

FCC FACT SHEET*

Receive-Only Earth Stations Operating with the Galileo Radionavigation-Satellite Service
Order – IB Docket No. 17-16

Background: In 2015, the National Telecommunications and Information Administration (NTIA) submitted to the FCC a request from the European Commission to waive certain of the Commission’s earth station licensing rules in order to permit non-Federal U.S. receive-only earth stations to operate with the Galileo Global Navigation Satellite System (GNSS). The Galileo GNSS was developed by the European Union and consists of a number of satellites operating in the radionavigation-satellite service (RNSS), similar to the U.S. Global Positioning System (GPS). The NTIA recommended grant of the requested waivers, and the International Bureau issued a Public Notice seeking comment on the potential public interest benefits and technical issues associated with the waiver request.

What the Order Would Do:

- Grant in part the request of the European Commission for waivers of certain of the Commission’s earth station licensing rules to permit non-Federal U.S. receive-only earth stations to operate with specific signals of the Galileo GNSS without obtaining a license or grant of market access.
- Find that the Galileo GNSS is uniquely situated as a foreign GNSS system with respect to the U.S. GPS, since the two systems are interoperable and radiofrequency compatible pursuant to the 2004 European Union/United States Galileo-GPS Agreement.
- Find that there are significant public interest benefits associated with operations of non-Federal U.S. receive-only earth stations with the Galileo GNSS, including increased availability, reliability, and resiliency of position, navigation, and timing services in the United States.
- Grant the request for operations with the Galileo E1 signal, which is transmitted over the 1559-1591 MHz frequency band.
- Grant the request, and a waiver of the non-Federal portion of the U.S. Table of Frequency Allocations, for operations with the Galileo E5 signal, which is transmitted over the 1164-1219 MHz frequency band.
- Deny the request for operations with the Galileo E6 signal, which is transmitted over the 1260-1300 MHz frequency band, since there is no Federal or non-Federal allocation for RNSS in the U.S. Table of Frequency Allocations in that band and grant of waiver could constrain our future spectrum management for non-Federal operations in the U.S. in spectrum above 1300 MHz, where potential changes in the non-Federal allocation are under consideration.

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Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of)
)
Waiver of Part 25 Licensing Requirements for) IB Docket No. 17-16
Receive-Only Earth Stations Operating with the)
Galileo Radionavigation-Satellite Service)
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ORDER*

Adopted: []

Released: []

By the Commission:

I. INTRODUCTION

1. Today, consumers and industry in the United States rely on the U.S. Global Positioning System (GPS) to support satellite-based positioning, navigation, and timing (PNT) services that are integral to numerous everyday applications ranging from driving directions to precision farming. The European Union (EU) has developed and initiated operations of its own Global Navigation Satellite System (GNSS), known as Galileo. The United States and the European Commission (EC) have worked together to ensure that the signals of the Galileo system are "interoperable" and "radio frequency compatible" with GPS, including through the 2004 Agreement on the Promotion, Provision and Use of Galileo and GPS Satellite-Based Navigation Systems and Related Applications, and have cooperated extensively to address any mutual concerns.1 The action we take today will permit non-Federal devices to

* This document has been circulated for tentative consideration by the Commission at its November 2018 open meeting. The issues referenced in this document and the Commission's ultimate resolutions of those issues remain under consideration and subject to change. This document does not constitute any official action by the Commission. However, the Chairman has determined that, in the interest of promoting the public's ability to understand the nature and scope of issues under consideration, the public interest would be served by making this document publicly available. The Commission's ex parte rules apply and presentations are subject to "permit-but-disclose" ex parte rules. See, e.g., 47 CFR §§ 1.1206, 1.1200(a). Participants in this proceeding should familiarize themselves with the Commission's ex parte rules, including the general prohibition on presentations (written and oral) on matters listed in the Sunshine Agenda, which is typically released a week prior to the Commission's meeting. See 47 CFR §§ 1.200(a), 1.1203.

1 See Agreement on the Promotion, Provision and Use of Galileo and GPS Satellite-Based Navigation Systems and Related Applications (June 26, 2004) (2004 EU/US Galileo-GPS Agreement), available at http://www.gps.gov/policy/cooperation/europe/2004/gps-galileo-agreement.pdf. This agreement provides a framework for cooperation between the EC (the executive arm of the European Union) and the United States in the promotion, provision, and use of civil GPS and Galileo navigation and timing signals and services, value-added services, augmentations, and global navigation and timing goods. Id., Article 1 (Objectives). Article 4 memorializes the agreement between the parties that GPS and Galileo "shall be radio frequency compatible" and "to the greatest extent possible, interoperable at the non-military user level." Id., Article 4. It also includes several other provisions, including provisions on national security compatibility. Id., Article 11. Article 20 provides that following the initial 10-year agreement term, the agreement is automatically renewable for 5-year periods absent notification. Id., Article 20. We note that no similar agreements are currently in place between the U.S. and Administrations responsible for other GNSS networks. See id., Article 1.

receive certain signals from the Galileo GNSS.² Specifically, we grant in part and deny in part the request of the EC for waivers of certain licensing requirements in our rules³ and also grant waiver of the United States Table of Frequency Allocations (U.S. Table).⁴ We include as part of this grant conditions to ensure that users of PNT services in the United States, which now may be supported by the Galileo GNSS, benefit from increased availability, reliability, and resiliency of those services.

2. As described in detail below, we grant the requested waivers for non-Federal receiver operations with two of the Galileo signals, E1 and E5, which transmit in the same Radionavigation-Satellite Service (RNSS) bands where GPS transmits its L1, L5, and L2 signals, and deny the requested waiver for the Galileo E6 signal. Subject to the Commission's rules not otherwise waived and the conditions specified herein, upon the effective date of this Order, receive-only earth stations operating in the U.S. will be permitted to operate with specified E1 and E5 signal transmissions from the Galileo GNSS without applying for the license or modification which would otherwise be required under our earth station licensing rules.⁵

II. BACKGROUND

3. In a letter to the Chief of the Commission's Office of Engineering and Technology dated March 2, 2011, the National Telecommunications and Information Administration (NTIA) outlined the criteria it would apply in considering whether to recommend waiver of the FCC's rules with respect to licensing of non-Federal receive-only earth stations operating with non-U.S.-licensed RNSS satellites.⁶ In that letter, NTIA also stated its intent to submit any such recommendation to the Commission and expressed its expectation that the FCC, prior to deciding whether to grant the waiver, would conduct its own review of the compatibility of the requested operations with non-Federal U.S.-licensed systems.⁷ Subsequently, the International Bureau issued a public notice, attaching NTIA's letter and stating that such waiver requests receiving NTIA's recommendation of an FCC grant would be placed on public

² See *FCC Seeks Comment on Waiver of Part 25 Licensing Requirement for Receive-Only Earth Stations Operating with the Galileo Radionavigation-Satellite Service*, Public Notice, IB Docket No. 17-16, 32 FCC Rcd 8225, 8225 (Jan. 6, 2017) (*Galileo Public Notice*). This Order is specific to the Galileo system and the signals whose technical characteristics are described in the EC's request, and does not address operations with any other GNSS systems or signals.

³ 47 CFR §§ 25.131(j), 25.137. Section 25.131(j)(1) requires that receive-only earth stations operating with non-U.S. licensed space stations must file an FCC Form 312 requesting a license or modification to operate such station; Section 25.137 sets forth the procedures and requirements for such filings. *Id.*

⁴ Section 2.106 of our rules sets forth the Federal and non-Federal frequency allocations in the United States Table of Frequency Allocations (U.S. Table). 47 CFR § 2.106.

⁵ 47 CFR § 25.131(j)(1).

⁶ See *National Telecommunications and Information Administration Provides Information Concerning Executive Branch Recommendations for Waiver of Part 25 Rules Concerning Licensing of Receive-Only Earth Stations Operating with Non-U.S. Radionavigation Satellites*, Public Notice, Attach. Letter from Karl Nebbia, Associate Administrator, Office of Spectrum Management, U.S. Department of Commerce, National Telecommunications and Information Administration, to Julius Knapp, Chief, Office of Engineering and Technology, FCC, at 1-2 (Mar. 2, 2011) (NTIA Mar. 2011 Letter), 26 FCC Rcd 3867, 3868-69 (IB Mar. 15, 2011) (*RNSS Public Notice*). NTIA's stated criteria for recommending an FCC grant of such waiver requests are as follows: (1) granting the waiver is in the public interest; (2) the system complies with the United Nation's Space Debris Mitigation guidelines; (3) the grant of a waiver is consistent with U.S. International trade and other treaty obligations; (4) the waiver request is limited to the receive-only RNSS (which includes positioning) and standard time and frequency satellite services; and (5) operation of the RNSS signals offered by the foreign RNSS system has been found compatible with U.S. government systems operating in the specified RNSS frequency bands. *Id.*

⁷ *Id.*, 26 FCC Rcd at 3869 and 3869 n.5.

notice to provide an opportunity for comment prior to FCC action on the request.⁸

4. On October 23, 2013, the EC submitted a letter to the U.S. Department of State (State Department) asking that the State Department request that the Commission waive its rules to permit operation of non-Federal receive-only earth stations operating with the Galileo system's E1, E5, and E6 signals (EC's waiver request).⁹ On August 12, 2014, the EC sent an additional letter to the State Department, including additional supplemental documentation.¹⁰ NTIA, in consultation with other relevant Executive Branch agencies, reviewed the technical, operational, policy, and various other considerations in the EC's waiver request under the criteria set forth in NTIA's March 2011 Letter, and concluded that the request satisfied these criteria for recommending a Commission waiver.¹¹ Accordingly, on January 30, 2015, NTIA submitted the EC's waiver request to the Commission's International Bureau and Office of Engineering and Technology, along with a letter recommending grant of a waiver.¹² NTIA noted that the *National Space Policy of the United States of America* specifically directs the United States to "engage with foreign GNSS providers to encourage compatibility and interoperability, promote transparency in civil service provision, and enable market access for U.S. industry."¹³ In addition, it noted that this policy provides that foreign PNT services may be used to augment and strengthen the resiliency of GPS.¹⁴ NTIA stated that authorizing the use of Galileo PNT services in the United States, which will supplement GPS signals, will advance these goals and bring significant benefits to the American public.¹⁵ NTIA specified that end users will benefit from increased PNT service availability, reliability, and resiliency.¹⁶ NTIA also emphasized that, pursuant to the 2004

⁸ *Id.* at 3867.

⁹ See *Galileo Public Notice*, Attach. Letter from Paul Weissenberg, Deputy Director-General, EC Enterprise and Industry Directorate-General, to Jonathan Margolis, Deputy Assistant Secretary, Bureau of Oceans and International Environmental and Scientific Affairs, U.S. Department of State (Oct. 23, 2013) (EC October 2013 Letter), 32 FCC Rcd. at 8243 (requesting a "block exemption" without limitation, of the FCC licensing requirement).

¹⁰ See *id.*, 32 FCC Rcd. at 8244-63, Attach. Letter from Matthias Petschke, EU Satellite Navigation Programmes Director, EC Enterprise and Industry Directorate-General, to Jonathan Margolis, Deputy Assistant Secretary (Aug. 12, 2014) (EC August 2014 Letter). The following supporting materials were described as attached to the August 12, 2014 letter from the EC and were submitted by the NTIA to the Commission: a revised technical exhibit providing information as specified in FCC Form 312, Schedule S (EC Schedule S) and a revised Technical Note on Galileo Programme Compliance with United Nations Space Debris Mitigation Guidelines. *Id.* It appears that some previous version of the supporting materials had been sent to the State Department initially, see EC August 2014 Letter, but only the "revised" versions of the supporting materials were included with NTIA's request.

¹¹ See *Galileo Public Notice*, Attach. Letter from Paige Atkins, Associate Administrator, Office of Spectrum Management, NTIA, to Mindel De La Torre, Chief, International Bureau, FCC and Julius Knapp, Chief, Office of Engineering and Technology, FCC (January 30, 2015) (NTIA Waiver Request Letter), 32 FCC Rcd at 8238-42. NTIA's letter attached the EC October 2013 Letter and the supporting materials from the EC regarding the waiver request. All of these documents were included as attachments to the *Galileo Public Notice*. *Id.* at 8243-63.

¹² See *id.*, Attach. NTIA Waiver Request Letter, 32 FC Rcd. at 8238.

¹³ *Galileo Public Notice*, Attach., NTIA Waiver Request Letter at 2, 32 FCC Rcd at 8239 (citing the *National Space Policy of the United States of America* (National Space Policy) (June 28, 2010) at 5, available at https://www.nasa.gov/sites/default/files/national_space_policy_6-28-10.pdf (U.S. Space Policy)). We note that more recent space policy directives have updated the United States space policy in a number of areas but have not yet addressed GNSS. See, e.g., Presidential Space Policy Directives-1, -2, and -3, available at <http://www.space.commerce.gov/policy/national-space-council-directives/>.

¹⁴ *Galileo Public Notice*, Attach. NTIA Waiver Request Letter at 2, 32 FCC Rcd at 8239.

¹⁵ *Id.*

¹⁶ *Id.*

EU/US Galileo-GPS Agreement between the EU (and its member states) and the United States,¹⁷ the Galileo system will be interoperable with GPS, as well as radio frequency (RF) compatible with U.S. government systems and equipment already in use and operating in the RNSS bands.¹⁸ The EU/US Galileo-GPS Agreement provides a framework for cooperation in the promotion, provision, and use of civil GPS and Galileo navigation and timing signals and services, value-added services, augmentations, and global navigation and timing goods.¹⁹ The Agreement also includes several other provisions, including provisions on national security compatibility.²⁰ Consistent with the previously-established procedures, NTIA requested that the Commission issue a public notice seeking comment on the EC's waiver request.²¹

5. On January 6, 2017, the International Bureau issued a public notice inviting interested parties to comment on the EC's waiver request.²² This *Galileo Public Notice* asked for comment on whether granting the requested waiver is in the public interest with respect to non-Federal operations.²³ Recognizing the potential for significant benefits to the American public that could result from operations using Galileo signals, the *Galileo Public Notice* invited comment on those benefits, including the potential for improving the availability, reliability, and resiliency of space-based PNT services in the United States.²⁴ In addition, the *Galileo Public Notice* identified issues that could affect the Commission's spectrum management with regard to non-Federal operations in the bands allocated for RNSS or in other bands, including adjacent or nearby bands.²⁵ In this regard, the *Galileo Public Notice* sought comment on the technical, operational, and policy issues to help inform the evaluation of public interest benefits and other considerations associated with the waiver request, including: issues pertaining to international and U.S. spectrum allocations, including non-Federal allocations in the affected bands; the potential impacts of the Galileo satellite signals on non-Federal receivers, including in those bands adjacent to or near the RNSS bands; and the electromagnetic compatibility of non-Federal Galileo receivers and non-Federal transmissions in bands allocated to RNSS and in the bands adjacent or nearby to the RNSS bands.²⁶

¹⁷ See 2004 EU/US Galileo-GPS Agreement.

¹⁸ *Galileo Public Notice*, Attach. NTIA Waiver Request Letter at 2, 4, 32 FCC Rcd at 8239, 8241 (citing 2004 EU/US Galileo-GPS Agreement and the technical specifications set forth in the European GNSS (Galileo) Open Service Signal-in-Space Interface Control Document, Issue 1, Revision 1 (Sept. 2010), available at <http://www.gsc-europa.eu/gnss-markets/segments-applications/os-sis-icd>). "Radio frequency compatibility" means the assurance that one system will not cause interference that unacceptably degrades the stand-alone service that the other system provides. "Interoperability at the user level" is defined as a situation whereby a combined system receiver with a mix of GPS or Galileo satellites in view can use the signals from both systems to achieve position, navigation, and timing solutions at the user level that are equivalent or better than those which can be achieved by either system alone. See 2004 EU/US Galileo-GPS Agreement, Article 2 (Definitions).

¹⁹ 2004 EU/US Galileo-GPS Agreement, Article 1 (Objectives), at 6.

²⁰ See generally 2004 EU/US Galileo-GPS Agreement.

²¹ *Galileo Public Notice*, Attach. NTIA Waiver Request Letter at 1, 32 FCC Rcd at 8238.

²² *Galileo Public Notice*, 32 FCC Rcd at 8225. The *Galileo Public Notice* announced that comments could be filed using the Commission's Electronic Comment Filing System (ECFS). *Id.* at 8236. Thus, the waiver request was assigned an ECFS docket number in lieu of an International Bureau Filing System (IBFS) file number. See *id.* at 8236; *RNSS Public Notice*, 26 FCC Rcd at 3867.

²³ 32 FCC Rcd at 8227.

²⁴ *Id.*

²⁵ *Id.*

²⁶ *Id.*

6. As discussed below, a number of parties filed comments in response to the *Galileo Public Notice*, including the EC, which filed comments clarifying particular aspects of its request.²⁷

III. DISCUSSION

A. Waiver Requests and Public Interest Benefits

7. In determining whether to grant the EC's requested waivers of the Commission's rules,²⁸ we conduct an independent assessment that takes into consideration NTIA's recommendation as part of the record. We emphasize that the waiver requests before us are specific to the Galileo GNSS, originating with the recommendation from NTIA. We proceed in our appraisal of the waiver requests with the understanding that the instant requests are informed by a bilateral effort between representatives of the U.S. and EU, including years of exchanges of information and discussions leading up to NTIA's recommendation with respect to the Galileo system.²⁹

8. *Waiver Standard.* Generally, the Commission may waive any rule for good cause shown.³⁰ A waiver is appropriate where the particular facts make strict compliance inconsistent with the public interest.³¹ In making this determination, we may take into account considerations of hardship, equity, or more effective implementation of overall policy on an individual basis.³² A waiver is therefore appropriate if special circumstances warrant a deviation from the general rule, such deviation will serve the public interest, and the waiver does not undermine the validity of the general rule.³³

9. *Application of Waiver Standard to Part 25 Rules.* Our rules require that receive-only earth stations operating with non-U.S. licensed space stations obtain a license.³⁴ An "earth station" is defined, in part, as "[a] station located [] on the Earth's surface . . ." intended for communication "[w]ith one or more space stations."³⁵ This broad definition covers all earth stations/receivers that would operate with the Galileo GNSS.³⁶ The EC has asked us to allow operators of receive-only earth stations to

²⁷ See, e.g., Comments of the European Commission, IB Docket No. 17-18 (filed Feb. 21, 2017) (EC Comments).

²⁸ 47 CFR §§ 25.131(j), 25.137.

²⁹ See, e.g., *Galileo Public Notice*, Attach. NTIA Waiver Request Letter at 4, 32 FCC Rcd at 8241.

³⁰ 47 CFR § 1.3.

³¹ *Northeast Cellular Tel. Co. v. FCC*, 897 F.2d 1164, 1166 (D.C. Cir. 1990).

³² *WAIT Radio v. FCC*, 418 F.2d 1153, 1159 (D.C. Cir. 1969), cert. denied, 409 U.S. 1027 (1972); *Northeast Cellular*, 897 F.2d at 1166.

³³ *NetworkIP, LLC v. FCC*, 548 F.3d 116, 125-28 (D.C. Cir. 2008); *Northeast Cellular*, 897 F.2d at 1166; *WAIT Radio*, 418 F.2d at 1158.

³⁴ See 47 CFR § 25.131(j). Section 25.131(j)(2) provides an exception, not applicable in this case, for receive-only earth stations operating with space stations that have been granted "market access" under the procedures specified in Section 25.137 of the rules. See 47 CFR § 25.137.

³⁵ 47 CFR § 25.103.

³⁶ While Trimble and Deere request that the Commission proceed with granting the EC's current waiver request using the current review process, they contend that the instant GNSS-specific process is unnecessarily complex and does not contemplate GPS or GNSS technologies that are intended for a global marketplace and not just the United States. Trimble and Deere Comments at 16-18. In reply comments, T-Mobile USA, Inc. (T-Mobile) supports grant of the waiver request, but also argues that the current review process is unnecessarily complex and should be reformed. See Reply Comments of T-Mobile USA, Inc., IB Docket No. 17-16, at 7-8 (T-Mobile Reply Comments). T-Mobile contends that, instead of waiving Section 25.131(j) of the rules, the better approach is for the Commission to find that the rule does not cover mobile wireless user devices. *Id.* T-Mobile's argument suggests a disagreement with the rule itself, which covers all earth stations, and the rationale underlying that rule, rather than a disagreement with the substance of this proceeding. In response to both Trimble and Deere and T-Mobile, we note that

(continued....)

communicate with the Galileo system without first obtaining a license.

10. Under the circumstances presented here, we find good cause to waive the licensing requirements in the Commission's rules with respect to non-Federal operations with Galileo signals E1 and E5, subject to certain technical constraints discussed below. We conclude that the special circumstances warrant deviation from the general rule, that waiver does not undermine the validity of the general rule, and as discussed in detail below, that there are also significant public interest benefits associated with waiving the rule. As the Commission has described, the purpose of the license requirement is to ensure, as a general matter and for multiple services, that there is a "regulatory control point" with respect to non-U.S.-licensed satellites transmitting to U.S. receive-only earth stations.³⁷ First, the Commission has established through the waiver process a comprehensive independent review of Galileo's proposed transmissions to these earth stations. The *RNSS Public Notice* identified a process for that review tailored specifically to the RNSS, by which NTIA would forward a recommendation alongside a waiver request to the Commission for evaluation outside of the existing Part 25 procedures.³⁸ Second, in light of the provisions of the 2004 EU/US Galileo-GPS Agreement and the long-standing history of cooperation between the US and the EC on the coordination of satellite transmissions, we believe there is a reliable mechanism for addressing any spectrum management issues that may arise in the future. Grant of a waiver in these circumstances does not undermine the rationale for the license requirement.

11. We also find good cause to grant, as requested by the EC, a waiver of the process and informational requirements associated with filing requests for non-U.S.-licensed space stations to provide service in the United States.³⁹ Waiver of formal market access application requirements is justified in this instance, since the information for evaluation of the proposed operations has been provided to the Commission under the RNSS-specific processes outlined by the Commission and NTIA.⁴⁰

12. *Public Interest Benefits.* Our evaluation leads us to conclude that the waiver conditioned as described below is consistent with the public interest. The potential public interest benefits associated with grant of waivers to permit non-federal receive-only earth station operations with particular Galileo signals are significant. The Galileo GNSS is uniquely situated as a foreign GNSS system with respect to the U.S. GPS, since the two systems are interoperable and RF compatible under the 2004 EU/US Galileo-GPS Agreement and subsequent EC/U.S. actions to implement that agreement.⁴¹ In establishing that agreement, the United States and the EC noted the desire to "provide satellite navigation users and equipment providers with a broader range of services and capabilities, leading to increased user applications, while assuring radio frequency compatibility with systems and equipment already in use."⁴² Based on NTIA's recommendation and our own independent assessment, we conclude that waiver of our

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contemplating an alteration to this established RNSS waiver process with respect to the Galileo GNSS is moot, and we decline to address the waiver process with respect to any potential future waiver requests for other systems at this time. Additionally, any revisions to the rule text of Section 25.131 are outside the scope of this proceeding.

³⁷ *Comprehensive Review of Licensing and Operating Rules for Satellite Services*, 30 FCC Rcd 14713, 14812, para. 313 (2015) (*2015 Part 25 Order*) (citing *Amendment of the Commission's Regulatory Policies to Allow Non-U.S. Licensed Space Stations to Provide Domestic and International Satellite Service in the United States*, Report and Order, 12 FCC Rcd 24094, 24179-80, para. 201 (1997)).

³⁸ See *RNSS Public Notice*, 26 FCC Rcd at 3867.

³⁹ 47 CFR § 25.137.

⁴⁰ See *RNSS Public Notice*, 26 FCC Rcd at 3867.

⁴¹ See e.g., Joint Statement on GPS and Galileo Cooperation, GPS.gov (Oct. 23, 2008), <http://www.gps.gov/policy/cooperation/europe/2008/joint-statement/>.

⁴² *Id.* at Preamble, 5.

rules will further the stated purpose and objectives of the EU/US Galileo-GPS agreement to promote the provision and use of civil GPS and Galileo navigation and timing signals and services, value-added services, augmentations, and global navigation and timing goods.⁴³

13. The *Galileo Public Notice* recognized the potential benefits associated with allowing non-Federal receivers to operate with Galileo GNSS signals to supplement GPS by increasing service availability, accuracy, and reliability of PNT services, and sought to develop a full record of these benefits.⁴⁴ In addition, the *Galileo Public Notice* sought comment on issues related to ensuring the resiliency of PNT services that operate with Galileo signals, including whether devices augmented to receive Galileo RNSS signals would be equally or more resilient to interference from other non-Federal services than PNT receivers operating with GPS alone, or whether there would be the potential for increased susceptibility to interference for receivers operating with both GPS and Galileo.⁴⁵

14. The public record developed in this proceeding supports our finding that grant of the waivers is in the public interest. NTIA emphasized in its Waiver Request Letter that use of Galileo PNT services will supplement GPS signals, which will benefit end users by increasing service availability, reliability, and resiliency.⁴⁶ The EC and commenters broadly agree that combining the use of Galileo and GPS signals would improve the reliability, accuracy, and resiliency of positioning for PNT applications and services.⁴⁷ For example, the European Global Navigation Satellite Systems Agency (GSA) states that the availability of Galileo to improve constellation geometry and the increase in robustness coming from use of multi-constellation, multi-frequency, multi-services receivers will result in improvements in accuracy, availability, and continuity of services.⁴⁸ In GSA's comments on consumer benefits, it suggests that there are eight market segments that would particularly benefit from operating Galileo-capable receivers in the United States: location-based services, road (e.g., driving directions), aviation, rail, maritime, agriculture, surveying and mapping, and timing and synchronization.⁴⁹ Topcon Positioning Systems, Inc. (Topcon) and Qualcomm Incorporated (Qualcomm) concur that supplementing GPS services with Galileo signals will improve availability, reliability, and resiliency of space-based PNT services.⁵⁰ Trimble, Inc. and Deere & Company (Trimble and Deere) contend that access to both Galileo and GPS signals in a single user device can increase service availability, accuracy, integrity, and continuity.⁵¹ They argue that access to Galileo signals will result in benefits to the American public in a

⁴³ 2004 EU/US Galileo-GPS Agreement, Article 1, Objectives, at 6.

⁴⁴ *Galileo Public Notice*, 32 FCC Rcd at 8235.

⁴⁵ *Id.*

⁴⁶ *Galileo Public Notice*, Attach. NTIA Waiver Request Letter at 2, 32 FCC Rcd at 8239.

⁴⁷ EC Comments, Attach. at 4. We note that the comments extolling the public interest benefits of granting waiver(s) to permit non-Federal earth station/receiver operations with Galileo signals vary significantly in terms of the level of detail and specificity provided. Many of the commenters express general support for permitting such operations with Galileo GNSS signals without discussing in detail, or distinguishing among, the specific Galileo signals (E1, E5, and/or E6). *See, e.g.*, Broadcom Comments; CNH Industries Comments, GSA Comments; Qualcomm Comments, Topcon Comments.

⁴⁸ Comments of the European Global Navigation Satellite Systems Agency, IB Docket No. 17-18, at 1-2 (filed Feb. 21, 2017) (GSA Comments) at 5.

⁴⁹ *Id.* at 1-2.

⁵⁰ Comments of Topcon Positioning Systems, Inc., IB Docket No. 17-18, at 2 (filed Feb. 21, 2017) (Topcon Comments) (stating that the ability to "double source" PNT information provides device manufacturers with a unique and important opportunity to mitigate disruption of high-precision devices); Comments of Qualcomm Incorporated, IB Docket No. 17-18 (filed Feb. 21, 2017) (Qualcomm Comments).

⁵¹ Comments of Trimble Inc. and Deere & Company, IB Docket No. 17-18, at 4-6 (filed Feb. 21, 2017) (Trimble and Deere Comments).

number of areas, such as by enabling safer and more efficient transportation by land, sea, and air; improving agriculture and food security; reducing risks of disaster; enabling emergency response, including Enhanced 911 (E-911);⁵² simplifying surveying and mapping, construction, and scientific research; and synchronizing financial operations, power grids, and other critical infrastructure.⁵³ Airbus Defense and Space Inc. (Airbus) states that use by GNSS receivers of both Galileo and GPS signals provides a number of advantages, including increased availability of signals in challenging environments (near buildings and under trees and bridges), improved ability to detect signal spoofing, and improved interference rejection and authentication capabilities.⁵⁴ CNH Industrial, a long-time supplier of GPS-aided farming equipment, believes the use of Galileo signals, especially during conditions of partial sky blockages, will improve the performance of its guidance and precision farming systems by increasing the availability, accuracy, and reliability of the positioning solution.⁵⁵ Hexagon Positioning Intelligence (Hexagon) suggests that reception of the Galileo signals would improve availability of PNT services by helping to mitigate obstructed views, and that it would improve the resiliency of GPS by deterring spoofing and helping with the resistance of interference.⁵⁶ Airbus, Broadcom Corporation (Broadcom), and CNH Industrial also agree that grant of the waiver request would increase system availability in challenging situations and environments.⁵⁷ The National Emergency Number Association (NENA), the 911 Association, states that the double power of the GPS L5 signal (operating in the 1164-1215 MHz band) and Galileo E5 signal (operating in the 1164-1215 MHz and 1215-1240 MHz bands), for example, adds significant public safety benefits by making available “dramatically superior positioning signals.”⁵⁸ Trimble and Deere state that permitting access to Galileo’s GNSS signals would promote U.S. Space-Based PNT policy for improving and maintaining back-up capabilities, which would strengthen GPS’s overall effectiveness.⁵⁹ They also state that approving such access would be consistent with the 2004 EU/US Galileo-GPS Agreement, and will help promote reciprocal acceptance of GPS in Europe, further strengthening the position of GPS worldwide.⁶⁰

15. As discussed below in detail, the record further supports our conclusion that, as conditioned below, grant of the waivers will not result in public interest harms. Commenters assert generally that receivers that operate with Galileo signals or Galileo/GPS signals would not be any more susceptible to interference than GPS-only receivers.⁶¹

⁵² See *infra* Part III.C for discussion of how the waiver grant relates to the provision of E-911 services.

⁵³ Trimble and Deere Comments at 4.

⁵⁴ Comments of Airbus Defense and Space Inc., IB Docket No. 17-18, at 1 (filed Feb. 21, 2017) (Airbus Comments).

⁵⁵ Comments of CNH Industrial, IB Docket No. 17-18 (filed Feb. 20, 2017) (CNH Industrial Comments).

⁵⁶ Comments of Hexagon Positioning Intelligence, IB Docket No. 17-18, at 4 (filed Feb. 21, 2017) (Hexagon Comments).

⁵⁷ Airbus Comments at 1; CNH Industrial Comments; Comments of Broadcom Corporation, IB Docket No. 17-18, at 4 (filed Feb. 20, 2017) (Broadcom Comments).

⁵⁸ Comments of NENA, the 911 Association, IB Docket No. 17-18, at 1 (filed Feb. 21, 2017) (NENA Comments).

⁵⁹ Trimble and Deere Comments at 11-12.

⁶⁰ *Id.* at 12-13.

⁶¹ For specific discussion on receiver design and related comments, see *infra* Part III.B. See e.g., *Galileo Public Notice*, 32 FCC Rcd at 8235 (seeking comment on whether certain types of receivers operating with the Galileo signals would potentially be more susceptible to interference from other operations, including adjacent or nearby operations).

16. The record provides broad support for our conclusion that there are significant public interest benefits in supplementing GPS with Galileo and enhancing PNT services, in the form of improved availability, accuracy, and reliability, without any adverse impact on the resiliency of these services.⁶²

B. Galileo Signals

17. The EC's waiver request identified three specific signals for U.S. earth station/receiver operations with the Galileo GNSS, corresponding with three different frequency bands.⁶³ The three signals are described generally as the Galileo E1, E5, and E6 signals.⁶⁴ Each of the signals presents unique issues from a radio frequency perspective. The *Galileo Public Notice* recognized that the issues implicated by the EC's request could potentially affect the Commission's spectrum management with regard to non-Federal operations in the bands allocated for RNSS or in bands adjacent to or nearby the RNSS bands,⁶⁵ and accordingly sought comment on a number of matters pertaining to the individual signals.⁶⁶ As discussed below, these included: (1) issues pertaining to international and U.S. spectrum allocations, including non-Federal allocations, in the affected bands; (2) the potential impacts of the Galileo satellite signals on other non-Federal receivers, including those in bands adjacent to or near the RNSS bands; and (3) the electromagnetic compatibility of non-Federal Galileo receivers and non-Federal transmissions in bands allocated to RNSS and in the bands adjacent to or nearby to the RNSS bands.⁶⁷ As part of our evaluation of the EC's waiver request, we review the record developed on these matters and analyze whether grant of the waivers is in the public interest with respect to each of the three signals.

1. E1 Signal

18. We grant waivers of the Commission's rules, to permit non-Federal receiver operations with the Galileo E1 signal, as conditioned below. In so doing, we consider the E1 signal characteristics and issues pertaining to spectrum allocations, impacts of the E1 satellite signal on non-Federal receivers, and the electromagnetic compatibility of Galileo E1 receivers and non-Federal transmissions in adjacent and nearby frequency bands. The grant of these waivers is limited to the E1 signal described in the EC's request, as further clarified in its comments.

19. *E1 Signal Characteristics and Affected Allocations.* In the technical documents submitted with its waiver request, the EC indicated that the Galileo E1 signal transmits over the 1559-1591 MHz frequency band, has a center frequency located at 1575.42 MHz, and an assigned bandwidth of 32 megahertz.⁶⁸ This is the same center frequency that is used by the GPS II L1 signal currently transmitting in the 1559-1610 RNSS band; E1 also has a signal bandwidth that overlaps, but is wider than the GPS II L1 signal bandwidth (20.49 megahertz) and the forthcoming GPS III L1C signal bandwidth

⁶² As discussed below in Part III.B.3, in drilling down on the specific characteristics of the three Galileo signals at issue, we find that the potential public interest benefits of waiving the rules for the E6 signal are outweighed by countervailing concerns. Accordingly, we are denying the waiver request with respect to the E6 signal.

⁶³ See *Galileo Public Notice*, Attach. NTIA Waiver Request Letter at 4, 32 FCC Rcd at 8241.

⁶⁴ See, e.g., *id.*, Attach. EC Schedule S at 7, 32 FCC Rcd at 8259. See also 2016 European GNSS (Galileo) Open Service Signal-In-Space Interface Control Document, OS SIS ICD, Issue 1.3 at 2 (Dec. 2016), available at https://www.gsc-europa.eu/system/files/galileo_documents/Galileo-OS-SIS-ICD.pdf (describing three independent Code Division Multiple Access (CDMA) signals, denoted as E5, E6, and E1, permanently transmitted by all Galileo satellites).

⁶⁵ 32 FCC Rcd at 8227.

⁶⁶ *Id.*

⁶⁷ *Id.*

⁶⁸ *Galileo Public Notice*, 32 FCC Rcd at 8227 (citing Attach. EC Schedule S at 6, 9).

(30.69 megahertz), but is within the 1559-1610 RNSS allocation.⁶⁹ To achieve interoperability and facilitate the joint use of the GPS and Galileo systems, parties to the 2004 EU/US Galileo-GPS Agreement agreed to realize their geodetic coordinate reference frames as closely as possible to the International Terrestrial Reference System and transmit the time offsets between Galileo and GPS system times in the navigation messages of their respective services.⁷⁰ As noted in the *Galileo Public Notice*, the Galileo E1 signal consists of the Open Service (OS) signal and the Public Regulated Service (PRS) signal.⁷¹ GSA reference documentation describes the OS as a free-of-charge service set up for positioning and timing services and the PRS as a service “restricted to government-authorized users, for sensitive applications that require a high level of service continuity.”⁷² The signal associated with the OS differs from the signal associated with the PRS, although both share the same center frequency.⁷³

20. The 1559-1610 MHz band is allocated to the RNSS on a primary basis in all three International Telecommunications Union (ITU) Regions in the International Table of Frequency Allocations (International Table) and on a primary basis in the U.S. Table for Federal and non-Federal use.⁷⁴ The band is also allocated on a primary basis to the Aeronautical Radionavigation Service (ARNS) internationally, and domestically this primary ARNS allocation is available for both Federal and non-Federal use.⁷⁵

21. The *Galileo Public Notice* recognized that there were varying descriptions of the E1 signal and bandwidth in various publicly-available sources.⁷⁶ In their comments, Inmarsat Inc. (Inmarsat) and Ligado Networks LLC (Ligado) each express concern that the EC’s description of the E1 signal was incomplete, and that the PRS signal extended into the Mobile-Satellite Service (MSS) band below 1559 MHz.⁷⁷ However, in its comments filed in response to the *Galileo Public Notice*, the EC provides clarification that the E1 signal is “intended to occupy a bandwidth of 32 [megahertz]” in the 1559-1591 MHz band, as indicated in its filings and the associated ITU satellite filings for Galileo.⁷⁸ The EC also states that the wideband PRS signal is transmitted in the 1559-1591 MHz range, but recognizes that a

⁶⁹ See *id.* at 8228, n.17 (citing *Global Positioning Systems Directorate Systems Engineering & Integration Interface Specification IS-GPS-200-H 24 SEP-2013 Navstar GPS Space Segment/Navigation User Interfaces* Sec. 3.3.1.1 Frequency Plan at 13-14, available at <http://www.gps.gov/technical/icwg/>).

⁷⁰ See 2004 EU/US Galileo-GPS Agreement, Article 4, Interoperability and Radio Frequency Compatibility, at 11.

⁷¹ See *Galileo Public Notice*, 32 FCC Rcd at 8228; European GNSS (Galileo) Initial Services, Open Service Definition Document, Issue 1.0 at Sections 1.5 and 1.6 (Dec. 2016), available at https://www.gsc-europa.eu/system/files/galileo_documents/Galileo-OS-SDD.pdf.

⁷² *Id.*

⁷³ See European GNSS (Galileo) Open Service Signal in Space Control Document, OS SIS ICD, Issue 1.3 at 25 (December 2016), available at https://www.gsc-europa.eu/system/files/galileo_documents/Galileo-OS-SIS-ICD.pdf

⁷⁴ 47 CFR § 2.106.

⁷⁵ *Id.*

⁷⁶ 32 FCC Rcd at 8228-29.

⁷⁷ Comments of Inmarsat Inc. at 2 (Inmarsat Comments) (expressing particular concern about the PRS signal, and the potential for harmful interference of that signal to MSS operations below 1559 MHz); Comments of Ligado Networks LLC at 4 (Ligado Comments) (noting that emissions from Galileo’s E1 signal extends outside the RNSS allocation into the MSS band below 1559 MHz).

⁷⁸ EC Comments, Attach. at 1 (distinguishing some “unofficial” sources from the system reference sources that indicate a 32-megahertz bandwidth as submitted in its filings).

small amount of signal energy falls below 1559 MHz.⁷⁹ The EC further clarifies its request by stating that Galileo users should not seek to claim protection for reception of signal energies outside of the RNSS allocation from systems operating in the lower adjacent band that are operating in accordance with the ITU Radio Regulations (ITU R.R.).⁸⁰ In their comments, Trimble and Deere request that the Commission permit reception of any Galileo E1 PRS signal below 1559 MHz so long as the Galileo E1 Open Service and Public Regulated Service signals are compatible and interoperable with GPS and the Galileo E1 Open Service signal remains available.⁸¹ In reply comments, Trimble and Deere note the EC's clarification that the E1 signal will occupy a bandwidth of 32 megahertz in the 1559-1591 MHz band, and support the EC's clarified request for waiver.⁸²

22. In Inmarsat's comments, it also expresses concern about the variances in power levels between the EC's original technical submissions and the ITU filing, including concern that the only constraint on Galileo's operations would be the higher specified power levels in the ITU filing.⁸³ In its initial comments, the EC notes that the most recent ITU filings for the Galileo satellites specify higher powers for the E1 and E6 signals than in the original filing (as described in the *Galileo Public Notice*), and that these have been successfully coordinated with other RNSS systems that use the same frequency ranges, including GPS.⁸⁴ In a subsequent filing, the EC clarifies its request at this time by stating that current Galileo operations are consistent with the power levels provided in the Schedule S submitted with its waiver request, and that the higher power levels that are specified in the ITU filings are part of the "Galileo 2nd Generation" system evolution; it further acknowledges that future action by the Commission may be required in connection with any future operations at higher powers.⁸⁵

23. Consistent with the EC's request on the E1 signal, as clarified, we grant a waiver for receivers to operate with the E1 signal that is transmitted within a 32-megahertz bandwidth over the 1559-1591 MHz frequencies in the 1559-1610 MHz RNSS band; the waiver that we are granting with respect to receivers operating with the E1 signal does not alter the harmful interference protection rights related to this signal, which are available for RNSS only on frequencies that have been allocated on a primary basis for non-Federal RNSS in the U.S. Table.⁸⁶ In addition, based on the EC's further clarification, we grant waivers for operations with the E1 signal limited to operations in compliance with the technical

⁷⁹ *Id.* The EC notes that some receiver manufacturers may choose to implement a wider front-end filter to maximize capture of information contained in frequency side lobes (which can serve to help improve performance of certain precision applications).

⁸⁰ *Id.*

⁸¹ Trimble and Deere Comments at 15-16 (indicating that the PRS signal extends below 1559 MHz).

⁸² Trimble and Deere Reply Comments at 5-6. In their initial comments, Trimble and Deere had supported a waiver to permit non-Federal receiver operations with the E1 signal that has a 40-megahertz bandwidth, including a PRS signal that extended outside of the RNSS into the MSS band below 1559 MHz. Trimble and Deere Comments at 15-16. Recognizing operations with PRS are restricted to government-authorized users for sensitive applications, non-federal operations with the PRS signal are outside of the scope of this Order, and would be permissible only to the extent that such operations would be consistent with an agreement between the United States and the EU.

⁸³ Inmarsat Comments at 2.

⁸⁴ EC Comments, Attach. at 2.

⁸⁵ Letter from Dominic Hayes, Signals and Frequencies Manager, Directorate-General for Internal Market, Industry, Entrepreneurship and SMEs, the European Commission, to Marlene H. Dortch, Secretary, FCC, IB Docket No. 17-18, at 1 (filed Oct. 2, 2017) (EC Oct. 2, 2017 *Ex Parte* Letter).

⁸⁶ See 47 CFR § 2.106.

information provided in EC's original submissions, including the power levels specified in that submission, rather than in the ITU filings.⁸⁷

24. *Potential Interference to non-Federal Receivers Operating in the RNSS Band or Adjacent/Nearby Bands.* As regards potential impacts relating to the Galileo E1 signal and non-Federal receivers operating in the RNSS band, the EC notes that the Galileo signals were designed to be fully interoperable with the next generation of GPS signals and are fully compatible with the current generation of GPS signals.⁸⁸ The EC states that because the Galileo signals were designed to be fully interoperable with the next generation of GPS signals and fully compatible with the current generation GPS C/A and P(Y) code signals, even if existing GPS receivers cannot utilize the Galileo signals, they should not suffer degradation.⁸⁹ As GSA notes, a "properly designed receiver" should be able to cope with processing data from both the Galileo and GPS constellations, resulting only in PNT performance improvements without any negative effects.⁹⁰ In their comments, Trimble and Deere support the conclusion that Galileo will be interoperable with GPS⁹¹ and RF compatible with U.S. government systems and equipment already in use in the frequency bands allocated to RNSS.⁹² Hexagon also agrees that no E1 signal compatibility issues arise with regard to GPS L1 and L1C signals.⁹³ As noted in the *Galileo Public Notice*, NTIA also had concluded that there are no RF compatibility issues with any Federal systems operating in the 1559-1610 MHz RNSS band (expressly noting compatibility with GPS L1 operations),⁹⁴ and as there are no non-Federal ARNS operations in this band⁹⁵ and nothing in the record to indicate any material differences in the general types of operations conducted by Federal and non-Federal users of the GPS L1 signal, we conclude that there are similarly no compatibility issues with any non-Federal operations in the band. We thus conclude that there are no significant interoperability or interference concerns with respect to non-

⁸⁷ As noted in the *Galileo Public Notice*, the 2004 EU/US Galileo/GPS Agreement provides certain flexibility with regard to changes in signal structures in order to maintain and improve the quality and security of services, to respond effectively to unforeseen changes in technology, user needs, and the spectrum environment, and to pursue modernization and development of their respective Galileo and GPS systems while maintaining the security and market benefits of compatible and interoperable common civil signals. See 2004 EU/US Galileo/GPS Agreement, Article 11, paras. 4-7. Given the EC's clarification with respect to the E1 signal power level, this grant of waiver is limited to the E1 signal described in the technical information that is part of the EC's waiver request, as clarified, but we do not preclude a future Commission action to address changes in the Galileo GNSS, should it become necessary.

⁸⁸ EC Comments, Attach. at 3.

⁸⁹ EC Comments, Attach. at 3.

⁹⁰ GSA Comments at 4. GSA notes that the only negative effect observed is a slightly higher consumption of batteries during the acquisition phase, due to the fact that more computing power is needed during that phase when processing two constellations, but that the observed impact on battery consumption does not exceed one percent with respect to GPS-only receivers, and the difference disappears once the receiver is in tracking mode, i.e., normal operations. *Id.*

⁹¹ Trimble and Deere Comments at 9-11 (noting that the Galileo E1 signal corresponds almost exactly with the GPS L1 signal in frequency and bandwidth, hence the RF section of any GPS receiver will be interoperable with the Galileo E1 signal).

⁹² *Id.* at 7-8.

⁹³ Hexagon Comments at 2.

⁹⁴ *Galileo Public Notice*, Attach. NTIA Waiver Request Letter at 4, 32 FCC Rcd at 8241 (stating that Galileo signals are compatible with the GPS L1 and L5 signals).

⁹⁵ Although there is a non-Federal allocation for ARNS in this band, there are no non-Federal ARNS licenses for such operations in this band.

Federal reception of the current GPS L1 or future GPS L1C signals operating in the 1559-1610 MHz RNSS band.

25. As for potential interference to non-Federal receivers operating outside of the 1559-1610 MHz RNSS band, Inmarsat expresses concern in its initial comments about the potential for the Galileo E1 signal to interfere with MSS earth station/receiver operations below 1559 MHz, supplying technical analyses (including confidentially-filed materials) in support of its assertions.⁹⁶ Inmarsat, which operates downlink signals for its MSS system in the 1525-1559 MHz band, contends that without appropriate filtering by Galileo, Inmarsat's mobile earth station/receiver operations below 1559 MHz could suffer interference from Galileo satellites.⁹⁷ In its comments, Ligado also expresses general concern regarding the potential for the out-of-band emissions from the E1 signal to interfere with adjacent MSS operations (which includes receivers) below 1559 MHz, although it provides no details or technical analyses.⁹⁸ Both Inmarsat and Ligado note that without efforts to filter out-of-band emissions, the out-of-band emissions level of the PRS signal into the MSS band would only be a few dB below the PRS maximum level, which would likely cause interference to MSS receivers operating below 1559 MHz.⁹⁹ Inmarsat requests that the FCC seek further information regarding specifically how Galileo would avoid such out-of-band emissions interference into the adjacent MSS band, and Ligado does as well.¹⁰⁰ In its comments, the EC states that Galileo has transmitted its wideband E1 PRS signal in the 1559-1591 MHz range since 2006 without any reports of interference to systems operating in the band below 1559 MHz.¹⁰¹

26. Subsequent to the filing of Inmarsat's initial comments and the EC's clarifications regarding the E1 signal parameters, Inmarsat and the EC filed joint reply comments stating that Inmarsat had committed to conducting measurements to assess the impact of Galileo signals to the Inmarsat receivers, and that if such emissions cause interference, EC and Inmarsat would coordinate bilaterally to minimize the impacts.¹⁰² Ligado provided no additional comments. Considering the arrangement between the EC and Inmarsat to address potential impacts to Inmarsat's MSS receivers, the EC's affirmation that Galileo has transmitted the PRS signal in the 1559-1591 MHz range since 2006 without reports of interference, and the lack of any analysis or technical support for Ligado's generalized concern on this issue, we find no basis to require additional demonstrations with respect to adjacent band MSS receiver operations before granting the requested waivers for operations with the E1 signal.¹⁰³

⁹⁶ Inmarsat Comments at 2-3 and Annex.

⁹⁷ Inmarsat Comments at 2-3. Inmarsat attached to its filing an analysis of the impact of Galileo PRS signal to Inmarsat operational mobile earth stations. *See id.*, Annex.

⁹⁸ Ligado Comments at 4-5. Ligado's MSS operations below 1559 MHz include MSS earth station/receiver operations; Ligado also has proposed MSS Ancillary Terrestrial Component (ATC) transmissions, as discussed below with respect to electromagnetic compatibility.

⁹⁹ Inmarsat Comments at 2; Ligado Comments at 4-5.

¹⁰⁰ Inmarsat Comments at 3; Ligado Comments at 5.

¹⁰¹ EC Comments, Attach. at 1.

¹⁰² Joint Reply Comments of the European Commission and Inmarsat Inc., IB Docket No. 17-16, at 1 (filed Mar. 23, 2017) (EC/Inmarsat Joint Comments); *see also* EC Oct. 2, 2017 *Ex Parte* Letter at 1 (stating that the Inmarsat testing campaign was ongoing, and while the EC had indicated to Inmarsat that it was not possible to modify the satellite design of the current Galileo system, "it had agreed with Inmarsat that if it is demonstrated that Galileo emissions cause interference to Inmarsat receivers resulting in an impact to Inmarsat service[]" the EC and Inmarsat would "coordinate bilaterally in order to minimize the impacts to Inmarsat services as soon as is feasible within the constraints of the European Union's international obligations.").

¹⁰³ We encourage satellite operators to cooperate in good faith to resolve any issues in the event they believe they are experiencing interference.

27. *Electromagnetic Compatibility of E1 Receivers with non-Federal Transmitters in the RNSS or Adjacent/Nearby Bands.* The *Galileo Public Notice* sought comment generally on potential impacts associated with non-Federal earth stations operating with the Galileo E1 signal, including the potential electromagnetic compatibility of such receivers with non-Federal transmissions in the frequency bands allocated to the RNSS and those adjacent or near to the RNSS band.¹⁰⁴ We requested information regarding receiver characteristics (including information about receiver designs that promote electromagnetic compatibility with other operations), the E1 receiver RF front end designs and variations, and whether receivers that operate with the E1 signal and the E5 and/or E6 signal(s) have separate front ends.¹⁰⁵ We also asked whether any further clarifications, limitations, or conditions should attach to any waiver grant.¹⁰⁶

28. Based on the record in this proceeding, we first conclude that there are no electromagnetic compatibility concerns regarding Galileo E1 receivers and non-Federal transmissions in the 1559-1610 MHz RNSS band. We received no comments suggesting that there are any electromagnetic compatibility concerns relating to E1 receivers and non-Federal transmissions. As noted above, the E1 signal is RF compatible with the Federal systems (which include transmissions) operating in this RNSS band and would be compatible with non-Federal GPS L1 operations in the band.¹⁰⁷ The Galileo system is also interoperable with GPS under the terms of the 2004 EU/US Galileo-GPS Agreement.

29. Regarding Galileo E1 receiver characteristics that may affect electromagnetic compatibility with transmissions in adjacent or nearby bands outside of the RNSS band, the EC notes that it does not prescribe how manufacturers design receivers to operate with the Galileo signals, indicating instead that manufacturers may choose different receiver designs for operating with the Galileo signals (as those signals are defined in the Galileo Open Service Signal-in-Space Interface Control Document), with the particular designs intended to maximize desired receiver performance levels.¹⁰⁸ Receiver manufacturer Broadcom states that “well-designed” consumer-grade GNSS receivers are not degraded by any licensed external signals¹⁰⁹ and, since the bandwidth difference between GPS-only and GPS and Galileo is small, all consumer receivers are “equally susceptible” to degradation of the reception of GPS due to adverse signal conditions whether or not they are capable of receiving Galileo signals.¹¹⁰ Hexagon, which manufactures NovAtel commercial GNSS receivers that track Galileo E1 and GPS L1 signal (along with the Galileo E5 signal and GPS L5 and L2 signals, discussed below), states that the Galileo E1 receiver is “extremely similar” to a GPS L1 receiver, with a similar amount of variation between the front ends of Galileo E1 and GPS L1 receivers.¹¹¹ Trimble and Deere state that the interference profile for a

¹⁰⁴ *Galileo Public Notice*, 32 FCC Rcd at 8233-34.

¹⁰⁵ *Id.* at 8234.

¹⁰⁶ *Id.* at 8235.

¹⁰⁷ See discussion in paragraph 24 above (noting that there are no non-Federal ARNS operations (including transmissions) in the 1559-1610 MHz band).

¹⁰⁸ EC Comments, Attach. at 3 (stating that receiver manufacturers have “the freedom to innovate to the maximum extent” to achieve desired performance levels).

¹⁰⁹ Broadcom Comments at 2 (noting that out-of-band emissions are sufficiently filtered in these consumer grade GNSS receivers).

¹¹⁰ *Id.* at 2-3 (noting that well-designed receivers have many stages of filtering, each optimized for performance, cost, and power consumption).

¹¹¹ Hexagon Comments at 2-3 (stating that the use of Galileo signals does not materially change the design of its receivers). Hexagon also designs and manufactures Antcom GNSS receivers and antennas. Hexagon notes that there are a variety of design choices for receivers, depending on what is prioritized in terms of accommodating the wider pass band for receiving the desired signal, which can impact costs, receiver size, power consumption, and out-

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receiver receiving Galileo and GPS signals will be the same as that of a receiver operating with only GPS L1, L2, and L5 signals;¹¹² according to Trimble and Deere, those signals that interfere with GPS-only receivers would also interfere with Galileo-only and combined Galileo/GPS receivers, thus access to Galileo does not affect the vulnerability of GNSS receivers either positively or negatively.¹¹³

30. In its comments, Ligado raises particular concerns regarding the electromagnetic compatibility of Galileo E1 receivers with existing and planned services operating in the adjacent band below 1559 MHz,¹¹⁴ requesting that the Commission not grant the requested waiver until the EC has demonstrated that these Galileo-enabled devices would be compatible with MSS and Ancillary Terrestrial Component (ATC) operations.¹¹⁵ Ligado contends that the extent to which the addition of Galileo-reception capabilities would make receivers more or less resilient to interference from operations in adjacent or nearby bands should be a critical factor in assessing whether the waiver request would serve the public interest in managing spectrum efficiently and productively.¹¹⁶ Hexagon states that, with regard to its future receiver designs, it has no concerns about interference from proposed ATC operations in adjacent bands.¹¹⁷ Noting the concerns of Immarsat and Ligado, T-Mobile asserts in reply comments that any waiver permitting the reception of signals outside the 1559-1610 MHz RNSS band should not create further restrictions on operations in adjacent bands, and that the Commission should make clear that reception of GNSS signals outside of the RNSS allocation are protected only insofar as GPS is protected in those bands.¹¹⁸

31. Considering the record discussed above, including the EC's clarifications regarding the E1 signal (both bandwidth and power levels) and that receivers operating with the Galileo E1 signal have a similar electromagnetic compatibility profile to receivers operating with the GPS L1 signal in the 1559-1610 MHz RNSS band, we find that no electromagnetic compatibility issues prevent us from granting a waiver for operations with the Galileo E1 signal. Receivers operating with both GPS L1 and Galileo E1 signals associated with the 1559-1610 MHz RNSS band should not be any less resilient to interference than receivers operating with the GPS L1 signal alone. Non-Federal receivers operating with the E1 signal under the primary RNSS allocation will have the same harmful interference protection rights afforded non-Federal receiver operations with the GPS L1 signal under the same allocation, which is consistent with T-Mobile's suggestion. Our decision enables the public to benefit from improved PNT services associated with Galileo E1 receivers, while also promoting use of the spectrum consistent with the electromagnetic compatibility of non-Federal GPS L1 receivers and other non-Federal operations in the adjacent or nearby bands.¹¹⁹

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of-band rejection performance. It further notes that a high precision receiver that supports GPS L1, L2, and L5 will have the same design tradeoffs as one that supports Galileo E1 and E5. *Id.* at 1-2.

¹¹² Trimble and Deere Comments at 14.

¹¹³ *Id.* at 14-15.

¹¹⁴ Ligado Comments at 1, 3. As noted in the *Galileo Public Notice*, Ligado holds an MSS license for operations in the 1525-1559 MHz band that includes an ATC authorization, conditioned on addressing potential interference concerns relating to GPS operations in the 1559-1610 MHz band. *Galileo Public Notice*, 32 FCC Rcd at 8233, n.50.

¹¹⁵ Ligado Comments at 3.

¹¹⁶ *Id.* at 5.

¹¹⁷ Hexagon Comments at 2.

¹¹⁸ T-Mobile Reply Comments at 3, 9-10.

¹¹⁹ Since Galileo E1 receivers have a similar electromagnetic compatibility profile to that of GPS L1 receivers, and we are not granting non-Federal receiver operations with the Galileo E1 signal any harmful interference protection rights beyond that already afforded to non-Federal receivers that operate with the GPS L1 signal, we need not

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2. E5 Signal

32. We also grant waivers of the Commission's rules to permit non-Federal receiver operations in the United States with the Galileo E5 signal,¹²⁰ and, on our own motion we waive the U.S. Table to allow non-Federal operations with the E5 signal in the 1215-1219 MHz portion of the 1215-1240 MHz band.¹²¹ In granting these waivers, we consider the E5 signal characteristics, the affected U.S. and International spectrum allocations, the potential impacts of the E5 satellite signal on non-Federal receivers in the affected bands, and the electromagnetic compatibility of Galileo E5 receivers and non-Federal transmissions in the affected RNSS bands and in adjacent and nearby frequency bands. The grant of these waivers is limited to the signal described in the EC's request, as clarified in its comments.

33. *E5 Signal Characteristics and the Affected Allocations.* In its request, the EC indicates that the E5 signal will transmit over the 1164-1219 MHz band, with a center frequency at 1191.5 MHz and a bandwidth of 55 megahertz, with a maximum equivalent isotropically radiated power (EIRP) of 34.6 dBw.¹²² Internationally, the 1164-1215 MHz band is allocated on a primary basis to RNSS and ARNS, and in the United States the 1164-1215 MHz band is allocated on a primary basis to RNSS and ARNS for both Federal and non-Federal use.¹²³ Thus, E5 operations in the 1164-1215 MHz band are consistent with the U.S. and international primary allocation for RNSS in that band.¹²⁴ The lower portion of the Galileo E5 signal overlaps with the GPS L5 signal that transmits in the 1164-1215 MHz band (at 1164.45-1188.45 MHz, with a bandwidth of 24 megahertz).¹²⁵ The E5 signal also operates in a small portion of the 1215-1240 MHz band, from 1215-1219 MHz.¹²⁶ The 1215-1240 MHz band is allocated on a primary basis for RNSS in all three ITU Regions in the International Table, and is also allocated internationally on a primary basis to the Earth Exploration-Satellite Service (EESS) (active), the Radiolocation Service (RLS), and the Space Research Service (SRS) (active).¹²⁷ In the United States, the 1215-1240 MHz band is allocated on a primary basis to the RNSS, EESS (active), RLS, and SRS (active) for Federal use only, and is allocated on a secondary basis to the EESS (active) and SRS (active) for non-Federal use.¹²⁸ Thus, non-Federal operations with the E5 signal in the 1215-1219 MHz portion of the 1215-1240 MHz band would not conform with the U.S. Table.¹²⁹ However, there is some overlap of this upper portion of the E5 signal with the GPS L2 signal that transmits in portions of the 1215-1240 MHz

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require any additional showing that Galileo E1 receivers are electromagnetically compatible with adjacent band operations, as requested by Ligado. We note that in a separate proceeding, IB Docket Nos. 11-109 and 12-340, Ligado has asked the Commission to permit Ligado ATC to commence operations in the 1526-1536 MHz portion of the 1525-1559 MHz band, under specified conditions. The instant Order does not address the issues raised in those proceedings, which include issues relating to the electromagnetic compatibility of GPS L1 operations with Ligado's proposed ATC operations.

¹²⁰ 47 CFR §§ 25.131(j), 25.137.

¹²¹ *Galileo Public Notice*, Attach. NTIA Waiver Request Letter at 4, 32 FCC Rcd at 8241.

¹²² See *Galileo Public Notice*, Attach. EC Schedule S at 9, 32 FCC Rcd at 8261.

¹²³ 47 CFR § 2.106.

¹²⁴ *Id.*

¹²⁵ See IS-GPS-705E, 25-APR-2018, GLOBAL POSITIONING SYSTEMS DIRECTORATE SYSTEMS ENGINEERING & INTEGRATION, INTERFACE SPECIFICATION, IS-GPS-705, Navstar GPS Space Segment/User Segment L5 Interfaces at 9, available at <https://www.gps.gov/technical/icwg/IS-GPS-705E.pdf>.

¹²⁶ See *Galileo Public Notice*, Attach. EC Schedule S at 9, 32 FCC Rcd at 8261.

¹²⁷ 47 CFR § 2.106.

¹²⁸ *Id.*

¹²⁹ See *id.*

band. The GPS II L2 signal operates in the 1217.37-1237.83 portion of the 1215-1240 MHz band.¹³⁰

34. The *Galileo Public Notice* recognized that there was a slight variation in the center frequency of the E5 signal as between the EC's waiver request and information in the 2015 Galileo Open Service Signal-in-Space Interface Control Document, and we requested that the EC provide any clarification regarding the E5 signal characteristics or proposed power levels, as appropriate.¹³¹ The EC clarifies in its comments that, although transmitted as a single emission, each half of the E5 AltBOC signal can be decoded and processed individually or as a whole, and that for this reason, three center frequencies (1176.450 MHz, 1191.795 MHz, and 1207.140 MHz) are listed, depending on how much of the E5 signal is processed.¹³² The EC states that its E5 signal operates within the specified power limits and operating conditions defined by ITU Resolution 609 (Rev. WRC-07) for the 1164-1215 MHz band.¹³³ It further states that, given the very limited E5 signal energy transmitted in the 1215-1219 MHz band, no interference effects are expected to be observed by non-Federal users of other systems operating in the 1215-1240 MHz band.¹³⁴

35. The *Galileo Public Notice* sought comment on whether we should grant a waiver, on our own motion, of the U.S. Table of Frequency Allocations for the portion of the E5 signal falling within the 1215-1240 MHz band that does not have a U.S. non-Federal RNSS allocation, but which does have a U.S. Federal RNSS allocation.¹³⁵ The Commission has granted a waiver of the U.S. Table for non-conforming uses in some instances where there is little potential for interference to any service authorized under the U.S. Table and where the non-conforming operator will accept any interference from authorized services.¹³⁶ In addition, NTIA has recommended grant of waiver related to operations with the E5 signal, noting that the signal is compatible with the GPS L5 signal.¹³⁷ As discussed in detail below, we find that there is little potential for interference from the Galileo E5 signal operations in the 1215-1219 MHz band to other services. Only this limited part of the E5 signal extends into the lowest portion of 1215-1240 MHz band.¹³⁸ We find it is in the public interest to grant a waiver of the U.S. Table for non-Federal receiver operations with the E5 signal, where such operations would be on a non-conforming basis and such non-Federal Galileo E5 receivers must accept harmful interference from authorized services in the 1215-1240 MHz band. We note as a practical matter that we do not anticipate that there would be any

¹³⁰ See IS-GPS-200J, 25-APR-2018, GLOBAL POSITIONING SYSTEMS DIRECTORATE SYSTEMS ENGINEERING & INTEGRATION, INTERFACE SPECIFICATION, IS-GPS-200, Navstar GPS Space Segment/Navigation User Segment Interfaces at 13, available at <https://www.gps.gov/technical/icwg/IS-GPS-200J.pdf>. We note that the GPS III L2 signal is planned for future operation in the 1212.256-1242.945 MHz band. *Id.*

¹³¹ *Galileo Public Notice*, 32 FCC Rcd at 8229, n. 26.

¹³² EC Comments, Attach. at 1.

¹³³ EC Comments, Attach. at 1. ITU Resolution 609 (Rev. WRC-07) relates to the protection of ARNS systems from the equivalent power flux-density produced by RNSS networks and systems in the 1164-1215 MHz band.

¹³⁴ EC Comments, Attach. at 2.

¹³⁵ *Galileo Public Notice*, 32 FCC Rcd at 8230.

¹³⁶ See, e.g., *Geostar Positioning Corp.*, Order and Authorization, 4 FCC Rcd 4538, 4538-39, paras. 6-7 (1989); *Application of Fugro-Chance, Inc.*, Order and Authorization, 10 FCC Rcd 2860, 2860, para. 2 (IB 1995); *Hughes Network Systems, LLC*, Declaratory Ruling, 26 FCC Rcd 8521, 8525, paras. 12-14 (IB 2011); *Boeing Company*, Order and Authorization, 16 FCC Rcd 5864, 5866-67, paras. 8-9 (IB and OET 2001).

¹³⁷ *Galileo Public Notice*, Attach. NTIA Waiver Request Letter at 4, 32 FCC Rcd at 8241.

¹³⁸ EC Comments, Attach. at 2 (stating that very limited signal energy is transmitted in the 1215-1219 MHz band).

harmful interference to non-Federal Galileo E5 receivers, given that the 1215-1240 MHz band is allocated to, and used for, Federal RNSS GPS L2 operations on a primary basis in the United States.¹³⁹

36. *Potential for E5 Signal to Interfere with Other Receiver Operations in the RNSS or Adjacent/Nearby Bands.* The *Galileo Public Notice* sought comment on any potential impact from the Galileo E5 signal to non-Federal receiver operations.¹⁴⁰ Based on the record before us, we first conclude that there are no significant electromagnetic compatibility or interoperability issues that would result from the E5 signal operations with respect to non-Federal reception of GPS signals in either the 1164-1215 MHz or 1215-1240 MHz bands (GPS L5 and L2 receivers). As discussed above, the United States and the EC have coordinated operation of the Galileo system with GPS, pursuant to the 2004 EC/US Galileo-GPS agreement.¹⁴¹ NTIA also recognized specifically that the Galileo signals are compatible with the GPS II L5 signal.¹⁴² As noted above, the upper portion of the E5 signal may overlap with a portion of the GPS II L2 signal, which also operates in the 1215-1240 MHz band. Trimble and Deere also state that there are two prevalent GPS receiver RF architectures that are interoperable with Galileo E5 receivers – a “channelized” receiver with an independent RF section for each RNSS band in which GPS operates, and a “wideband” receiver that operates across more than one RNSS band. With regard to the Galileo E5 signal, they state that a channelized GPS receiver operating with the GPS L5 signal in the 1164-1215 MHz band is interoperable with the lower portion of the Galileo E5 signal (i.e., the E5a signal),¹⁴³ and that the wideband GPS receiver operates with both the GPS L5 and L2 signals (across the 1164-1239 MHz continuum in both the 1164-1215 MHz and 1215-1240 MHz RNSS bands) and the E5 signal (in the 1164-1219 MHz continuum).¹⁴⁴ Hexagon states that its NovAtel GNSS receivers track the Galileo E5 signal (as well as the E1 signal in the 1559-1610 MHz band) along with the GPS L5 and L2 signals (as well as the L1 signal in the 1559-1610 MHz RNSS band), and that E5 transmissions do not raise any interference concerns or electromagnetic issues with respect to GPS L5 or L2.¹⁴⁵

37. In addition to our conclusion above with respect to GPS L5 and L2 receiver operations in the 1164-1215 MHz and 1215-1240 MHz bands, respectively, we conclude there are no potential interference issues with ARNS systems in the 1164-1215 MHz band because coordination of Galileo GNSS operations in this RNSS band with ARNS in the 960-1215 MHz band has been ongoing since 2003 through the required ITU Resolution 609 (Rev. WRC-07) consultation processes specified in footnote 5.328A of Article 5 of the ITU Radio Regulations.¹⁴⁶ The EC specifies that the E5 signal operates

¹³⁹ As discussed above, the GPS II L2 signal is transmitted in the 1217.37-1237.83 MHz portion of the 1215-1240 MHz band, and thus has some overlap with the E5 signal. Given that the 1215-1240 MHz band is allocated for Federal RNSS operations on a primary basis, non-Federal Galileo receivers operating with the E5 signal on a non-conforming basis in the 1215-1219 portion of the band effectively will benefit from the harmful interference protection rights afforded to Federal receivers operating with the GPS L2 signal with respect to other Federal co-primary services (EESS, Radiolocation, and SRS) and any secondary non-Federal operations (EESS and SRS).

¹⁴⁰ *Galileo Public Notice*, 32 FCC Rcd at 8231.

¹⁴¹ See generally 2004 EU/US Galileo-GPS Agreement.

¹⁴² *Galileo Public Notice*, Attach. NTIA Waiver Request Letter at 4, 32 FCC Rcd at 8241.

¹⁴³ See Trimble and Deere Comments at 10 (stating that the E5a portion of the Galileo E5 signal at 1164-1188 MHz is coincident with the GPS L5 signal in frequency and bandwidth, ensuring RF interoperability for all GPS L5 capable receivers).

¹⁴⁴ *Id.* at 10 (noting also, however, that the channelized GPS receiver associated with the Galileo E5a signal would not be interoperable with the Galileo E5b signal).

¹⁴⁵ Hexagon Comments at 1-2.

¹⁴⁶ See 47 CFR § 2.106, international footnote 5.328A (“Stations in the radionavigation-satellite service in the band 1164-1215 MHz shall operate in accordance with the provisions of Resolution 609 (Rev. WRC-07) and shall not claim protection from stations in the aeronautical radionavigation service in the band 960-1215 MHz.”).

entirely within the international RNSS allocations, and within the specified power limits and operating conditions defined by ITU Resolution 609 (Rev. WRC-07) for the 1164-1215 MHz band.¹⁴⁷ The EC notes that this is “to ensure that RNSS systems are compatible with, and therefore protect, Distance Measuring Equipment (DME) used by the [ARNS], which RNSS systems recognize as an incumbent user.”¹⁴⁸ In addition, given the very limited E5 signal energy that falls in the 1215-1219 MHz band above 1215 MHz, we do not expect any interference to other non-Federal receivers in the 1215-1240 MHz band.¹⁴⁹

38. We also conclude that the Galileo E5 signal would not interfere with other non-Federal receivers in the adjacent or nearby bands. In particular, we do not expect that there will be any interference issues between the Galileo E5 signal and non-Federal receivers operating in the adjacent 960-1164 MHz band below 1164 MHz, including operations under the ARNS and Aeronautical Mobile Route Service allocations given the coordination required under ITU Resolution 609 (Rev. WRC-07). Furthermore, we do not expect any interference issues with other services’ receivers operating under the secondary EESS and SRS allocations above 1215 MHz,¹⁵⁰ a conclusion consistent with NTIA’s determination with respect to Federal systems operating in these same services.¹⁵¹ We also note that Hexagon comments generally that it is not aware of any interference or interoperability concerns raised by Galileo signals with any other services authorized to operate in adjacent or nearby bands.¹⁵²

39. *Electromagnetic Compatibility of E5 Receivers with non-Federal Transmitters in the RNSS or Adjacent/Nearby Bands.* The *Galileo Public Notice* sought comment on the electromagnetic compatibility of non-Federal receivers that operate with the Galileo E5 signal with non-Federal operations in the 1164-1215 MHz or 1215-1240 MHz frequency bands, or any adjacent or nearby bands.¹⁵³ The *Galileo Public Notice* also inquired about the technical parameters associated with Galileo E5 receiver design, including the assumptions about the RF environment, the variation in Galileo receiver front ends, how receivers operating with the E5 signal are designed to operate with the E1 and/or E6 signal(s), and how the Galileo receivers are designed to promote electromagnetic compatibility with other operations.¹⁵⁴

40. As indicated in the *Galileo Public Notice*, NTIA stated that RF compatibility has been achieved between the Galileo GNSS and Federal systems operating in the bands allocated internationally for RNSS, and pointed out that the Galileo system is interoperable with GPS pursuant to the 2004 EU/US Galileo-GPS Agreement.¹⁵⁵ As discussed above, Trimble and Deere state that the interference profile of Galileo receivers operating with the E5 and E1 signals will be the same as those operating with the GPS L1, L5, and L2 signals, and that what interferes with GPS-only receivers will also interfere with both Galileo-only receivers and with combined GPS/Galileo receivers.¹⁵⁶ Hexagon notes that its NovAtel

¹⁴⁷ EC Comments, Attach. at 1.

¹⁴⁸ *Id.*

¹⁴⁹ *See* EC Comments, Attach. at 2.

¹⁵⁰ 47 CFR § 2.106.

¹⁵¹ *Galileo Public Notice*, Attach. NTIA Waiver Request Letter at 4, 32 FCC Rcd at 8241.

¹⁵² Hexagon Comments at 1.

¹⁵³ 32 FCC Rcd at 8234.

¹⁵⁴ *Id.*

¹⁵⁵ *Id.*, NTIA Waiver Request Letter at 4, 32 FCC Rcd at 8241.

¹⁵⁶ Trimble and Deere Comments at 14 (stating that what interferes with GPS-only receivers will also interfere with both Galileo-only receivers and with combined GPS/Galileo receivers).

receivers have been designed to track the Galileo E5 and GPS L5 and L2 signals (along with the Galileo E1 and GPS L1 signals), that the use of the Galileo signals does not materially change the design of the receivers, and that high precision receivers that support Galileo E1 and E5 signals have the same design performance tradeoffs as those supporting GPS L1, L5, and L2 signals.¹⁵⁷ Accordingly, we do not anticipate that there will be any electromagnetic compatibility issues with respect to the non-Federal receivers operating with the Galileo E5 signal and non-Federal transmissions in the 1164-1215 MHz and 1215-1240 MHz RNSS bands, or in the adjacent or nearby bands, that are any different than those associated with GPS receivers operating with the GPS L5 and L2 signals in those same bands.

41. Accordingly, non-Federal receivers operating with the Galileo E5 signal transmitting across 1164-1219 MHz will benefit from the harmful interference protection rights afforded receivers operating under the primary RNSS allocations with GPS L5 and L2 signals in the 1164-1215 MHz and 1215-1240 MHz bands, respectively.¹⁵⁸ With regard to Galileo E5 receivers that are multi-band and also operate with the E1 signal (and/or the GPS L1 signal) transmitting in the 1559-1610 MHz band, our waiver grant permits operation of non-Federal receivers that have front ends that operate with both the Galileo E5 and E1 signals transmitting in their associated RNSS bands.¹⁵⁹ As discussed below, we deny the waiver for non-Federal operations with the E6 signal in the United States.

3. E6 Signal

42. The Galileo E6 signal transmits in the 1240-1300 MHz band.¹⁶⁰ In the United States, unlike in other countries, there is no allocation for RNSS operations in this band. Further, as discussed below, the adjacent 1300-1350 MHz band is currently being studied for potential reallocation for non-Federal wireless broadband services in the United States and accordingly there are uncertainties associated with the RF environment in which Galileo E6 receivers would operate in the future. Under these circumstances, we deny waivers for non-Federal earth stations/receivers in the United States to operate with the Galileo E6 signal.

43. *E6 Signal and Affected Allocations.* In its request, the EC indicates that the E6 signal will transmit over the 1260-1300 MHz portion of the 1240-1300 MHz band, with a center frequency at 1280

¹⁵⁷ Hexagon Comments at 2. Hexagon also states that receivers that operate with E1 as well as E5 (and E6) signals typically have a common antenna where there may be separate RF paths for the upper and lower L-bands. *Id.* at 3. The 1559-1610 MHz RNSS band is in the upper L-band; the 1164-1215 MHz and 1215-1240 MHz RNSS bands are in the lower L-band. In addition, Hexagon indicates that multi-constellation receivers may be programmable through software to select which satellite signal(s) are used, even if a single antenna is used for the signal types. *Id.* See also Broadcom Comments at 2 (indicating that specific signals can be excluded from use if problematic).

¹⁵⁸ Since the E5 signal transmits across 1164-1219 MHz, it overlaps extensively with both the GPS L5 signal (1164.45-1188.45 MHz), which operates in the 1164-1215 MHz band allocated for both Federal and non-Federal RNSS, and the GPS L2 signal (1217.37-1237.83 MHz), which operates in the 1215-1240 MHz band allocated for Federal RNSS. See *supra* paragraph 33. In addition, receivers that have been designed to operate with the Galileo E5 signal also track the GPS L5 and L2 signals, and the record indicates that E5 receivers have the same interference profile as GPS L5 and L2 receivers. See *supra* paragraph 40; see also *supra* note 139.

¹⁵⁹ For non-Federal multiband receivers that operate with both the Galileo E5 signal (in the 1164-1215 MHz and 1215-1240 MHz RNSS bands) and the E1 signal (in the 1559-1610 MHz RNSS band), the harmful interference protection rights, to the extent applicable, will be the same as discussed above for each of those signals in the particular RNSS bands. Commenters have indicated that Galileo receivers may have a front end that receives both the E5 signal and the E1 signal. See, e.g., Trimble and Deere Comments at 10; Hexagon Comments at 3. To the extent that non-Federal Galileo receivers have a front end that receives transmissions outside of the associated U.S. RNSS bands (e.g., in bands between 1240 MHz and 1559 MHz), such receivers may not be afforded any harmful interference protection rights with respect to the signals received outside of these RNSS bands in the United States.

¹⁶⁰ See *Galileo Public Notice*, 32 FCC Rcd at 8229 (citing Attach. EC Schedule S at 6); EC Comments, Attach. at 1.

MHz and an assigned bandwidth of 40 megahertz.¹⁶¹ As noted in the *Galileo Public Notice*, the E6 signal does not conform with the U.S. Table.¹⁶² While the 1240-1300 MHz band is allocated internationally for RNSS on a primary basis, there is no such Federal or non-Federal RNSS allocation in the United States.¹⁶³ Specifically, this band is allocated to the RNSS on a primary basis in the International Table, along with international primary allocations for the EESS (active), RLS, SRS (active), and an international secondary allocation to the Amateur Radio service.¹⁶⁴ In the United States the 1240-1300 MHz band is allocated on a primary basis for Federal operations to the ARNS, EESS, RLS, and SRS, and for non-Federal operations on a primary basis to the ARNS and on a secondary basis to the EESS, SRS, and Amateur Radio service.¹⁶⁵

44. The *Galileo Public Notice* sought comment on whether, on our own motion, we should waive the relevant provisions in Part 2 of the Commission's rules to permit non-Federal Galileo E6 receiver operations in the 1240-1300 MHz band, which is not allocated to the RNSS in the United States.¹⁶⁶ In its comments, the EC states that its E6 signal operates within the 1260-1300 MHz band in accordance with ITU Radio Regulations.¹⁶⁷ In its comments, GSA supports non-Federal operations with the E6 signal to provide "added-value" services (i.e., enhanced high precision with improved authentication features) through the Galileo Commercial Service (CS),¹⁶⁸ while Trimble and Deere also support such operations, noting generally that there would be potential GNSS enhancements associated with operations with the E6 signal.¹⁶⁹ In a more recent filing, the EC provides further clarification about the E6 signal and its intended use of that signal, including the power levels requested,¹⁷⁰ as well as the services to be provided, which currently would be limited to a Galileo PRS (available only to government-authorized users of the European Union Member States) and in the future also would be used by the Galileo CS to provide professional, high-precision, and authentication uses.¹⁷¹ In response to this later submission, Trimble expresses concerns about Galileo's proposed future operations with the E6 signal to provide its Commercial Service with a free "High Accuracy" service.¹⁷²

¹⁶¹ *Id.*

¹⁶² 47 CFR § 2.106.

¹⁶³ *Id.* See *WRC-02/WRC-03 R&O*, 18 FCC Rcd 23441, para. 34 (declining to consider non-Federal RNSS use of the 1215-1300 MHz band); *WRC-03 R&O*, 20 FCC Rcd at 6608, para 101 (2005) ("Because the record indicated no interest on the matter by any party, we decline to expand the RNSS allocation at 1215-1240 MHz, which is currently limited to Federal use, to the band 1215-1300 MHz and to make it available for both Federal and non-Federal use.").

¹⁶⁴ 47 CFR § 2.106.

¹⁶⁵ *Id.*

¹⁶⁶ *Galileo Public Notice*, 32 FCC Rcd at 8230. See 47 CFR § 2.106.

¹⁶⁷ EC Comments, Attach. at 1.

¹⁶⁸ GSA Comments at 3.

¹⁶⁹ Trimble and Deere Comments at 15.

¹⁷⁰ The EC states that while the current Galileo operations are consistent with the power levels provide in the EC's original submission it its waiver request, the higher power levels for the E6 signal specified in the "Galileo-2" ITU filings define a maximum envelope of potential future emissions as part of the Galileo 2nd Generation system evolution, and that it understood that future action by the Commission may be required in connection with future higher power operations. EC Oct. 2, 2017 *Ex Parte* Letter at 1.

¹⁷¹ *Id.* at 2.

¹⁷² Letter from Russell H. Fox, Mintz, Levin, Counsel for Trimble Inc., to Marlene H. Dortch, Secretary, FCC, IB Docket No. 17-16, Attach. at 1 (filed Dec. 21, 2017) (Trimble Dec. 21, 2017 *Ex Parte* Letter). See also EC Oct. 2, 2017 *Ex Parte* Letter at 2. Trimble is specifically concerned that offering a free service will disrupt existing

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45. We deny the requested waiver for non-Federal receivers to operate with the Galileo E6 signal. Unlike the E1 and E5 signals that transmit in bands allocated for RNSS in the United States, the E6 signal transmits in the 1240-1300 MHz band where there is no such RNSS allocation in the United States. And, unlike in the other bands, where GPS signals overlap with the Galileo signals and are interoperable and RF compatible, no GPS signals overlap with the Galileo E6 signal in the 1240-1300 MHz band and there are no corresponding harmful interference protection rights for GNSS receivers operating with the E6 signal in this band based on any related GPS operations.¹⁷³ We are concerned that granting a waiver for non-Federal receiver operations with the E6 signal at this time, without more extensive consideration of the U.S. allocation issues associated with E6 receiver operations in the 1240-1300 MHz band, would result in significant uncertainty regarding the nature of any harmful interference protection rights that could be afforded operations with the E6 signal now or in the future. We are additionally concerned that granting a waiver has the significant potential of creating problematic electromagnetic compatibility concerns in the future that could constrain our spectrum management regarding non-Federal operations in the United States in the spectrum above 1300 MHz, where potential changes in the non-Federal allocation are under consideration (as discussed below). Accordingly, for these reasons this Order does not afford any harmful interference protection rights to Galileo receivers operating with the E6 signal in the United States.¹⁷⁴ Given that we are not granting a waiver for operations with the E6 signal at this time, we do not address Trimble's *ex parte* filing expressing concerns associated with the E6 signal's Commercial Service.

46. *Potential for E6 Signal to Interfere with Other Receiver Operations in the 1240-1300 MHz band or Adjacent/Nearby Bands.* In its 2015 letter recommending a waiver regarding the E6 signal, NTIA noted that, although the Galileo E6 signal would exceed established protection criteria of Federal radars operating in the 1240-1300 MHz band, the affected Federal agencies have agreed that they can mitigate potential interference.¹⁷⁵ In its comments, the EC states that it is not aware of any interference issues associated with its E6 signal and any current receiver operations in the 1240-1300 MHz or adjacent/nearby bands.¹⁷⁶ While it states that there is some potential for harmful interference with respect to operations of long range radars, it asserts that these concerns can be addressed by interference mitigation techniques and frequency diversity,¹⁷⁷ and notes that it has successfully coordinated its E6 signal with at least two EESS systems that operate in the 1240-1300 MHz band.¹⁷⁸ Trimble and Deere, meanwhile, note that currently there are only limited non-Federal operations near the E6 signal, and state that the risk of interference to these operations is low.¹⁷⁹ Although we conclude that potential interference to non-Federal receivers that *currently* operate in the 1240-1300 MHz band and the adjacent/nearby bands could be addressed by interference mitigation measures, we nonetheless are concerned about potential

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commercial markets and commercial investments that provide High Accuracy services for a fee. *See* Trimble Dec. 21, 2017 *Ex Parte* Letter.

¹⁷³ See discussion above, in which we are granting waivers for non-Federal receiver operations with both the E1 and E5 signals, respectively, and such receivers will have or benefit from the same harmful interference protection rights afforded receivers operating with GPS signals in the associated RNSS bands.

¹⁷⁴ To the extent that non-Federal Galileo receivers have a front end that is capable of receiving the E6 signal transmission in the 1240-1300 MHz band, such receivers may not be afforded any harmful interference protection rights with respect to this signal in the United States. *See supra* note 159.

¹⁷⁵ NTIA Waiver Request Letter at 4, 32 FCC Rcd at 8241.

¹⁷⁶ EC Comments, Attach. at 2.

¹⁷⁷ EC Comments, Attach. at 3; EC October 2, 2017 *Ex Parte* at 2.

¹⁷⁸ EC Comments, Attach. at 2.

¹⁷⁹ Trimble and Deere Comments at 15.

receiver operations in the 1240-1300 MHz band and other electromagnetic compatibility concerns that may arise in the future with respect to operations in the adjacent 1300-1350 MHz band, where consideration is being given to migrating current long-range radar operations out of the band to enable reallocation of the spectrum for non-Federal wireless broadband operations, as discussed below.

47. *Electromagnetic Compatibility of Galileo E6 Receivers and non-Federal Transmissions in the 1240-1300 MHz Band or in Adjacent or Nearby Bands.* The record before us provides very limited information regarding the design of Galileo E6 receivers and their interference profile. As discussed above, the EC does not prescribe how manufacturers design Galileo receivers. Hexagon comments that the Galileo E6 signal in the 1260-1300 MHz band extends the passband beyond what GPS multi-frequency support requires, and that addition of the E6 signal requires specific receiver design choices to simultaneously support use of that signal in conjunction with the Galileo E1 and E5 and GPS L1, L5, and L2 signals.¹⁸⁰ Hexagon notes further that the RF assumptions that it employs when designing receivers are based on the approved uses in the adjacent or nearby bands at the time of the design.¹⁸¹ No comments specifically addressed the electromagnetic compatibility of Galileo E6 receivers with non-Federal transmitters in the adjacent or nearby bands, including whether or how such receivers may be designed to include front ends that may be effective against, or mitigate, interference from such operations in those bands.

48. Subsequent to the EC's filing of its waiver request and NTIA's 2015 letter recommending the Commission's grant of a waiver with respect to non-Federal operations with the Galileo E6 signal, NTIA identified the 1300-1350 MHz band (a sub-band in the 1300-1390 MHz band) as potential spectrum for accommodating new non-Federal wireless broadband operations.¹⁸² More recently, in 2017, several Federal agencies jointly began conducting feasibility studies, as part of the Spectrum Efficient National Surveillance Radar (SENSR) program, to consider the potential migration of certain Federal long-range radar systems out of this sub-band, which in turn could lay the foundation for making 30 or more megahertz of this spectrum available for re-allocation and auction by the Commission for shared use of the band by non-Federal wireless broadband services.¹⁸³ This Federal effort, which received funding in June 2017 from the Spectrum Relocation Fund,¹⁸⁴ was authorized by Congress in the Spectrum Pipeline Act of 2015.¹⁸⁵

¹⁸⁰ Hexagon Comments at 2

¹⁸¹ Hexagon Comments at 3.

¹⁸² See NTIA, *Quantitative Assessments of Spectrum Usage* at 7-8, 57-58 (Nov. 17, 2016), https://www.ntia.doc.gov/files/ntia/publications/ntia_quant_assessment_report-no_appendices.pdf.

¹⁸³ These agencies include the Federal Aviation Administration, the Department of Defense, the Department of Homeland Security, and the Department of Commerce's National Oceanic and Atmospheric Administration, which are participating in the Spectrum Efficient National Surveillance Radar (SENSR) program. See SENSR Spectrum Pipeline Plan, Version 5.0, Jan. 3, 2017, at 3, 5-6. The SENSR Spectrum Pipeline Plan, Version 5.0, is currently available on the FAA Contract Opportunities Internet page under FAA Solicitation/Contract No. 26320 in Attachment 1 of the Spectrum Efficient National Surveillance Radar Program (SENSR) – Formal Request for Information (RFI) Public Announcement – Pre-SIR, (posted Jan. 3, 2017) (SENSR Program RFI), at <https://faaco.faa.gov/index.cfm/announcement/view/26320> (last visited Oct. 18, 2018).

¹⁸⁴ See *SENSR Team Gets Green Light for Spectrum Analysis*, Federal Aviation Administration, June 2, 2017, https://www.faa.gov/news/updates/?newsId=88187&omniRss=news_updatesAoc&cid=101_N_U (noting that the Office of Management and Budget distributed \$71.5 million to the Federal agencies to proceed with the SENSR program feasibility studies). The Spectrum Pipeline Act of 2015 authorized use of the Spectrum Relocation Fund for research and development, engineering studies, economic analyses, activities with respect to systems, or other planning activities intended to improve the efficiency and effectiveness of the spectrum use by Federal entities. 47 U.S.C. §§ 928(g)(2)(A), (B). Also as part of the Spectrum Pipeline Act of 2015, Congress directed that by 2022 the Secretary of Commerce identify 30 megahertz of spectrum below 3 GHz for reallocation from Federal use to non-

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49. As discussed above, at this time we deny a waiver for non-Federal receivers to operate with the Galileo E6 signal.¹⁸⁶ Such a grant could adversely affect the Commission's spectrum management responsibilities with respect to U.S. allocations in the 1240-1300 MHz band and the 1300-1350 MHz band, including any potential accommodation of non-Federal wireless broadband in the 1300-1350 MHz band. The future RF environment around the 1300-1350 MHz band is uncertain, and the type of allocation and service rules that might be developed to accommodate wireless broadband is undetermined at this time. We are also particularly concerned about the electromagnetic compatibility of non-Federal receivers operating with the E6 signal in the 1240-1300 MHz band with potential non-Federal wireless broadband operations in the adjacent 1300-1350 MHz band. There is nothing in the record to indicate whether or how Galileo E6 receivers might be compatible with possible future changes in the non-Federal allocation for wireless broadband or the corresponding RF environment in the immediately adjacent 1300-1350 MHz band. As Hexagon indicates, receiver manufacturers often design receivers for electromagnetic compatibility with other operations that exist at the time of design,¹⁸⁷ and accordingly such receivers may not be designed to ensure compatibility with other, different types of operations that potentially may arise in the future. Moreover, we are concerned that approving use in the United States of non-Federal receivers that operate with the E6 signal, where such receivers have not been designed effectively to address potential non-Federal wireless broadband operations above 1300 MHz, could have the potential in the future to adversely affect overall PNT performance, reliability, and interference resiliency of these receivers and services that users may have come to rely upon to the extent such devices are not electromagnetically compatible with future non-Federal wireless broadband operations. We do not want to take any action in this Order that would potentially undermine the reliability and resilience, and the associated public interest benefits, of space-based PNT services in the United States.

C. Other Considerations

50. *Enhanced 911*. A number of comments addressing the public interest benefits of granting the requested waiver also described the potential benefits of utilizing the Galileo signals in support of E911.¹⁸⁸ For example, NENA expressed general support for grant of the waiver request, noting that grant of the waiver could help to ensure the availability of the Galileo signals for next generation E911.¹⁸⁹ In 2015, the Commission issued an order addressing, among other things, use of foreign GNSS signals for E911.¹⁹⁰ It emphasized that the Commission had not approved any waiver petition or application that

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Federal or shared use, and for the Commission to auction such spectrum by 2024. Spectrum Pipeline Act of 2015, 10 U.S.C. §§ 1004(a), (c).

¹⁸⁵ Spectrum Pipeline Act of 2015, Pub. L. 114-74, §1005(g), 129 Stat. 621 (Nov. 2, 2015), codified at 47 U.S.C. §928(g) (Spectrum Pipeline Act).

¹⁸⁶ In denying a waiver to permit Galileo receivers to operate with the E6 signal in the United States, Galileo multiband receivers that have front ends that include the capability to receive the E6 signal are not permitted to operate with this signal in the United States. As discussed above, commenters have indicated that multiband receivers capable of receiving the E6 signal may be programmable through software or otherwise designed to exclude operations with this particular signal. *See supra* note 157 (citing Hexagon and Broadcom comments). *See also infra* paragraph 50 (noting that the Commission has not at this time authorized Galileo receivers to use the E1 and E5 signals in support of E911).

¹⁸⁷ Hexagon Comments at 3.

¹⁸⁸ *See, e.g.*, NENA Comments; Trimble and Deere Comments at 4; T-Mobile Reply Comments at 3-5.

¹⁸⁹ NENA Comments at 1.

¹⁹⁰ *Wireless E911 Location Accuracy Requirements*, Fourth Report and Order, 30 FCC Rcd 1259, 1272-73 paras. 38-40 (2015).

would seek authorized use of any non-U.S. GNSS to support E911 location services, noted concerns with such operations, and identified procedures for Commercial Mobile Radio Service (CMRS) providers to follow before non-U.S. GNSS signals could be integrated into E911.¹⁹¹ This Order does not address these additional procedures that CMRS providers must follow before integrating the Galileo E1 and E5 signals for E911 location services.

51. *Orbital Debris Mitigation.* When NTIA outlined the criteria it would apply in considering whether to recommend waiver of the FCC rules related to operations with non-U.S. licensed GNSS, NTIA specified that it would consider whether the system complies with the *United Nations Space Debris Mitigation Guidelines*.¹⁹² We note that in its recommendation to grant the EC's requested waiver, NTIA stated its view that the Galileo system complies with the *United Nations Space Debris Mitigation Guidelines*.¹⁹³ It further stated that the Galileo system is being built and operated under the European Space Agency (ESA) space debris mitigation requirements, and that the U.S. State Department had stated that ESA's requirements comply with the *United Nations Space Debris Mitigation Guidelines*.¹⁹⁴ The EC included with its request a technical note addressing compliance with the *United Nations Space Debris Mitigation Guidelines*.¹⁹⁵ We have reviewed the information provided and conclude that it is sufficient to satisfy our requirements regarding orbital debris mitigation.

52. Finally, we emphasize that this Order is specific to the Galileo system and the signals whose technical characteristics are described in the EC's request, as subsequently clarified. This Order does not address, or provide waiver with respect to, non-Federal earth station/receiver operations with any other GNSS networks or signals.¹⁹⁶

IV. ORDERING CLAUSES

53. Accordingly, IT IS ORDERED, that the request for waivers of Sections 25.131(j)(1) and 25.137 of the Commission's rules, 47 CFR §§ 25.131(j)(1), 25.137, to permit non-Federal earth stations within the United States to operate with certain signals from the Galileo GNSS without an earth station license or a Galileo GNSS market access grant, as submitted by the European Commission via the National Telecommunications and Information Administration, IS GRANTED-IN-PART, pursuant to

¹⁹¹ See *id.* at 1272-73, paras. 39-40. In addition to ensuring that devices have the proper authorizations as requested by the EC here, these identified procedures by CMRS providers include: "conduct[ing] testing to ensure that operation with [non-U.S. satellite] signals does not inadvertently introduce vulnerabilities to the devices that could impair E911 performance or compromise data integrity[]"; evaluating devices to "determine their capabilities to detect and mitigate the effects of inaccurate or corrupted data from any RNSS system that could result in incorrect location information, or no information at all, being relayed to a [public safety answering point]"; certifying "that the devices have been tested to determine their ability to detect and mitigate the effects of harmful interference[]"; and coordinating with the Commission's Public Safety and Homeland Security Bureau to "confirm that [the non-U.S. GNSS] signals are interoperable with GPS and that measures to prevent interference are appropriate." *Id.*

¹⁹² *GNSS Public Notice*, 26 FCC Rcd at 3868.

¹⁹³ *Galileo Public Notice*, Attach. NTIA Waiver Request Letter at 3, 32 FCC Rcd at 8240 (citing United Nations Office for Outer Space Affairs, *Space Debris Mitigation Guideline of the Committee on the Peaceful Uses of Outer Space* (2010), available at http://www.unoosa.org/pdf/bst/COPUOS-SPACE_DEBRIS_MITIGATION_GUIDELINES.pdf).

¹⁹⁴ *Id.*

¹⁹⁵ *Galileo Public Notice*, Attach. ESA Technical Note, 32 FCC Rcd at 8245-52 (the Technical Note on Galileo Programme Compliance with United Nations Space Debris Mitigation Guidelines was part of the EC's waiver request).

¹⁹⁶ We note that there are no agreements in place between the U.S. and Administrations responsible for other GNSS networks. Nor are we aware of any compatibility or interoperability agreements in place between the EC and other Administrations responsible for other GNSS networks.

Section 303(r) of the Communications Act of 1934, as amended, 47 U.S.C. § 303(r), and Section 1.3 of the Commission's Rules, 47 CFR § 1.3. Waiver is granted with respect to the following signals, as clarified by the European Commission regarding the bandwidth and power levels:

a. Non-Federal U.S. earth stations are permitted to operate with the Galileo E1 signal in the 1559-1591 MHz frequency band.¹⁹⁷

b. Non-Federal U.S. earth stations are permitted to operate with the Galileo E5 signal in the 1164-1219 MHz frequency band.¹⁹⁸ Operations with the Galileo E5 signal in the 1215-1219 MHz band are on a non-conforming basis, as discussed in paragraph 35 and are subject to ITU Resolution 609 (Rev. WRC-07) ("Protection of aeronautical radionavigation service systems from the equivalent power-flux density produced by radionavigation-satellite service networks and systems in the 1164-1215 MHz frequency band").

54. IT IS FURTHER ORDERED that on our own motion, waiver of the United States Table of Frequency Allocations, Section 2.106 of the Commission's rules, 47 CFR § 2.106, is GRANTED, to permit the operation of earth stations in the United States with the portion of the Galileo E5 signal that extends into the 1215-1240 MHz frequency band, specifically the 1215-1219 MHz band.

55. IT IS FURTHER ORDERED that the EC's waiver request with respect to earth stations operating with the Galileo E6 signal (centered at 1278.75 MHz) is DENIED.

56. IT IS FURTHER ORDERED that this grant is limited to receive-only GNSS (which includes positioning¹⁹⁹) devices and standard time and frequency satellite services.

FEDERAL COMMUNICATIONS COMMISSION

Marlene H. Dortch
Secretary

¹⁹⁷ These operations are within the 1559-1610 MHz frequency band which is allocated for RNSS in the U.S. and internationally. *See* U.S. Table of Frequency Allocations, 47 CFR § 2.106.

¹⁹⁸ These operations are in the 1164-1215 MHz frequency band, which is allocated for RNSS in the U.S. and internationally, and in the 1215-1240 MHz frequency band, which is allocated for RNSS in the U.S. for Federal systems and internationally. *See id.*

¹⁹⁹ *See* ITU Radio Regulations Nos. 1.9 and 1.10 and NTIA Manual Chapter 6.