array of proprietary hardware and software which operate in concert in the field. A handheld Trimble data collector or rugged tablet can connect and communicate seamlessly with mobile Trimble antennae, relay information to a Trimble receiver base station, and receive RTK correction from cell or satellite delivered Trimble services. Deploying a Trimble solution can work very neatly in many use cases: surveying; marine applications; machine control and guidance; small site and utility management; but ultimately may not be boundlessly applicable for all purposes. Trimble licenses come with an inbuilt dependency, and whilst there are some areas which offer full customization, others are more limited, relying on the vendor for updates, enhancements, and responses to innovating fields. Researchers may run into issues resulting from the restrictions in place on device compatibility and data structures, “locking in” some or all of their work to the proprietary system.

One alternative is the “bring your own device” (BYOD) approach marketed by Eos positioning systems, an American manufacturer which produces high accuracy GNSS hardware. This option natively enables flexibility, developed as a direct response to the increasing variability of fieldwork as geospatial technology grew and expanded in multiple directions. All of Eos’ receivers have frequency support for all GNSS constellations, are compatible with any iOS, Android, or Windows mobile device, and work with any off-the-shelf data collection app. There is a reduced requirement to learn a new system, and a reduced cost of entry overall. Buying in to an entire new architecture for one research project may be prohibitive both skills-wise and financially, but BYOD approaches allow fieldworkers to make use of the materials and expertise they may hold already. Selecting components and workflows from different vendors in this way allows for finer tuned customisation, increases interoperability and adaptability, and has a stronger likelihood of future-proofed field work wherein researchers can ensure that their fieldwork infrastructure remains current and reliable for their specific uses.

Bluetooth connectivity also supports connections with laser rangefinders, barcode scanners, and a whole host of environmental sensors, allowing for multimodal data capture. This incredible flexibility cuts both ways. Each additional component adds complexity, opportunities for failure, and new demands for fieldworker training. When contending with rain, sun glare, gloves, or unstable surfaces, the elegance of a multi-device solution may quickly falter in the face of embodied constraints.

Additionally, mobile GIS is not restricted to digital devices. Paper notebooks, sketch maps, and voice recordings remain essential tools in almost all field contexts. They offer resilience where digital versions can fail, and cognitive, emergent, flexibility where schemas prove overly rigid. Field notes capture a situated nuance and ambiguity that pre-coded dropdown menus cannot. This hybridity introduces a second layer of interpretive work when the data is transcribed and reconciled with digital systems. The temporal lag between observation and digitisation also opens a space in which social meaning may drift. Where paper persists

alongside state-of-the-art digital tools, there is a reminder that field data capture is always embedded in practices of judgment, reflection, and partiality.

Returning to the mobile devices, there is a nonmaterial interface too. Most data capture is performed on mobile GIS applications. Selecting the appropriate app is a decision shaped by project goals, user capacity, disciplinary and organisation standards, and many other factors. As an example from one industry standard provider, Esri, there are three field apps to choose from:

- Survey123 – a form-centric interface for structured data collection. Useful for regulatory and standardised purposes. Excels in repeatability and integration with formal schemas and can be customised extensively in the companion desktop app, Survey123 Connect.
- ArcGIS Quick Capture – a big-button interface data collection app. Well-suited for fast-moving operations which require minimal training. Easy customisation using a no-code app builder.
- ArcGIS Field Maps – a map-centric app with mobile forms which enable users to add, edit, and delete features directly. Includes support for navigation and routing. Particularly useful in contexts where spatial context matters, can be configured from any web map.

It is also worth noting that there are free and open-source versions of these apps, notably QField for QGIS and the community edition of Mergin Maps. The apps are available in most app stores, can be configured to work offline using an outbox function, and can be modified to suit almost any data capture requirements. Each one also implicitly encodes a model of fieldwork: what is important; how should it be recorded; and by whom? The assumptions, hardcoded into the apps, affect how fieldworkers will interpret their surroundings and what they choose to record. The interfaces, by their nature, filter observations according to their own predetermined schema.

Logistically, memory, battery life, and weatherproofing are three key concerns. Device failure could easily lead to data gaps, inaccurate records, or missed opportunities. Equipment should be planned for both optimal and *good enough* performance. A resilient mobile GIS is one which anticipates uncertainty, allows for local workarounds, and can be recreated with limited resources.

The mobile GIS is another inscription in the epistemic scaffold. It enables the capture of significant phenomena yet also works to constitute the phenomena themselves – what can be seen, recorded, and remembered – and enact specific ways of knowing. Appreciating the situated positional affordances of sensor-integrated devices, GNSS receivers, Bluetooth, and mobile apps as part of an ecosystem in the support of location-based services in each environment is key. Workflows and field-emergent workarounds are responses to environmental contingencies, and reflect assumptions about what kids of movement, presence, and location are important to capture. The choices made when configuring this ensemble shape how the field itself is spatialised and how representations are granted authority.

4. Measuring Where, What, and When in the Field

Field data capture is not only about *what* is observed, but also *where* and *when*. Each dimension requires careful design, interpretation, and translation. Together, they define a spatiotemporal data model framing how GI is represented in a GIS. In practice, these dimensions are not captured uniformly, nor are they free from ambiguity (Goodchild et al., 2007). They are shaped by devices, data, conditions, and research aims.

4.1 Location, as a measured variable, is commonly treated as the most objective: derived from GNSS signals or corrected through differential systems like differential or real-time kinematic positioning (RTK). In the field, factors such as canopy cover, built environments, or political borders can interfere with signal strength and introduce positional uncertainty. Bluetooth GNSS receivers, internal device sensors, or even manual digitisation from basemaps can all introduce spatial bias. An important question for fieldworkers then is "*how do we know where this is?*", followed by "*with what confidence?*", which goes beyond a simple "*where is this?*"

4.2 Attribute information, as another observed variable, is often treated within GI Science as discrete categories or standardised descriptors: land use type, building material, maintenance condition, habitat classification, or observed behaviour. These values are usually predefined within a data schema, optimised for consistency and interoperability. However, the meaning of a particular attribute in the field can shift depending on context. Fieldworkers may interpret categories differently, rely on tacit knowledge, or encounter edge cases which defy classification. What constitutes "dilapidated," "under construction," or "informal use," for instance, may vary across time or locale. Instruments should be designed so as not to eliminate interpretive ambiguity. Fieldworkers should move past "*what is this?*", to ask "*by what sociotechnical processes is this recognised as a thing?*", and even "*through what forms of knowledge and expertise is agreement on this made possible?*"

4.3 Time, the third axis of field data capture, is also commonly assumed as self-evident: a timestamp logged automatically by a device. Like location and attribute information though, there is a socially produced, technologically mediated aspect to its collection. In high-precision domains, such as RTK surveying, time is tightly regulated, and precise synchronisation between data streams and sources informs position itself. Temporal resolution here is not just an operational consideration, but an essential criterion for trust and action, especially in use cases like surveying or disaster response. Elsewhere, time has different implications, like seasonal phonologic changes in ecology, or recurring maintenance cycles for utility workers. These intuit their own temporal knowledges, rising from situated practice. There are unfolding dimensions: linear; cyclical; event-based, each structuring the kinds of GI which can be recorded and acted upon. Field data capture practices make time, just as they make space, through their configurations of tools, users, and workflows. Rather than "*when was this recorded?*", it becomes necessary to ask "*how is temporal granularity, sequencing, or rhythm, shaping what counts as a meaningful event or trend?*"

It is evident that field data capture technological assemblages structure the recording of *where*, *what*, and *when*. These are not neutral questions, and nor should they have objective, positionless responses. They shape the manner of representation, and deeply influence conventional understandings of accuracy, precision, and reliability.

5. Conclusion

Field data capture technologies are central to the spatial sciences, serving as the interface between material and social realities and the contingent models deployed to represent them. Surpassing definition as solely technical tools, they structure how geographic information is collected, interpreted, and acted upon in the field. This entry traces a set of steps to prepare for fieldwork, consider the equipment and techniques used, and reflect on the nature of the data which is generated. It examined the legacy and assumptions which stem from the colonial origins and understanding of “the field”, and how these may be simultaneously upheld and challenged by institutional contexts, the limitations of a mobile GIS, and the adoption of different epistemological frameworks. It explored how fieldwork depends on a matrix of decision-making: what to include; what to leave out; how to classify; and how to measure phenomena across time and space.

As spatial praxis, the assemblage of field data capture technologies foregrounds the ongoing negotiation between the world and its representation in GIS; mediated through an evolving network of technology, methodology, and human practice. By treating each fieldwork endeavour as a multi-sited ethnography, paying close attention to the details of practice, the empirical legitimacy of the work can be increased, so long as the field is acknowledged as distributed and multiple, participating itself in the fabrication of a research event. This is an exciting prospect for fieldworkers, who are at the forefront of open-ended and experimental GI science, witnessing first hand the ontological transformations which connect the world to the model.

References

Goodchild, M. F., Yuan, M. & Cova, T. J. (2007). Towards a General Theory of Geographic Representation in GIS. International Journal of Geographic Information Science 21(3): 239–260.

Hein, J.R., Evans, J. and Jones, P. (2008). Mobile Methodologies: Theory, Technology and Practice. Geography Compass, 2: 1266-1285.

Massey, D. (2003). Imagining the Field. In: Pryke, M.; Rose, G. and Whatmore, S. (eds.) Using social theory: thinking through research. First Edition. UK: Sage Publications.

Pickles, J. (1997). Tool or science? GIS, technoscience and theoretical turn. Annals of the Association of American Geographers, 87, 363-372.

Randall, D., Harper, R., & Rouncefield, M. (2007). Fieldwork For Design: Theory and Practice. London: Springer London.