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OpenIndexMaps: A New Iteration of Collaborative Digital Index Mapping

Keywords: index maps; discovery; interoperability; map series; Geodex; OpenIndexMaps

Summary: Librarians in the GeoBlacklight community have been collaboratively developing a digital geographic index map standard. OpenIndexMaps (openindexmaps.org) is an interoperable standard, using the GeoJSON format, for creating and sharing geographic index information for map series and other collections. OpenIndexMaps is catalyzed by the adoption of Geographic Information Systems in libraries and map collections. The Geodex system, carto-bibliography software developed in the 1980s at the American Geographical Society Library at the University of Wisconsin-Milwaukee, did not reach a critical level of adoption and long-term support, but set the groundwork for creating and sharing index information among map collections. OpenIndexMaps has the potential to bring about the original aim of the Geodex project—to create a union catalog of large paper map series and other collections held across various institutions. Ultimately, OpenIndexMaps will advance collection management of paper map series and air photo collections, enhance discoverability of geographic collections, and improve cooperation between institutions.

Introduction

Large paper map series pose access, discovery, and documentation challenges for map and geospatial librarians. Sheet-by-sheet cataloging is impractical for series with many sheets and therefore large sets or series are often cataloged as single records. Paper index maps are a commonplace way to document holdings and determine which sheets cover which area (See Figure 1). While paper index maps can be scanned and displayed on websites or included in digital repositories, more advanced digital index maps can serve the same functions while allowing for remote users to determine holdings. Digital index maps can help users discover and access digital holdings such as scanned maps, aerial photo frames, or geospatial data held in digital collections.

Digital index maps are files that store both qualitative attributes and geospatial information about component items in a set or series. These files can then be used to generate interactive web map interfaces that display bounding boxes for map sheets. A user could, for example, pan and zoom the map to the area of interest, select a sheet, and view metadata about the item or click a hyperlink to the holding in a digital collection or catalog. To anyone familiar with GIS technology, these capabilities are relatively straightforward. Computer methods to store geographic index information has a history of at least 3 decades but today librarians are working to standardize methods and formats to enable more interoperability and collaboration among collections.

The American Geographical Society Library at the University of Wisconsin-Milwaukee Libraries (AGSL) embraced the idea of automating index mapping in the 1980s. Former curator Christopher Baruth developed the Geodex software. The present paper will not discuss Geodex at length, see the author's previous work in *e-Perimetron* for details (Appel and Bidney, 2016). This is an update on that continuing project.

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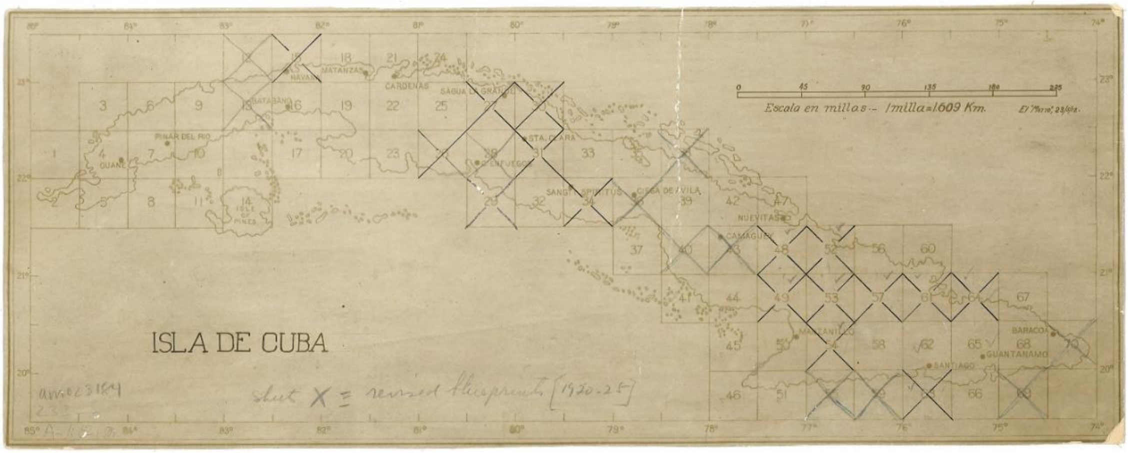

Figure 1: A paper index map for a map set of Cuba Military Maps held by the American Geographical Society Library

Synopsis of Digital Index Mapping

Geodex was useful not only for rapid cataloging of paper map sheets in large series but was state-of-the-art for searching by geography; Geodex functionality included using coordinate searches to identify map sheets by geographic location within a map set or series. Baruth envisioned Geodex as a collaborative technology that map collections around the world could use to record their own collections and share that information back to the AGSL. The AGSL would in turn issue updates to the community of users. While there was some adoption, such a community was short lived and depended on posting physical media through the mail along with a newsletter. The Geodex command line interface, lack of source code access, methods for file storage, and dependence on DOS or DOS-like operating systems (see Figure 2) made it challenging to maintain in an increasingly internet-enabled and GUI environment of library automation.

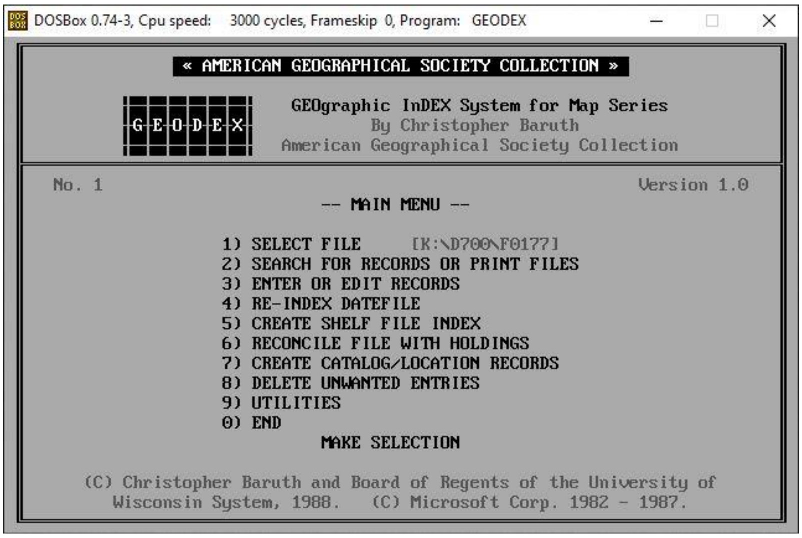

Figure 2: The main menu of the original Geodex application when viewed in a DOSBox

By the 2010s, the Geodex system was being used exclusively by the AGSL for its own holdings. Data from Geodex was extracted and saved in an SDE Geodatabase on the UW-Milwaukee ArcGIS server. The author developed an extension to ArcMap using the ArcObjects SDK for the

Visual Basic .NET framework to allow records to be entered and modified and leveraging database and spatial analysis tools. A patron-facing web mapping interface for querying the database was developed by an AGSL student intern using both open source and ArcGIS tools including leaflet and the ArcGIS API for JavaScript (see Figure 3). The forthcoming end of product support of the ArcGIS Desktop platform (planned for March 2026) is once again threatening the longevity of the Geodex project.

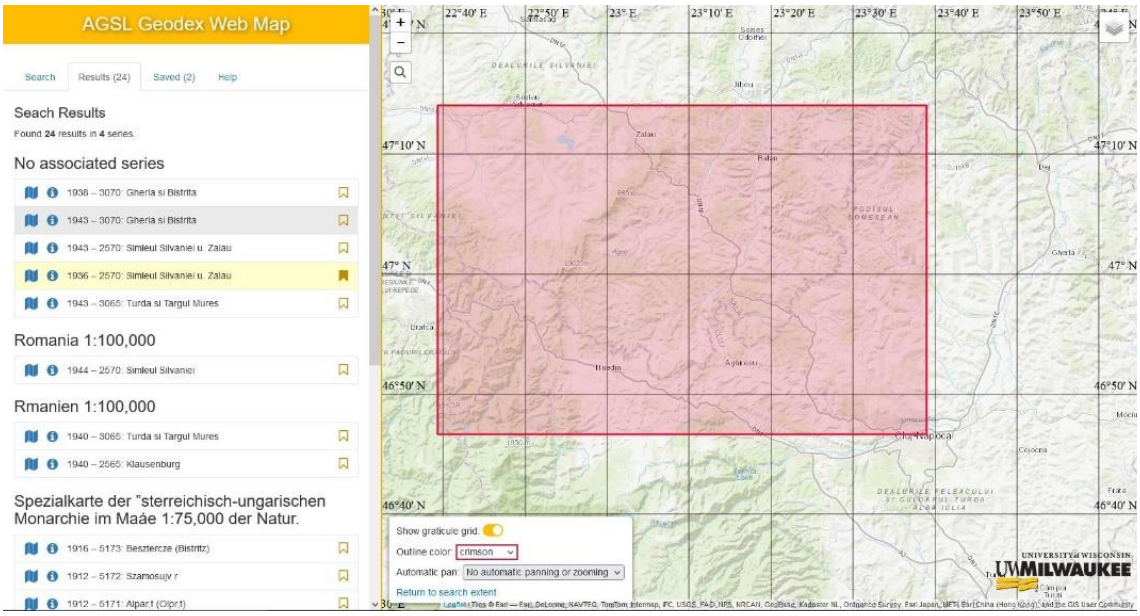

Figure 3: Screenshot of the Geodex Web Map application showing a bounding box for the selected record

The AGSL was not the only library thinking about digital index mapping. Librarians at Pennsylvania State University (PSU) Libraries recognized that while libraires were making strides in digital catalogs providing discovery access to remote users, maps and map sets still presented unique challenges for cataloging, discovery, and access (Jensen et al, 2004). They were thinking about remote patrons asking, "which piece of the map set contains the location of interest, and will the level of detail be sufficient?" (Ibid, p. 81). While some sheet level data is often included in the catalog record, "catalog records rely on words to indicate holdings, unlike the map index which is a graphical tool." (Ibid, p. 82). They also point to an all-too-common situation where a patron arrives at the library, only to find that the single sheet they need from a set is not included in the library's holdings. Online digital index maps are clearly useful for user discovery while searching these collections.

While the project at PSU did make use of GIS technology to create the online index maps, the final product was a static map on the web that essentially served the same function as a paper index, albeit accessible outside the library building. Advances in online GIS and web mapping over the next two decades proved to assuage such limitations.

Christopher Thiry, Geospatial Information Librarian at Colorado School of Mines in Golden, Colorado, discussed GIS-based discovery of paper map sets in a previous issue of *e-Perimetron* (Thiry, 2017). Thiry and student workers at Arthur Lakes Library's map room used ArcGIS Desktop to create index files and used ArcGIS Online to store and share digital index maps for paper map series. Unlike during the time of early work on digital index mapping at the AGSL or PSU Libraries, scanning maps and posting them in digital collections has become commonplace as the price of scanning hardware has decreased considerably and li. This meant that index maps were now not only needed for identifying a sheet in the physical collection but could also be used to link to digitized map sheets in a digital collection or repository. Use of the popular ESRI ArcGIS Desktop software and ArcGIS Online platform meant that librarians could use these familiar tools that are often available through institutional licenses at their universities. An ArcGIS Online group was created in 2013 that encouraged others to create and contribute GIS index maps to the project. The AGSL sent versions of Geodex files to be included in the project which still seems to be active at the time of writing.

Indiana University Bloomington followed Thiry's lead in using ArcGIS Online to create an interactive index map for their collection of Soviet Red Army topographic maps. The map set is incomplete and component maps are from various sources. Some are "captured maps", some have stamps from the US Central Intelligence Agency or the Library of Congress, and others include hand-written annotations (Dalmau and Quill, n.d.). The interactive index map has useful features including symbology for different scales, links to both original items and georeferenced items, and a visual mosaic of scanned map images for some sheets. Clicking on hyperlinks to original items takes users to a Google Drive where downloadable versions are available.

Another recent example took a different approach. University of California-Santa Barbara libraries Curator of Geospatial and Digital Collections Tom Brittnacher presented a poster (Brittnacher, 2017) on Index Maps at Samvera Connect 2017. In this use case, the paper index map was scanned in high resolution and is displayed on the set-level page in their Alexandria Digital Research Library employing a IIIF (International Image Interoperability Framework) viewer. This allows a user to zoom in to see the details on the index map. Thumbnail links to map sheets, labeled by their sheet number, are below the index map on the page. His poster explores the complex relationships between a map set and its component sheets. The index map itself is "typically not part of the same intellectual work as the component maps, as it was most likely published in a separate document or was created by hand" (Ibid, n.p.).

OpenIndexMaps Development and Specification

The OpenIndexMaps project got underway during a session at the 2017 Geo4LibCamp meeting at Stanford University. Geo4LibCamp, an annual "unconference" hosted by Stanford University Libraries for members of the GeoBlacklight community, is described as a "hands-on meeting to bring together those building repository services for geospatial data" (geo4libcamp.org). Based on the session, a website with the first version of the specification was drafted.

GeoBlacklight (geoblacklight.org) is a discovery-focused platform and web application for geospatial data that is collaboratively developed by a loosely organized collaborative of map and geospatial librarians at academic or public library institutions often called Geo4Lib, or increasingly, the GeoBlacklight Community. The platform has a focus on discovery and seeks to address the particular challenges faced by library patrons searching for geospatial information including GIS data, digitized maps, geospatial web services, among other items. Importantly, GeoBlacklight is designed to work as a federated portal, with search results returning not only local holdings but also holdings from other geoportals participating in the community.

OpenIndexMaps uses the GeoJSON format, "a geospatial data interchange format based on JavaScript Object Notation (JSON)" (Butler et al, 2016). Popular for web mapping, GeoJSON files are text files containing structured data optimized for manipulation using JavaScript methods. The structure forms a series of objects with both qualitative attributes and coordinate-based geometry. For OpenIndexMaps, each map sheet or air photo frame is represented as one such object.

Geography stored for a map sheet can be a simple bounding box defined by a series of 4 coordinate pairs, but the GeoJSON specification does not limit the geography to being so simple. It is possible to define more complex polygons including non-rectangular geometry, multi-polygons, and methods for addressing the 180th meridian problem (defining a bounding box using coordinate geometry can be ambiguous for polygons crossing the 180th meridian). While the current specification for OpenIndexMaps does not make specific recommendations for geography beyond using one polygon per sheet. However, methods for representing more complex geometry such as maps with inset maps which may extend beyond the bounds of the primary extent, single sheets with multiple discrete maps with non-contiguous extents, non-rectangular extents, et cetera, are certainly possible within the GeoJSON specification.

OpenGeoMetadata (opengeometadata.org), another project of Geo4Lib, leverages GitHub to host repositories of geospatial metadata to be consumed by federated portals. Similar GitHub repositories have already been initialized for hosting OpenIndexMaps. Hosting OpenIndexMaps files on GitHub allows for transparent editing and makes the files easily shareable. Each institution has its own repository within the OpenIndexMaps GitHub organization.

Having been created by members of the GeoBlacklight community, there was an emphasis on ensuring that the specification did not recommend or require functionality that is not available in the GeoBlacklight application. It is possible that GeoBlacklight applications could leverage OpenIndexMaps files to enhance discovery of other items in the repository like scanned maps, aerial photo frames, or any geographic information distributed in a gridded or net-like pattern. OpenIndexMaps is already driving innovation back to development of the GeoBlacklight application itself; for example, OpenIndexMaps can include two completely co-incident polygons representing different versions of the same sheet. The latest version of the GeoBlacklight application was updated to allow display functionality in such cases. In fact, all requirements in the specification (as opposed to recommendations) are because of GeoBlacklight requirements except for the GeoJSON format itself and the WGS84 coordinate reference system (which is a requirement of GeoJSON, albeit one that has exceptions for special use cases).

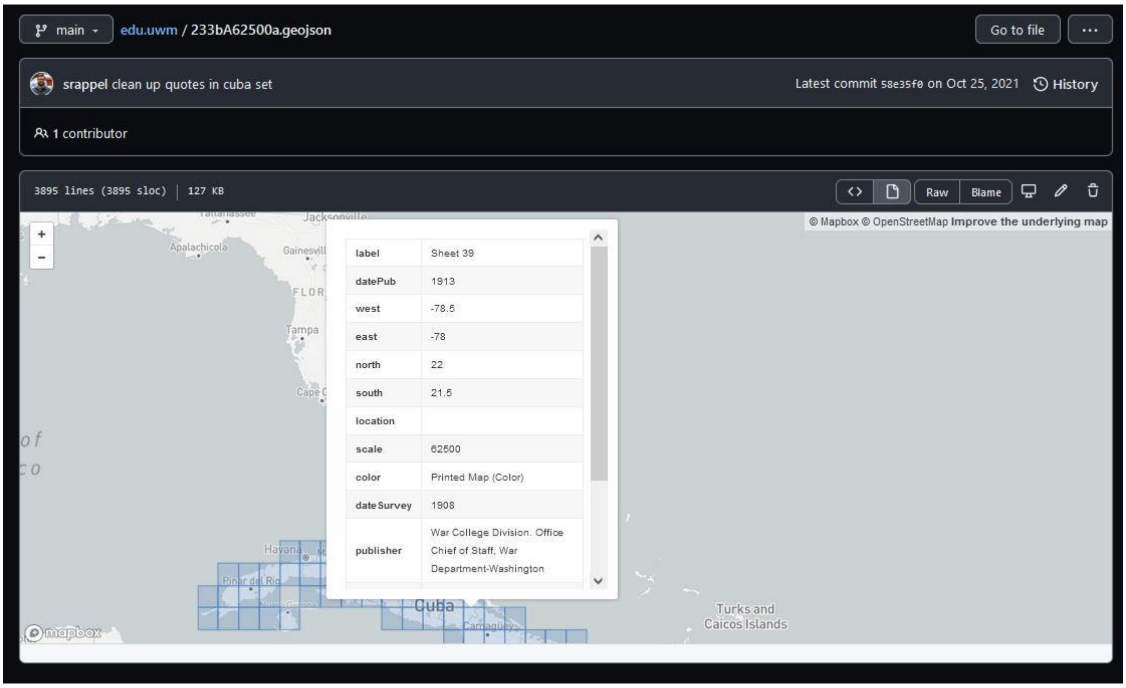

Figure 4: Screenshot of the OpenIndexMaps file for the Cuba Military Map set as previewed on GitHub

The specification recommends that individual (GeoJSON) files represent one map set or air photo flight. Valid GeoJSON requires using WGS84 as a coordinate system, however both the GeoJSON and OpenIndexMaps specifications recognize that exceptions could be made. In recognizing that many workflows will see OpenIndexMaps file created using GIS software, the 10-character limit for element names of the ESRI Shapefile was adopted as a recommendation for maximum interoperability. Additionally, element names should be camel case (e.g., camelCase) as is expected by the GeoBlacklight application.

Developers of the specification recognize that institutions may have uses for local elements. It is anticipated that as examples and use cases are shared, additional recommended elements may be added.

The specification includes ways to indicate both physical and digital holdings. Holdings are represented as a Boolean: *true* or *false*. Physical holdings may be indicated by a link to a catalog record. For digital holdings, GeoBlacklight requires a URL that provides direct access to the digital item (such as a URI for an institutional repository or digital collection). Institutions using OpenIndexMaps independent of a GeoBlacklight instance have more flexibility in how the holdings fields are utilized.

Frames or sheet numbers are often used to label the geometry in a web map interface. Therefore, it is recommended to enter the sheet or frame label as it appears on the item. It is recommended that dates are entered as strings using the extended date time format (EDTF) from the Library of Congress (e.g., YYYY, YYYY-MM-DD).

Fields that can hold multiple values can be stored as arrays. An example of such a field is *location*. A map may contain many locations, and this field will allow each to be stored independently. This could be very useful for linked data use cases or for searching by place name. The Cuba Military Map example on UWM Libraries' OpenIndexMaps repository is a great example of how this field can be used effectively (see section starting on line 1231 of the GeoJSON).

Websites and URLS in the records work best in a GeoBlacklight application if they utilize Hypertext Transfer Protocol Secure (HTTPS) and are served with Cross-Origin Resource Sharing (CORS) enabled.

Schema Elements

The Schema elements are described in four tables below.

Element	Used for	Type	Description	Example
label	Sheet/frame no.	string	Alphanumeric code identifying the sheet or frame. The value of this field is used as a tool tip in GeoBlacklight.	L-16
labelAlt	Alternate sheet/frame no.	string	Alphanumeric code for the sheet or frame that was used for previous or subsequent editions, or for when there are multiple labels	NW8
labelAlt2	Second alternate sheet/frame no.	string	Alphanumeric code for the sheet or frame when there are multiple labels	C17
datePub	Publication date	string	The date that the sheet or frame was published or made available	1978-08
date	Date	string	Used when no other date field is relevant	1978
west	Westernmost longitude	number	Farthest west extent of the sheet/frame bounding box (using the Greenwich Meridian)	-112.32645

east	Easternmost longitude	number	Farthest east extent of the sheet/frame bounding box (using the Greenwich Meridian)	-108.32555
north	Northernmost latitude	number	Farthest north extent of the sheet/frame bounding box	38.7221
south	Southernmost latitude	number	Farthest south extent of the sheet/frame bounding box	30.4656
location	Location	array string	Geographic place name identifying the area covered by the map sheet or air photo frame	[“Fresno”, “Clovis”]
scale	Scale	string	Scale statement (representative fraction plus qualifiers) of the individual sheet/frame	approximately 1:250,000
color	Color, b&w, infrared	string	Indicates whether the sheet/frame is color, black and white, color infrared or another color type	Color, Black and white

Table 1: Elements pertaining to both map sheets and air photo frames

Element	**Used for**	**Type**	**Description**	**Example**
title	Sheet name	string	Title of map, usually a geographic location on that sheet	Santiago
titleAlt	Alternate sheet name	string	Alternate title for the sheet that was used for previous or subsequent editions, or for when there are multiple titles	Rio Branco
dateSurvey	Survey date	string	Date that the map sheet was surveyed	1957
datePhoto	Photocorrected date	string	Date that the map sheet was photo corrected	1966
dateReprnt	Reprint date	string	Date that the map sheet was reprinted	1972
overprint	Overprint	string		
edition	Edition	string	Statement indicating the edition of the map sheet	3rd edition
publisher	Publisher	string	Publisher of the individual sheet (can be used if publishers vary within a map set)	Conselho Nacional de Geografia
overlays	Overlays	string	Describe any overlays or overprints	
projection	Projection	string	The map’s projection, coordinate system and datum	
lcCallNo	LC Call Number	string	Library of Congress call number	
contLines	Contour lines	boolean	Indication of whether or not there are contour lines on the map	true / false
contInterv	Contour interval	string	Distance between contour lines. Include unit (or abbreviation).	200 m
bathLines	Bathymetric lines	boolean	Indication of whether or not there are bathymetric contour lines on the map	true / false
bathInterv	Bathymetric interval	string	Distance between bathymetric contour lines. Include unit (or abbreviation)	200 m
primeMer	Prime Meridian	string	Indicates a prime meridian other than Greenwich	Ferro

Table 2: Elements pertaining to map sheets only

Element	Used for	Type	Description	Example
photo-mos	Photomo-saic	Bool-ean	Indication that the image is a mosaic of several air photos	true / false
bands	Bands	string	Spectral bands present (near infrared, red, green, blue, etc)	
rectificn	Rectifica-tion	string	Any corrections done to adjust the air photo image	orthorecti-fied
rollNo	Roll num-ber	string	Identifier for the film reel from which the air photo comes	

Table 3: Elements pertaining to air photo frames only

Element	Used for	Type	Description	Example
inst	Institution	string	Local institution holding material	
sheetId	Sheet ID	string	Local institution's unique identifier for the sheet/frame	G103 U51 1970 S-34
available	Available	bool-ean	Indication if the institution holds the item at this location in any format	true / false
physHold	Physical holdings	string	Indication if the institution holds the item in a physical format, or a link to information about the physical object	
digHold	Digital holdings	string	Indication if the institution holds the item in a digital format, or a link to information about the digital object, or a link to the digital object itself	
in-stCallNo	Local call number	string	Call number used locally (other than Library of Congress call number)	3200s 250 u5
recId	Record identifier	string	Local institution's unique identifier for the digital object	yr314gw9982
download	Download URL	string	Link used to directly download the digital object	
web-siteUrl	Website URL	string	Link used to direct users to a website with metadata or a download link for the digital object	
thumbUrl	Thumbnail URL	string	Link used to access the thumbnail for the digital object	
iiifUrl	IIIF URL	string	Link used to access the digital image using IIIF	
fileName	File name	string	Digital file associated with sheet/frame	6840s_100_r8_e-49-63.tif
note	Notes	string	Free text for local comments as well as general notes applying to everyone's copy	

Table 4: Elements for entering metadata pertaining to a specific institution only

OpenIndexMaps Projects and Use Cases

The AGSL is working to convert data from the Geodex system into OpenIndexMaps compliant GeoJSON files and host them within the OpenIndexMaps GitHub organizational repository. At the time of writing, the AGSL has published four OpenIndexMaps to our repository. GitHub defaults to previewing these files on a web map interface which makes for a convenient way to preview these files (See figure 4).

I have been working with an AGSL Student Intern and UWM Geography Masters Candidate to develop a python script to rapidly convert Geodex data into GeoJSON files compliant with the OpenIndexMaps specification. Some manual intervention is still required, especially considering that since Geodex was developed in the 1980s, information about digital collections was not included.

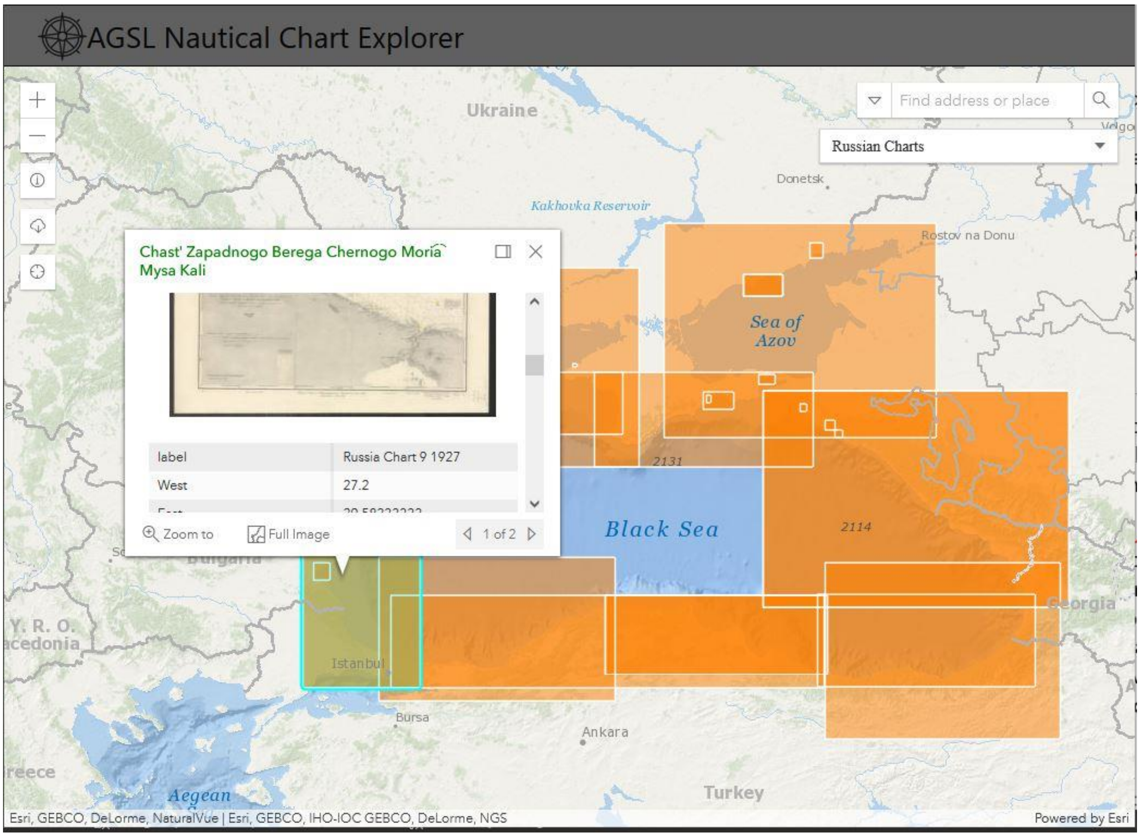

Figure 5: Screenshot of the AGSL Nautical Chart Explorer

The AGSL Nautical Chart Explorer application, a web map interface for searching and viewing historical nautical charts, was AGSL's first attempt to implement the OpenIndexMaps schema for a project. These charts from the 19th and 20th centuries had been digitized and cataloged after fundraising allowed for hiring student interns to assist with these projects. Bounding box information was included in the catalog record and scripts extract this bounding box information from the MARC records and generate OpenIndexMaps compliant GeoJSON files. Additional catalog information was also extracted including publisher information, dates, and other relevant elements.

The application was developed by a field worker doing a remote internship through the UW-Milwaukee School of Information Studies. You can read more detail about the application and its development in his write up on the project for the Western Association of Map Libraries (WAML) *Information Bulletin* (Cowling, 2021).

Not only does the application leverage the GeoJSON format and the OpenIndexMaps specification, but it also links with the UWM Digital Collections, hosted on the ContentDM platform, to display the images in high resolution within the application. ContentDM stores the images using IIIF and allows for API calls to display the image in an open-source viewer. When a user clicks on a footprint in the app they see a popup displaying the image thumbnail and some core metadata. Clicking the image will expand the popup into a high-resolution interactive viewer. The popup also links out to the permalink record for the image in the UWM Digital Collections.

Other participants in the project have been testing out OpenIndexMaps for projects. The University of British Columbia has started to use OpenIndexMaps in their project to digitize their index maps for paper map collections, particularly for prioritized Canadian map series. They have also done some introductory work on templating OpenIndexMaps displays in Mapbox, a popular web mapping platform.

Stanford University has been using OpenIndexMaps to improve access and discovery for paper map series on their Earthworks Geoportal. Their collection, Gaihōzu: Japanese Imperial Maps, was established before the more refined specification was developed, but is a great example of how these index maps can be used to quickly identify areas and sheets of interest.

Cornell University published some early examples of OpenIndexMaps to the GitHub repository before the current specification was finalized. Their GIS & Geospatial Applications Librarian, Keith Jenkins, taught a workshop at the 2020 Geo4LibCamp that used QGIS to create OpenIndexMaps GeoJSON files.

The GeoBlacklight community has maintained a converter on the openindexmaps.org website to convert ESRI Shapefile format index map files into OpenIndexMaps compliant GeoJSON files. It was last updated following the release of the most recent specification in 2021.The community that developed OpenIndexMaps has no immediate plans for updates or changes. At the time of writing, many of the participants are testing out workflows that make sense for their own institutions and sharing out examples and tips on the GeoBlacklight Slack.

The table below shows the current participants in OpenIndexMaps development along with their institutional affiliations.

Participant	**Institution**
Stephen Appel	University of Wisconsin-Milwaukee
Tom Brittnacher	University of California-Santa Barbara
Kim Durante	Stanford University
Dave Hendlin	University of California-Santa Barbara
Taylor Hixson	New York University-Abu Dhabi
Keith Jenkins	Cornell University
Stace Maples	Stanford University
David Medeiros	Stanford University
Susan Powell	University of California-Berkeley
Jack Reed	Stanford University
Evan Thornberry	University of British Columbia
Phil White	University of Colorado-Boulder
Amy Work	University of California-San Diego

Table 5: OpenIndexMaps Participants and Institutions as of the schema release in April 2021

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