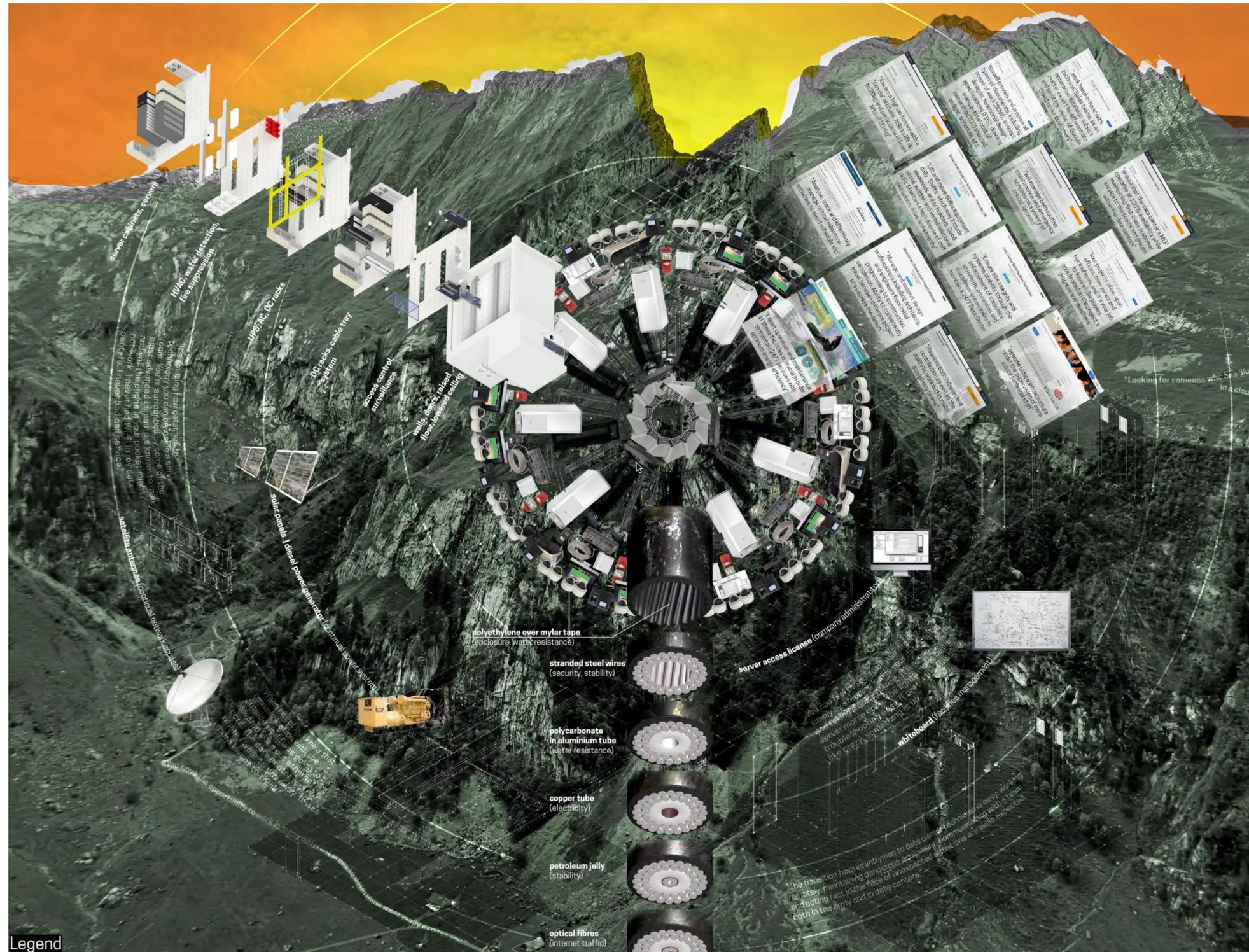


# Radio Explorations: Data Observatories of Environmental Radio Transmissions

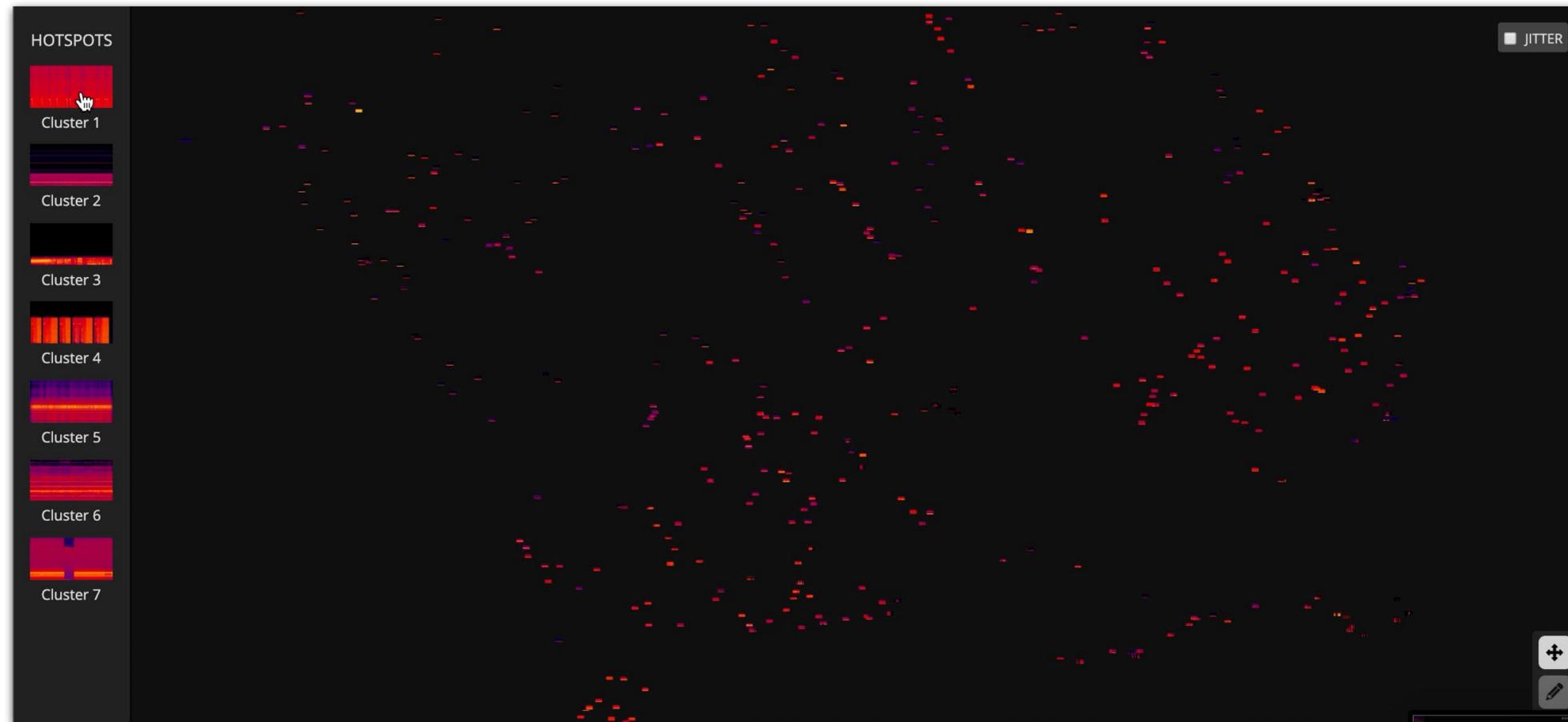


Radio Explorations

Savić, S., Bruder, J., Ganesh, M. Cloud Cosmogram <http://cloudcosmogram.space>

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One of the premisses of this project is to question the way we order things. Haunted by Cartesian thought, we rely on the habit of dualism and hyper-separations to know the world. Nature and culture, body and mind, information and noise. Furthermore, we attempt to fix layers of operation, responsibility and communication, to organise things into coherent sub-domains. This ordering of what we know and experience, informs how we understand and interact with the world, or attempt to design it.



A data-driven approach promises to treat the world with computational objectivity. Taken at face value, it rationalizes the world in ways inaccessible to humans. This can absolve us from agency and responsibility in deciding what matters and how. I propose to invert these concerns and explore how data can be organized. I look at recordings of environmental radio transmissions as digital artefacts. I ask how this can provide avenues for working with other kinds of environmental data?



Radio Explorations

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

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Radio is an interesting phenomenon to challenge the dualisms and hyper-separations previously mentioned. It is a natural phenomenon, but it can be artificially generated, engineered and used in human communication. Radio is one way the city leaks into nature.

**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](mailto: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](mailto:sigidwiki_AT_gmail_DOT_com) for an invite to the server.

[Add A Signal](#) [Regulatory Databases](#)

### 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

| VLF | LF | MF | HF  | VHF | UHF |
|-----|----|----|-----|-----|-----|
|     |    |    |     |     |     |
| 15  | 24 | 33 | 213 | 121 | 156 |

## CATEGORIES

| All Identified Signals |            |                       |               | Unidentified Signals |            |
|------------------------|------------|-----------------------|---------------|----------------------|------------|
|                        |            |                       |               |                      |            |
| Military               | Radar      | Common/Active         | Rare/Inactive | Amateur Radio        | Commercial |
|                        |            |                       |               |                      |            |
| Aviation               | Marine     | Analogue              | Digital       | Trunked Radio        | Utility    |
|                        |            |                       |               |                      |            |
| Satellite              | Navigation | Interfering Emissions | Requested     | Numbers Stations     | Time       |

The Signal Identification Guide (SIGID) wiki 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. Known signals are divided up in categories based on different listeners community interests, such as the military, amateur radio, trunked signals or satellite reception. Each signal is characterized by its different properties, a short description and includes a recording sample with the spectrogram. Any radio signal that can be received and recorded can be included in the database.



Radio Explorations

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I organize concrete manifestations of radio, collected by radio enthusiasts around the world, in a grid space using the unsupervised machine learning algorithm, self-organising map. Interestingly, the data itself - audio samples of radio signal transmissions - means nothing to us as humans. It is hard to say what, if anything, the clustering means then. I take this as an additional degree of freedom - and responsibility - to articulate precisely and specifically what I am looking for.

# DESCRIPTIONS

The image shows a screenshot of the 'Radio Explorations' website. On the left side, there is a large grid of spectrograms, each representing a different radio signal. The spectrograms are color-coded, with red and orange indicating higher intensity. On the right side, there is a sidebar titled 'show selected elements' which lists several radio signals with their names, known status, and descriptions. The signals listed are:

- DBOUE research beacon** (known | 88): This is a research beacon for training beacon networks.
- High Frequency Active Auroral Research Program (HAARP)** (known | 157): HAARP is a ionospheric research program conducted in Gakona, Alaska.
- STEREO** (known | 304): STEREO is a radio transmission, also known as STEREO-1000, was the STEREO-1000 Simplex, and STEREO-1000 was the STEREO-1000 Simplex, and STEREO-1000 was the STEREO-1000 Simplex.
- Unknown 155p5** (unknown | 480): I have found an unknown signal at 155.500 Mhz in germany, Hameln near Hannover. This continuously signal has a bandwidth of 1000Hz (rate: 10'3 Hz).
- Unknown-162** (unknown | 589): Signal was captured in Belarus (near Russia border). It is emitting everytime. Maybe this is airport signals...

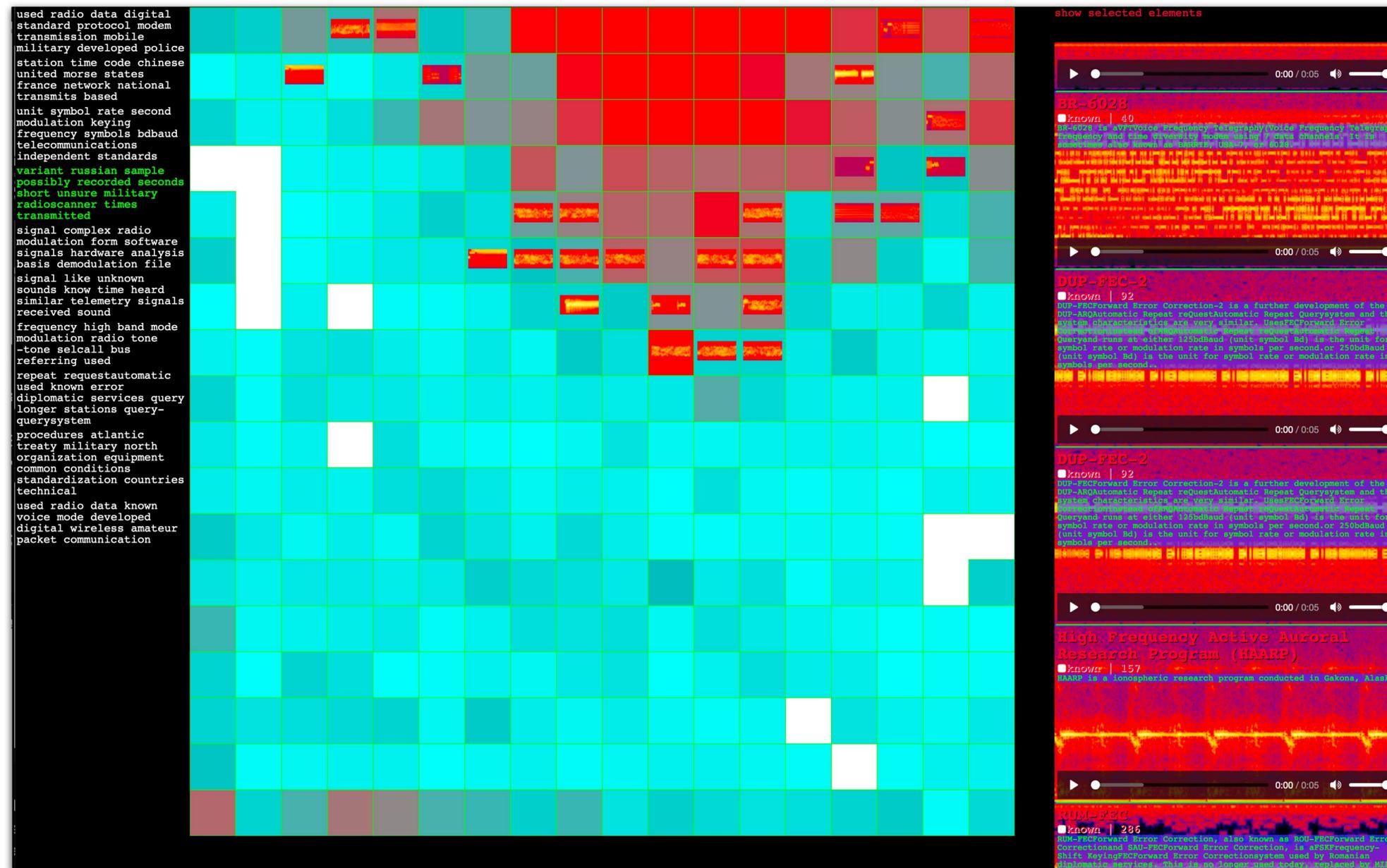
Radio Explorations

[https://radioexplorations.ch/study-1/visualize\\_radio/](https://radioexplorations.ch/study-1/visualize_radio/)

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How do I know where to start? Let's take any signal and look at it. For example: 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. This is quite a good find for our topic today. 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



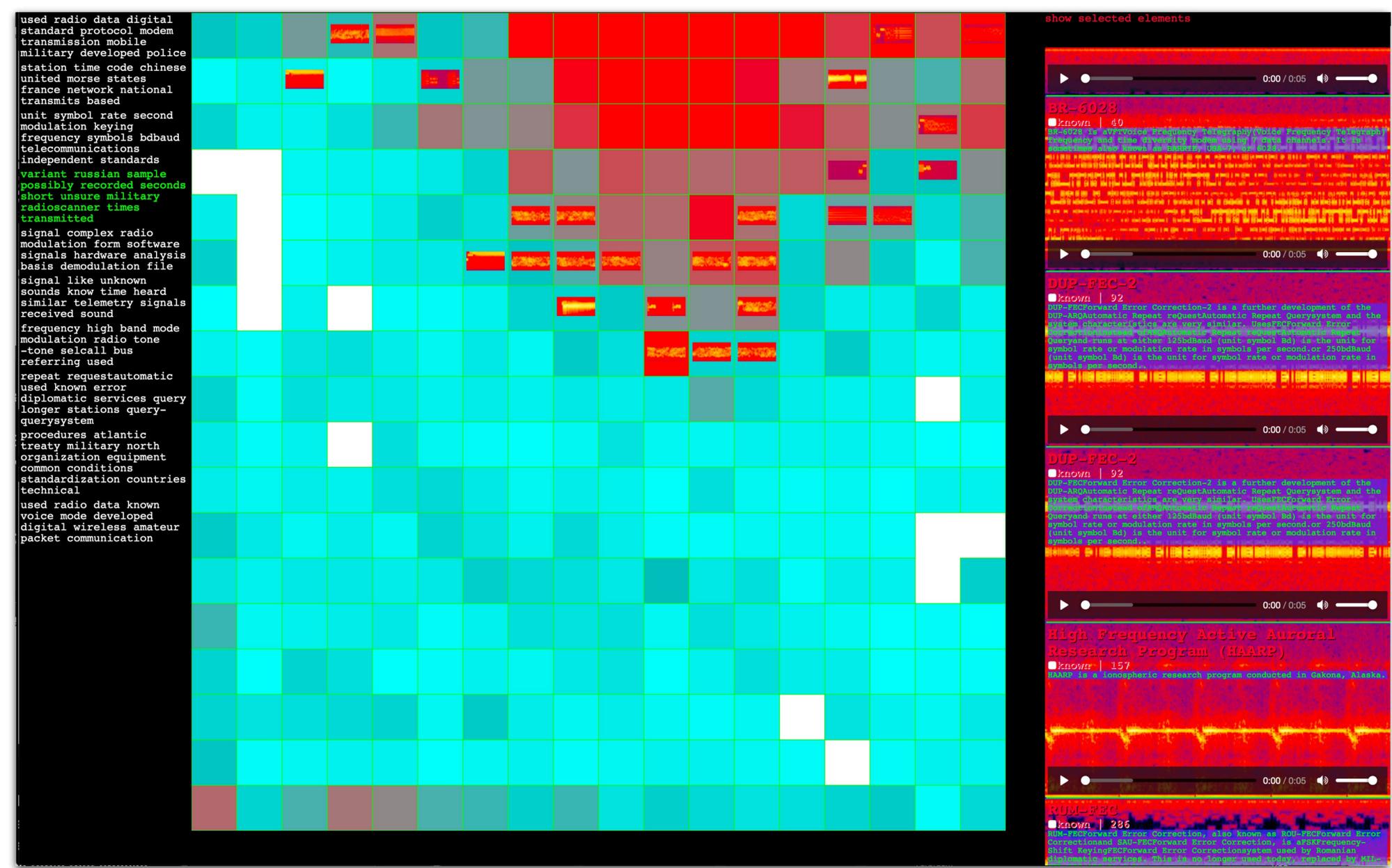
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This is a story that can emerge from descriptions of radio signal transmissions. This is why I built the first data observatory around text. I extracted ‘topics’ from all descriptions of all signals in the archive. Now, let’s say that I am interested 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.

# DESCRIPTIONS



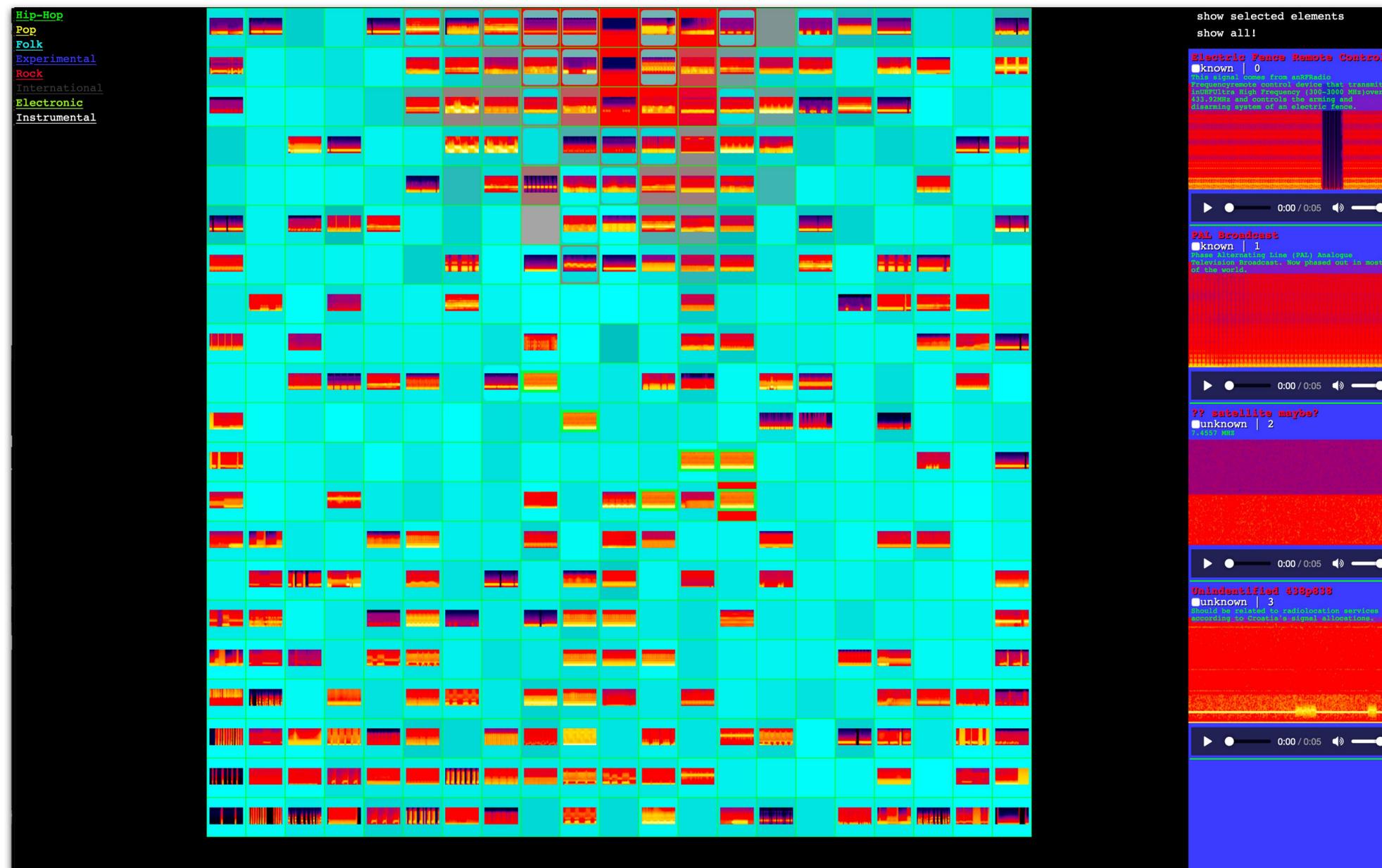
Radio Explorations

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What do these relationships say about governance, democracy and planning more generally? Military clearly cares about information control, and people seek access to these secret transmissions. As the existence of the SIGID wiki itself asserts, there is always a pushback from the citizens to KNOW about this communication, not only in terms of content (journalism) but also in terms of the infrastructure it operates on. The channels, the protocols. There is an interest in technology. My work contributes to specific insights: we start to pay attention to the way protocols, modulations, application and histories intersect in these explorations of radio signals.

# PROJECTIONS



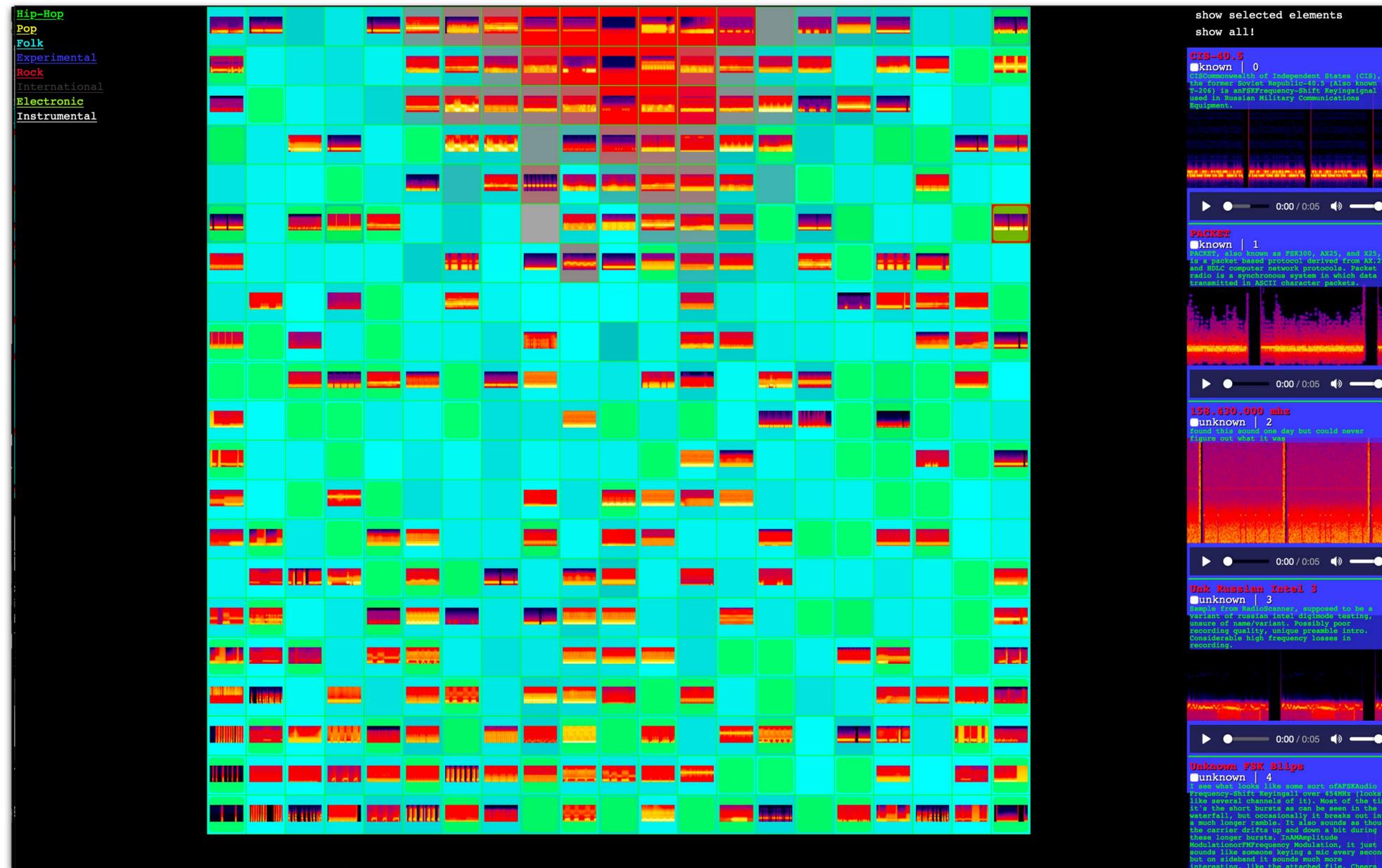
Radio Explorations

[https://radioexplorations.ch/study-2/visualize\\_radio/](https://radioexplorations.ch/study-2/visualize_radio/)

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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

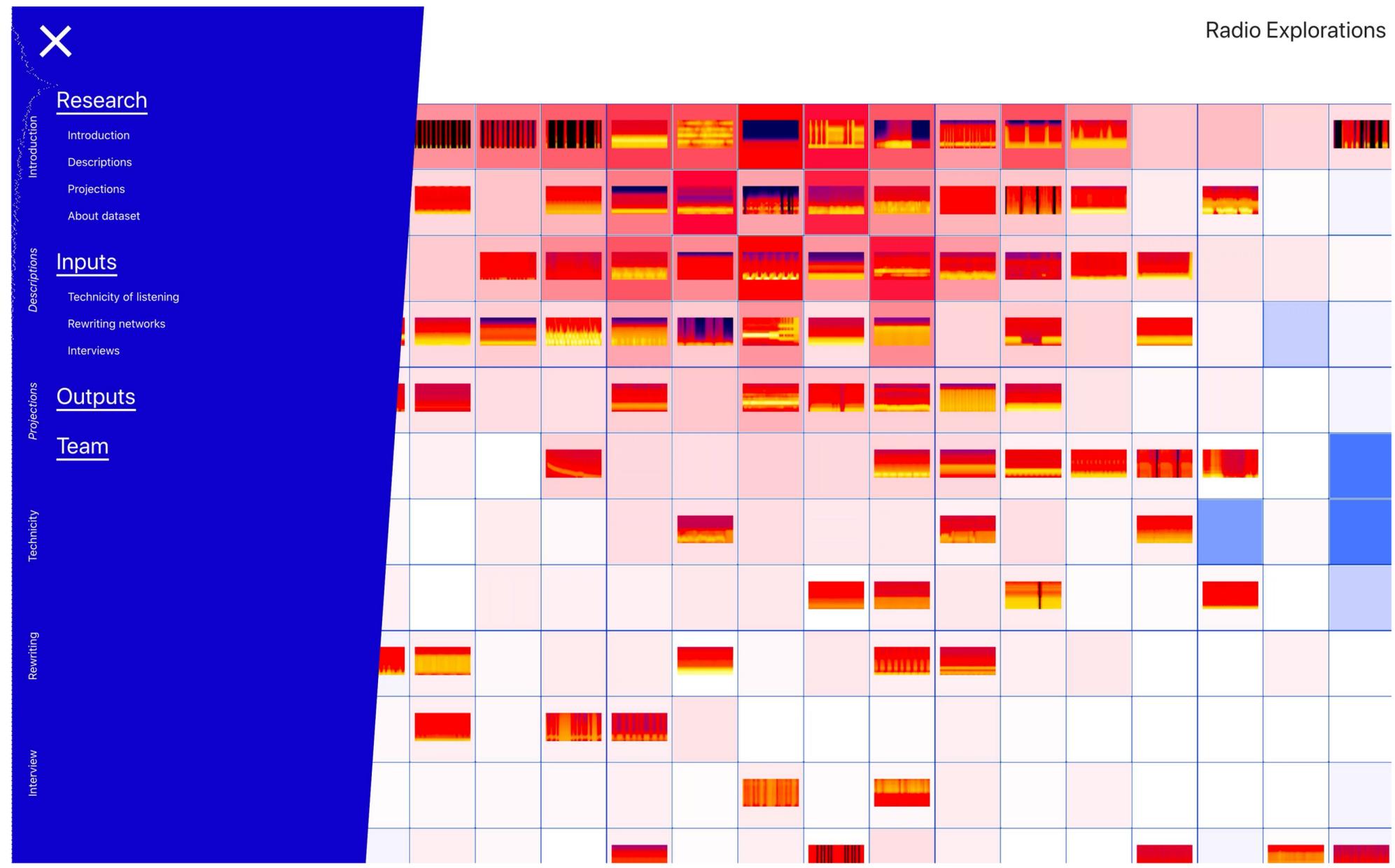


Radio Explorations

[https://radioexplorations.ch/study-2/visualize\\_radio/](https://radioexplorations.ch/study-2/visualize_radio/)

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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'. We have to be aware that a lot of data we use to monitor, plan and predict the use of space - is possibly very noisy, or is speaking of a different phenomenon altogether. Good examples of misleading proxies can be found in Cathy O'Neil's book Weapons of Math Destruction, but this is not the point I want to make. Working with data in an open-ended manner exposes the 'noisiness' of data in the environment. This contingent information is something we can work with, if we are able to expose it.

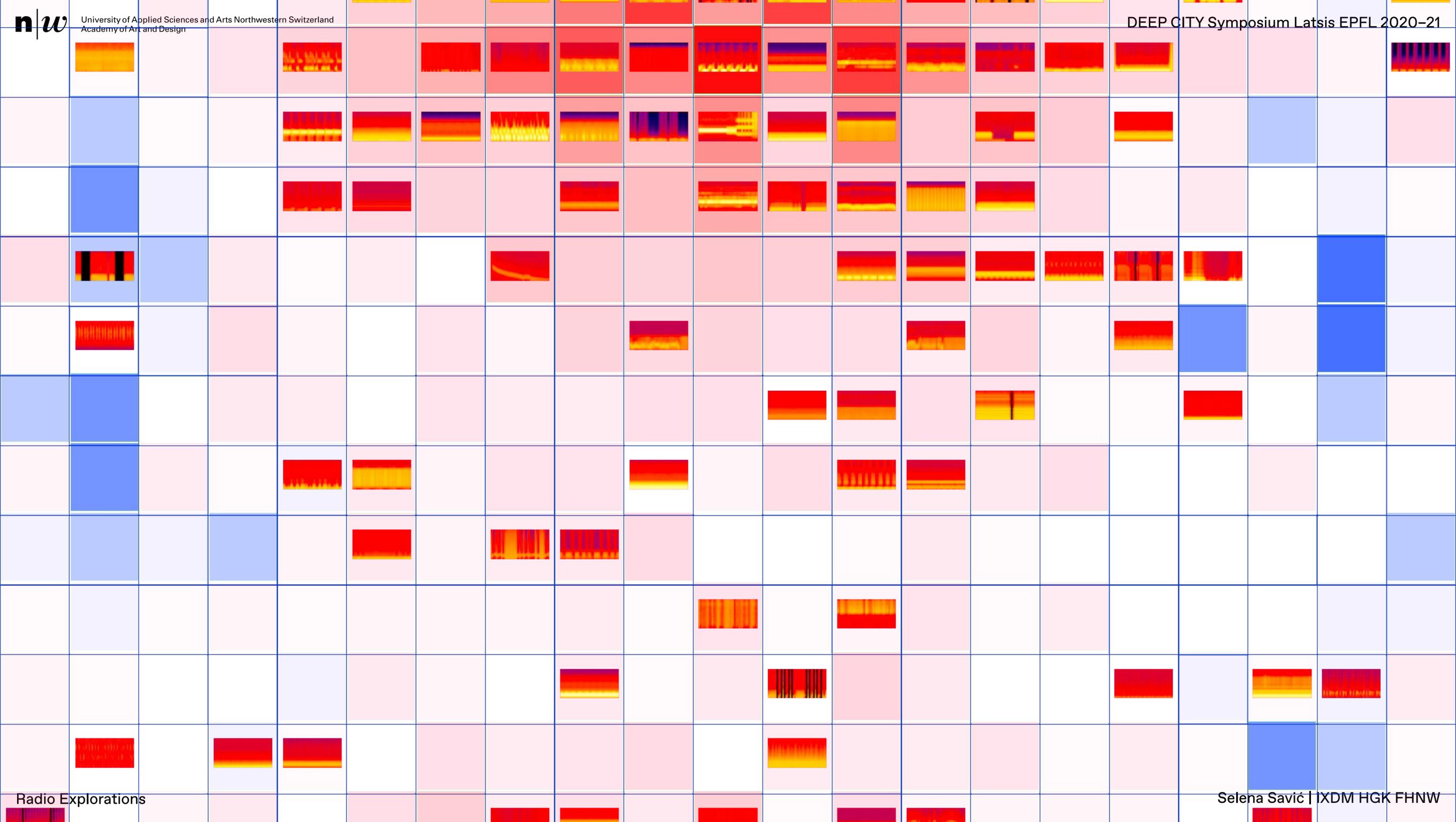


Radio Explorations

<https://radioexplorations.ch>

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To wrap up, I would like to point out two important things about this research: radio cannot be known through engineering knowledge alone or indeed any single perspective. Without pertaining to be comprehensive, I gathered many perspectives on radio - through interviews and research meetings with experts in signal engineering, music classification, architecture's overlap with information technology, data-driven architectural and urban design, artistic interventions in infrastructure. This interdisciplinarity informs, powers the intentionality I exercise vis a vis the alien, meaningless radio signal data. It is a difficult but rewarding research practice that exposes all sorts of assumptions and biases that normally remain undeclared.



Radio Explorations

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The second point I would like make concerns digital literacy. How can I get to work with digital tools like an instrument - to both measure and perform? The idea is to see coding on a level which is not about problem solving, but about articulating: it is about techniques of organizing information to tell a story, rather than showing the objectivity of the world. This project demonstrates a way to work with machine learning, through combining and bringing things together, rather than cutting apart.