November 13–14, 2024 | Online

Developing Powerful GUIs in MATLAB for Spectrum Monitoring: An ANATEL Case Study

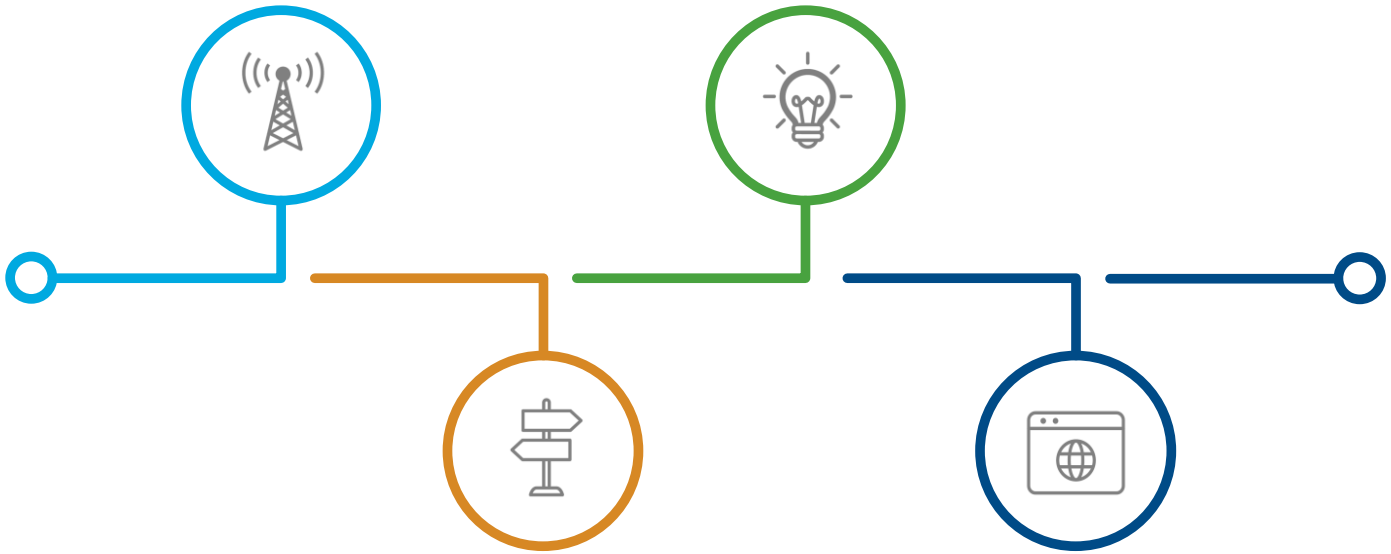
Eric Delgado, Anatel

MATLAB EXPO

Agenda

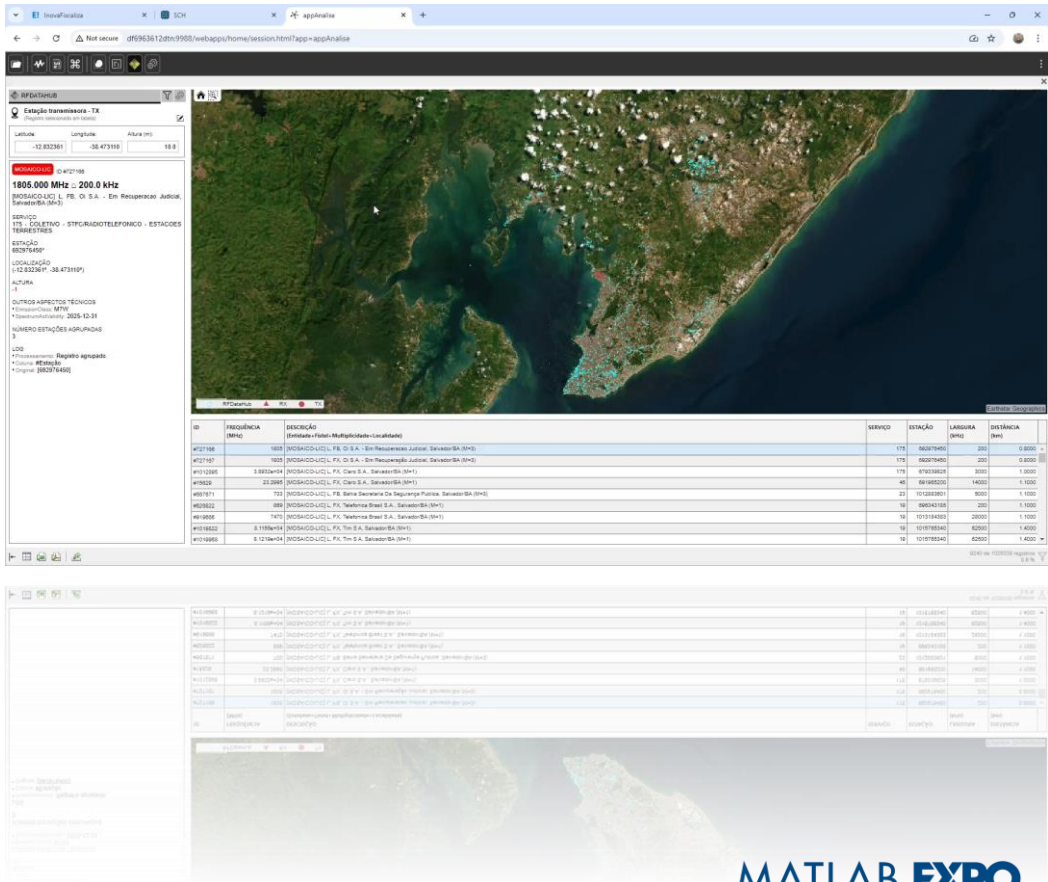
Overview of Brazil's Spectrum Monitoring Process

MATLAB Applications to Address These Challenges



Challenges in Data Collection and Processing

Solutions to Overcome some Limitations of Web Apps



Brazil's Spectrum Monitoring Began in 1980 with 25 Stations Covering Up to 1 GHz

1980 – 2000
9kHz – 1GHz
25 stations (17 mobile)

João vai inaugurar radiomonitoragem

As constantes interferências de emissoras estrangeiras nas transmissões internas do Brasil poderão ser evitadas a partir do dia cinco de maio. É quando o presidente Figueiredo inaugura a Rede Nacional de Radiomonitoragem

A rede vai fiscalizar os serviços de Rádio Cidadão, Rádio Amador, Móvel Marítimo, Móvel Aeronáutico, Limitado (Serviço de radiocomunicação para pessoas físicas ou jurídicas,

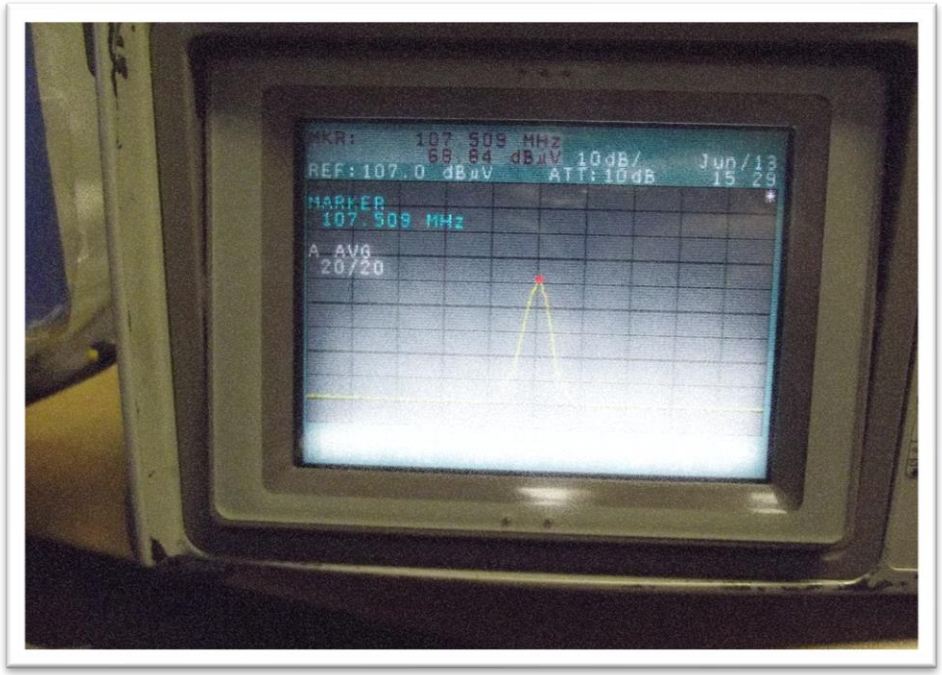
20 Years Later: 84 Stations Expanding Coverage Up to 3 GHz

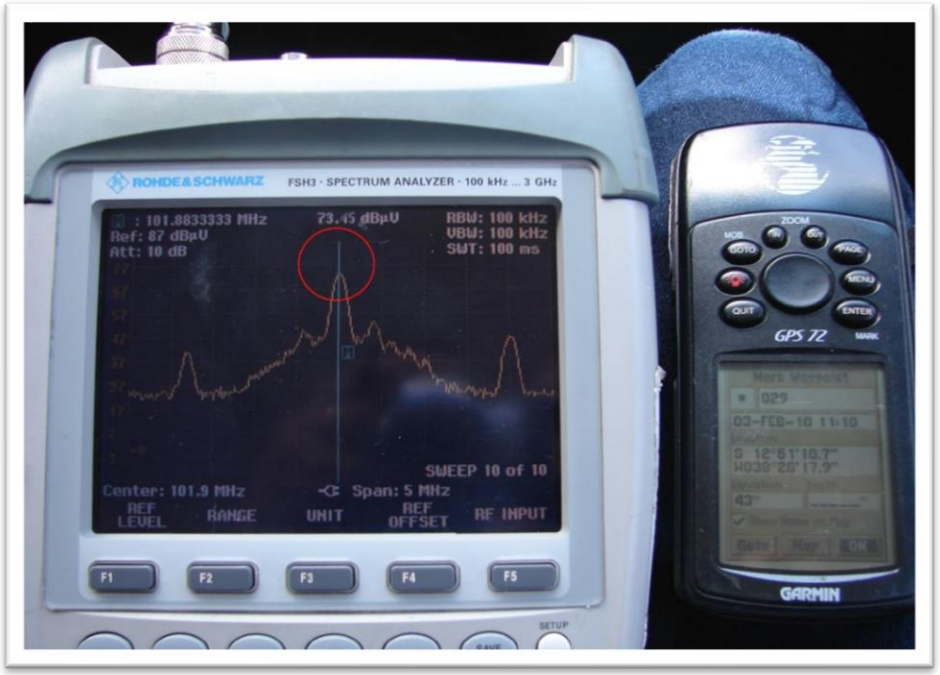
2000 – 2014
9kHz – 3GHz
84 stations (28 mobile)

MATLAB EXPO

Data Collection and Processing Methods Have Evolved Over Time

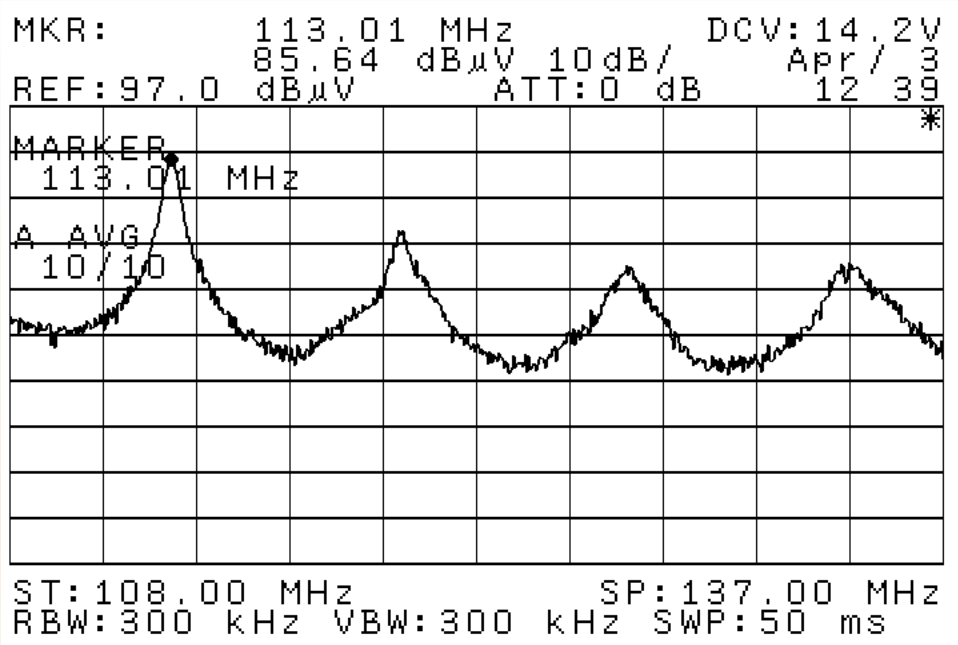
2000 – 2014
Transition from **photos** …



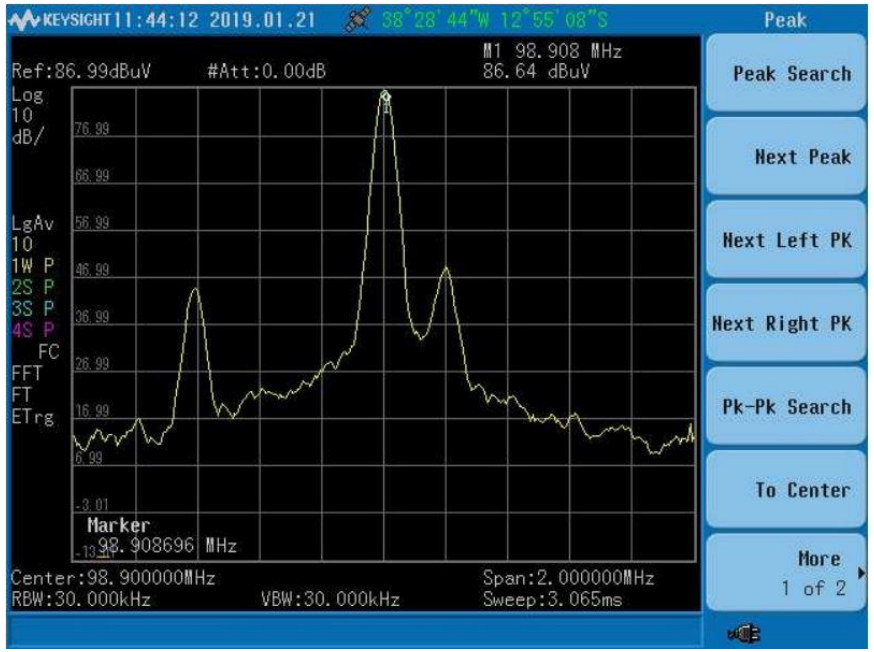


Data Collection and Processing Methods Have Evolved, But We Were Still Relying on Photos and Images

2000 – 2014
… to **screenshots**! :)



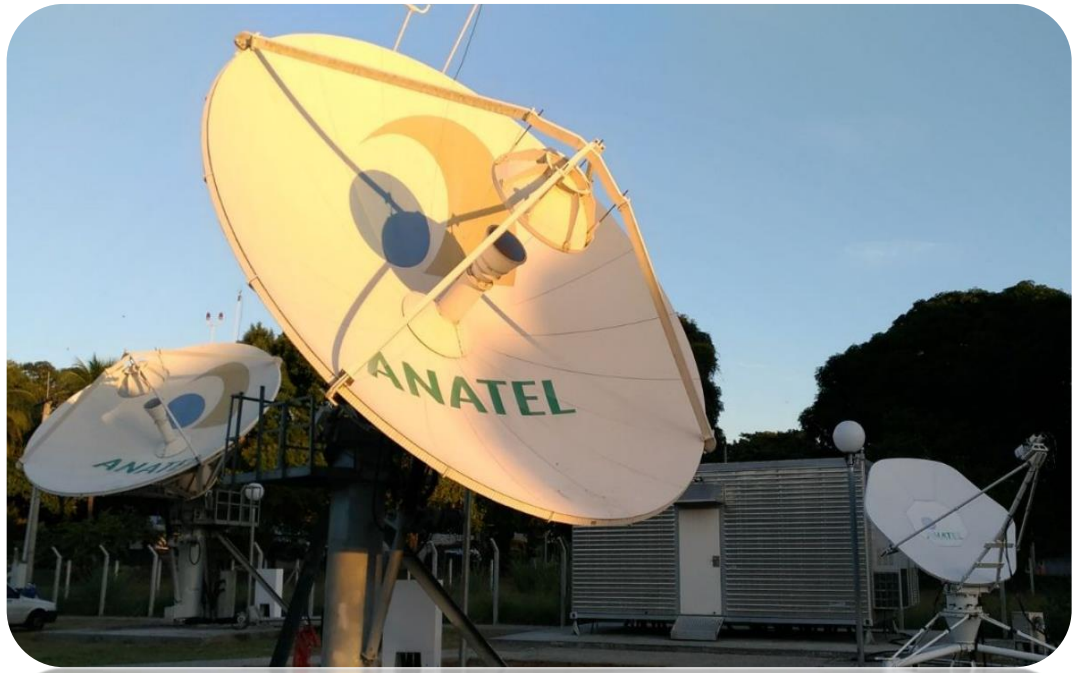
Screenshot of the Advantest T3641 spectrum analyzer.



Screenshot of the KeySight N9344C spectrum analyzer.

The Current Network of 500 Sensors Enables Complex Real-Time Analysis

2014 – 2024
9kHz – 43.5GHz
500 sensors (≈ 250 fixed stations, and 48 mobile)
Geostationary satellites in C, Ku, and Ka bands



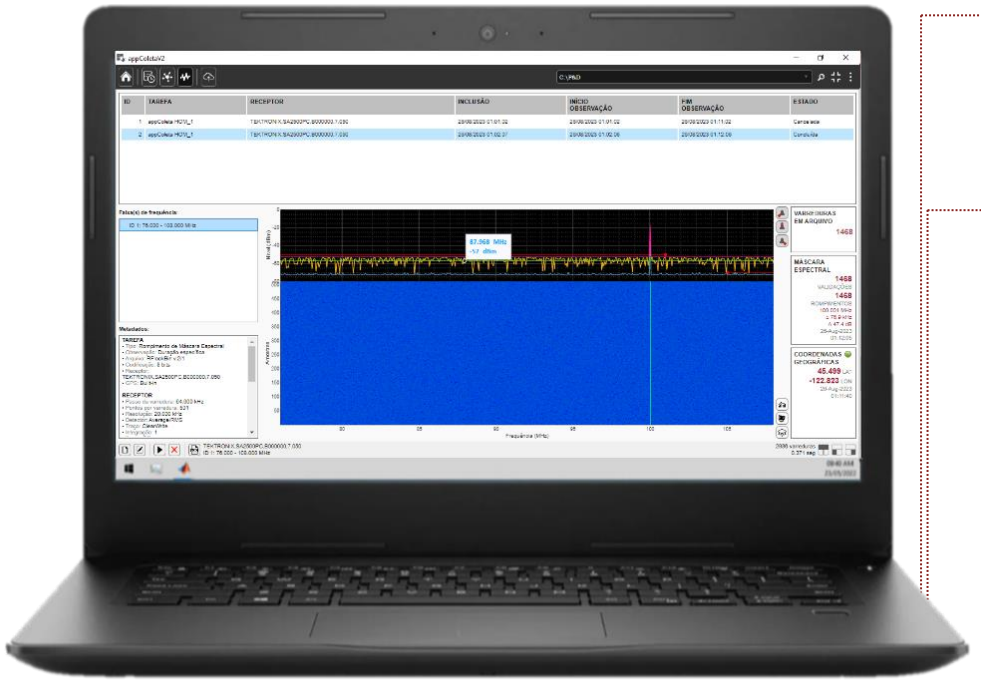
Some Challenges in Data Collection and Processing Persisted…

- How can we create a unified tool to control instruments from different manufacturers?
- How can we build a custom monitoring station using our existing spectrum analyzers and antennas?
- How can we streamline the analysis and reporting of large data sets?

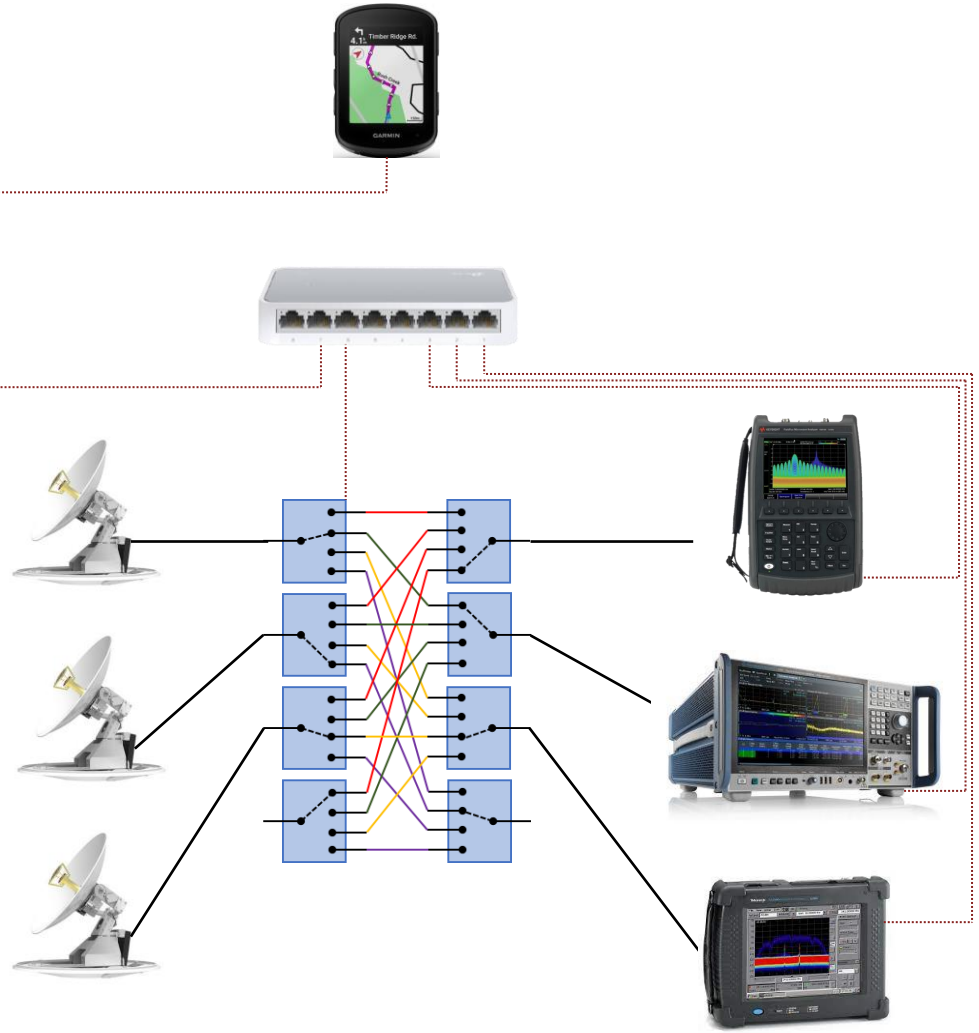
The Current Solution is a Combination of Tools Developed in MATLAB, Python, C++, C# and Zabbix

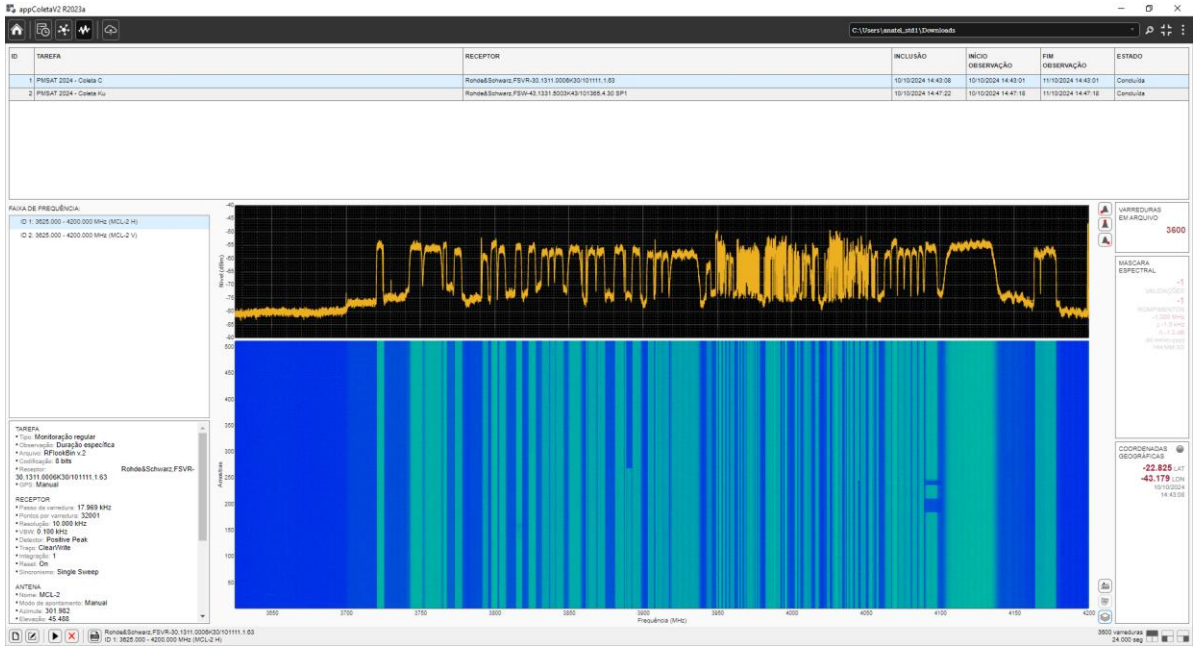
The literal translations into English for appColeta and appAnalise are “appCollection” and “appAnalysis”, respectively. SCH is the acronym for Sistema de Certificação e Homologação (“Certification and Homologation System” in English).

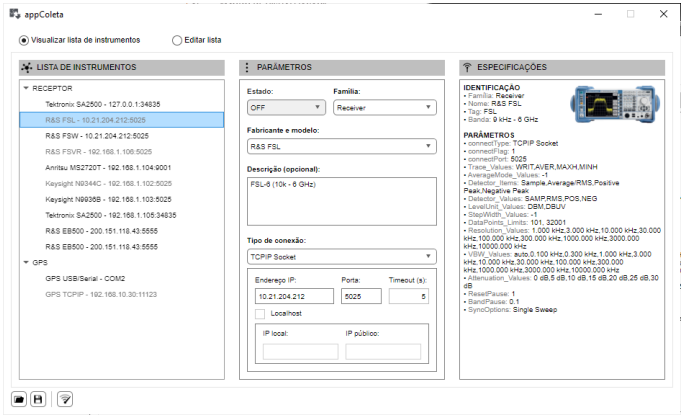
The Main Challenges of Data Collection Are Now in the Past

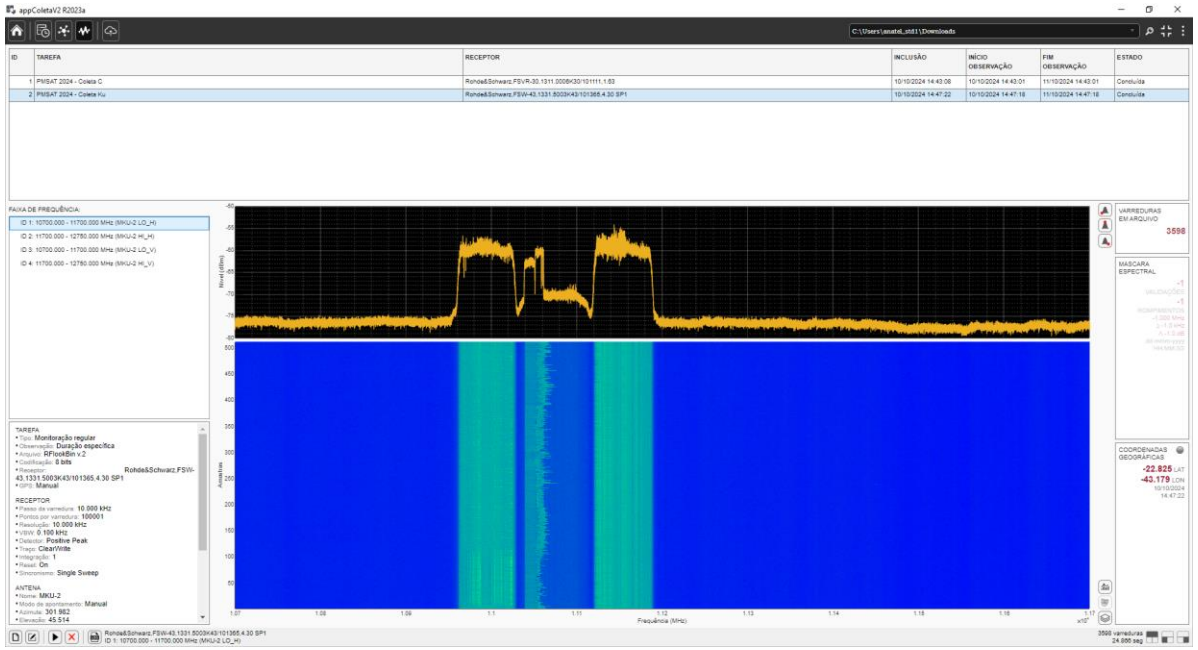


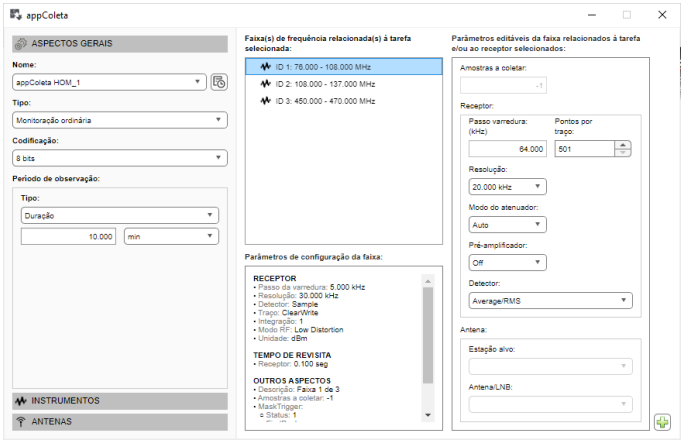
appColeta

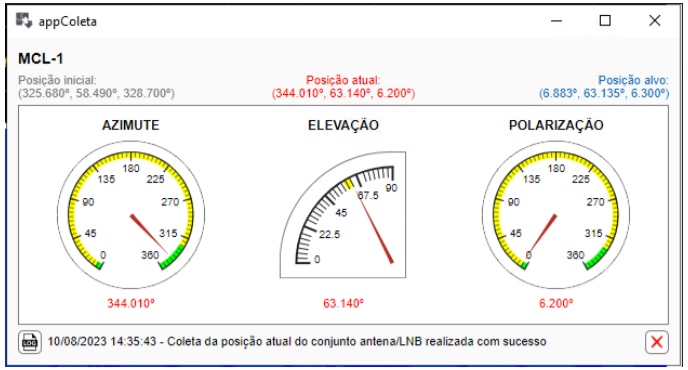










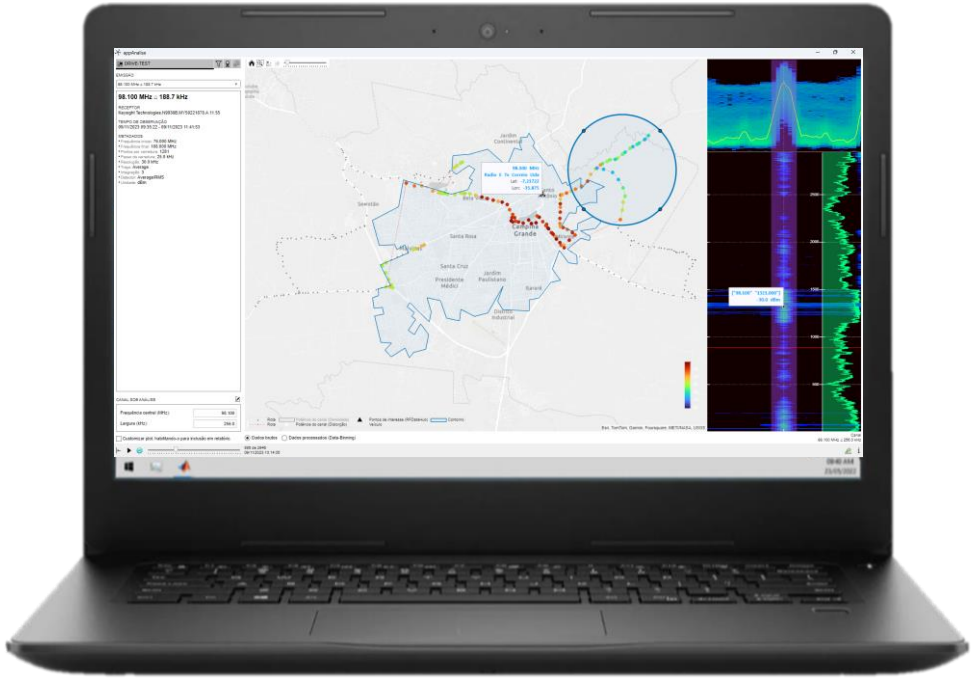


- One-to-many relationship.
- Automatic management.
- Spectral mask violation detection.

Highlighted Results

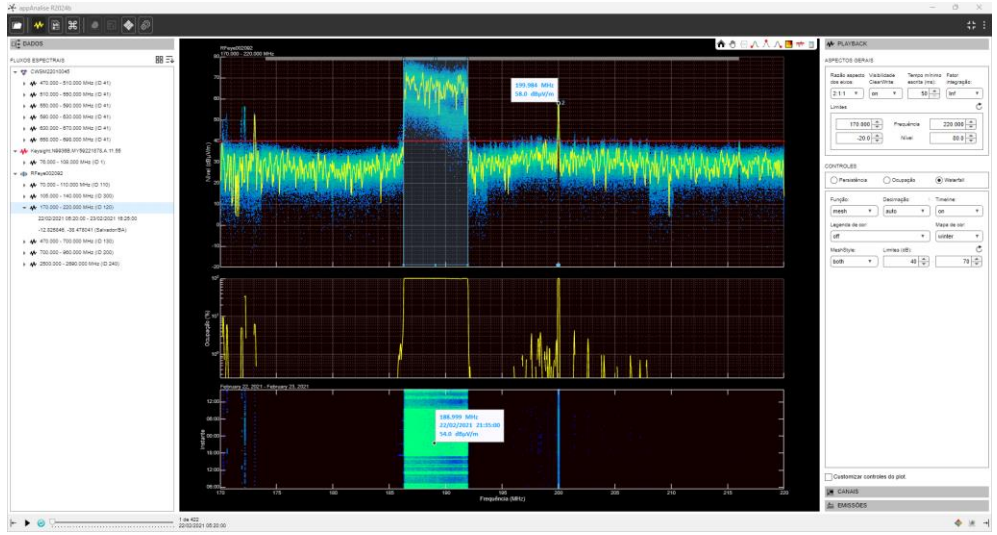
- Before:
  - No solution to extract data from 200 spectrum analyzers.
  - Satellite monitoring files were 10 GB each, and one task at a time.
- Now:
  - Unified solution for controlling and extracting data from sensors.
  - Custom stations communicate with the management center.
  - Satellite monitoring files reduced to 140 MB, and multiple tasks simultaneously.

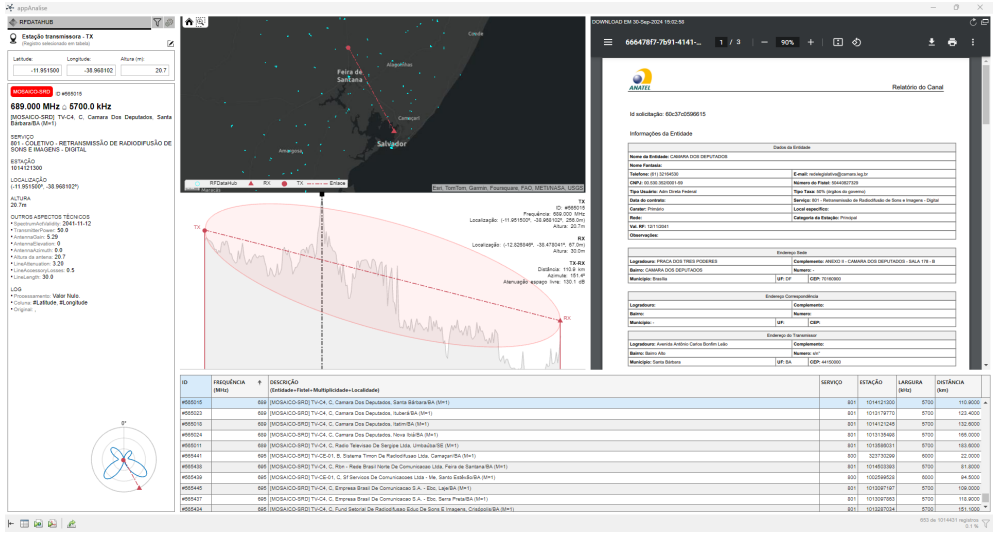
The Main Challenges of Data Post-Processing Are Also in the Past

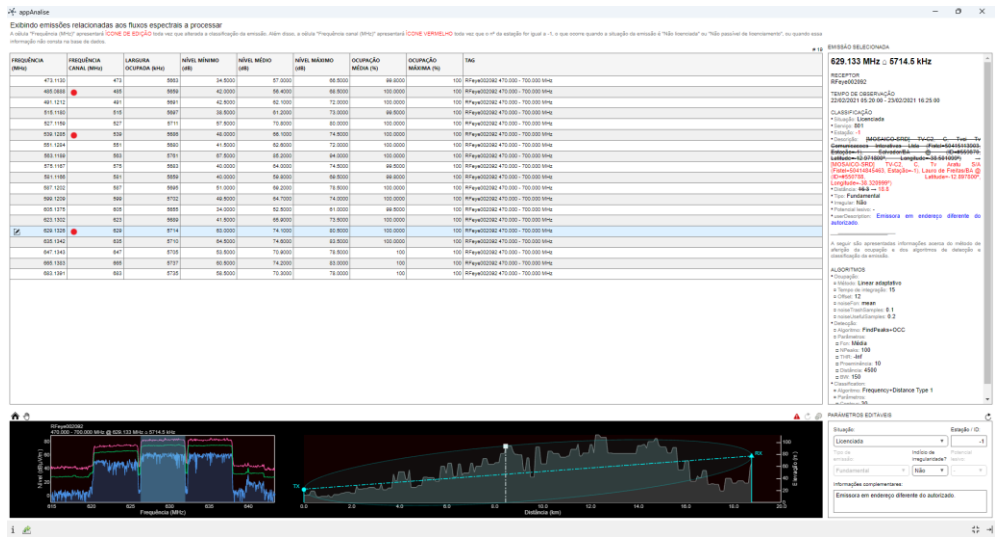


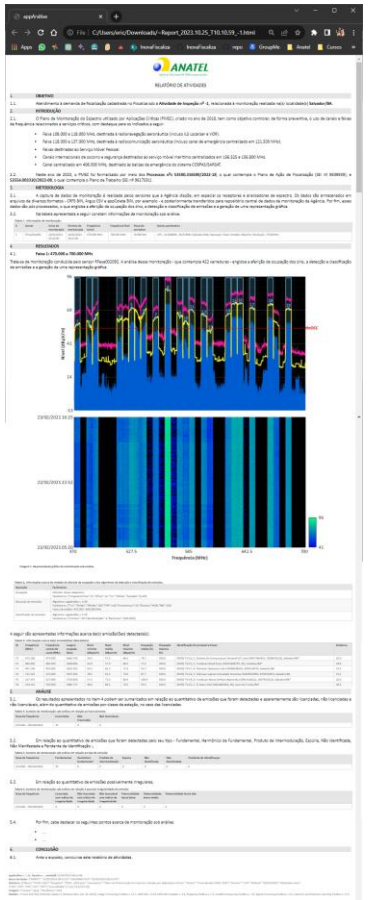
appAnalise

- Playback.
- Automatic detection and classification of emissions.
- Report generator.
- Connecting to internal systems using Python libraries.
- Connecting to external APIs.









WEB MAP SERVICE SERVERS

REDMINE

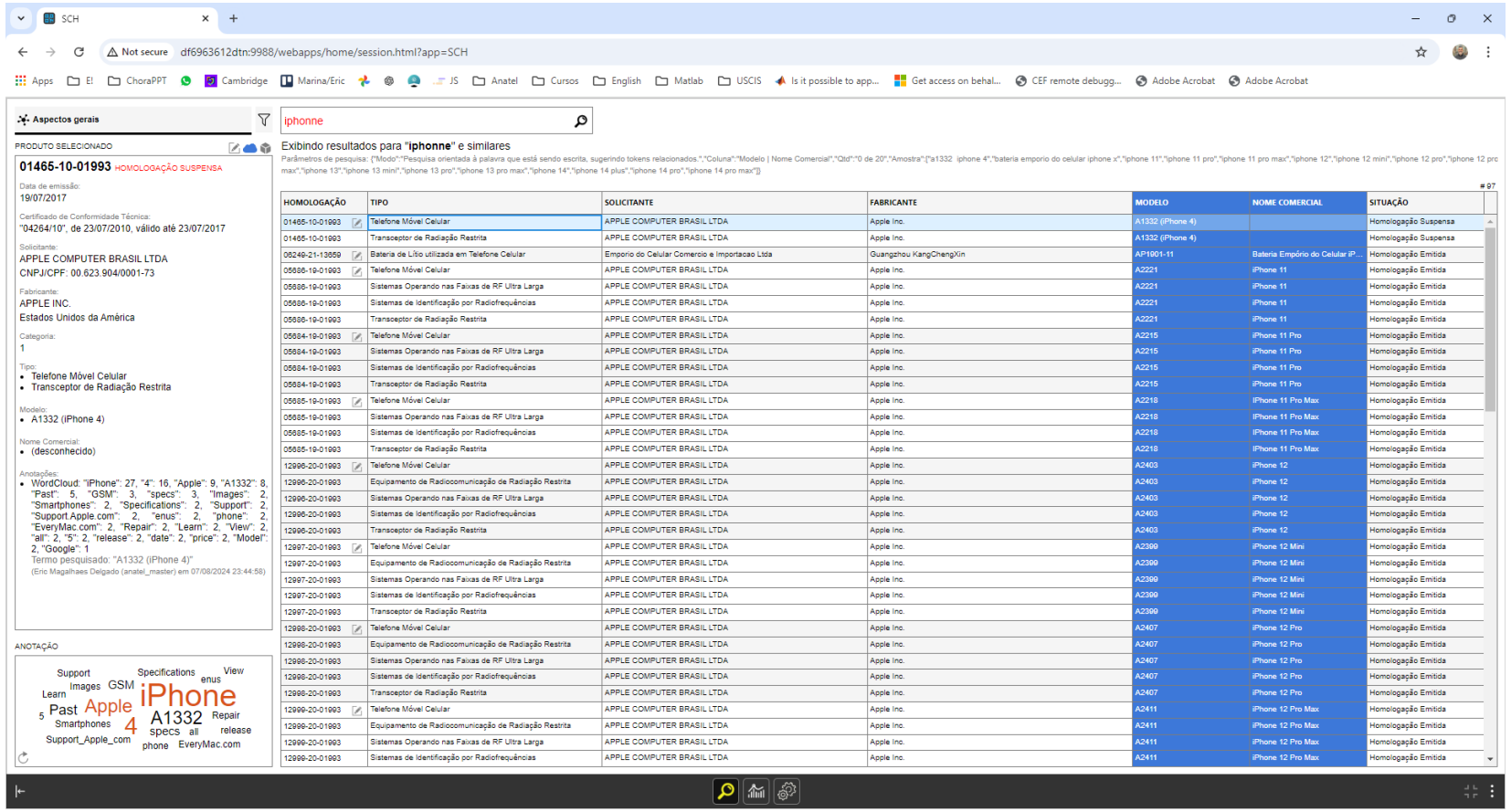
ICAO, AISWEB, MOSAICO ETC

MATLAB EXPO

Achieved Results

- Before:
  - Non-standardized analysis and reports.
  - Post-processing data from one sensor took 3 to 10 days.
- Now:
  - Standardized analysis and reports.
  - Post-processing data for one sensor can take as little as 10 minutes.

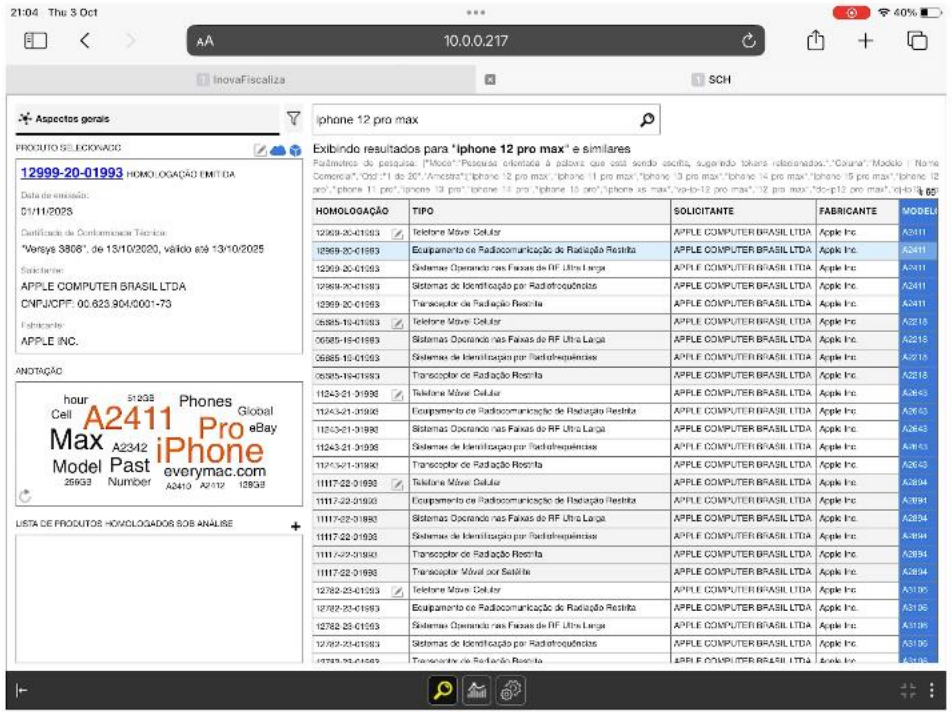
We've Started an Exciting Journey into Web Apps Using MATLAB

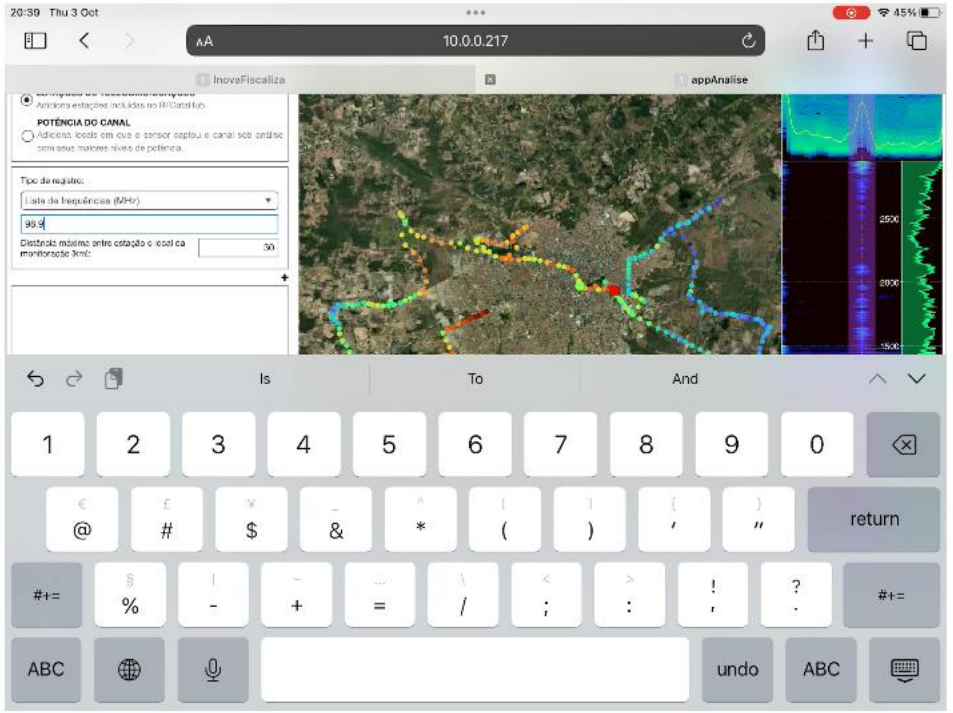


SCH

- Database queries and annotation.
- Filling forms interactively.
- Report generator.

Apps Run on a Tablet Without Adjustments and Work Quite Well!





Creating Apps in MATLAB Is Easy, But You'll Face Some Challenges

Unsupported Functionality

Some functionality is not supported in deployed web apps. This table lists the unsupported functionality that is most relevant to app building workflows.

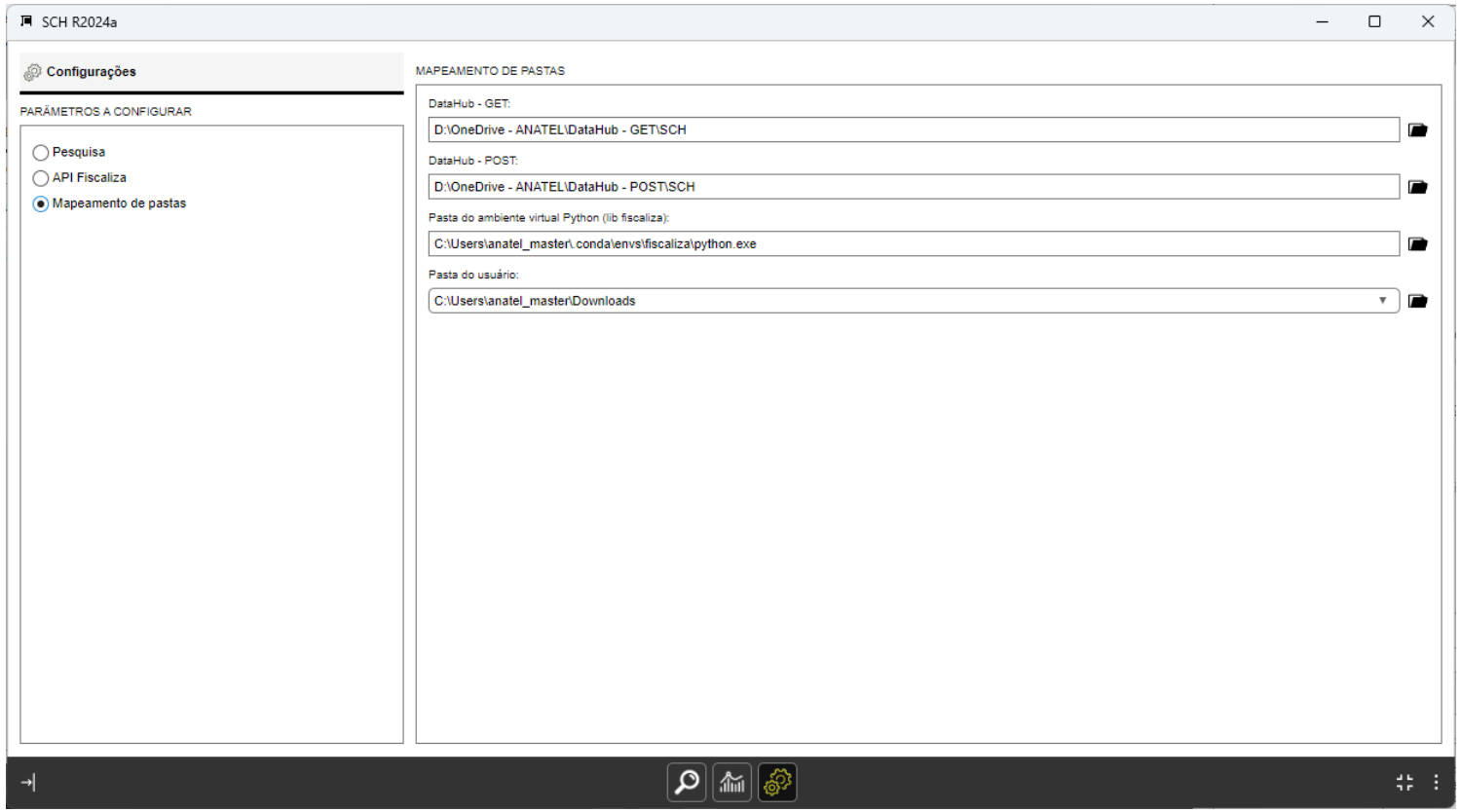
Category	Not Supported
Multiwindow apps	Multiple calls to `figure` or `uifigure` are not supported. In addition, functions that create dialog boxes that appear as a separate window are not supported. These functions include `dialog`, `msgbox`, `errordlg`, `warndlg`, `helpdlg`, `listdlg`, `questdlg`, `inputdlg`, `uisetcolor`, and `uisetfont`. However, functions that create dialog boxes within a figure window, such as `uialert` (MATLAB), `uiconfirm` (MATLAB), and `uiprogressdlg` (MATLAB), are supported.
File dialog boxes	Opening a folder selection dialog box on the client using `uigetdir` is not supported.
Saving and printing	The `print`, `printpreview`, and `exportapp` functions are not supported.
Plotting functions	The `wordcloud` function is not supported.
Axes toolbar interactions	*Before R2023b: Data brushing is not supported.*
Copy and paste	Copying and pasting text to and from the system clipboard using the `clipboard` function is not supported.
Project features	Project features such as `matlab.project.createProject` and `matlab.project.loadProject` are not supported.
OLE Automation	The `actxserver` function is not supported.

https://www.mathworks.com/help/webappserver/ug/unsupported-functionality.html

First, You Need to Know Which Version of the App Is Running: Web App or Desktop?

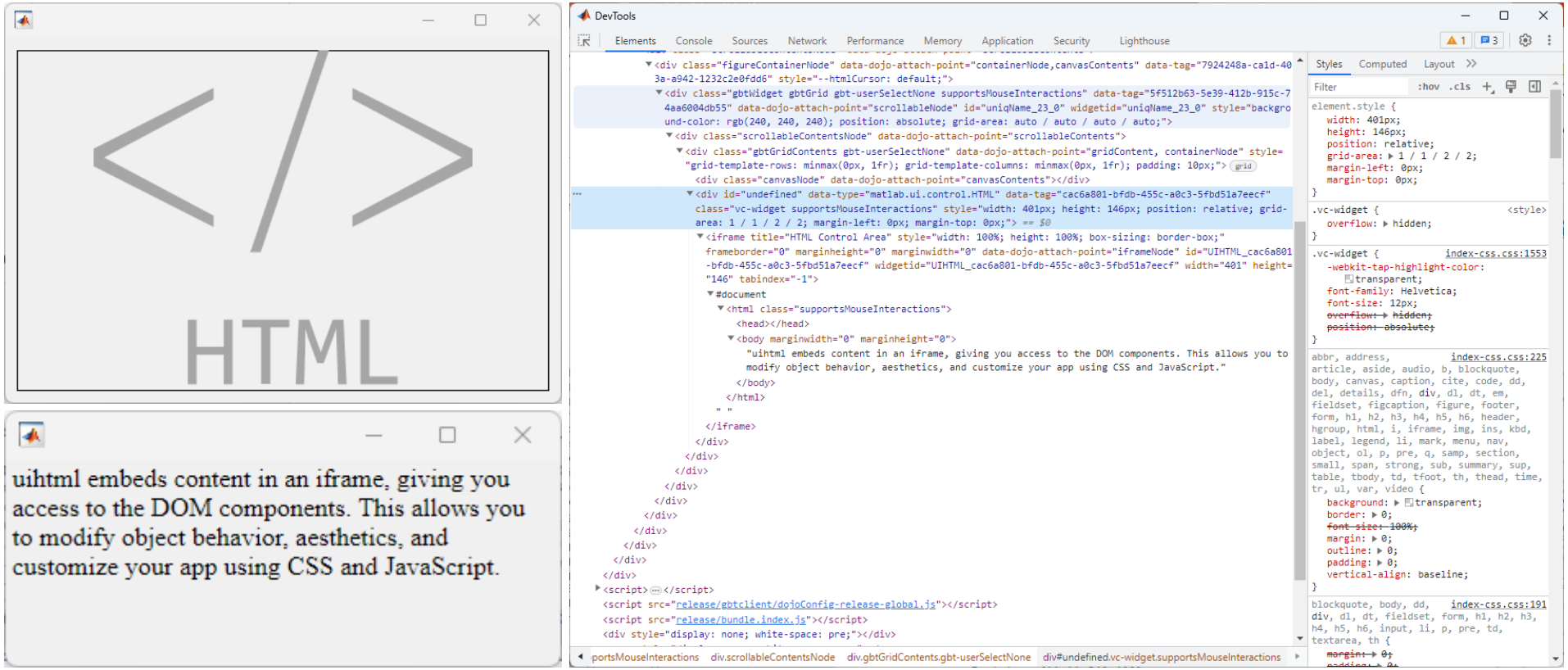
```
function executionMode = ExecutionMode(hFigure)
    % In MATLAB R2024a, the containers for the desktop and web app
    % versions of an app are the files "cefComponentContainer.html"
    % and "webAppsComponentContainer.html", respectively.

    % >> struct(struct(struct(hFigure).Controller).PlatformHost).ReleaseHTMLFile
    % 'cefComponentContainer.html'     (MATLAB and MATLAB Runtime)
    % 'webAppsComponentContainer.html' (MATLAB WebServer)

    htmlAppContainer = struct(struct(struct(hFigure).Controller).PlatformHost).ReleaseHTMLFile;
    if contains(htmlAppContainer, 'webApp', 'IgnoreCase', true)
        executionMode = 'webApp';
    else
        if isdeployed
            executionMode = 'desktopStandaloneApp';
        else
            executionMode = 'MATLABEnvironment';
        end
    end
end
```

Write Code in a Way that Supports Both Web App and Desktop Outputs From a Single Project



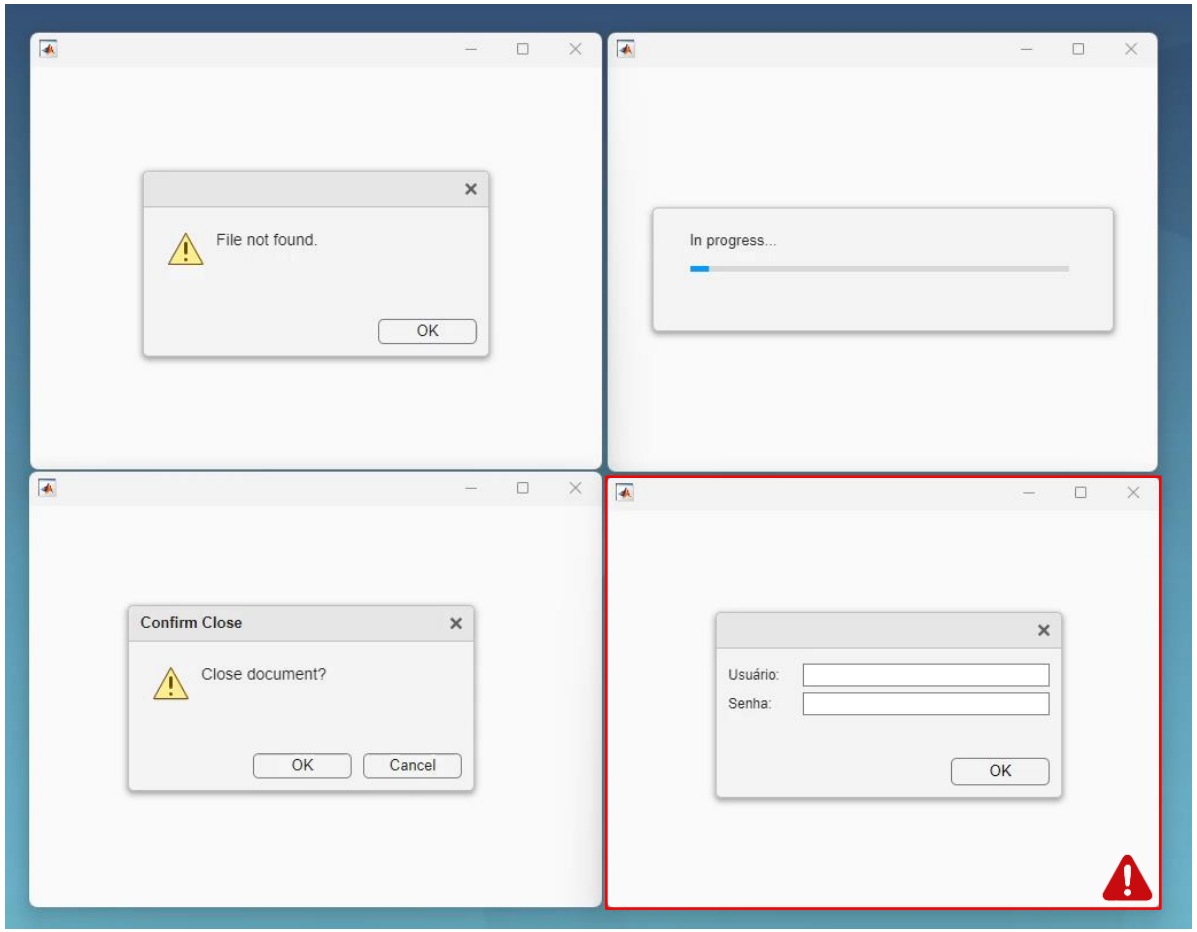

```
function startupFcn(app)
    app.executionMode = appUtil.ExecutionMode(app.UIFigure);

    switch app.executionMode
        case 'webApp'
            % Disable the button that restores the initial position
            % of the figure, as it's not controllable in a web app.
            app.FigurePositionButton.Visible = 0;

            % Disable the button that changes the Python environment.
            app.PythonEnvFolderButton.Enable = 0;

        otherwise % 'desktopStandaloneApp' | 'MATLABEnvironment'
            % Center the app figure on the largest monitor.
            appUtil.winPosition(app.UIFigure)

            % Enable the button that restores the initial position
            % of the figure.
            app.FigurePositionButton.Visible = 1;

            % Enable the button that changes the Python environment.
            app.PythonEnvFolderButton.Enable = 1;
    end
end
```

uihtml is More Powerful Than It Appears! Let's Take a Closer Look at It.



MATLAB EXPO

Using uihtml to Create Modal Dialog Boxes with Forms (Credential Dialog Box)

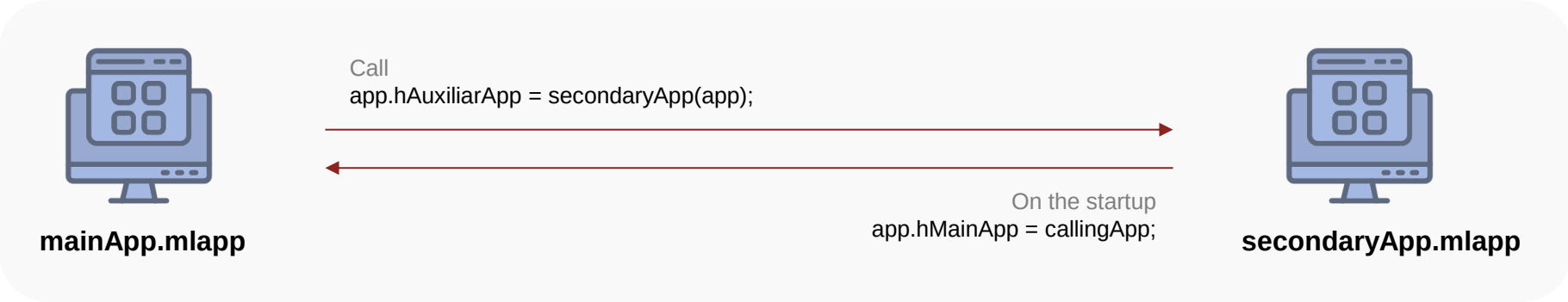


MATLAB Built-in modal dialogs: uialert (top left), uiprogressdlg (top right) and uiconfirm (bottom left).
Credential modal dialog created in JavaScript using uihtml (bottom right)

- A simple method for providing data input in a form-style format.

How to Change the Container of an App (Multiwindow Docked-style Web Apps)

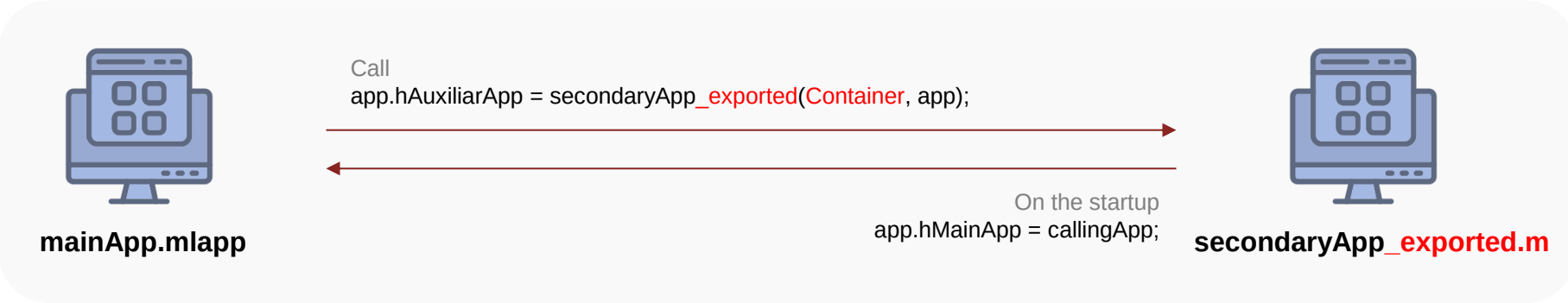
- Default approach:
  - Each app creates its own figure
  - Not supported in web apps



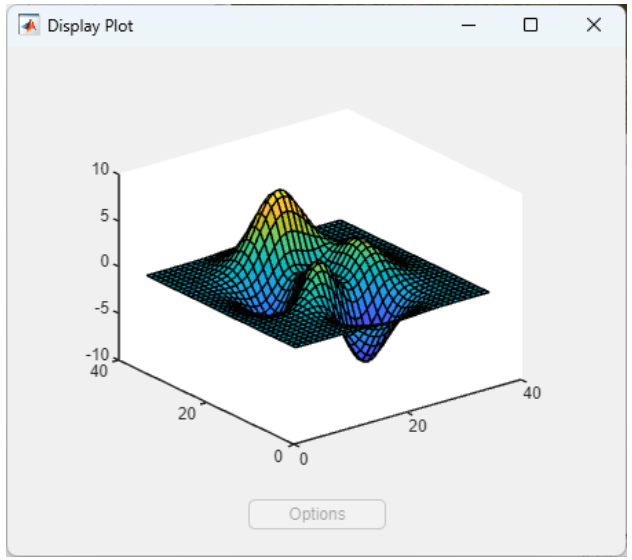
MATLAB EXPO

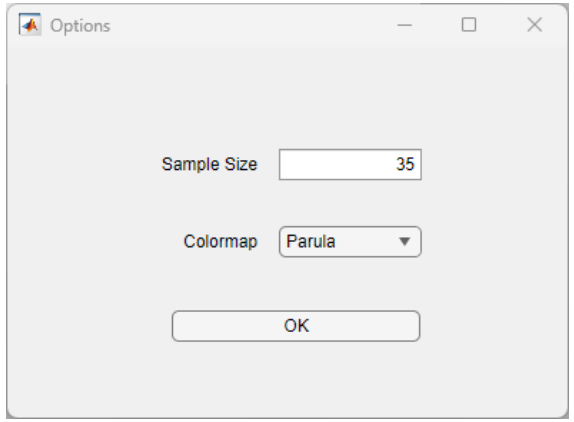
How to Change the Container of an App (Multiwindow Docked-style Web Apps)

- Implemented approach:
  - An app can have a figure, gridlayout, panel, or tabgroup as its container
  - Supported in web apps

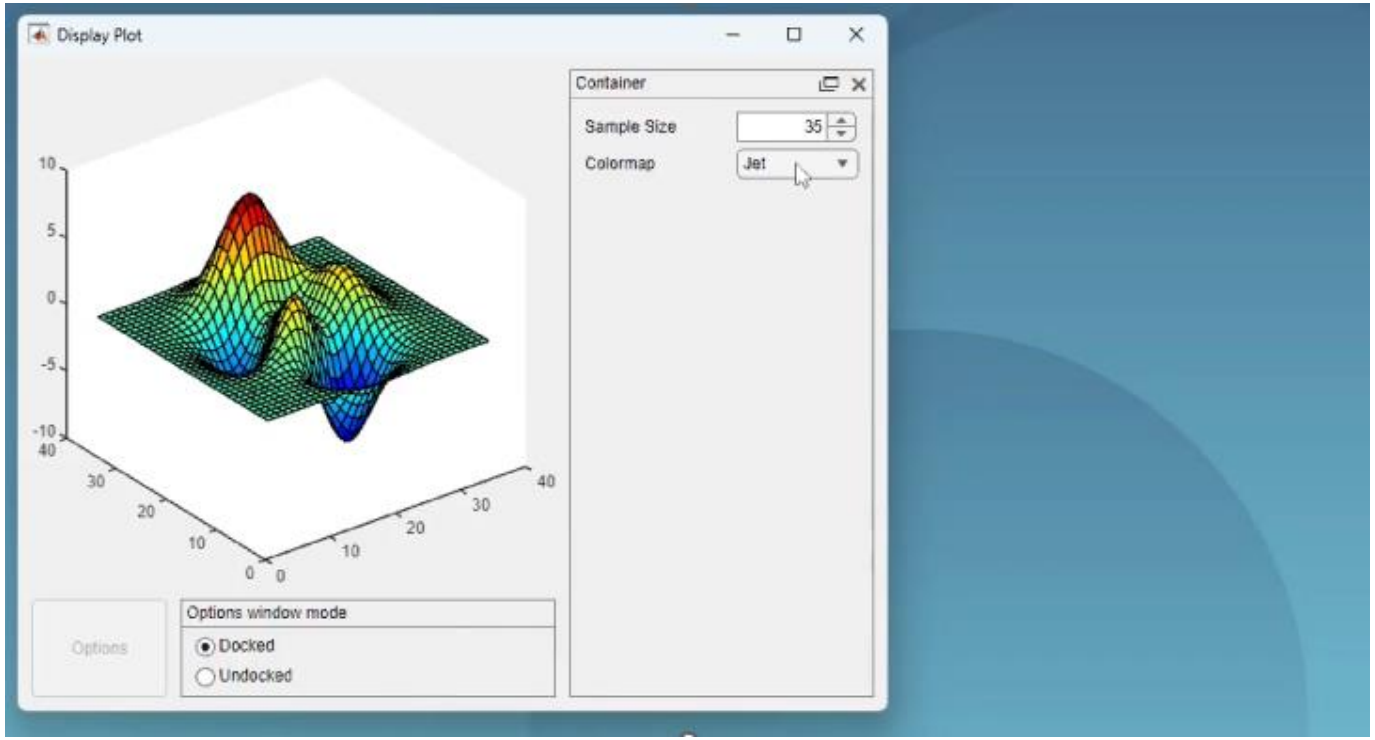


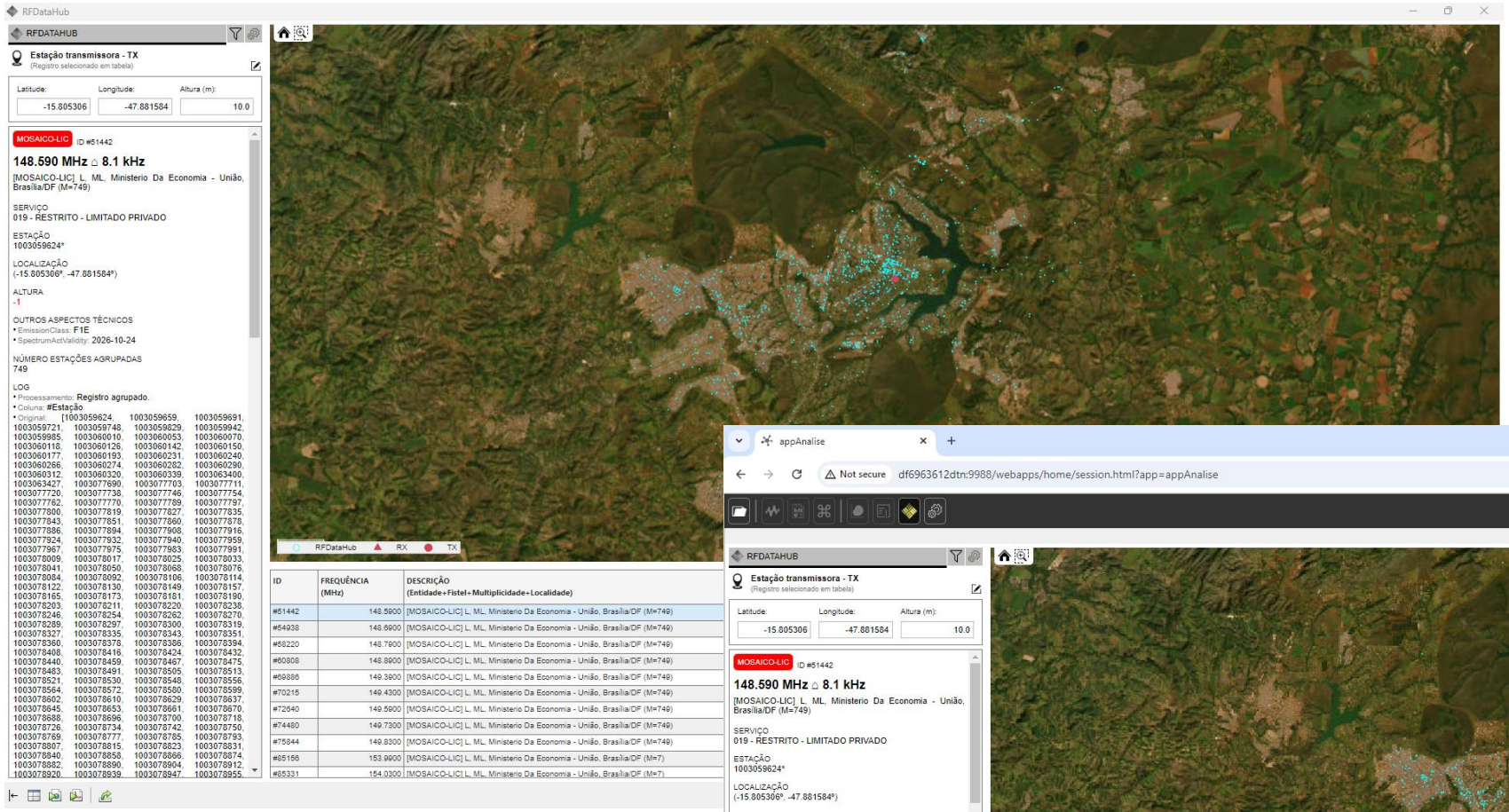
MATLAB EXPO

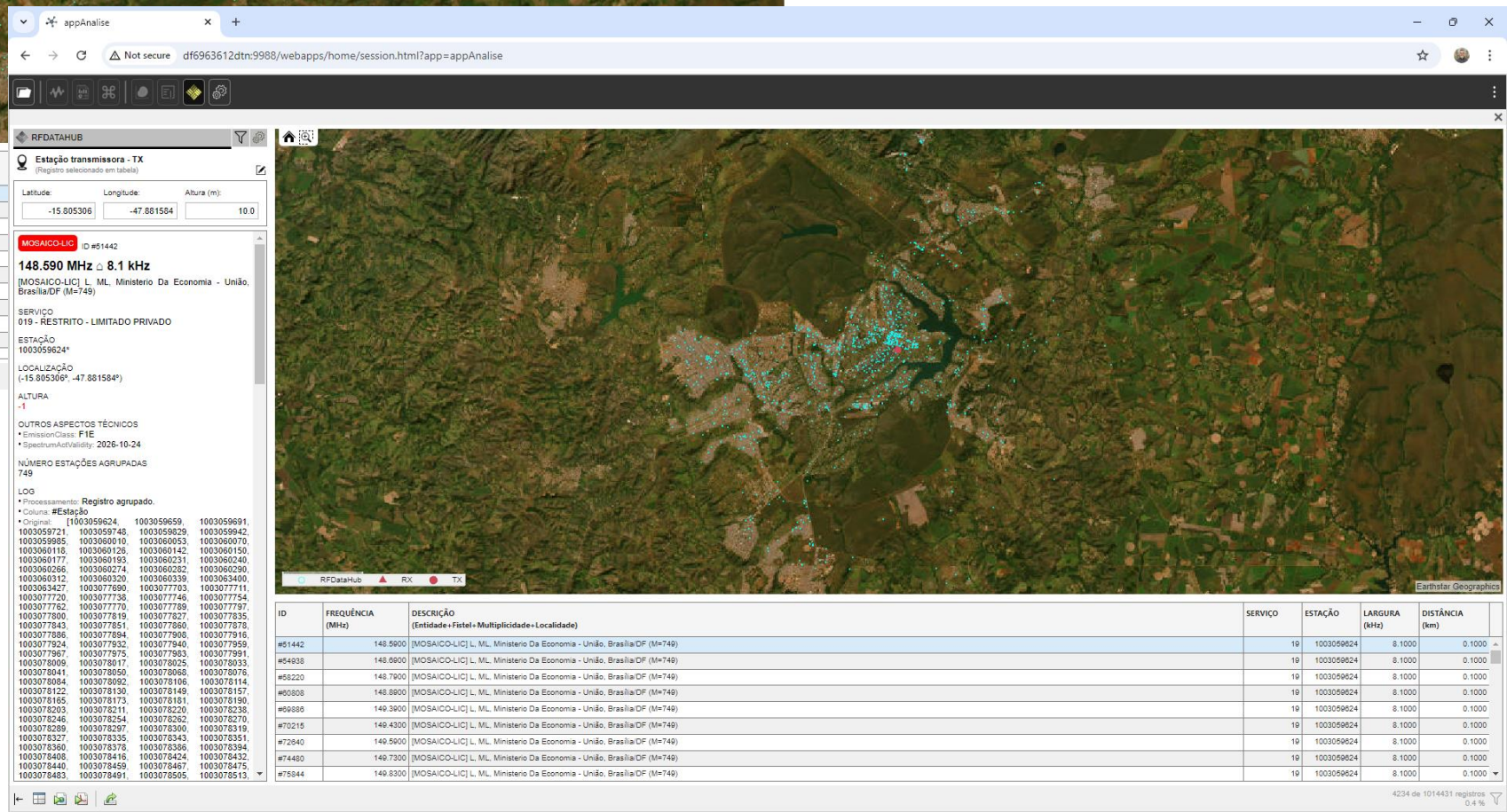




https://www.mathworks.com/help/matlab/creating_guis/multiwindow-app-gui-in-app-designer.html

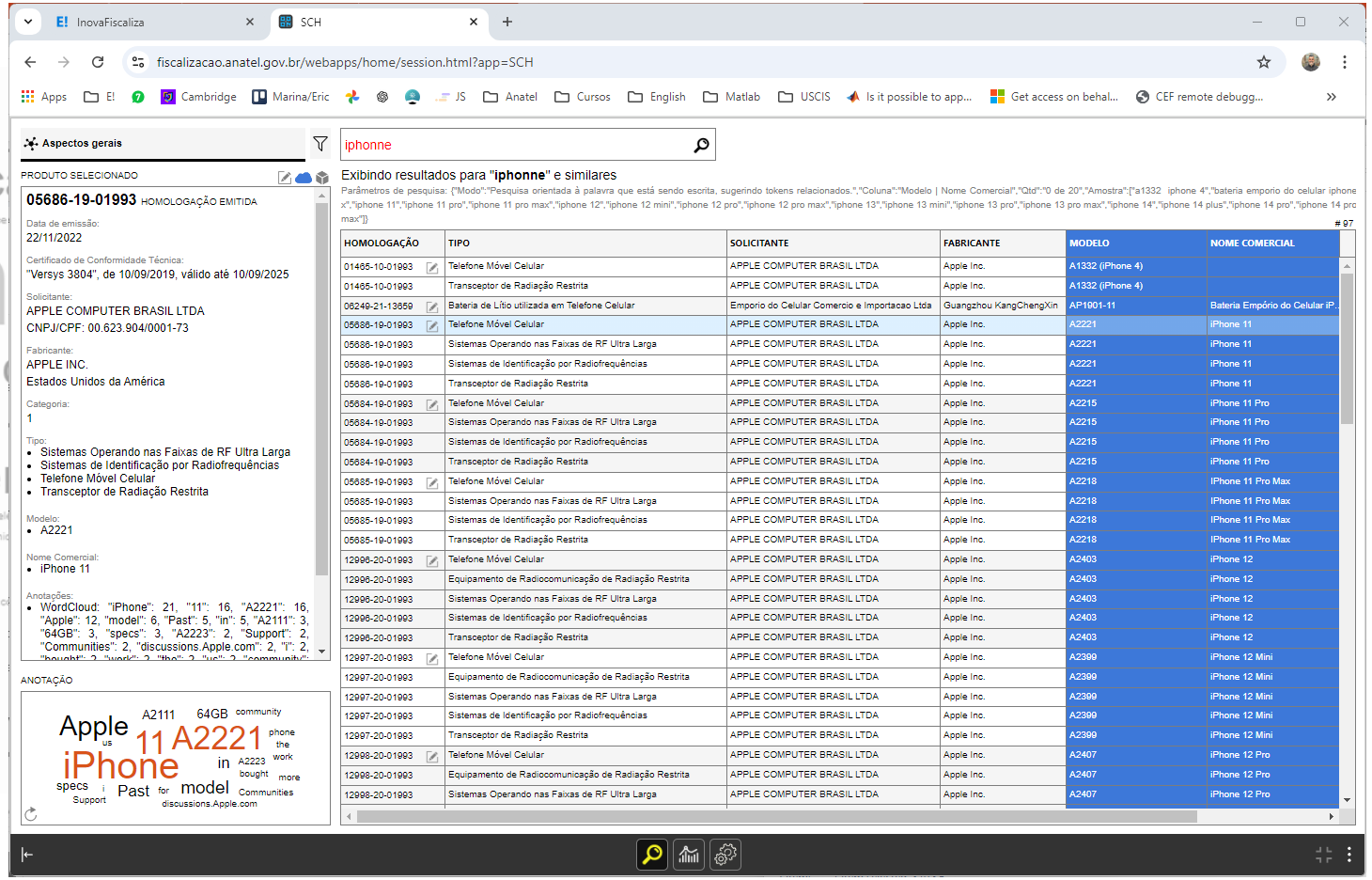



RFDataHub
RFDATAHUB
Estação transmissora - TX
(Registro selecionado em tabela)
Latitude:
Longitude:
Altura (m):
-15.805306
-47.881584
10.0
MOSAICO-LIC
ID #51442
148.590 MHz ⌂ 8.1 kHz
[MOSAICO-LIC] L, ML, Ministerio Da Economia - União, Brasília/DF (M=749)
SERVIÇO
019 - RESTRITO - LIMITADO PRIVADO
ESTAÇÃO
1003059624*
LOCALIZAÇÃO
(-15.805306°, -47.881584°)
ALTURA
-1
OUTROS ASPECTOS TÉCNICOS
• EmissionClass: F1E
• SpectrumActValidity: 2026-10-24
NÚMERO ESTAÇÕES AGRUPADAS
749
LOG
• Processamento: Registro agrupado.
• Coluna: #Estação
• Original: [1003059624, 1003059659, 1003059691,
1003059721, 1003059748, 1003059829, 1003059942,
1003059985, 1003060010, 1003060053, 1003060070,
1003060118, 1003060126, 1003060142, 1003060150,
1003060177, 1003060193, 1003060231, 1003060240,
1003060266, 1003060274, 1003060282, 1003060290,
1003060312, 1003060320, 1003060339, 1003063400,
1003063427, 1003077690, 1003077703, 1003077711,
1003077720, 1003077738, 1003077746, 1003077754,
1003077762, 1003077770, 1003077789, 1003077797,
1003077800, 1003077819, 1003077827, 1003077835,
1003077843, 1003077851, 1003077860, 1003077878,
1003077886, 1003077894, 1003077908, 1003077916,
1003077924, 1003077932, 1003077940, 1003077959,
1003077967, 1003077975, 1003077983, 1003077991,
1003078009, 1003078017, 1003078025, 1003078033,
1003078041, 1003078050, 1003078068, 1003078076,
1003078084, 1003078092, 1003078106, 1003078114,
1003078122, 1003078130, 1003078149, 1003078157,
1003078165, 1003078173, 1003078181, 1003078190,
1003078203, 1003078211, 1003078220, 1003078238,
1003078246, 1003078254, 1003078262, 1003078270,
1003078289, 1003078297, 1003078300, 1003078319,
1003078327, 1003078335, 1003078343, 1003078351,
1003078360, 1003078378, 1003078386, 1003078394,
1003078408, 1003078416, 1003078424, 1003078432,
1003078440, 1003078459, 1003078467, 1003078475,
1003078483, 1003078491, 1003078505, 1003078513,
1003078521, 1003078530, 1003078548, 1003078556,
1003078564, 1003078572, 1003078580, 1003078599,
1003078602, 1003078610, 1003078629, 1003078637,
1003078645, 1003078653, 1003078661, 1003078670,
1003078688, 1003078696, 1003078700, 1003078718,
1003078726, 1003078734, 1003078742, 1003078750,
1003078769, 1003078777, 1003078785, 1003078793,
1003078807, 1003078815, 1003078823, 1003078831,
1003078840, 1003078858, 1003078866, 1003078874,
1003078882, 1003078890, 1003078904, 1003078912,
1003078920, 1003078939, 1003078947, 1003078955,
RFDataHub
RX
TX
ID
FREQUÊNCIA (MHz)
DESCRIÇÃO (Entidade+Fistel+Multiplicidade+Localidade)
#51442 148.5900 [MOSAICO-LIC] L, ML, Ministerio Da Economia - União, Brasília/DF (M=749)
#54938 148.6900 [MOSAICO-LIC] L, ML, Ministerio Da Economia - União, Brasília/DF (M=749)
#58220 148.7900 [MOSAICO-LIC] L, ML, Ministerio Da Economia - União, Brasília/DF (M=749)
#60808 148.8900 [MOSAICO-LIC] L, ML, Ministerio Da Economia - União, Brasília/DF (M=749)
#69886 149.3900 [MOSAICO-LIC] L, ML, Ministerio Da Economia - União, Brasília/DF (M=749)
#70215 149.4300 [MOSAICO-LIC] L, ML, Ministerio Da Economia - União, Brasília/DF (M=749)
#72640 149.5900 [MOSAICO-LIC] L, ML, Ministerio Da Economia - União, Brasília/DF (M=749)
#74480 149.7300 [MOSAICO-LIC] L, ML, Ministerio Da Economia - União, Brasília/DF (M=749)
#75844 149.8300 [MOSAICO-LIC] L, ML, Ministerio Da Economia - União, Brasília/DF (M=749)
#85156 153.9900 [MOSAICO-LIC] L, ML, Ministerio Da Economia - União, Brasília/DF (M=7)
#85331 154.0300 [MOSAICO-LIC] L, ML, Ministerio Da Economia - União, Brasília/DF (M=7)


appAnalise
Not secure
df6963612dtn:9988/webapps/home/session.html?app=appAnalise
RFDATAHUB
Estação transmissora - TX
(Registro selecionado em tabela)
Latitude:
Longitude:
Altura (m):
-15.805306
-47.881584
10.0
MOSAICO-LIC
ID #51442
148.590 MHz ⌂ 8.1 kHz
[MOSAICO-LIC] L, ML, Ministerio Da Economia - União, Brasília/DF (M=749)
SERVIÇO
019 - RESTRITO - LIMITADO PRIVADO
ESTAÇÃO
1003059624*
LOCALIZAÇÃO
(-15.805306°, -47.881584°)
ALTURA
-1
OUTROS ASPECTOS TÉCNICOS
• EmissionClass: F1E
• SpectrumActValidity: 2026-10-24
NÚMERO ESTAÇÕES AGRUPADAS
749
LOG
• Processamento: Registro agrupado.
• Coluna: #Estação
• Original: [1003059624, 1003059659, 1003059691,
1003059721, 1003059748, 1003059829, 1003059942,
1003059985, 1003060010, 1003060053, 1003060070,
1003060118, 1003060126, 1003060142, 1003060150,
1003060177, 1003060193, 1003060231, 1003060240,
1003060266, 1003060274, 1003060282, 1003060290,
1003060312, 1003060320, 1003060339, 1003063400,
1003063427, 1003077690, 1003077703, 1003077711,
1003077720, 1003077738, 1003077746, 1003077754,
1003077762, 1003077770, 1003077789, 1003077797,
1003077800, 1003077819, 1003077827, 1003077835,
1003077843, 1003077851, 1003077860, 1003077878,
1003077886, 1003077894, 1003077908, 1003077916,
1003077924, 1003077932, 1003077940, 1003077959,
1003077967, 1003077975, 1003077983, 1003077991,
1003078009, 1003078017, 1003078025, 1003078033,
1003078041, 1003078050, 1003078068, 1003078076,
1003078084, 1003078092, 1003078106, 1003078114,
1003078122, 1003078130, 1003078149, 1003078157,
1003078165, 1003078173, 1003078181, 1003078190,
1003078203, 1003078211, 1003078220, 1003078238,
1003078246, 1003078254, 1003078262, 1003078270,
1003078289, 1003078297, 1003078300, 1003078319,
1003078327, 1003078335, 1003078343, 1003078351,
1003078360, 1003078378, 1003078386, 1003078394,
1003078408, 1003078416, 1003078424, 1003078432,
1003078440, 1003078459, 1003078467, 1003078475,
1003078483, 1003078491, 1003078505, 1003078513,
RFDataHub
RX
TX
Earthstar Geographics
ID
FREQUÊNCIA (MHz)
DESCRIÇÃO (Entidade+Fistel+Multiplicidade+Localidade)
SERVIÇO
ESTAÇÃO
LARGURA (kHz)
DISTÂNCIA (km)
#51442 148.5900 [MOSAICO-LIC] L, ML, Ministerio Da Economia - União, Brasília/DF (M=749) 19 1003059624 8.1000 0.1000
#54938 148.6900 [MOSAICO-LIC] L, ML, Ministerio Da Economia - União, Brasília/DF (M=749) 19 1003059624 8.1000 0.1000
#58220 148.7900 [MOSAICO-LIC] L, ML, Ministerio Da Economia - União, Brasília/DF (M=749) 19 1003059624 8.1000 0.1000
#60808 148.8900 [MOSAICO-LIC] L, ML, Ministerio Da Economia - União, Brasília/DF (M=749) 19 1003059624 8.1000 0.1000
#69886 149.3900 [MOSAICO-LIC] L, ML, Ministerio Da Economia - União, Brasília/DF (M=749) 19 1003059624 8.1000 0.1000
#70215 149.4300 [MOSAICO-LIC] L, ML, Ministerio Da Economia - União, Brasília/DF (M=749) 19 1003059624 8.1000 0.1000
#72640 149.5900 [MOSAICO-LIC] L, ML, Ministerio Da Economia - União, Brasília/DF (M=749) 19 1003059624 8.1000 0.1000
#74480 149.7300 [MOSAICO-LIC] L, ML, Ministerio Da Economia - União, Brasília/DF (M=749) 19 1003059624 8.1000 0.1000
#75844 149.8300 [MOSAICO-LIC] L, ML, Ministerio Da Economia - União, Brasília/DF (M=749) 19 1003059624 8.1000 0.1000
4234 de 1014431 registros
0.4 %

Using uihtml to Create ~~Unsupported~~ Word Clouds in Web Apps

- Download an open-source JavaScript library.
- Add a uihtml component to the application.
- Call the JavaScript library in an offline environment.



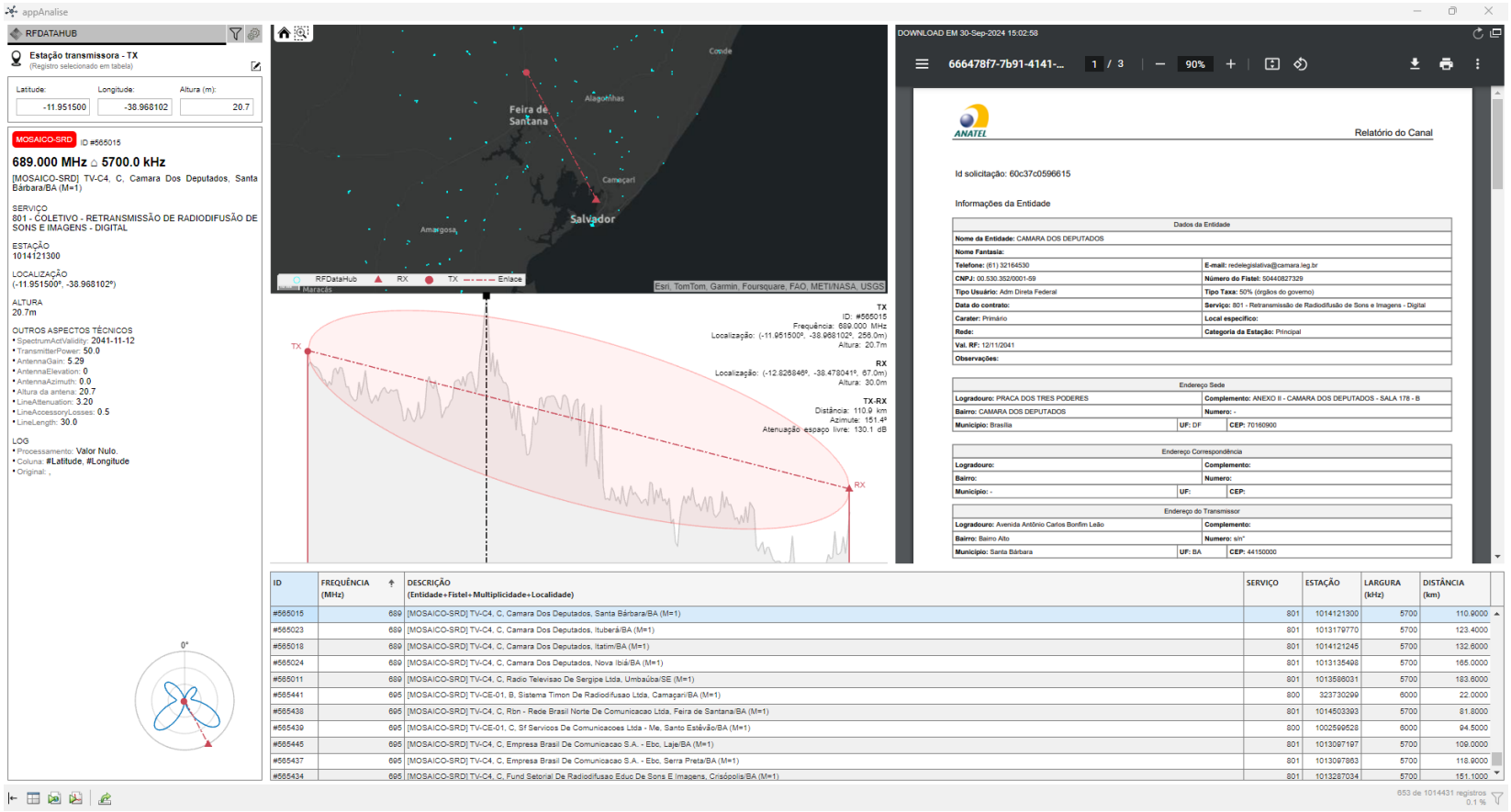
Using uihtml to Create a Google-Like Search Field by Adding Listeners for Keyboards Events

- Place the uidropdown below the uieditfield.
- Modify the behavior of the uieditfield component by creating a keydown listener for the keys:
  - "ArrowUp“
  - "ArrowDown“
  - "Enter“
  - "Escape“
  - "Tab"
- Configure the WindowButtonDown callback for the app's uifigure.

And Since We're at MATLAB EXPO, I Couldn't Miss the Chance to Share a Few Tips...

- uigridlayout and tiledlayout as containers whenever possible.
- Programmatically control uitabgroup with menu buttons.
- Leverage uihtml for text boxes, PDFs, and DOM access.
- Write code to support both desktop and webapp outputs from a single project.
- Stay updated on MATLAB's new features.

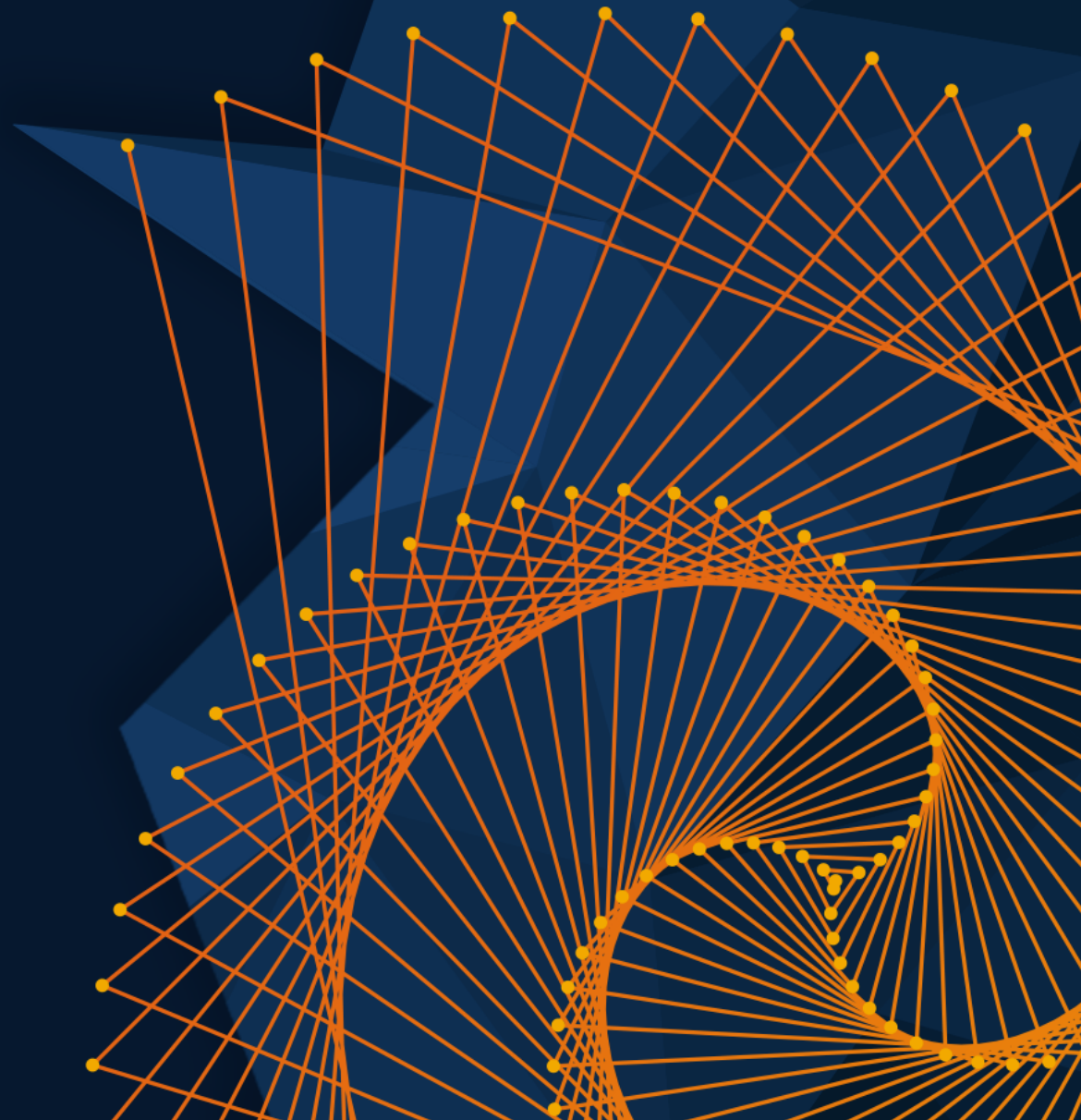
https://www.mathworks.com/help/matlab/release-notes.html
https://blogs.mathworks.com/graphics-and-apps/



MATLAB EXPO

MATLAB EXPO

Thank you!



MathWorks®

© 2024 The MathWorks, Inc. MATLAB and Simulink are registered trademarks of The MathWorks, Inc. See *mathworks.com/trademarks* for a list of additional trademarks. Other product or brand names may be trademarks or registered trademarks of their respective holders.