# LEOP support of Galileo Constellation Launch Flight #10 (GSAT219, GSAT220, GSAT221, and GSAT222 vehicles) from USN's Hawaii ground station

Galileo Flight #10 will place the 20th, 21st, 22nd, and 23th spacecraft of the "Full Operational Capability" in their operational orbit of the Galileo navigation constellation for the EU. The launch consists of 4 spacecraft that will be launched from French Guiana on an Ariane 5 ES vehicle on July 25th 2018 at 11:25:01 UTC. USN has been contracted to support the Galileo spacecraft LEOP(s) for a period of up to 17 days and then a subsequent period of 30 days in September 2018 for orbit raising subject to a future analysis.

The spacecraft(s) are a Medium Earth Orbiting (MEO) spacecraft in a high mid-latitude orbit (56 degrees) with a near circular orbit of altitude of 23400 Km. This orbit allows a nominal 1 visibility over the USN Hawaii station every day. Each spacecraft contact is on the order of 1 to 16 hours.
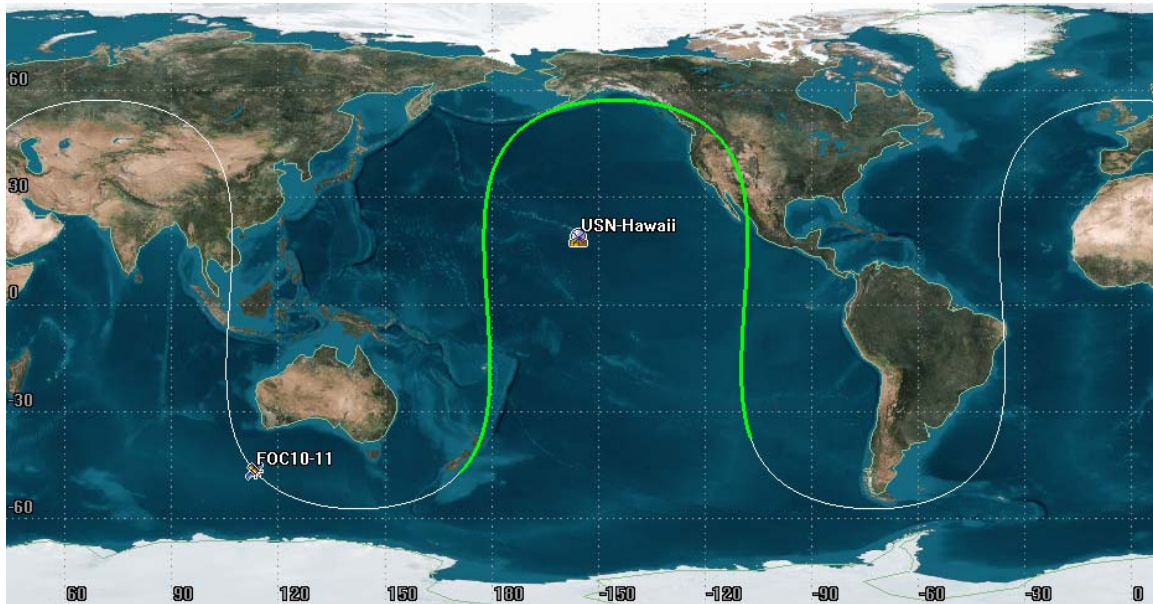
GSAT219, GSAT220, GSAT221, and GSAT222 nominal orbit and Hawaii coverage

The spacecraft's will be supported from injection and three initial orbital maneuvers for spacing. A subsequent orbital plane change campaign will take place in September 2018 to place satellites in their operational orbits. USN will apply for a separate authorization for the orbital plane raising campaign. The below analysis covers all possible visibilities from USN Hawaii, but not all visibilities will be supported.

Spacecraft injection

All four spacecraft are still in same antenna beamwidth after injection for passes one thru four (1 – 4) and then begin to drift apart. For the first four passes the spacecraft's are supported by selecting different RF frequencies. Subsequent to the first four passes the spacecraft(s) are supported separately. Post maneuver TLE's and maximum visibilities are shown below for each event and each spacecraft.

	Downlink	Uplink
GSAT219	2215.818 MHz	2040.399 MHz
GSAT220	2234.232 MHz	2057.355 MHz
GSAT221	2228.094 MHz	2051.703 MHz
GSAT222	2221.956 MHz	2046.051 MHz

GSAT219-injection
1 98986 18999A   18206.62576620 +.00000000 +00000-9 +74807-3 2 00000
2 98986 056.3173 060.1362 0005444 211.9402 358.3812 01.72991131000005

GSAT220-injection
1 98987 18999B   18206.63965278 +.00000000 +00000-9 +74806-3 2 00002
2 98987 056.3207 060.1341 0003984 237.3432 341.6478 01.73033549000007

GSAT221-injection
1 98988 18999C   18206.62576620 +.00000000 +00000-9 +74804-3 2 00009
2 98988 056.3173 060.1362 0002510 025.9599 184.1133 01.73197393000008

GSAT222-injection
1 98989 18999D   18206.63965278 +.00000000 +00000-9 +74806-3 2 00004
2 98989 056.3204 060.1341 0002222 090.9287 128.0277 01.73167501000001

GSAT219 Injection

Access	Start Time (UTCG)	Stop Time (UTCG)
1	25 Jul 2018 18:48:58	26 Jul 2018 05:47:49
2	27 Jul 2018 03:02:01	27 Jul 2018 10:20:57
3	27 Jul 2018 12:47:35	27 Jul 2018 17:42:43
4	28 Jul 2018 09:26:47	28 Jul 2018 09:58:48
5	28 Jul 2018 15:27:26	29 Jul 2018 00:56:03

GSAT219 Maneuvers and possible support times pass # 6 - 16

GSAT219-V1
1 98986 18999A   18210.36509259 +.00000000 +00000-9 +75150-3 2 00002
2 98986 056.3272 060.0329 0048868 017.7578 001.3713 01.71591645000000

Access	Start Time (UTCG)	Stop Time (UTCG)
6	29 Jul 2018 21:04:07	30 Jul 2018 07:36:31

GSAT219-V2
1 98986 18999A   18211.82524306 +.00000000 +00000-9 +75449-3 2 00005
2 98986 056.3284 059.9922 0003184 320.6722 240.4517 01.70382040000002

Access	Start Time (UTCG)	Stop Time (UTCG)
7	31 Jul 2018 05:31:28	31 Jul 2018 11:03:09
8	31 Jul 2018 13:11:09	31 Jul 2018 20:31:34

GSAT219-V3
1 98986 18999A   18212.96480324 +.00000000 +00000-9 +75466-3 2 00001
2 98986 056.3292 059.9608 0001945 266.0683 274.0436 01.70316318000002

Access	Start Time (UTCG)	Stop Time (UTCG)
9	1 Aug 2018 18:15:19	2 Aug 2018 05:29:41
10	3 Aug 2018 03:17:12	3 Aug 2018 10:23:44
11	3 Aug 2018 12:16:22	3 Aug 2018 18:15:15
12	4 Aug 2018 16:14:32	5 Aug 2018 03:13:31
13	6 Aug 2018 00:32:50	6 Aug 2018 08:51:31
14	6 Aug 2018 12:19:58	6 Aug 2018 16:00:35
15	7 Aug 2018 07:34:14	7 Aug 2018 09:59:38
16	7 Aug 2018 14:23:41	7 Aug 2018 23:09:19

GSAT220 Injection

```
     Access          Start Time (UTCG)          Stop Time (UTCG)
     ------          ------------------------   ------------
       1              25 Jul 2018 18:48:54       26 Jul 2018 05:47:32
       2              27 Jul 2018 03:00:57       27 Jul 2018 10:20:19
       3              27 Jul 2018 12:47:45       27 Jul 2018 17:41:27
       4              28 Jul 2018 09:20:54       28 Jul 2018 10:03:28
       5              28 Jul 2018 15:26:12       29 Jul 2018 00:52:05
       6              29 Jul 2018 20:47:03       29 Jul 2018 22:39:58*
```

* Note that spacecraft stays in view of Hawaii during TLE update V1 below, therefore visibility continues into pass #7.

GSAT220 Maneuvers and possible support times pass # 7 - 16

GSAT220-V1
1 98987 18999B   18210.94442130 +.00000000 +00000-9 +75003-3 2 00008
2 98987 056.3272 060.0133 0028141 015.9817 004.6308 01.72227326000001

```
        Access          Start Time (UTCG)          Stop Time (UTCG)
        ------          ------------------------   ------------------------
          7              29 Jul 2018 22:39:58       30 Jul 2018 07:22:55
          8              31 Jul 2018 05:02:26       31 Jul 2018 09:32:10*
```

* Note that spacecraft stays in view of Hawaii during TLE update V2 below, therefore visibility continues into pass #9.

GSAT220-V2
1 98987 18999B   18212.39733796 +.00000000 +00000-9 +75202-3 2 00001
2 98987 056.3283 059.9725 0004149 240.8368 320.6255 01.71421012000008

```
        Access          Start Time (UTCG)          Stop Time (UTCG)
        ------          ------------------------   ------------------------
          9              31 Jul 2018 09:32:10       31 Jul 2018 11:02:00
         10              31 Jul 2018 12:52:14       31 Jul 2018 19:49:54
```

GSAT220-V3
1 98987 18999B   18213.52946759 +.00000000 +00000-9 +75212-3 2 00003
2 98987 056.3291 059.9409 0005096 224.1404 315.9874 01.71380135000008

```
        Access          Start Time (UTCG)          Stop Time (UTCG)
        ------          ------------------------   ------------------------
         11              1 Aug 2018 17:27:38        2 Aug 2018 04:33:55
         12              3 Aug 2018 01:58:24        3 Aug 2018 09:37:23
         13              3 Aug 2018 12:21:49        3 Aug 2018 16:57:34
         14              4 Aug 2018 08:44:43        4 Aug 2018 09:39:57
         15              4 Aug 2018 15:00:00        5 Aug 2018 00:48:29
         16              5 Aug 2018 20:59:20        6 Aug 2018 07:22:11
```

GSAT221 Injection

```
    Access          Start Time (UTCG)            Stop Time (UTCG)
    ------      ------------------------      ------------
      1          25 Jul 2018 18:49:44         26 Jul 2018 05:47:16
      2          27 Jul 2018 02:58:29         27 Jul 2018 10:18:35
      3          27 Jul 2018 12:48:09         27 Jul 2018 17:37:51
      4          28 Jul 2018 09:07:45         28 Jul 2018 10:13:06
      5          28 Jul 2018 15:22:13         29 Jul 2018 00:38:28
      6          29 Jul 2018 20:37:21         30 Jul 2018 07:11:50
      7          31 Jul 2018 04:40:50         31 Jul 2018 10:57:14
      8          31 Jul 2018 12:41:04         31 Jul 2018 19:14:03
      9           1 Aug 2018 16:39:59          2 Aug 2018 03:23:19
```

GSAT221 Maneuvers and possible support times pass # 10 - 17

GSAT221-V1
1 98988 18999C   18214.98039352 +.00000000 +00000-9 +74876-3 2 00002
2 98988 056.3279 059.9004 0013830 021.5147 357.9227 01.72906619000004

```
    Access          Start Time (UTCG)            Stop Time (UTCG)
    ------      ------------------------      ------------------------
      10          2 Aug 2018 23:44:17          3 Aug 2018 08:29:19
      11          3 Aug 2018 12:54:20          3 Aug 2018 15:06:42
      12          4 Aug 2018 06:21:31          4 Aug 2018 10:38:35
```

GSAT221-V2
1 98988 18999C   18216.45949074 +.00000000 +00000-9 +74941-3 2 00000
2 98988 056.3289 059.8582 0005104 344.1485 235.9910 01.72640156000004

```
    Access          Start Time (UTCG)            Stop Time (UTCG)
    ------      ------------------------      ------------------------
      13          4 Aug 2018 13:33:22          4 Aug 2018 21:10:53
```

GSAT221-V3
1 98988 18999C   18217.50067130 +.00000000 +00000-9 +74945-3 2 00005
2 98988 056.3298 059.8284 0004604 344.2200 163.0335 01.72627025000005

```
    Access          Start Time (UTCG)            Stop Time (UTCG)
    ------      ------------------------      ------------------------
      14          5 Aug 2018 18:20:47          6 Aug 2018 05:20:47
      15          7 Aug 2018 02:42:05          7 Aug 2018 09:51:51
      16          7 Aug 2018 12:00:59          7 Aug 2018 17:23:03
      17          8 Aug 2018 15:06:55          9 Aug 2018 01:12:04
```

GSAT222 Injection

Access	Start Time (UTCG)	Stop Time (UTCG)
1	25 Jul 2018 18:48:59	26 Jul 2018 05:46:39
2	27 Jul 2018 02:58:21	27 Jul 2018 10:18:26
3	27 Jul 2018 12:48:08	27 Jul 2018 17:37:57
4	28 Jul 2018 09:08:26	28 Jul 2018 10:12:40
5	28 Jul 2018 15:22:26	29 Jul 2018 00:39:28
6	29 Jul 2018 20:38:21	30 Jul 2018 07:12:33
7	31 Jul 2018 04:42:12	31 Jul 2018 10:57:30
8	31 Jul 2018 12:41:32	31 Jul 2018 19:15:39
9	1 Aug 2018 16:41:31	2 Aug 2018 03:25:34

GSAT222 Maneuvers and possible support times pass # 10 - 17

GSAT222-V1
```
1 98989 18999D   18214.40531250 +.00000000 +00000-9 +74933-3 2 00008
2 98989 056.3383 059.9186 0020505 026.5631 353.6904 01.72661534000001
```

Access	Start Time (UTCG)	Stop Time (UTCG)
10	2 Aug 2018 23:56:34	3 Aug 2018 08:35:00
11	3 Aug 2018 12:49:44	3 Aug 2018 15:17:18

GSAT222-V2
```
1 98989 18999D   18215.88519676 +.00000000 +00000-9 +75058-3 2 00008
2 98989 056.3393 059.8766 0004618 311.9942 268.1443 01.72147882000001
```

Access	Start Time (UTCG)	Stop Time (UTCG)
12	4 Aug 2018 06:34:41	4 Aug 2018 10:35:30
13	4 Aug 2018 13:43:56	4 Aug 2018 21:33:13

GSAT222-V3
```
1 98989 18999D   18216.92939815 +.00000000 +00000-9 +75065-3 2 00003
2 98989 056.3401 059.8469 0003734 306.1072 201.1709 01.72122446000000
```

Access	Start Time (UTCG)	Stop Time (UTCG)
14	5 Aug 2018 18:43:19	6 Aug 2018 05:43:48
15	7 Aug 2018 03:14:51	7 Aug 2018 10:09:57
16	7 Aug 2018 12:01:23	7 Aug 2018 17:57:36
17	8 Aug 2018 15:40:18	9 Aug 2018 02:17:07

Flux Density impinging on the ground in Hawaii from Galileo GSAT219, GSAT220, GSAT221, and GSAT222

The Flux density is calculated as:

$$Flux\ density = EIRP \div (4\,\pi\,Rse^2)$$

> Where Rse is the distance from spacecraft to the ground?
> Where $EIRP$ is the Effective Isotropic Radiated Power of the spacecraft?

Data from the spacecraft vendor indicates that the nominal EIRP of each GSAT spacecraft is -1.10 dBW. Being a near circular orbit, the altitude (and thus the closest distance to earth during an overhead pass) is = 23,400 Km.

Converting -1.10 dBW to scalar watts = 0.776 watts transmitted at 2221.9 MHz

Therefor:

$$Flux\ density = 0.776 \div (4\,\pi * 23,400,000\ meters^2)$$

Flux density = 1.127 x 10^{-16} Watts/meter^2
Or
Flux density = 1.127 x 10^{-17} mW/cm^2

Exhibit C
PETITION FOR WAIVER OF SECTION 25.137 AND 25.114 AND OF
THE U.S. TABLE OF FREQUENCY ALLOCATIONS

I.   **TO THE EXTENT THEY APPLY, GOOD CAUSE EXISTS FOR A WAIVER OF**
        CERTAIN PORTIONS OF SECTIONS 25.137 AND 25.114

Universal Space Network, Inc. (USN) is provided limited legal and technical information for the GALILEO (GSAT219, GSAT220, GSAT221, and GSAT222), twentieth thru twenty-third spacecraft of the "Full Operational Capability" series) Satellites.[1] Pursuant to Section 25.137 of the Federal Communications Commission's ("Commission" or "FCC") rules, the same technical information required by Section 25.114 for U.S.-licensed space station, and certain legal information, must be submitted by earth station applicants "requesting authority to operate with a non-U.S. licensed space station to serve the United States…"[2] USN seeks authority to support the needed Telemetry, Tracking, and Control ("TT&C") during launch and early orbit support ("LEOP") of the GALILEO (GSAT219, GSAT220, GSAT221, and GSAT222) spacecraft from launch to medium earth orbit , not commercial service to the United States, and thus believes that Section 25.137 does not apply.

To the extent the Commission determines, however, that USN's request for authority to provide LEOP on a special temporary basis is a request to serve the United States with a non-U.S-licensed satellite, USN respectfully requests a waiver of Sections 25.137 and 25.114 of the Commission's rules, to the extent that USN has not herein provided the information required by these rules. [3] The Commission may grant a waiver for good cause shown.[4] A waiver is therefore appropriate if special circumstances warrant a deviation from the general rule, and such a deviation will serve the public interest.

In this case, good cause for a waiver of portions of Section 25.114 exists. USN seeks authority only to conduct LEOP support for GALILEO (GSAT219, GSAT220, GSAT221, and GSAT222). Thus, any information sought by Section 25.114 that is not relevant to the LEOP – e.g., antenna patterns, energy and propulsion and orbital debris - USN does not have. In addition, USN would not easily be able to obtain such information because USN is not the operator of the GALILEO (GSAT219, GSAT220, GSAT221, and GSAT222) satellites, nor is USN in contractual privity with that operator. Rather, USN has contracted with Swedish Space Corporation, Solona Sweden (SSC) to support the Launch and Early Orbit (LEOP) portion in S-Band of the satellite prior to its operation.

As evidenced by the Comsearch report attached to this request, USN has coordinated the LEOP of the GALILEO (GSAT219, GSAT220, GSAT221, and GSAT222) satellites with potentially affected terrestrial operators. Moreover, as with any STA, USN will conduct the LEOP on an unprotected, non-interference basis to government operations.

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[1] FCC Form 312 Section B

[2] 47 C.F.R. § 25.137(a)

[3] 47 C.F.R. §§25.137 and 25.114

[4] 47 C.F.R. §1.3

Because it is not relevant to the service for which USN seeks authorization, and because obtaining the information would be a hardship, USN seeks a waiver of all the technical and legal information required by Section 25.114, to the extent it is not provided herein. As noted above, USN has provided the required information to the extent that it is relevant to the LEOP service for which USN seeks authorization.

Good cause also exists to waive portions of Section 25.137, to the extent the information required is not herein provided. Section 25.137 is designed to ensure that "U.S.-licensed satellite systems have effective competitive opportunities to provide analogous services" in other countries. Here, there is no service being provided by the satellite; USN is providing TT&C while the satellite is on the way to it's medium earth orbit. Thus, the purpose of the information required by Section 25.137 is not implicated here. For example, Section 25.137(d) requires earth station applicants requesting authority to operate with a non-U.S.-licensed space station that is not in orbit and operating to post a bond. [5] The underlying purpose in having to post a bond – i.e., to prevent warehousing of orbital locations by operators seeking to serve the United States – would not be served by requiring USN to post a bond in order to conduct 17 days of LEOP support of the GALILEO (GSAT219, GSAT220, GSAT221, and GSAT222) satellites.

It is USN's understanding that GALILEO (GSAT219, GSAT220, GSAT221, and GSAT222) is licensed by ESA (European Space Agency). GALILEO (GSAT219, GSAT220, GSAT221, and GSAT222) are the twentieth thru twenty-third spacecraft of the European navigation constellation. The spacecraft family is primarily meant to serve the EU. Thus, the purpose of Section 25.137 – to ensure that U.S. satellite operators enjoy "effective competitive opportunities" to serve foreign markets and to prevent warehousing of orbital locations service the United States – will not be undermined by grant of this waiver request.

Finally, USN notes that it expects to communicate with the GALILEO (GSAT219, GSAT220, GSAT221, and GSAT222) satellite using its U.S. earth station for a period of 17 days. Requiring USN to obtain technical and legal information from an unrelated party, where there is no risk of interference and the operation will cease within 17 days would pose undue hardship without serving underlying policy objectives. Given these particular facts, the waiver sought herein is appropriate.

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[5] 47 C.F.R. §25.137(d)(4)

II.   GOOD CAUSE EXISTS FOR A WAIVER OF THE UNITED STATES TABLE OF FREQUENCY ALLOCATIONS

USN further requests a waiver of the United States Table of Frequency Allocations ("U.S. Table") as described in section 2.106 of the rules for the frequency bands 2025 – 2110 MHz (Earth-to-Space) and 2200 – 2290 MHz (Space-to-Earth).[6] Section footnotes allow for non-federal Government use of these bands in the United States on a case-by-case non-interference basis. Such use by USN necessitates a waiver of the U.S. Table.

Good cause exists to grant USN a limited waiver of the U.S. Table to allow LEOP of the GALILEO (GSAT219, GSAT220, GSAT221, and GSAT222) satellites. In considering request for case-by-case spectrum uses, the Commission has indicated that is would generally grant such waivers "where there is little potential for interference into any service authorized under the Table of Frequency Allocations and when the case-by-case operator accepts any interference from authorized services." [7] USN will coordinate with other parties operating communication systems in compliance with the Table of Frequency Allocations to ensure that no harmful interference is caused. USN seeks to operate only pursuant to special temporary authorization and thus agrees to accept any interference from authorized services. In summary, USN's operation on a non-interference, non-protected basis support waiver of the U.S. Table.

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[6] 47 C.F.R. §2.106

[7] Previously approved STA's for Universal Space Network SES-STA-20020725-01174; SES-STA-20021112-02008; SES-STA-20040315-00475