# Radio Explorations: Computing Identities of Transmissions



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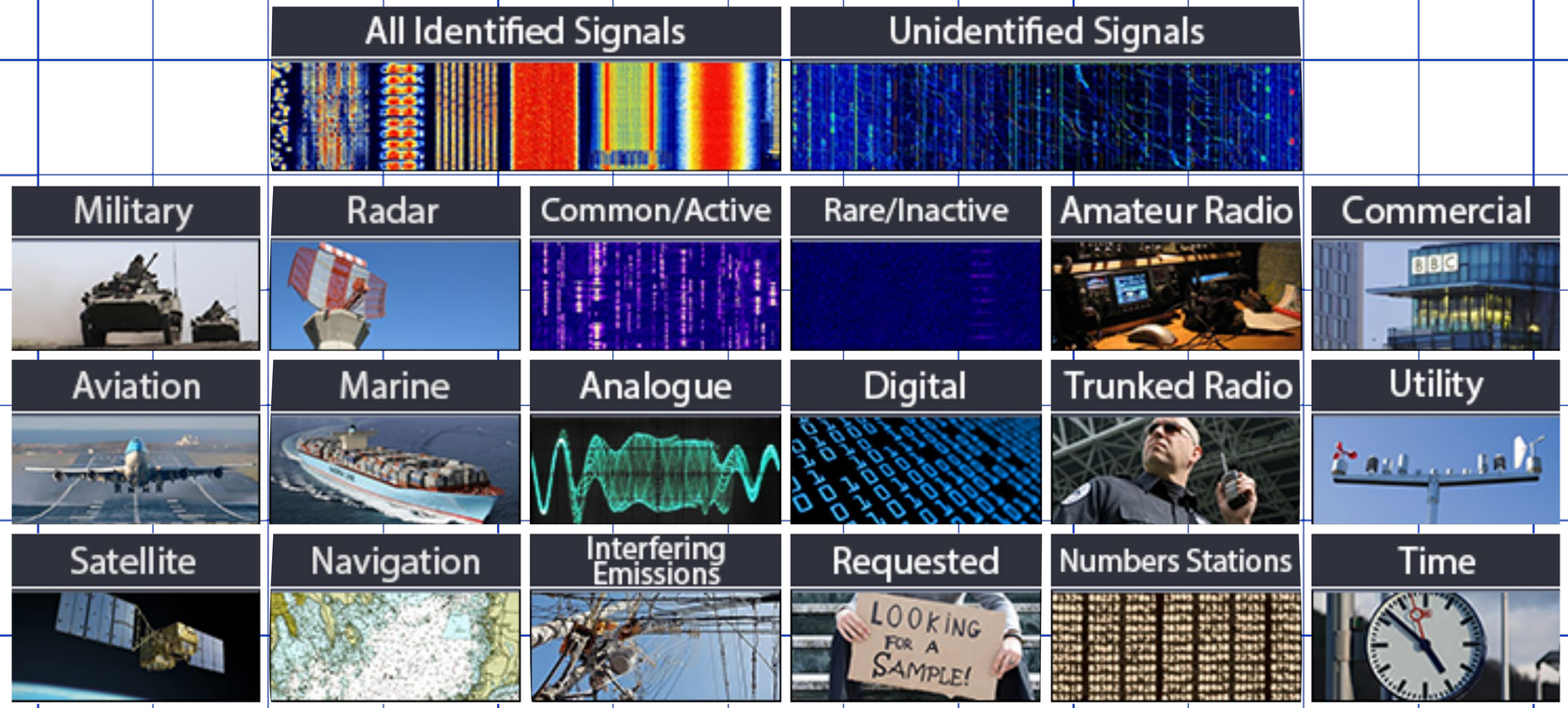
Radio Explorations project addresses onto-epistemologies of radio signals: the technical, the cultural, and the sociological ways of knowing these transmissions. We cannot sense electromagnetic waves that radio signals are made of, but we make sense of them through classification, categorization and identification.






Everything we encounter appears already categorized in some way, which further propagates the presumption that these categories are meaningful in themselves. With the example of a radio signal dataset, I strive to challenge conventional dualisms and classification as normative modes of thinking, perpetrating a singular logic of the world (for example: the logic of a radio amateur's fascination with communication engineering). I propose to develop nomadic identities for radio signals, always made anew through computational comparisons across a dataset of recordings of different radio transmissions.To counter this, I will propose nomadic identities for radio signals, always made anew through computational comparisons across a dataset of recordings of different radio transmissionsradio transmissions.

Radio Explorations

“Radio was heard before it was invented” D. Kahn, *Earth Sound, Earth Signal,* 2013

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Radio is a phenomenon that is particularly relevant to challenge the habit of dualism and hyper-separations  onto nature and culture, and other oppositions and exclusions that informed burgeoning anthropocentrism since Enlightenment, or earlier even. Radio was ‘heard’ before it was ‘invented’. Douglas Kahn recounted the strange experiences of Alexander Bell’s assistant, Thomas Watson, who often listened to natural radio over the telephone wires at night. Hiss, Whistler, Dawn chorus are some of the names given to naturally occurring radio waves in the Earth’s ionosphere or magnetosphere. On the other hand, a larger portion of signals on Earth are man-made wireless communication signals that follow specific protocols for transmission, encoding and transporting information relevant to us, humans.

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SIGIDWIKI.COM
SIGNAL IDENTIFICATION GUIDE

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# Signal Identification Guide

This wiki is intended to help identify radio signals through example sounds and waterfall images. Most signals are received and recorded using a software defined radio such as the RTL-SDR, Airspy, SDRPlay, HackRF, BladeRF, Funcube Dongle, USRP or others.

**Editing:** Anyone can edit this wiki, so if you see missing or wrong information please feel free to correct it by clicking the 'edit with form' button at the stop of the signals page. When doing an edit, if you are not logged in as a user, you will be asked to answer a very simple spam prevention question which will appear at the top of the screen after clicking on Save page. If you are not experienced with editing Wiki Markup, refer to this reference card, Quick Guide of editing pages, or just email the requested changes at sigidwiki_AT_gmail_DOT_com.

**Discussion:** You can also discuss the signals by using the discussion tab at the top of every page, or just by using the comments box at the bottom of this page (note that the comments section will be periodically pruned to reduce its length).

**We now have a Discord server up for people who would like to chat about signals as well. To join you must send an email to sigidwiki_AT_gmail_DOT_com for an invite to the server.**

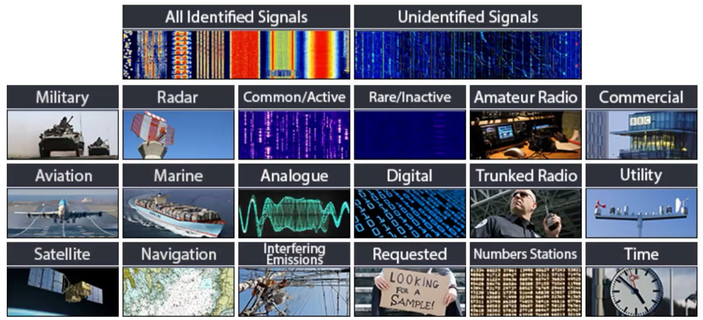

## Software

**Artemis 3**

Check out Artemis 3, the main companion app to this guide! Artemis 3 gives you all known reference signals in an easy to access offline format, with improved sorting and filters and offline audio samples and waterfalls.

## Frequency Bands


## Categories




Radio Explorations

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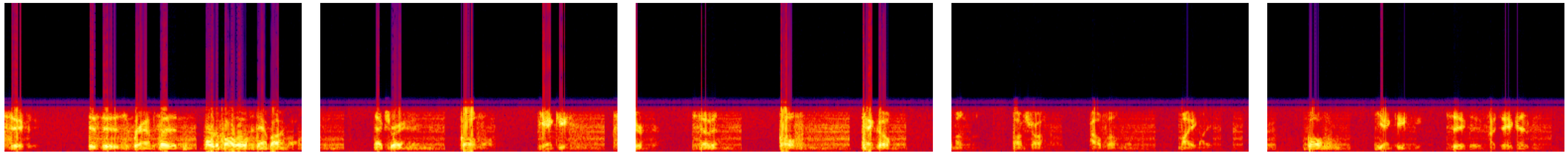
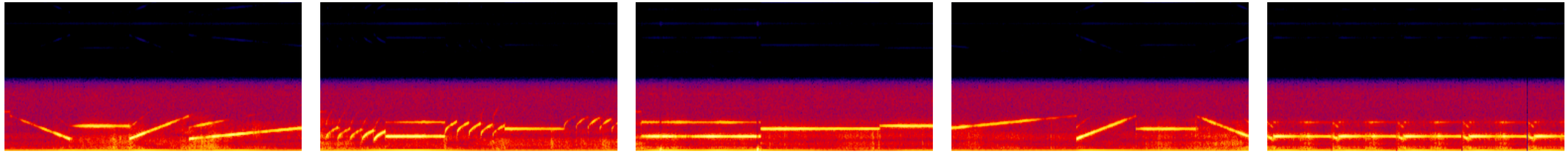
I work with the data on radio signals from the Signal Identification Guide (SIGID) wiki. This is an organized collection of information about radio signals, held among a community of radio amateurs and enthusiasts. There are currently 424 known or identified and 318 non-identified signal pages on the website. The archival strategy is contingent on community interest in different radio signal application domain, such as the military, amateur radio, commercial, marine, trunked signals or satellite reception. Known signals are divided up in categories based on these applications. They are also organized according to signal properties such as analogue or digital information encoding, or frequency band they occupy (very low, low, middle, high).

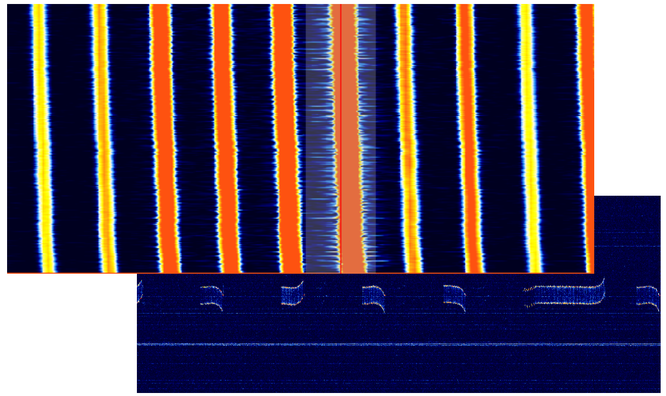




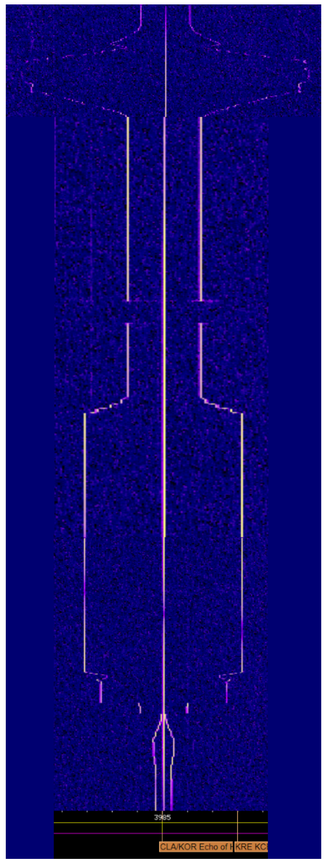


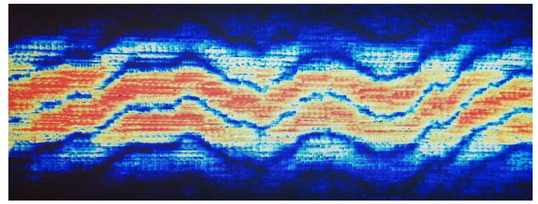
How can we approach radio transmissions outside of these categorizations? Radio signals are already hard to characterize because they are time-based: most signals do not have a static representation but, especially when transmitting data, operate in different modes, phases, and other temporal variations.

# IDENTIFICATION







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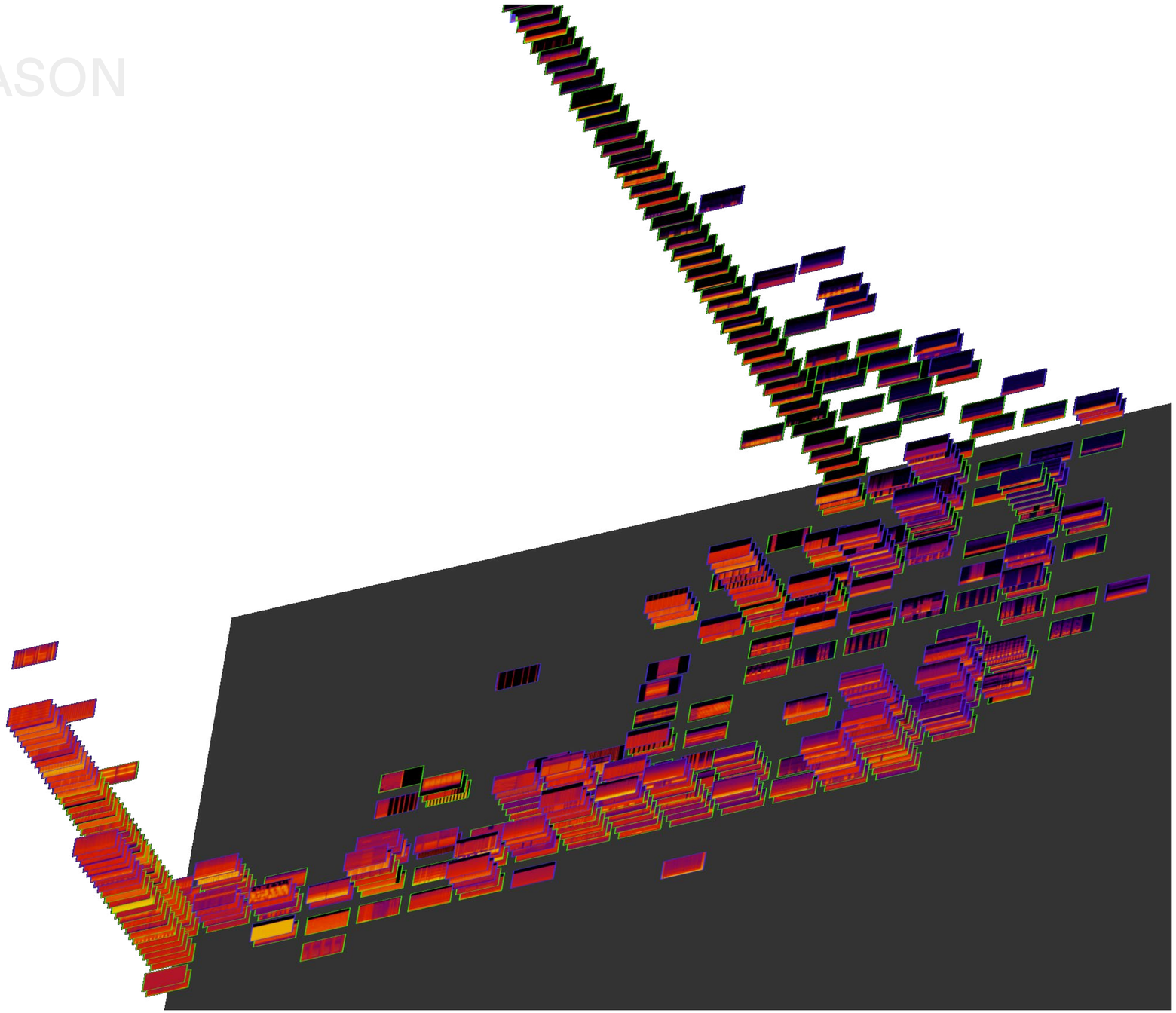
What gives identity to radio signals? Here, I focus on unpacking radio signal identification process as it is practiced by radio enthusiasts, who approach it from what they can do for us (anthropocentric view) and how they exist technically (a form of essentialism), in order to de-territorializes or rather re-territorializes identity in terms of other radio signals - organizing a radio signals space.

# MACHINE REASON



Radio Explorations

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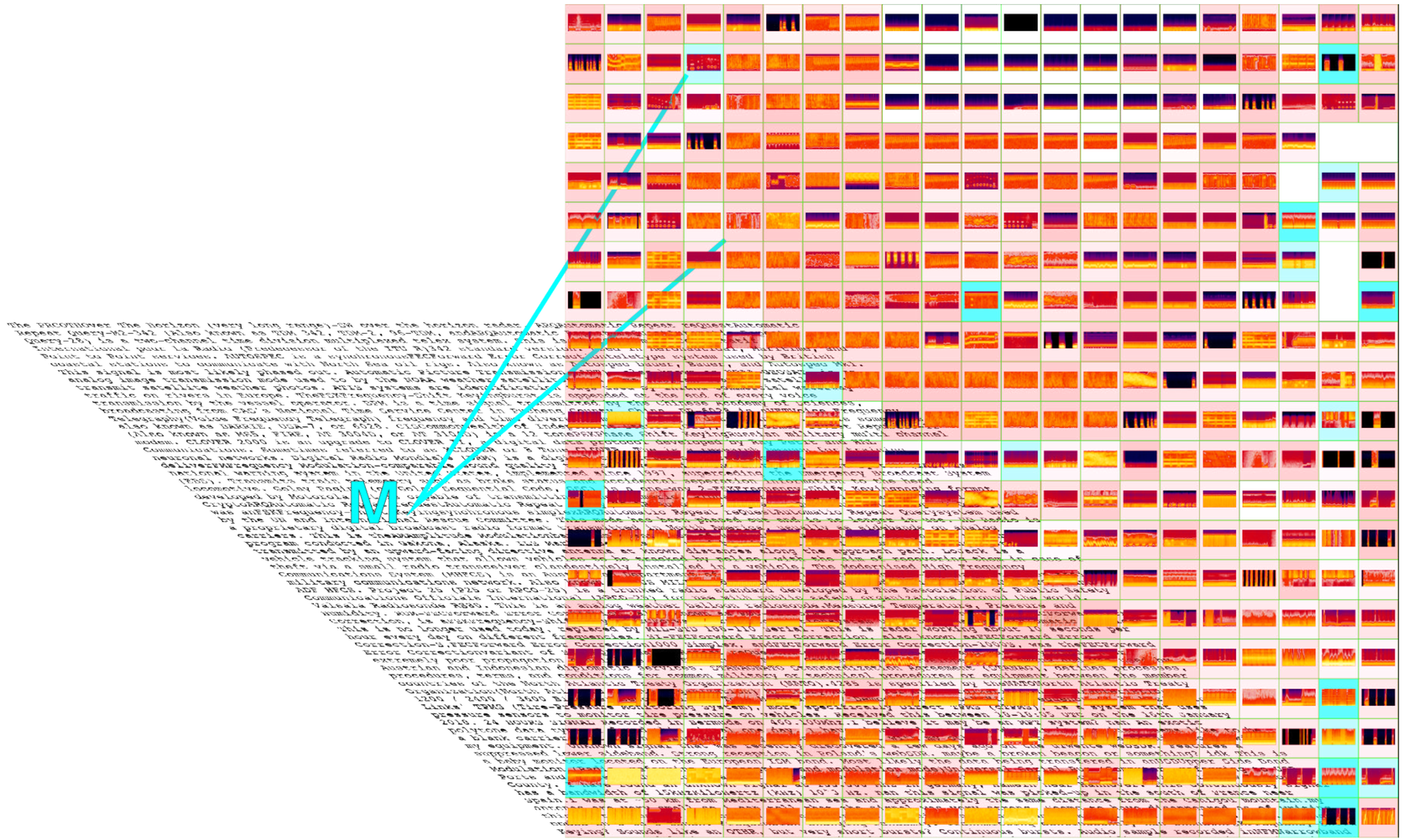
I examine the capacity of machine learning techniques to support reasoning about environmental radio transmissions. One particular machine learning algorithm that facilitates identification of unlabelled classes and their organisation is interest: Self-organizing map (SOM) is an unsupervised machine learning technique introduced in 1980s by a finish computer scientist Teuvo Kohonen. It is known for its ability to classify data in an intuitive manner, emergent from the data. SOM has been widely applied across different fields such as text mining, genetics and synthetic biology, ecology along with numerous engineering applications. We can observe in these efforts, how machine learning algorithms challenge the way we ask questions: it is not so much about finding correlations - they are abundant; but about constructing meaningful ways to interpret them. How do we choose what is meaningful to us?

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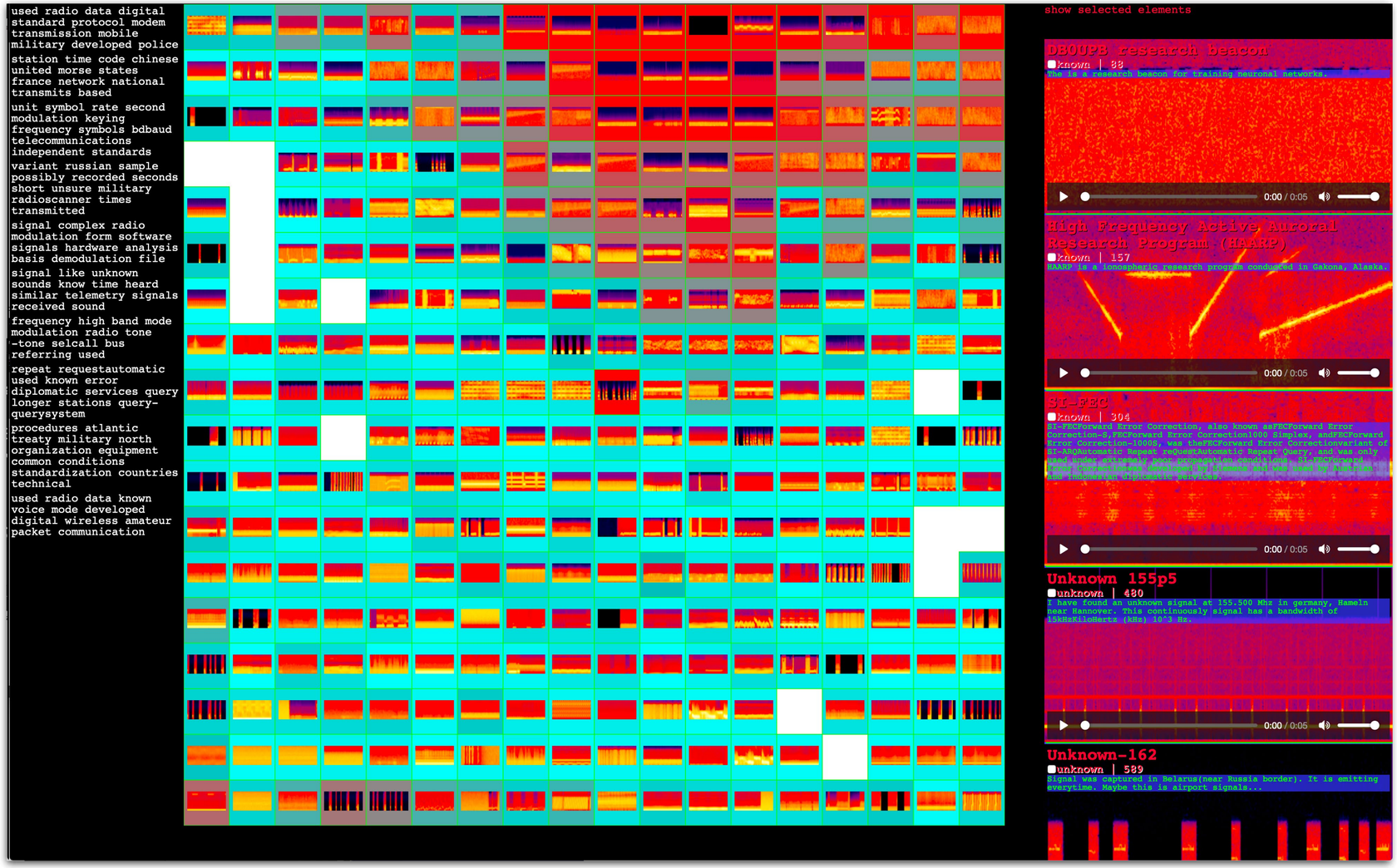
Starting from an unordered collection of recordings of different transmissions and their meta-data, I organise radio signals, somewhat ironically, in a rectangular grid. These are concrete manifestations of radio transmissions, collected by radio enthusiasts around the world. The relationships that emerge within the grid are observed only as projections, filtered through topologies of other data, in a volumetric thinking setup. The aim is to articulate signals' identities in terms of their own characteristics, and in a number of different ways.

# DESCRIPTIONS




Radio Explorations

https://radioexplorations.ch/study-1/visualize_radio/

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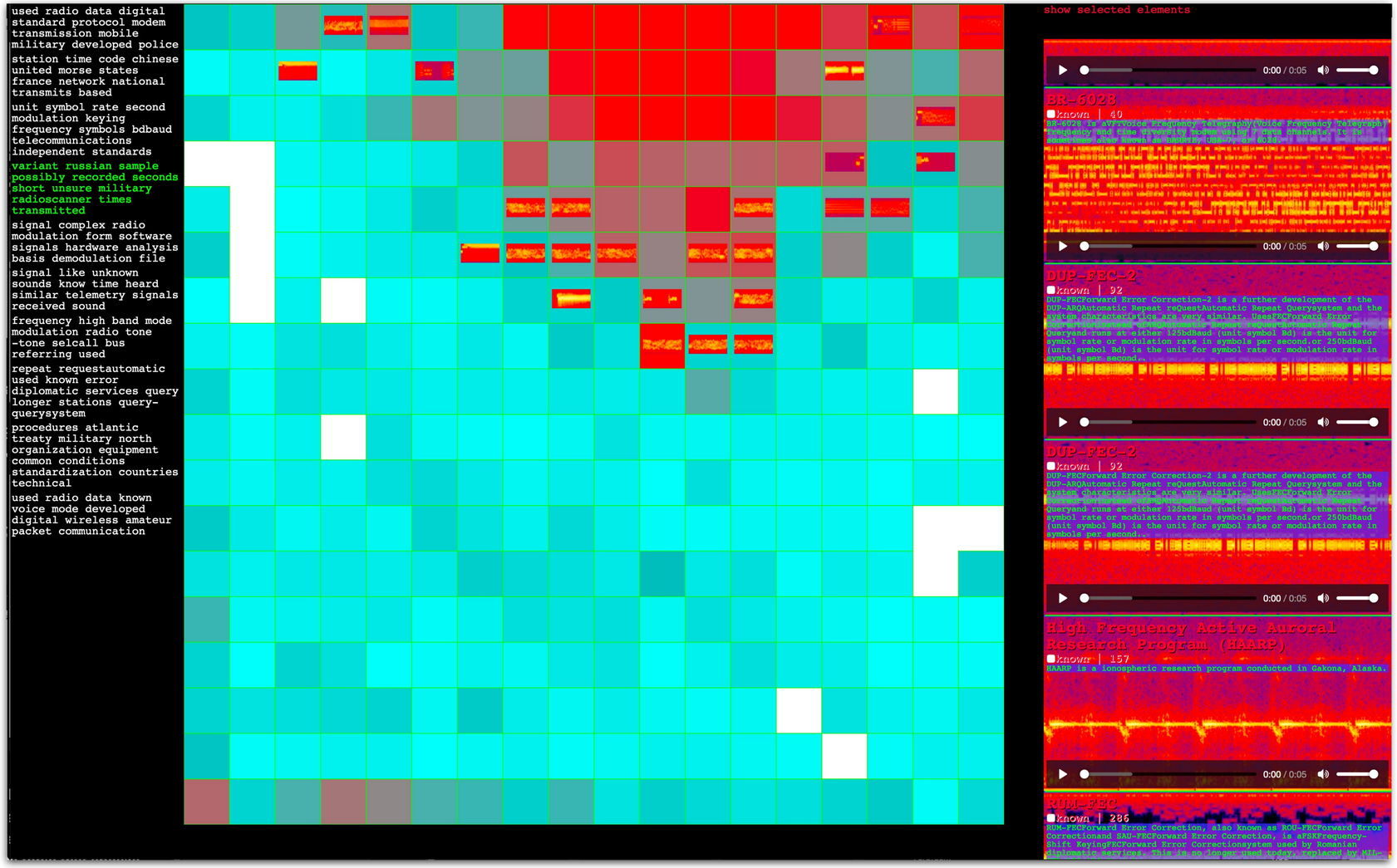
This is one way to organize the data, the first ‘data observatory’. How do I know where to start? Let’s take any signal and look at it. For example this one here: High frequency active auroral research programme . It looks like a photograph of neon lamps in space. But this is a spectrogram. It is a Time-frequency representation of sound. The description says it belongs to a research programme studying the properties and behavior of the Earth’s ionosphere. Reading about ionospherics elsewhere, I learned that some climate research uses data on lightnings to measure the degree of climate change. They found, already in 1999, a significant correlation between the increase in temperature and in lightning activity in the northern hemisphere of our planet.

# DESCRIPTIONS

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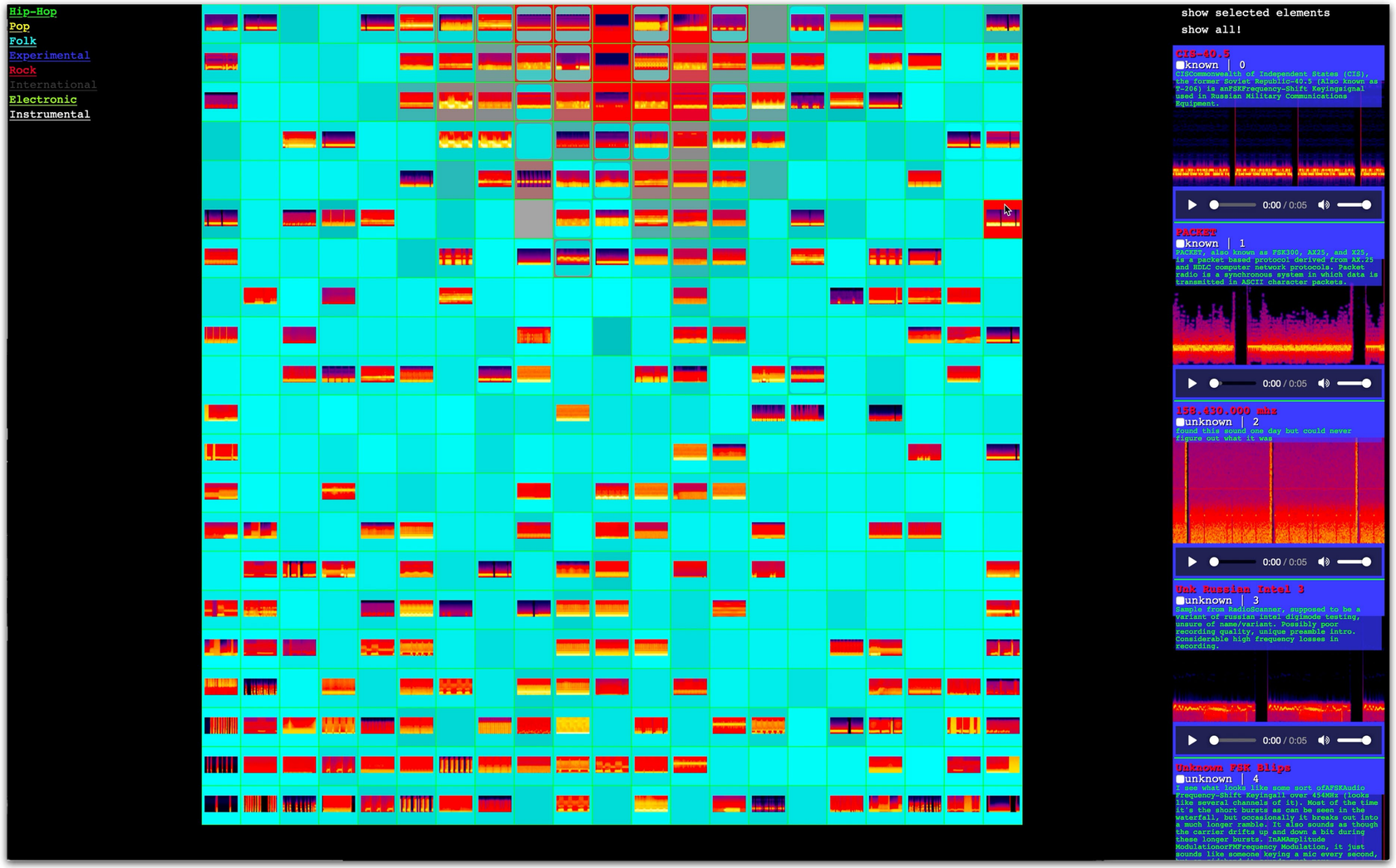
This is a story that can emerge from descriptions of radio signal transmissions. This is why I built the first data observatory around text. I extracted ‘topics’ from all descriptions of all signals in the archive. Now, let’s say that I am interested in the relationship of radio and military. Is there something new and specific we can learn from this setup? I highlight one topic that speaks about military and some related keywords. Interestingly, the signal we just looked at, is found in one of the cells at the bottom of this area. It is a rhythmical sample that has a similar rhythm and spectral power to DUP-FEC-2. I notice the FEC in the names of other signals. Apparently, FEC stands for “Forward error correction” - an error control method used in situations where retransmissions are impossible. What this cell tells us about military: it is tightly connected with diplomacy and intelligence; impossibility of retransmission is characteristic of military communication.

# PROJECTIONS

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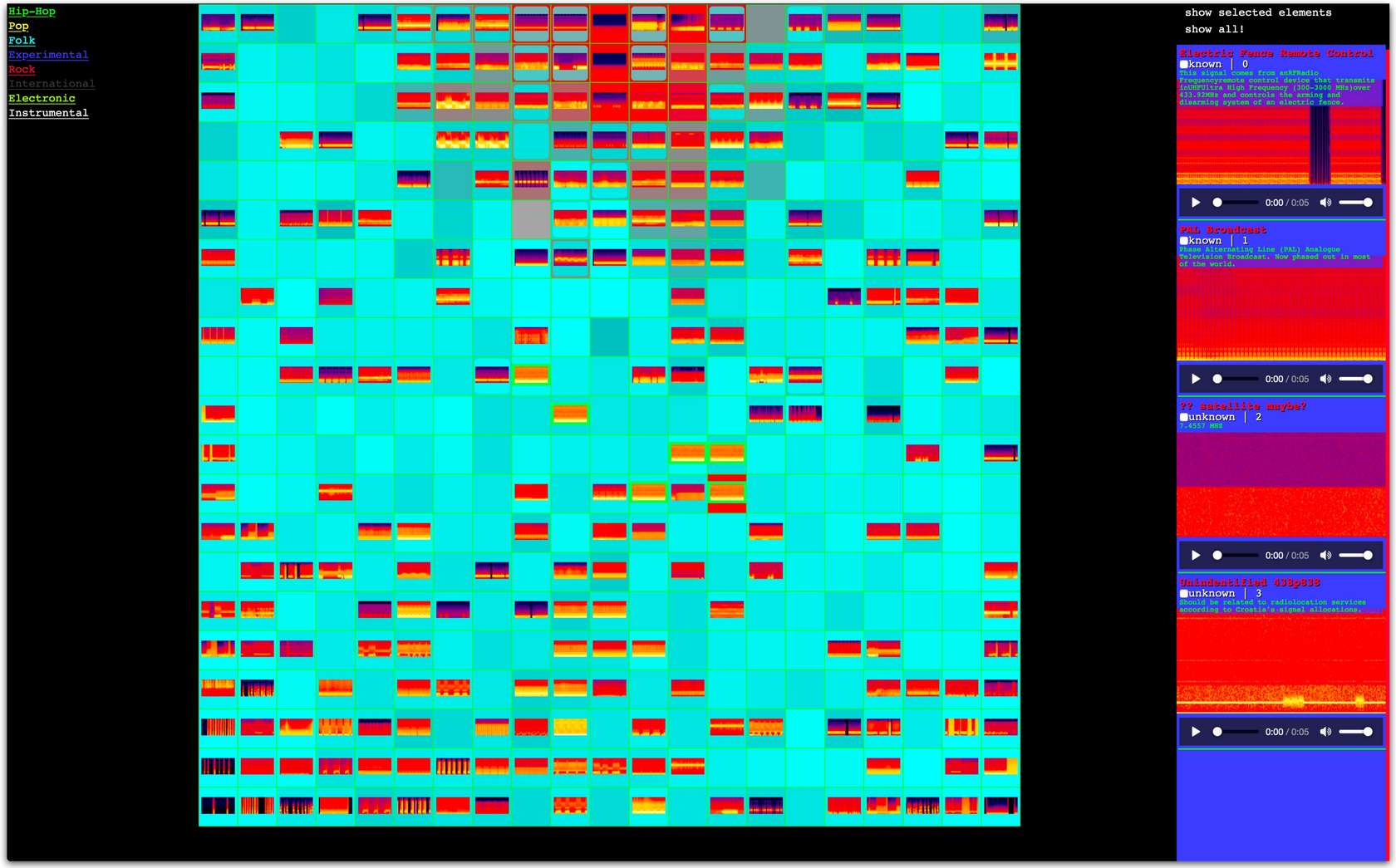
A pragmatic question to ask is whether this organization can support identification of ‘unknown’ signals? This would mean, in our case, matching a signal categorized as ‘unknown’ to a ‘known’ signal from the database. This is normally done by careful observation of different signal properties by someone who has already ‘seen’ and ‘heard’ a large number of signals, and understand patterns left by different communication protocols. I propose to work differently: I propose to find a different plane of similarity, in comparison to which I can establish similarities between signals in projections and reflections off of a different kind of data, something I can actually understand and compare.

# PROJECTIONS

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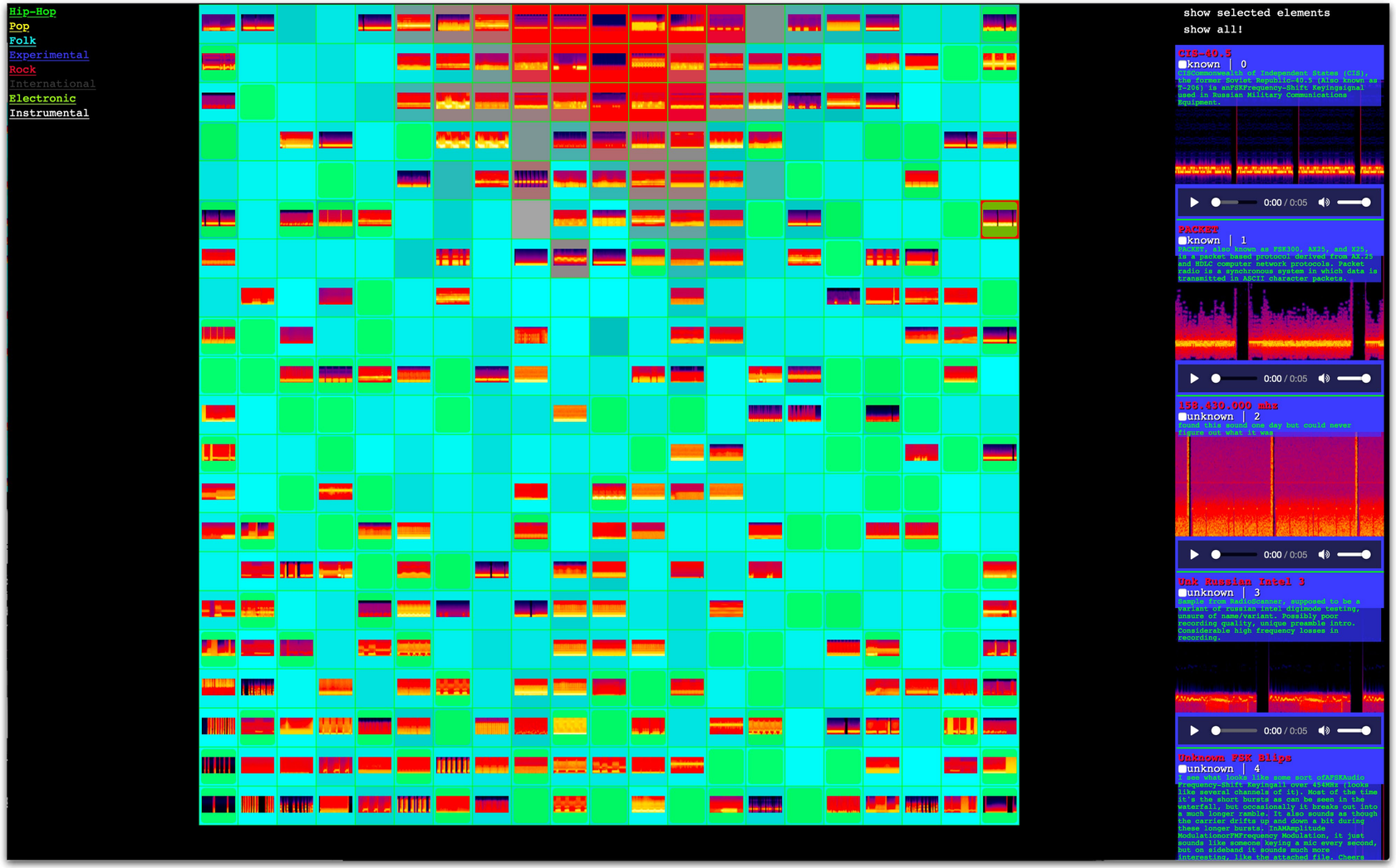
The second data observatory organizes radio signals through musical genres. It does not compare them to the genres, but projects radio signals onto a SOM that organises songs from the Free Music Archive (FMA) dataset for music analysis. Signals ‘land’ in those cells that correspond to them. Some cells do not attract any radio signals. Folk genre, as represented in this dataset, appears to have a lot in common with radio signals. Now, it is also relevant how radio is placed next to each other.
I tried to use this system to identify unknown signals, together with the administrator of the SIGID website. We identified some interesting groupings of unknown signals.

# PROJECTIONS

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The imperfectness of data comes to focus. In terms of information content, these are like recordings of a pop song in a club. We found out that a lot of the ‘similarity’ between songs and radio signals comes in as an artefact of recording, listening itself, the fact that these are transmissions in the environment, modulated by the spatial conditions, and equipment operation. This points to the importance of not taking the results of algorithmic processes on data as ‘truth about the world’. Data can be very noisy, or is speaking of a different phenomenon altogether. Therefore, it is only interesting to use algorithms in order to gain multiple perspectives on the data, to articulate careful and specific questions, and then maybe do something about it.

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While machine learning is often discussed in humanities in terms of its biases and problems with optimization, this project stresses the importance of digital literacy when working with digital information. I articulate how identities can be read in machine learning statistical models. It is an experimental method of workin with biases, in order to make them legible, countable and accountable. I propose these identification processes as arbitrary, nomadic renderings of reality in the eyes of a machine, affirming inherent instability and flexibility of a signal's identity. By rendering signals commensurable in this way, I propose to take an active stance with regards to machine learning algorithms and expose a research interest from which we can learn and tell stories about signals.