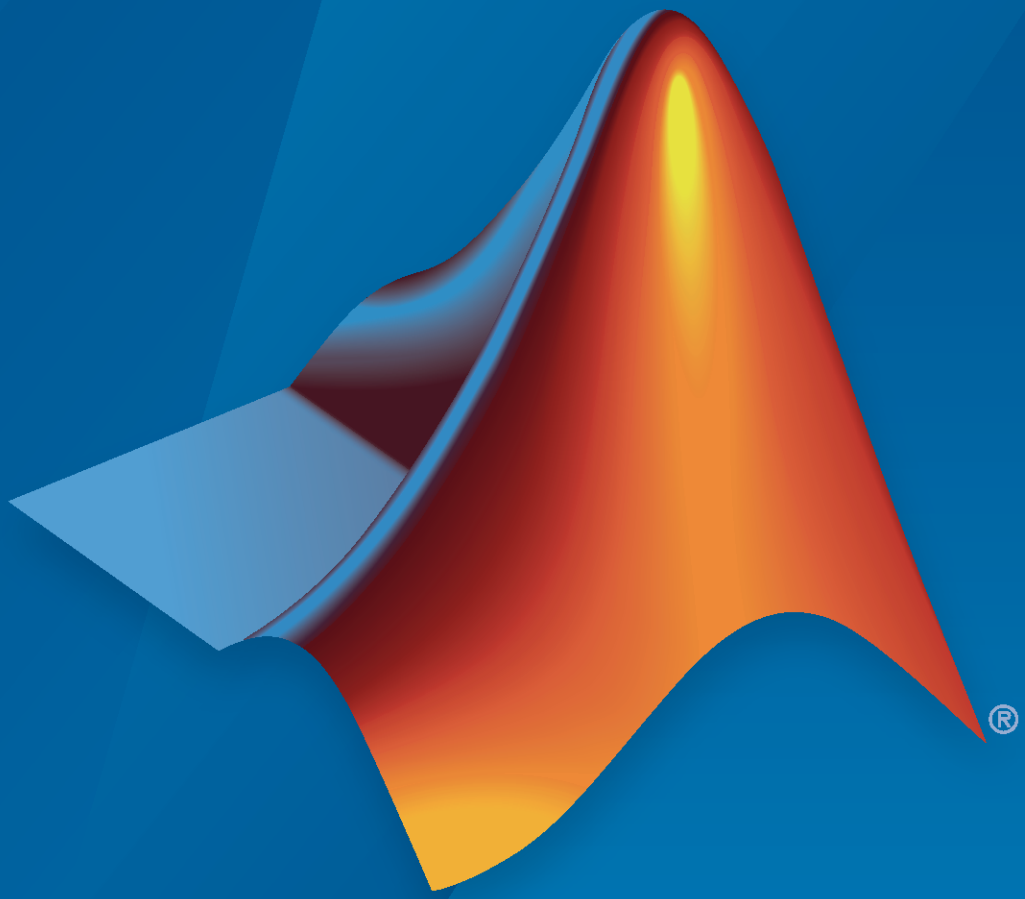
Satellite Communications Toolbox Release Notes



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Satellite Communications Toolbox Release Notes

Contents

R2021b

R2021a

R2021b

Version: 1.1

New Features

Satellite scenario enhancements

- Satellite radiation pattern visualization

  The `pattern` function enables visualization of satellite and ground station antenna radiation patterns in the `satelliteScenarioViewer`.

- Calculate latency and Doppler in a satellite scenario

  The “Calculate Latency and Doppler in a Satellite Scenario” example calculates the latency, Doppler frequency, and latency and Doppler rates of changes between an orbiting satellite and a ground station.

- Interference from a satellite constellation on a communications link

  The “Interference from Satellite Constellation on Communications Link” example analyzes downlink interference by calculating signal-to-interference-plus-noise ratio (SINR) for a geosynchronous satellite to a ground station located in the Pacific Ocean, with a constellation of multiple low Earth orbit (LEO) satellites causing interference.

Improved performance for computing satellite orbits

The `satelliteScenario` object shows improved simulation performance when you use Two-Body-Keplerian, SGP4, or SDP4 orbit propagators. The performance improvement is observable when the scenario involves large satellite constellations involving 40 or more satellites and/or when the scenario contains more than 1000 time samples between start and stop times.

For example, compared to the previous release, the following code demonstrates that the computation of the position history of 1000 satellites using Two-Body-Keplerian, SGP4, and SDP4 orbit propagators is about 51x, 64x, and 50x faster, respectively.

```
% Create 3 satellite scenario objects. The specified start,
% stop, and sample times result in 1441 time samples in the
% scenario. Each scenario tests a specific orbit propagator.
startTime = datetime(2021,7,8);
stopTime = startTime + days(1);
sampleTime = 60;
scTBK = satelliteScenario(startTime,stopTime,sampleTime);
scSGP4 = satelliteScenario(startTime,stopTime,sampleTime);
scSDP4 = satelliteScenario(startTime,stopTime,sampleTime);

% Use the Keplerian elements to add 1000 satellites to each
% scenario with the orbit propagator in order:
% Two-Body-Keplerian, SGP4, and SDP4.
semiMajorAxis = ones(1,1000)*10000000;
eccentricity = ones(1,1000)*0.1;
inclination = ones(1,1000)*60;
rightAscensionOfAscendingNode = repmat(0:18:360-18,1,50);
argumentOfPeriapsis = zeros(1,1000);
trueAnomaly = sort(repmat(0:7.2:360-7.2,1,20));
satTBK = satellite(scTBK, ...
    semiMajorAxis, ...
    eccentricity, ...
    inclination, ...
    rightAscensionOfAscendingNode, ...
    argumentOfPeriapsis, ...
```

```
    trueAnomaly, ...
    "OrbitPropagator","two-body-keplerian");
satSGP4 = satellite(scSGP4, ...
    semiMajorAxis, ...
    eccentricity, ...
    inclination, ...
    rightAscensionOfAscendingNode, ...
    argumentOfPeriapsis, ...
    trueAnomaly, ...
    "OrbitPropagator","sgp4");
satSDP4 = satellite(scSDP4, ...
    semiMajorAxis, ...
    eccentricity, ...
    inclination, ...
    rightAscensionOfAscendingNode, ...
    argumentOfPeriapsis, ...
    trueAnomaly, ...
    "OrbitPropagator","sdp4");

% Initialize an array to store the satellite position in the
% GCRF frame.
numTimeSamples = ceil(seconds(stopTime - startTime) ...
                      /sampleTime) + 1;
positionsTBK = zeros(3,numTimeSamples,1000);
positionsSGP4 = zeros(3,numTimeSamples,1000);
positionsSDP4 = zeros(3,numTimeSamples,1000);

% Time the simulation with Two-Body-Keplerian.
tic

% Fill out the position array using the states function.
% The first call to states simulates the scenario.
for idx = 1:1000
    positionsTBK(:,:,idx) = states(satTBK(idx));
end

% Store the execution time.
executionTime = toc;

% Display the execution time.
disp("Time to compute the satellite states using ...
      Two-Body-Keplerian = " + executionTime + " seconds.");

% Time the simulation with SGP4.
tic

% Fill out the position array using the states function.
% The first call to states simulates the scenario.
for idx = 1:1000
    positionsSGP4(:,:,idx) = states(satSGP4(idx));
end

% Store the execution time.
executionTime = toc;

% Display the execution time.
disp("Time to compute the satellite states using SGP4 = " ...
                            + executionTime + " seconds.");
```

```
% Time the simulation with SDP4.
tic

% Fill out the position array using the states function.
% The first call to states simulates the scenario.
for idx = 1:1000
    positionsSDP4(:,:,idx) = states(satSDP4(idx));
end

% Store the execution time.
executionTime = toc;

% Display the execution time.
disp("Time to compute the satellite states using SDP4 = " ...
                                + executionTime + " seconds.");
```

The approximate execution times are:

R2021a: Two-Body-Keplerian – 393.49 s, SGP4 – 515.55 s, and SDP4 – 734.12 s

R2021b: Two-Body-Keplerian – 7.63 s, SGP4 – 7.95 s, and SDP4 – 14.53 s

The code was timed on a Windows 10, Intel(R) Xeon(R) W-2133 CPU @ 3.60 GHz test system by running this script.

You can observe the performance improvement in all functions related to satellite scenario objects.

Improved performance for access analysis

The `Access` object functions (`accessPercentage`, `accessIntervals`, and `accessStatus`) show improved performance, which is observable when the number of access analysis objects in the scenario is 40 or more, and/or when the scenario contains more than 1000 time samples between start and stop times.

For example, compared to the previous release, the following code is about 29x faster.

```
% Create a satellite scenario object.
startTime = datetime(2021,7,8);
stopTime = startTime + days(1);
sampleTime = 60;
sc = satelliteScenario(startTime,stopTime,sampleTime);

% Add 40 satellites.
sat = satellite(sc,'leoSatelliteConstellation.tle');

% Point the satellites at a specified geographical coordinate.
for idx = 1:numel(sat)
    pointAt(sat(idx),[0;0;0]);
end

% Add gimbals to the satellites, and then add a conical sensor
% to the gimbal.
for idx = 1:numel(sat)
    gim = gimbal(sat(idx));
    conicalSensor(gim);
end
```

```
% Add a ground station.
gs = groundStation(sc);

% Point the gimbals at the ground station.
gim = [sat.Gimbals];
for idx = 1:numel(gim)
    pointAt(gim(idx),gs);
end

% Add access analysis between each conical sensor and
% the ground station.
sensor = [gim.ConicalSensors];
for idx = 1:numel(sensor)
    access(sensor(idx),gs);
end

% Retrieve the access objects.
ac = [sensor.Accesses];

% Time the computation of the access intervals for all the
% access objects.
tic;
intvls = accessIntervals(ac);
executionTime = toc;
disp("Execution of accessIntervals = " + executionTime + ...
     " seconds.");
```

The approximate execution times are:

R2021a: 48.18 s

R2021b: 1.64 s

The code was timed on a Windows 10, Intel(R) Xeon(R) W-2133 CPU @ 3.60 GHz test system by running this script.

Improved performance for satellite scenario viewer

The graphic updates on the `satelliteScenarioViewer` are observed to be faster when the satellite scenario contains 50 or more satellites.

For example, compared to the previous release, the following code for updating the visualization of 1000 satellites on the satellite scenario viewer is about 5x faster.

```
% Create a satellite scenario object.
startTime = datetime(2021,7,8);
stopTime = startTime + days(1);
sampleTime = 60;
sc = satelliteScenario(startTime,stopTime,sampleTime);

% Add 1000 satellites to the scenario using Keplerian elements.
semiMajorAxis = ones(1,1000)*10000000;
eccentricity = ones(1,1000)*0.1;
inclination = ones(1,1000)*60;
rightAscensionOfAscendingNode = repmat(0:18:360-18,1,50);
argumentOfPeriapsis = zeros(1,1000);
```

```
trueAnomaly = sort(repmat(0:7.2:360-7.2,1,20));
sat = satellite(sc, ...
    semiMajorAxis, ...
    eccentricity, ...
    inclination, ...
    rightAscensionOfAscendingNode, ...
    argumentOfPeriapsis, ...
    trueAnomaly);

% Before launching the satellite scenario viewer, hide the
% satellite labels.
for idx = 1:numel(sat)
    sat(idx).ShowLabel = false;
end

% Launch the satellite scenario viewer and hide the satellites.
v = satelliteScenarioViewer(sc);
hide(sat);

% Show the satellites and time, again.
tic;
show(sat);
updateTime = toc;
disp("Time to update the graphics = " + updateTime + ...
     " seconds.");
```

The approximate execution times are:

R2021a: 77.76 s

R2021b: 14.15 s

The code was timed on a Windows 10, Intel(R) Xeon(R) W-2133 CPU @ 3.60 GHz test system by running this script.

Improved performance for field of view visualization

The visualization using the `fieldOfView` function of `ConicalSensor` object is observed to be faster. The performance improvement is observable even if only one field-of-view contour is displayed and becomes pronounced as you add more contours and/or the number of time samples between the satellite scenario start and stop times is greater than 1000.

For example, compared to the previous release, the following code for visualizing 40 field-of-view contours with 86,401 sample times is about 2.7x faster.

```
% Create a satellite scenario object.
startTime = datetime(2021,7,8);
stopTime = startTime + days(1);
sampleTime = 60;
sc = satelliteScenario(startTime,stopTime,sampleTime);

% Add 40 satellites.
sat = satellite(sc,"leoSatelliteConstellation.tle");

% Add conical sensors to each satellite.
for idx = 1:numel(sat)
    conicalSensor(sat(idx));
```

```
end

% Point the satellites at a specified geographical location.
for idx = 1:numel(sat)
    pointAt(sat(idx),[0;0;0]);
end

% Add field-of-view visualization to the conical sensors.
sensors = [sat.ConicalSensors];
fieldOfView(sensors);

% Launch the satellite scenario viewer.
v = satelliteScenarioViewer(sc);

% Play the scenario to visualize the evolution of field-of-view
% contours, and time it.
tic;
play(sc);
executionTime = toc;
disp("Time taken to calculate and visualize the ...
     field-of-view contours = " + executionTime + " seconds.");
```

The approximate execution times are:

R2021a: 102.52 s

R2021b: 37.56 s

The code was timed on a Windows 10, Intel(R) Xeon(R) W-2133 CPU @ 3.60 GHz test system by running this script.

Improved performance for link analysis when using Gaussian antennas

The `Link` object functions (`linkPercentage`, `linkStatus`, and `linkIntervals`) show improved performance when using Gaussian antennas. This improvement is observable when the number of link analysis objects in the scenario is 40 or more, and/or when the scenario contains more than 1000 time samples between start and stop times.

For example, compared to the previous release, the following code is about 34x faster.

```
% Create a satellite scenario object.
startTime = datetime(2021,7,8);
stopTime = startTime + days(1);
sampleTime = 60;
sc = satelliteScenario(startTime,stopTime,sampleTime);

% Add 40 satellites.
sat = satellite(sc,'leoSatelliteConstellation.tle');

% Point the satellites at a specified geographical coordinate.
for idx = 1:numel(sat)
    pointAt(sat(idx),[0;0;0]);
end

% Add gimbals to the satellites, and then add a transmitter
```

```
% to the gimbal.
for idx = 1:numel(sat)
    gim = gimbal(sat(idx));
    transmitter(gim);
end

% Add a ground station, and then add a receiver to it.
gs = groundStation(sc);
rx = receiver(gs,"MountingAngles",[0;180;0]);

% Point the gimbals at the ground station.
gim = [sat.Gimbals];
for idx = 1:numel(gim)
    pointAt(gim(idx), gs);
end

% Add link analysis between each satellite transmitter and the
% ground station receiver.
tx = [gim.Transmitters];
for idx = 1:numel(tx)
    link(tx(idx),rx);
end

% Retrieve the link objects.
lnk = [tx.Links];

% Time the computation of the link intervals for all the
% link objects.
tic;
intvls = linkIntervals(lnk);
executionTime = toc;
disp("Execution of linkIntervals = " + executionTime + " seconds.");
```

The approximate execution times are:

R2021a: 49.75 s

R2021b: 1.43 s

The code was timed on a Windows 10, Intel(R) Xeon(R) W-2133 CPU @ 3.60 GHz test system by running this script.

Satellite Link Budget Analyzer app enhancements

The **Satellite Link Budget Analyzer** app now supports link availability analysis with P.618 propagation data and prediction methods. For more information, see Satellite Link Budget Analyzer.

Support for DVB-RCS2

Use the features listed in this table to encode and decode Digital Video Broadcasting Second Generation Return Channel over Satellite (DVB-RCS2) duo-binary turbo codes, generate a DVB-RCS2 standard-based waveform, and recover the signal.

Function	Description
`dvbrcs2TurboEncode`	Encode DVB-RCS2-compliant turbo codes
`dvbrcs2TurboDecode`	Decode DVB-RCS2-compliant turbo codes
`dvbrcs2WaveformGenerator`	Generate DVB-RCS2 waveform
`dvbrcs2RecoveryConfig`	DVB-RCS2 receiver configuration parameters
`dvbrcs2BitRecover`	Recover bits for DVB-RCS2 waveform

Support for satellite navigation systems

Use the features listed in this table to generate coarse acquisition codes (C/A-codes) and precision codes (P-codes).

Function	Description
`gnssCACode`	Generate C/A-code for GPS, NavIC, and QZSS satellites
`gpsPCode`	Generate P-code for GPS satellites

For more information on how to configure and generate a GPS waveform using C/A and P-codes, see “GPS Waveform Generation”.

End-to-End Simulation examples

- “End-to-End DVB-S2X Simulation with RF Impairments and Corrections for VL-SNR Frames” — This example shows how to measure the bit error rate (BER) and packet error rate (PER) of a single stream Digital Video Broadcasting Satellite Second Generation extended (DVB-S2X) link for very low signal-to-noise ratio (VL-SNR) frames.
- “DVB-S2 Bent Pipe Simulation with RF Impairments and Corrections” — This Simulink® example models a DVB-S2 bent-pipe satellite link and calculates the end-to-end PER and a low density parity check (LDPC) coding BER.
- “End-to-End CCSDS Flexible Advanced Coding and Modulation Simulation with RF Impairments and Corrections” — This example shows how to measure the BER of the end-to-end chain of the Consultative Committee for Space Data Systems (CCSDS) flexible advanced coding and modulation (FACM) scheme for a high-rate telemetry (TM) applications system.

Receive and analyze captured satellite data

Use the Amazon® Web Services (AWS) Ground Station service with MATLAB® to receive data from an Earth observation satellite. Set up access to AWS, configure and set up data capture, schedule contact with the satellite, and download the received satellite data. For details, see “Capture Satellite Data Using AWS Ground Station”.

MATLAB Compiler Support

MATLAB Compiler™ now supports Satellite Communications Toolbox software. For information about product limitations, see MATLAB Compiler and Simulink Compiler.

MATLAB Online Support

MATLAB Online™ now supports Satellite Communications Toolbox software. For information about product limitations, see Specifications and Limitations.

R2021a

Version: 1.0

New Features

Introducing Satellite Communications Toolbox

Satellite Communications Toolbox provides standards-based tools for designing, simulating, and verifying satellite communications systems and links. The toolbox enables you to model and visualize satellite orbits and perform link analysis and access calculations. You can also design physical layer algorithms together with RF components and ground station receivers, generate test waveforms, and perform golden reference design verification.

With the toolbox you can configure, simulate, measure, and analyze end-to-end satellite communications links. You can also create and reuse tests to verify that your designs, prototypes, and implementations comply with satellite communications and navigations standards, including DVB-S2X, DVB-S2, CCSDS, and GPS.

Satellite Scenario: Simulate, analyze, and visualize satellites in orbit

Use functions and reference examples that enable you to simulate, analyze, and visualize satellites in orbits. Use the `satelliteScenario` object to:

- Define satellites and their orbits.
- Define ground stations.
- Visualize satellites in orbit and ground tracks.
- Visualize satellite field-of-view on Earth.
- Analyze line-of-sight access between satellites and ground stations.
- Analyze the closure of communications links between satellites and ground stations.
- View a satellite scenario with playback animation.

For more information, see Satellite Scenario Basics and Scenario Generation and Visualization.

Satellite link budget analysis

Use the **Satellite Link Budget Analyzer** app to analyze, design, and visualize the link budget for satellite communications. For more information, see Link Budget Analysis.

Standards-based waveform generation

Use standards-based functions and reference examples to design, model, and verify satellite communications and navigation systems. The toolbox offers these standards-based waveforms:

- Consultative Committee for Space Data Systems (CCSDS) Telecommand (TC)
- CCSDS Telemetry (TM)
- Digital Video Broadcasting Satellite Second Generation (DVB-S2)
- Digital Video Broadcasting Satellite Second Generation extended (DVB-S2X)
- Global Positioning System (GPS)

For more information, see Generate Waveforms and Signal Transmission.

Channel models and RF propagation loss

Use ITU-R P.618 functions to design Earth-space links by calculating the signal propagation loss through the atmosphere. With these toolbox features, you can also model and visualize noisy single input single output (SISO) channels that have Rician or Land Mobile Satellite (LMS) fading profiles. For more information, see RF Propagation and Channel Models.

Signal recovery

Use receiver functions to decode and demodulate waveforms. Use reference examples to model end-to-end communications links and analyze link performance. For more information, see End-to-End Simulation.

C and C++ code generation support

Satellite Communications Toolbox supports ANSI®/ISO® compliant C/C++ code generation. For an alphabetized list of features that support C/C++ code generation, see Satellite Communications Toolbox – Functions and Objects Filtered by C/C++ Code Generation.