RS-HL-2: Generate Contact Chart of Given Constellation

Hongseok Kim

Ver 1.1

Last Revised: 6/7/2024

Revision History

Ver 1.0: Initial Draft [6/5/2024]

Ver 1.1: Added several functions [6/7/2024]

Scope

Interface Specification

```
clc; clear;
addpath('~/Desktop/Redstone_Project/RS_HL/
RS_HL_1_Constellation_Scinario_Formulation/')
```

I. Input information

I.1 Time Parameter

```
% Initial Epoch Definition

Year = 2024;
Month = 3;
Day = 21;
Hour = 0;
Minute = 0;
Seconds = 0;

% Duration and Steptime
duration = hours(24);
steptime = 15; % seconds

startTime = datetime(Year,Month,Day,Hour,Minute,Seconds);

time_parameters.startTime = datetime(Year,Month,Day,Hour,Minute,Seconds);
time_parameters.duration = duration;
time_parameters.steptime = steptime;
```

```
scenario = scenario_initalization(time_parameters);
```

I.2 Satellite Constellation - Walker Configuration (24 SATs in Single Orbit)

```
% Intial Orbit Settings

Altitude = 500; % (km)
Eccentricity = 1e-5;
Inclinaton = 97.4022; % (deg)
RAAN = 90;   % (deg)
AOP = 0; % (deg)

% Number of satellites
number_of_SATs = 24;

% Satellite Characteristics - This will entail -1, -2, ... for
% constallation
satellite_name = "RS-1";

% Orbit Propagator
Orbit_Propagator = 'SGP4';


orbit_information.SMA = Altitude*1000 + 6378000;
orbit_information.ecc = Eccentricity;
orbit_information.inc = Inclinaton;
orbit_information.RAAN = RAAN;
orbit_information.AOP = AOP;

% Generate First Stream of Satellites
satellites_orbit_1 = single_orbit_constellation(scenario, orbit_information,
number_of_SATs, Orbit_Propagator, satellite_name);


% Generate Second Steram of Satellites
RAAN = 105;
orbit_information.RAAN = RAAN;
satellite_name = "RS-2";
satellites_orbit_2 = single_orbit_constellation(scenario, orbit_information,
number_of_SATs, Orbit_Propagator, satellite_name);

% Merge Satellite Informations
satellites = [satellites_orbit_1, satellites_orbit_2];
```

I.4 gs Station Location

```
gs_info = ["Austin", 30.2672, -97.7431, 15;
           "New York", 40.7128, -74.0060, 10;
           "Los Angeles", 34.0522, -118.4837, 71;
           "Chicago", 41.8781, -87.6298, 181;
           "Houston", 29.7604, -95.3698, 30;
           "Phoenix", 33.4484, -112.0740, 331;
           "Philadelphia", 39.9526, -75.1652, 12;
           "San Antonio", 29.4481, -98.4936, 198;
           "San Diego", 32.7157, -117.1611, 22;
           "Dallas", 32.7767, -96.7970, 137;
           "London", 51.5074, -0.1278, 35;
           "Tokyo", 35.6895, 139.6917, 6;
           "Paris", 48.8566, 2.3522, 35;
           "Moscow", 55.7558, 37.6176, 155;
           "Sydney", -33.8688, 151.2093, 19;
           "Toronto", 43.6511, -79.3830, 76;
           "Berlin", 52.5200, 13.4050, 34;
           "Rome", 41.9028, 12.4964, 17;
           "Seoul", 37.5665, 126.9780, 23;
           "Mumbai", 19.0760, 72.8777, 14;
           "Beijing", 39.9042, 116.4074, 43;
           "Mexico City", 19.4326, -99.1332, 2240;
           "São Paulo", -23.5505, -46.6333, 780;
           "Bangkok", 13.7563, 100.5018, 2;
           "Istanbul", 41.0082, 28.9784, 39;
           "Cairo", 30.0444, 31.2357, 23;
           "Dubai", 25.2769, 55.2963, 4;
           "Singapore", 1.3521, 103.8198, 15;
           "Hong Kong", 22.3193, 114.1694, 39;
           "Sydney", -33.8688, 151.2093, 19];


gs = groundStation(scenario,"Name",gs_info(:,1), ...
                   "Latitude",str2double(gs_info(:,2)), ...
                   "Longitude", str2double(gs_info(:,3)), ...
                   "Altitude", str2double(gs_info(:,4)), ...
                   "MinElevationAngle", 15);
```

II. GS to Satellite Access Information Generation

```
[time_vector, ...
  gs_to_sat_access_table, ...
  gs_to_sat_access_matrix, ...
  gs_to_sat_access_info, ...
  contact_1_sat, ...
  contact_2_sat, ...
  contact_3_sat, ...
  contact_4_plus_sat] =
gs_to_sat_access_info_generation(scenario,satellites,gs)
```

time_vector = 1×5761 datetime
21-Mar-2024 00:00:0021-Mar-2024 00:00:1521-Mar-2024 00:00:3021-Mar-2024 00:00:45 ···
gs_to_sat_access_table = 3611×8 table

..

	Source	Target	IntervalNumber	StartTime	EndTime	Duration
1	"Austin"	"RS-1-1"	1	21-Mar-2024 00:05:15	21-Mar-2024 00:11:00	345
2	"Austin"	"RS-1-1"	2	21-Mar-2024 13:13:45	21-Mar-2024 13:19:00	315
3	"Austin"	"RS-1-1"	3	21-Mar-2024 23:46:15	21-Mar-2024 23:50:45	270
4	"Austin"	"RS-1-2"	1	21-Mar-2024 00:01:30	21-Mar-2024 00:07:00	330
5	"Austin"	"RS-1-2"	2	21-Mar-2024 13:09:45	21-Mar-2024 13:15:15	330
6	"Austin"	"RS-1-2"	3	21-Mar-2024 23:42:30	21-Mar-2024 23:46:45	255
7	"Austin"	"RS-1-3"	1	21-Mar-2024 00:00:00	21-Mar-2024 00:03:00	180
8	"Austin"	"RS-1-3"	2	21-Mar-2024 13:06:00	21-Mar-2024 13:11:15	315
9	"Austin"	"RS-1-3"	3	21-Mar-2024 23:38:45	21-Mar-2024 23:42:45	240
10	"Austin"	"RS-1-4"	1	21-Mar-2024 13:02:00	21-Mar-2024 13:07:30	330
11	"Austin"	"RS-1-4"	2	21-Mar-2024 23:35:15	21-Mar-2024 23:38:45	210
12	"Austin"	"RS-1-5"	1	21-Mar-2024 12:58:00	21-Mar-2024 13:03:45	345
13	"Austin"	"RS-1-5"	2	21-Mar-2024 23:31:30	21-Mar-2024 23:34:30	180
14	"Austin"	"RS-1-6"	1	21-Mar-2024 12:54:00	21-Mar-2024 12:59:45	345
15	"Austin"	"RS-1-6"	2	21-Mar-2024 23:28:00	21-Mar-2024 23:30:15	135
16	"Austin"	"RS-1-7"	1	21-Mar-2024 12:50:15	21-Mar-2024 12:56:00	345
17	"Austin"	"RS-1-7"	2	21-Mar-2024 23:25:00	21-Mar-2024 23:25:30	30
18	"Austin"	"RS-1-8"	1	21-Mar-2024 12:46:15	21-Mar-2024 12:52:00	345
19	"Austin"	"RS-1-9"	1	21-Mar-2024 01:10:00	21-Mar-2024 01:11:15	75
20	"Austin"	"RS-1-9"	2	21-Mar-2024 12:42:30	21-Mar-2024 12:48:00	330
21	"Austin"	"RS-1-10"	1	21-Mar-2024 01:05:30	21-Mar-2024 01:08:00	150
22	"Austin"	"RS-1-10"	2	21-Mar-2024 12:38:30	21-Mar-2024 12:44:00	330
23	"Austin"	"RS-1-11"	1	21-Mar-2024 01:01:15	21-Mar-2024 01:04:30	195
24	"Austin"	"RS-1-11"	2	21-Mar-2024 12:34:45	21-Mar-2024 12:40:15	330

	Source	Target	IntervalNumber	StartTime	EndTime	Duration
25	"Austin"	"RS-1-12"	1	21-Mar-2024 00:57:00	21-Mar-2024 01:00:45	225
26	"Austin"	"RS-1-12"	2	21-Mar-2024 12:30:45	21-Mar-2024 12:36:15	330
27	"Austin"	"RS-1-13"	1	21-Mar-2024 00:53:00	21-Mar-2024 00:57:15	255
28	"Austin"	"RS-1-13"	2	21-Mar-2024 12:27:00	21-Mar-2024 12:32:15	315
29	"Austin"	"RS-1-14"	1	21-Mar-2024 00:48:45	21-Mar-2024 00:53:30	285
30	"Austin"	"RS-1-14"	2	21-Mar-2024 12:23:15	21-Mar-2024 12:28:15	300
31	"Austin"	"RS-1-15"	1	21-Mar-2024 00:44:45	21-Mar-2024 00:49:45	300
32	"Austin"	"RS-1-15"	2	21-Mar-2024 12:19:30	21-Mar-2024 12:24:00	270
33	"Austin"	"RS-1-16"	1	21-Mar-2024 00:40:45	21-Mar-2024 00:45:45	300
34	"Austin"	"RS-1-16"	2	21-Mar-2024 12:15:45	21-Mar-2024 12:20:00	255
35	"Austin"	"RS-1-17"	1	21-Mar-2024 00:36:45	21-Mar-2024 00:42:00	315
36	"Austin"	"RS-1-17"	2	21-Mar-2024 12:12:00	21-Mar-2024 12:15:45	225
37	"Austin"	"RS-1-18"	1	21-Mar-2024 00:32:45	21-Mar-2024 00:38:15	330
38	"Austin"	"RS-1-18"	2	21-Mar-2024 12:08:30	21-Mar-2024 12:11:45	195
39	"Austin"	"RS-1-18"	3	21-Mar-2024 13:42:30	21-Mar-2024 13:44:30	120
40	"Austin"	"RS-1-19"	1	21-Mar-2024 00:28:45	21-Mar-2024 00:34:15	330
41	"Austin"	"RS-1-19"	2	21-Mar-2024 12:04:45	21-Mar-2024 12:07:30	165
42	"Austin"	"RS-1-19"	3	21-Mar-2024 13:38:15	21-Mar-2024 13:41:00	165
43	"Austin"	"RS-1-20"	1	21-Mar-2024 00:24:45	21-Mar-2024 00:30:30	345
44	"Austin"	"RS-1-20"	2	21-Mar-2024 12:01:30	21-Mar-2024 12:03:00	90
45	"Austin"	"RS-1-20"	3	21-Mar-2024 13:34:15	21-Mar-2024 13:37:30	195
46	"Austin"	"RS-1-21"	1	21-Mar-2024 00:21:00	21-Mar-2024 00:26:30	330
47	"Austin"	"RS-1-21"	2	21-Mar-2024 13:30:00	21-Mar-2024 13:34:00	240
48	"Austin"	"RS-1-22"	1	21-Mar-2024 00:17:00	21-Mar-2024 00:22:45	345
49	"Austin"	"RS-1-22"	2	21-Mar-2024 13:26:00	21-Mar-2024 13:30:15	255
50	"Austin"	"RS-1-22"	3	21-Mar-2024 23:57:30	22-Mar-2024 00:00:00	150
51	"Austin"	"RS-1-23"	1	21-Mar-2024 00:13:00	21-Mar-2024 00:18:45	345
52	"Austin"	"RS-1-23"	2	21-Mar-2024 13:21:45	21-Mar-2024 13:26:30	285
53	"Austin"	"RS-1-23"	3	21-Mar-2024 23:53:45	21-Mar-2024 23:59:00	315
54	"Austin"	"RS-1-24"	1	21-Mar-2024 00:09:15	21-Mar-2024 00:15:00	345
55	"Austin"	"RS-1-24"	2	21-Mar-2024 13:17:45	21-Mar-2024 13:22:45	300
56	"Austin"	"RS-1-24"	3	21-Mar-2024 23:50:00	21-Mar-2024 23:55:00	300
57	"Austin"	"RS-2-1"	1	21-Mar-2024 01:40:00	21-Mar-2024 01:45:00	300

	Source	Target	IntervalNumber	StartTime	EndTime	Duration
58	"Austin"	"RS-2-1"	2	21-Mar-2024 13:15:00	21-Mar-2024 13:19:15	255
59	"Austin"	"RS-2-2"	1	21-Mar-2024 01:36:00	21-Mar-2024 01:41:15	315
60	"Austin"	"RS-2-2"	2	21-Mar-2024 13:11:15	21-Mar-2024 13:15:00	225
61	"Austin"	"RS-2-2"	3	21-Mar-2024 14:46:15	21-Mar-2024 14:47:00	45
62	"Austin"	"RS-2-3"	1	21-Mar-2024 01:32:00	21-Mar-2024 01:37:30	330
63	"Austin"	"RS-2-3"	2	21-Mar-2024 13:07:45	21-Mar-2024 13:10:45	180
64	"Austin"	"RS-2-3"	3	21-Mar-2024 14:41:45	21-Mar-2024 14:43:45	120
65	"Austin"	"RS-2-4"	1	21-Mar-2024 01:28:00	21-Mar-2024 01:33:30	330
66	"Austin"	"RS-2-4"	2	21-Mar-2024 13:04:00	21-Mar-2024 13:06:30	150
67	"Austin"	"RS-2-4"	3	21-Mar-2024 14:37:30	21-Mar-2024 14:40:15	165
68	"Austin"	"RS-2-5"	1	21-Mar-2024 01:24:00	21-Mar-2024 01:29:45	345
69	"Austin"	"RS-2-5"	2	21-Mar-2024 13:00:45	21-Mar-2024 13:02:00	75
70	"Austin"	"RS-2-5"	3	21-Mar-2024 14:33:15	21-Mar-2024 14:36:45	210
71	"Austin"	"RS-2-6"	1	21-Mar-2024 01:20:00	21-Mar-2024 01:25:45	345
72	"Austin"	"RS-2-6"	2	21-Mar-2024 14:29:15	21-Mar-2024 14:33:15	240
73	"Austin"	"RS-2-7"	1	21-Mar-2024 01:16:15	21-Mar-2024 01:22:00	345
74	"Austin"	"RS-2-7"	2	21-Mar-2024 14:25:00	21-Mar-2024 14:29:30	270
75	"Austin"	"RS-2-8"	1	21-Mar-2024 01:12:15	21-Mar-2024 01:18:00	345
76	"Austin"	"RS-2-8"	2	21-Mar-2024 14:21:00	21-Mar-2024 14:25:45	285
77	"Austin"	"RS-2-9"	1	21-Mar-2024 01:08:30	21-Mar-2024 01:14:00	330
78	"Austin"	"RS-2-9"	2	21-Mar-2024 14:17:00	21-Mar-2024 14:22:00	300
79	"Austin"	"RS-2-10"	1	21-Mar-2024 01:04:30	21-Mar-2024 01:10:15	345
80	"Austin"	"RS-2-10"	2	21-Mar-2024 14:13:00	21-Mar-2024 14:18:15	315
81	"Austin"	"RS-2-11"	1	21-Mar-2024 01:00:45	21-Mar-2024 01:06:15	330
82	"Austin"	"RS-2-11"	2	21-Mar-2024 14:09:00	21-Mar-2024 14:14:30	330
83	"Austin"	"RS-2-12"	1	21-Mar-2024 00:57:00	21-Mar-2024 01:02:15	315
84	"Austin"	"RS-2-12"	2	21-Mar-2024 14:05:00	21-Mar-2024 14:10:30	330
85	"Austin"	"RS-2-13"	1	21-Mar-2024 00:53:00	21-Mar-2024 00:58:15	315
86	"Austin"	"RS-2-13"	2	21-Mar-2024 14:01:15	21-Mar-2024 14:06:45	330
87	"Austin"	"RS-2-14"	1	21-Mar-2024 00:49:15	21-Mar-2024 00:54:15	300
88	"Austin"	"RS-2-14"	2	21-Mar-2024 13:57:15	21-Mar-2024 14:02:45	330
89	"Austin"	"RS-2-15"	1	21-Mar-2024 00:45:30	21-Mar-2024 00:50:15	285
90	"Austin"	"RS-2-15"	2	21-Mar-2024 13:53:15	21-Mar-2024 13:59:00	345

	Source	Target	IntervalNumber	StartTime	EndTime	Duration
91	"Austin"	"RS-2-16"	1	21-Mar-2024 00:42:00	21-Mar-2024 00:46:15	255
92	"Austin"	"RS-2-16"	2	21-Mar-2024 13:49:15	21-Mar-2024 13:55:00	345
93	"Austin"	"RS-2-17"	1	21-Mar-2024 00:38:15	21-Mar-2024 00:42:00	225
94	"Austin"	"RS-2-17"	2	21-Mar-2024 13:45:30	21-Mar-2024 13:51:15	345
95	"Austin"	"RS-2-18"	1	21-Mar-2024 00:34:30	21-Mar-2024 00:38:00	210
96	"Austin"	"RS-2-18"	2	21-Mar-2024 02:09:00	21-Mar-2024 02:10:45	105
97	"Austin"	"RS-2-18"	3	21-Mar-2024 13:41:30	21-Mar-2024 13:47:15	345
98	"Austin"	"RS-2-19"	1	21-Mar-2024 00:31:00	21-Mar-2024 00:33:45	165
99	"Austin"	"RS-2-19"	2	21-Mar-2024 02:04:45	21-Mar-2024 02:07:15	150
100	"Austin"	"RS-2-19"	3	21-Mar-2024 13:37:45	21-Mar-2024 13:43:15	330

.
.
.

```
gs_to_sat_access_matrix = 30×5761
     1     1     1     1     1     1     2     2     2     2     2     2     2 ···
     2     2     2     2     2     2     2     1     1     1     1     1     1
     0     0     0     0     0     0     0     0     0     0     0     0     0
     2     2     3     3     4     4     4     3     3     3     2     2     2
     1     1     1     1     1     2     2     2     2     2     2     2     2
     0     0     0     0     0     0     0     0     0     0     0     0     0
     2     2     2     2     2     2     1     1     1     1     1     1     1
     1     1     1     1     1     1     2     2     2     2     2     2     1
     0     0     0     0     0     0     0     0     0     0     0     0     0
     1     1     1     1     1     1     1     1     2     2     2     2     2
     .
     .
     .

gs_to_sat_access_info =
  1x48 Access array with properties:

    Sequence
    LineWidth
    LineColor
contact_1_sat = 18941×2
     1     1
     2     1
     3     1
     4     1
     5     1
     6     1
    14     1
    15     1
    16     1
    17     1
     .
     .
     .

contact_2_sat = 16573×2
     7     1
     8     1
     9     1
    10     1
    11     1
    12     1
    13     1
    22     1
    23     1
```

```
    24       1
      .
      .
      .
contact_3_sat = 3897×2
   116       1
   117       1
   118       1
   119       1
   132       1
   133       1
   134       1
   135       1
   136       1
   148       1
      .
      .
      .
contact_4_plus_sat = 1017×2
   169       1
   183       1
   184       1
   198       1
   199       1
   200       1
   213       1
   214       1
   215       1
   229       1
      .
      .
      .
```
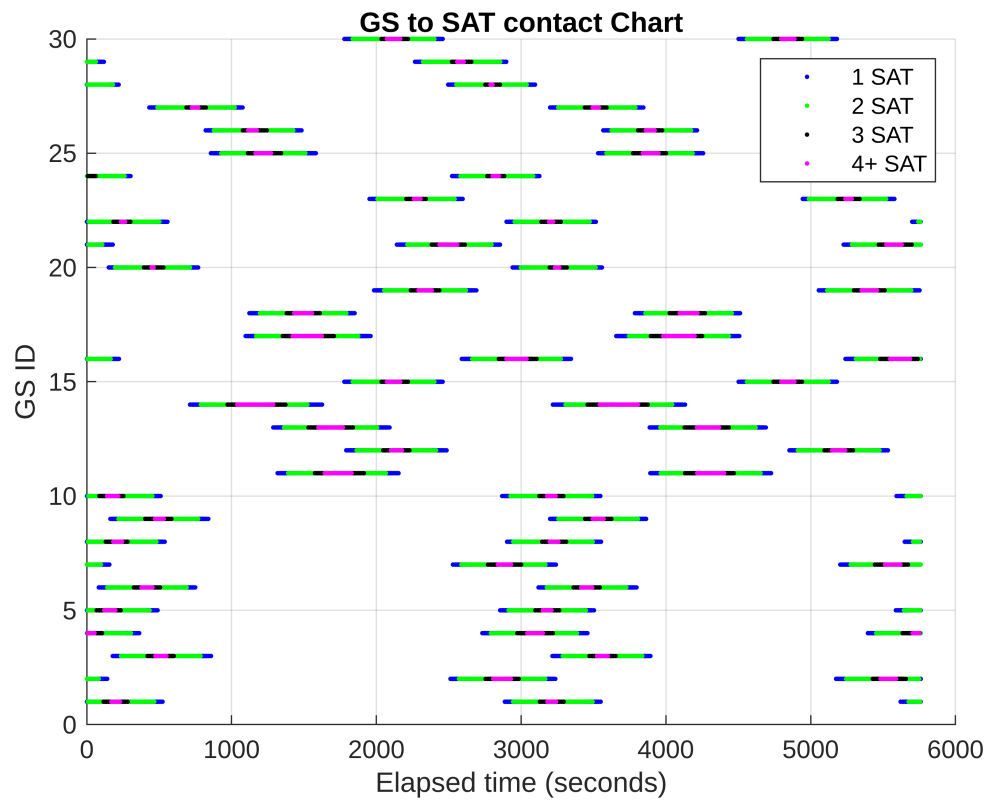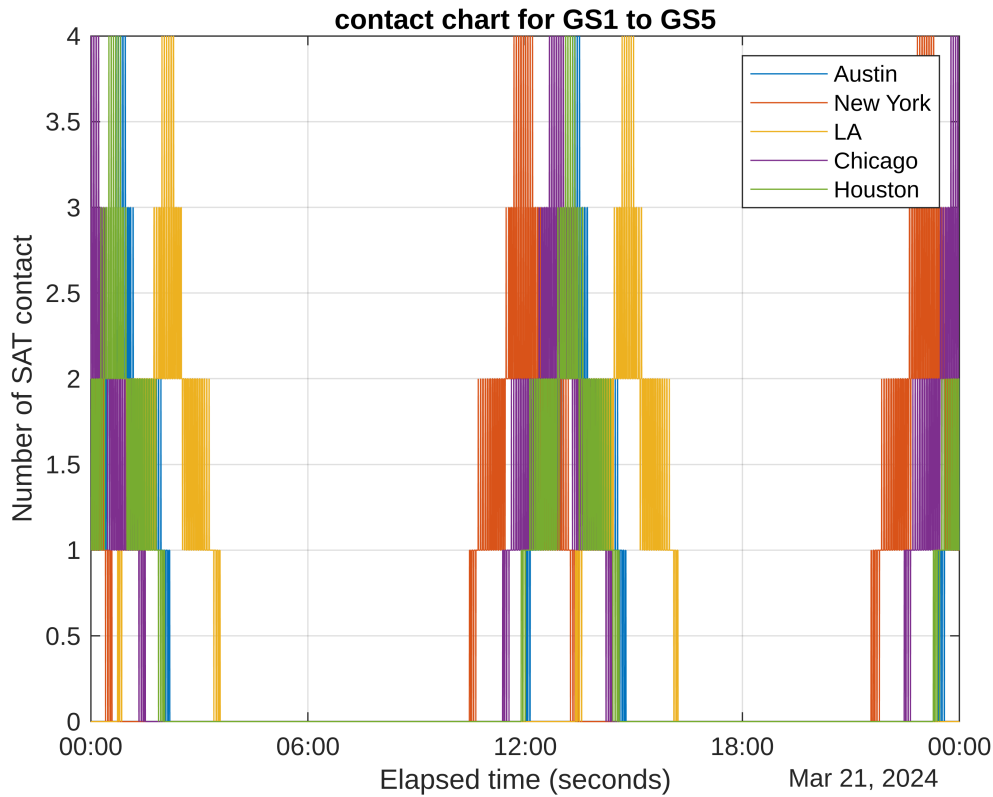
```matlab
figure;
scatter(contact_1_sat(:,1),contact_1_sat(:,2),'.','b')
hold on
scatter(contact_2_sat(:,1),contact_2_sat(:,2),'.','g')
scatter(contact_3_sat(:,1),contact_3_sat(:,2),'.','k')
scatter(contact_4_plus_sat(:,1),contact_4_plus_sat(:,2),'.','m')
hold off
title('GS to SAT contact Chart')
xlabel('Elapsed time (seconds)')
ylabel('GS ID')
legend('1 SAT', '2 SAT', '3 SAT', '4+ SAT')
grid on
```

GS to SAT contact Chart

Legend:
- 1 SAT (blue)
- 2 SAT (green)
- 3 SAT (black)
- 4+ SAT (magenta)

X-axis: Elapsed time (seconds)
Y-axis: GS ID

```
figure;
plot(time_vector,gs_to_sat_access_matrix(1,:))
hold on
plot(time_vector,gs_to_sat_access_matrix(2,:))
plot(time_vector,gs_to_sat_access_matrix(3,:))
plot(time_vector,gs_to_sat_access_matrix(4,:))
plot(time_vector,gs_to_sat_access_matrix(5,:))
hold off
title('contact chart for GS1 to GS5')
xlabel('Elapsed time (seconds)')
ylabel('Number of SAT contact')
legend('Austin', 'New York', 'LA', 'Chicago', 'Houston')
grid on
```

contact chart for GS1 to GS5

III. Satellite to gs Acces Information Generation

```
[time_vector, ...
 sat_to_gs_access_table, ...
 sat_to_gs_access_matrix, ...
 sat_to_gs_access_info, ...
 contact_1_gs, ...
 contact_2_gs, ...
 contact_3_gs, ...
 contact_4_plus_gs] =
sat_to_gs_access_info_generation(scenario,satellites,gs)
```

time_vector = 1×5761 datetime
21-Mar-2024 00:00:0021-Mar-2024 00:00:1521-Mar-2024 00:00:3021-Mar-2024 00:00:45 ⋯
sat_to_gs_access_table = 3611×8 table

⋯

	Source	Target	IntervalNumber	StartTime	EndTime	Duration
1	"RS-1-1"	"Austin"	1	21-Mar-2024 00:05:15	21-Mar-2024 00:11:00	345
2	"RS-1-1"	"Austin"	2	21-Mar-2024 13:13:45	21-Mar-2024 13:19:00	315
3	"RS-1-1"	"Austin"	3	21-Mar-2024 23:46:15	21-Mar-2024 23:50:45	270
4	"RS-1-1"	"New York"	1	21-Mar-2024 11:36:15	21-Mar-2024 11:42:00	345
5	"RS-1-1"	"New York"	2	21-Mar-2024 22:13:45	21-Mar-2024 22:19:15	330

10

	Source	Target	IntervalNumber	StartTime	EndTime	Duration
6	"RS-1-1"	"Los Angeles"	1	21-Mar-2024 01:40:45	21-Mar-2024 01:46:30	345
7	"RS-1-1"	"Los Angeles"	2	21-Mar-2024 14:47:30	21-Mar-2024 14:52:15	285
8	"RS-1-1"	"Chicago"	1	21-Mar-2024 00:08:45	21-Mar-2024 00:13:00	255
9	"RS-1-1"	"Chicago"	2	21-Mar-2024 11:37:15	21-Mar-2024 11:41:15	240
10	"RS-1-1"	"Chicago"	3	21-Mar-2024 13:11:15	21-Mar-2024 13:14:30	195
11	"RS-1-1"	"Chicago"	4	21-Mar-2024 23:48:15	21-Mar-2024 23:53:45	330
12	"RS-1-1"	"Houston"	1	21-Mar-2024 00:05:00	21-Mar-2024 00:10:45	345
13	"RS-1-1"	"Houston"	2	21-Mar-2024 13:14:15	21-Mar-2024 13:18:30	255
14	"RS-1-1"	"Houston"	3	21-Mar-2024 23:45:45	21-Mar-2024 23:51:00	315
15	"RS-1-1"	"Phoenix"	1	21-Mar-2024 01:40:45	21-Mar-2024 01:45:45	300
16	"RS-1-1"	"Phoenix"	2	21-Mar-2024 13:14:00	21-Mar-2024 13:18:15	255
17	"RS-1-1"	"Philadelphia"	1	21-Mar-2024 11:36:30	21-Mar-2024 11:42:15	345
18	"RS-1-1"	"Philadelphia"	2	21-Mar-2024 22:13:45	21-Mar-2024 22:19:00	315
19	"RS-1-1"	"San Antonio"	1	21-Mar-2024 00:05:15	21-Mar-2024 00:10:45	330
20	"RS-1-1"	"San Antonio"	2	21-Mar-2024 13:14:00	21-Mar-2024 13:19:15	315
21	"RS-1-1"	"San Antonio"	3	21-Mar-2024 23:46:15	21-Mar-2024 23:50:30	255
22	"RS-1-1"	"San Diego"	1	21-Mar-2024 01:40:30	21-Mar-2024 01:46:00	330
23	"RS-1-1"	"San Diego"	2	21-Mar-2024 14:48:15	21-Mar-2024 14:52:15	240
24	"RS-1-1"	"Dallas"	1	21-Mar-2024 00:06:00	21-Mar-2024 00:11:30	330
25	"RS-1-1"	"Dallas"	2	21-Mar-2024 13:13:15	21-Mar-2024 13:18:15	300
26	"RS-1-1"	"Dallas"	3	21-Mar-2024 23:46:30	21-Mar-2024 23:51:45	315
27	"RS-1-1"	"London"	1	21-Mar-2024 06:49:30	21-Mar-2024 06:55:00	330
28	"RS-1-1"	"London"	2	21-Mar-2024 17:32:15	21-Mar-2024 17:38:00	345
29	"RS-1-1"	"Tokyo"	1	21-Mar-2024 08:00:30	21-Mar-2024 08:05:45	315
30	"RS-1-1"	"Tokyo"	2	21-Mar-2024 21:05:45	21-Mar-2024 21:11:30	345
31	"RS-1-1"	"Paris"	1	21-Mar-2024 06:50:00	21-Mar-2024 06:55:30	330
32	"RS-1-1"	"Paris"	2	21-Mar-2024 17:31:30	21-Mar-2024 17:37:00	330
33	"RS-1-1"	"Moscow"	1	21-Mar-2024 03:39:30	21-Mar-2024 03:44:45	315
34	"RS-1-1"	"Moscow"	2	21-Mar-2024 05:13:45	21-Mar-2024 05:17:45	240
35	"RS-1-1"	"Moscow"	3	21-Mar-2024 14:24:30	21-Mar-2024 14:30:00	330
36	"RS-1-1"	"Moscow"	4	21-Mar-2024 15:59:45	21-Mar-2024 16:02:45	180
37	"RS-1-1"	"Sydney"	1	21-Mar-2024 07:42:30	21-Mar-2024 07:47:00	270
38	"RS-1-1"	"Sydney"	2	21-Mar-2024 19:49:30	21-Mar-2024 19:55:00	330

	Source	Target	IntervalNumber	StartTime	EndTime	Duration
39	"RS-1-1"	"Toronto"	1	21-Mar-2024 11:35:45	21-Mar-2024 11:41:30	345
40	"RS-1-1"	"Toronto"	2	21-Mar-2024 22:15:15	21-Mar-2024 22:19:45	270
41	"RS-1-1"	"Toronto"	3	21-Mar-2024 23:50:00	21-Mar-2024 23:52:30	150
42	"RS-1-1"	"Berlin"	1	21-Mar-2024 05:15:00	21-Mar-2024 05:20:15	315
43	"RS-1-1"	"Berlin"	2	21-Mar-2024 06:49:30	21-Mar-2024 06:53:00	210
44	"RS-1-1"	"Berlin"	3	21-Mar-2024 15:58:30	21-Mar-2024 16:03:45	315
45	"RS-1-1"	"Berlin"	4	21-Mar-2024 17:33:15	21-Mar-2024 17:36:45	210
46	"RS-1-1"	"Rome"	1	21-Mar-2024 05:17:45	21-Mar-2024 05:23:15	330
47	"RS-1-1"	"Rome"	2	21-Mar-2024 15:56:45	21-Mar-2024 16:00:15	210
48	"RS-1-1"	"Rome"	3	21-Mar-2024 17:30:15	21-Mar-2024 17:34:15	240
49	"RS-1-1"	"Seoul"	1	21-Mar-2024 09:35:15	21-Mar-2024 09:40:30	315
50	"RS-1-1"	"Seoul"	2	21-Mar-2024 21:07:15	21-Mar-2024 21:09:45	150
51	"RS-1-1"	"Seoul"	3	21-Mar-2024 22:40:15	21-Mar-2024 22:44:15	240
52	"RS-1-1"	"Mumbai"	1	21-Mar-2024 00:41:15	21-Mar-2024 00:44:15	180
53	"RS-1-1"	"Mumbai"	2	21-Mar-2024 12:40:15	21-Mar-2024 12:45:15	300
54	"RS-1-1"	"Beijing"	1	21-Mar-2024 09:36:00	21-Mar-2024 09:41:30	330
55	"RS-1-1"	"Beijing"	2	21-Mar-2024 22:39:15	21-Mar-2024 22:45:00	345
56	"RS-1-1"	"Mexico City"	1	21-Mar-2024 00:03:00	21-Mar-2024 00:08:00	300
57	"RS-1-1"	"Mexico City"	2	21-Mar-2024 13:17:00	21-Mar-2024 13:21:30	270
58	"RS-1-1"	"Mexico City"	3	21-Mar-2024 23:45:00	21-Mar-2024 23:47:00	120
59	"RS-1-1"	"São Paulo"	1	21-Mar-2024 08:44:15	21-Mar-2024 08:49:45	330
60	"RS-1-1"	"São Paulo"	2	21-Mar-2024 21:56:45	21-Mar-2024 22:00:45	240
61	"RS-1-1"	"Bangkok"	1	21-Mar-2024 11:03:45	21-Mar-2024 11:09:15	330
62	"RS-1-1"	"Bangkok"	2	21-Mar-2024 22:48:15	21-Mar-2024 22:51:00	165
63	"RS-1-1"	"Istanbul"	1	21-Mar-2024 03:44:30	21-Mar-2024 03:48:00	210
64	"RS-1-1"	"Istanbul"	2	21-Mar-2024 05:18:00	21-Mar-2024 05:21:45	225
65	"RS-1-1"	"Istanbul"	3	21-Mar-2024 15:54:45	21-Mar-2024 16:00:15	330
66	"RS-1-1"	"Cairo"	1	21-Mar-2024 03:46:30	21-Mar-2024 03:51:30	300
67	"RS-1-1"	"Cairo"	2	21-Mar-2024 15:51:45	21-Mar-2024 15:57:30	345
68	"RS-1-1"	"Dubai"	1	21-Mar-2024 02:13:00	21-Mar-2024 02:18:00	300
69	"RS-1-1"	"Dubai"	2	21-Mar-2024 14:15:45	21-Mar-2024 14:21:30	345
70	"RS-1-1"	"Singapore"	1	21-Mar-2024 11:00:15	21-Mar-2024 11:06:00	345
71	"RS-1-1"	"Singapore"	2	21-Mar-2024 22:50:00	21-Mar-2024 22:55:15	315

	Source	Target	IntervalNumber	StartTime	EndTime	Duration
72	"RS-1-1"	"Hong Kong"	1	21-Mar-2024 09:33:00	21-Mar-2024 09:36:00	180
73	"RS-1-1"	"Hong Kong"	2	21-Mar-2024 22:44:00	21-Mar-2024 22:49:30	330
74	"RS-1-1"	"Sydney"	1	21-Mar-2024 07:42:30	21-Mar-2024 07:47:00	270
75	"RS-1-1"	"Sydney"	2	21-Mar-2024 19:49:30	21-Mar-2024 19:55:00	330
76	"RS-1-2"	"Austin"	1	21-Mar-2024 00:01:30	21-Mar-2024 00:07:00	330
77	"RS-1-2"	"Austin"	2	21-Mar-2024 13:09:45	21-Mar-2024 13:15:15	330
78	"RS-1-2"	"Austin"	3	21-Mar-2024 23:42:30	21-Mar-2024 23:46:45	255
79	"RS-1-2"	"New York"	1	21-Mar-2024 11:32:30	21-Mar-2024 11:38:00	330
80	"RS-1-2"	"New York"	2	21-Mar-2024 22:10:00	21-Mar-2024 22:15:15	315
81	"RS-1-2"	"Los Angeles"	1	21-Mar-2024 01:37:00	21-Mar-2024 01:42:30	330
82	"RS-1-2"	"Los Angeles"	2	21-Mar-2024 14:43:30	21-Mar-2024 14:48:30	300
83	"RS-1-2"	"Chicago"	1	21-Mar-2024 00:04:30	21-Mar-2024 00:09:15	285
84	"RS-1-2"	"Chicago"	2	21-Mar-2024 11:33:30	21-Mar-2024 11:37:15	225
85	"RS-1-2"	"Chicago"	3	21-Mar-2024 13:07:15	21-Mar-2024 13:11:00	225
86	"RS-1-2"	"Chicago"	4	21-Mar-2024 23:44:15	21-Mar-2024 23:49:45	330
87	"RS-1-2"	"Houston"	1	21-Mar-2024 00:01:15	21-Mar-2024 00:06:45	330
88	"RS-1-2"	"Houston"	2	21-Mar-2024 13:10:15	21-Mar-2024 13:15:00	285
89	"RS-1-2"	"Houston"	3	21-Mar-2024 23:42:00	21-Mar-2024 23:47:00	300
90	"RS-1-2"	"Phoenix"	1	21-Mar-2024 01:36:45	21-Mar-2024 01:42:00	315
91	"RS-1-2"	"Phoenix"	2	21-Mar-2024 13:10:15	21-Mar-2024 13:14:15	240
92	"RS-1-2"	"Phoenix"	3	21-Mar-2024 14:45:00	21-Mar-2024 14:46:45	105
93	"RS-1-2"	"Philadelphia"	1	21-Mar-2024 11:32:30	21-Mar-2024 11:38:15	345
94	"RS-1-2"	"Philadelphia"	2	21-Mar-2024 22:10:00	21-Mar-2024 22:15:00	300
95	"RS-1-2"	"San Antonio"	1	21-Mar-2024 00:01:30	21-Mar-2024 00:06:45	315
96	"RS-1-2"	"San Antonio"	2	21-Mar-2024 13:10:00	21-Mar-2024 13:15:30	330
97	"RS-1-2"	"San Antonio"	3	21-Mar-2024 23:42:30	21-Mar-2024 23:46:30	240
98	"RS-1-2"	"San Diego"	1	21-Mar-2024 01:36:30	21-Mar-2024 01:42:15	345
99	"RS-1-2"	"San Diego"	2	21-Mar-2024 14:44:00	21-Mar-2024 14:48:30	270
100	"RS-1-2"	"Dallas"	1	21-Mar-2024 00:02:00	21-Mar-2024 00:07:45	345

$\vdots$

sat_to_gs_access_matrix = 48×5761

```
    0    0    0    0    0    0    0    0    0    0    0    0    1 ⋯
    1    1    1    1    1    2    4    4    5    5    5    5    5
    4    4    5    5    5    5    5    5    5    5    5    5    4
    1    1    1    1    1    1    1    0    0    0    0    0    0
    0    0    0    0    0    0    0    0    0    0    0    0    0
```

```
       0      0      0      0      0      0      0      0      0      0      0      0      0
       0      0      0      0      0      0      0      0      0      0      0      0      0
       0      0      0      0      0      0      0      0      0      0      0      0      0
       0      0      0      0      0      0      0      0      0      0      0      0      0
       0      0      0      0      0      0      0      0      0      0      0      0      0
       .
       .
       .
sat_to_gs_access_info =
  1x30 Access array with properties:

    Sequence
    LineWidth
    LineColor
contact_1_gs = 17494x2
     13      1
     14      1
     15      1
     16      1
     17      1
     18      1
     19      1
     20      1
     48      1
     49      1
      .
      .
      .
contact_2_gs = 10015x2
     21      1
     46      1
     47      1
    425      1
    899      1
    900      1
    907      1
    908      1
    909      1
    910      1
      .
      .
      .
contact_3_gs = 3914x2
     45      1
    404      1
    405      1
    406      1
    407      1
    408      1
    409      1
    410      1
    411      1
    412      1
      .
      .
      .
contact_4_plus_gs = 4004x2
     22      1
     23      1
     24      1
     25      1
     26      1
     27      1
     28      1
     29      1
     30      1
     31      1
```
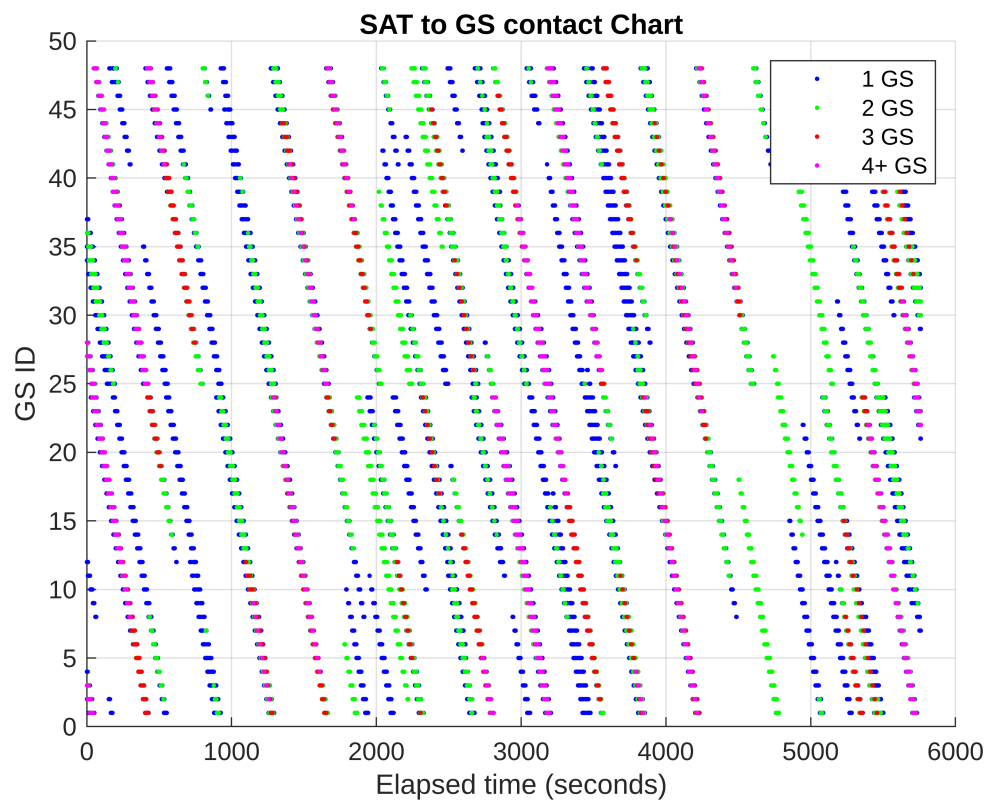
```
figure;
scatter(contact_1_gs(:,1),contact_1_gs(:,2),'.','b')
hold on
scatter(contact_2_gs(:,1),contact_2_gs(:,2),'.','g')
scatter(contact_3_gs(:,1),contact_3_gs(:,2),'.','r')
scatter(contact_4_plus_gs(:,1),contact_4_plus_gs(:,2),'.','m')
hold off
grid on
title('SAT to GS contact Chart')
xlabel('Elapsed time (seconds)')
ylabel('GS ID')
legend('1 GS', '2 GS', '3 GS', '4+ GS')
grid on
```
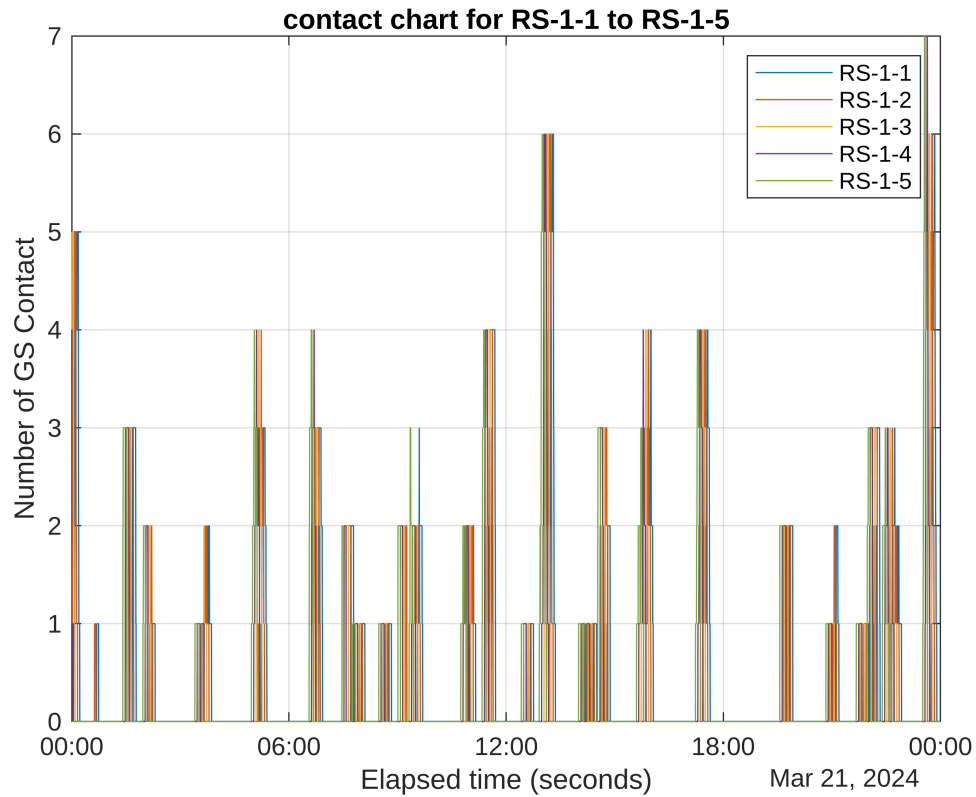


```
figure;
plot(time_vector,sat_to_gs_access_matrix(1,:))
hold on
plot(time_vector,sat_to_gs_access_matrix(2,:))
plot(time_vector,sat_to_gs_access_matrix(3,:))
```

```
plot(time_vector,sat_to_gs_access_matrix(4,:))
plot(time_vector,sat_to_gs_access_matrix(5,:))
hold off
title('contact chart for RS-1-1 to RS-1-5')
xlabel('Elapsed time (seconds)')
ylabel('Number of GS Contact')
legend('RS-1-1', 'RS-1-2', 'RS-1-3', 'RS-1-4', 'RS-1-5')
grid on
```


IV. 3D Data Visualization

```
figure;


% play(scenario)
```

V. Data Analysis