

THE UNITED STATES FEDERAL COMMUNICATIONS COMMISSION'S REGULATIONS CONCERNING MITIGATION OF ORBITAL DEBRIS

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ABSTRACT

In June of 2004, the United States (U.S.) Federal Communications Commission (FCC) adopted a comprehensive set of regulations concerning mitigation of orbital debris. These regulations apply to licensing of commercial U.S. satellites and to the use of non-U.S. satellites to provide service in the United States. The rules require disclosure, prior to authorization, of debris mitigation measures, including end-of-life measures. They also state operational requirements for U.S. satellites, including a requirement that satellites in geostationary orbit follow end-of-life disposal measures consistent with the guidelines adopted by the Inter-Agency Debris Coordinating Committee (IADC). This paper provides background information concerning the FCC and its licensing process, a short history of FCC actions concerning debris mitigation, and a detailed discussion of the scope and major elements of the FCC decision.

1. INTRODUCTION

The United States (U.S.) Federal Communications Commission (FCC) is the U.S. agency responsible for licensing radio transmissions by private entities, including transmissions by satellite. Approximately 90 geostationary and 170 non-geostationary satellites operate under an FCC license, and approximately an additional 40 foreign-licensed satellites provide service to satellite earth stations licensed by the FCC.

The FCC was created in 1934, prior to the advent of satellite communications, by the Communications Act of 1934. The Communications Act gives the FCC broad authority to regulate the operations of private radio stations in the "public interest." The Act's core provisions concerning radio have remained largely unchanged since 1934. No changes to the Act were needed in order to begin licensing satellites.

In June of 2004, the FCC adopted a comprehensive set of rules concerning mitigation of orbital debris. The FCC concluded that orbital debris can affect the cost, reliability, continuity, and safety of satellite operations, and of the services they provide to the public. The FCC also noted that robotic spacecraft are typically controlled by radiocommunication links. The FCC

concluded, therefore, that orbital debris and related mitigation issues are "relevant in determining whether the public interest would be served by authorization of any particular satellite system, or by any particular practice or operating procedure of satellite systems."

2. THE FCC LICENSING PROCESS

The FCC licenses radio stations using a public process. An operator must submit an application for any authorization. The FCC's rules specify the necessary information that must be submitted with the application. The application is a public document, available through the FCC's internet site. Prior to acting on applications, the FCC provides public notice and an opportunity for comment, except in emergency circumstances.

Applications for satellite service authorizations must include basic technical information about the spacecraft involved, such as anticipated or actual orbital parameters and spacecraft characteristics. Licenses are typically for fifteen years, although the FCC may also issue shorter term authorizations. The license includes any terms and conditions of authorization. Licensed stations are also subject to operational requirements in the FCC's rules.

3. FCC ACTIONS CONCERNING ORBITAL DEBRIS PRIOR TO 2004

FCC involvement with debris mitigation issues, particularly in the licensing process, is a relatively recent development. The FCC first officially noted the issue of debris mitigation in 1994, in connection with the authorization of so-called "Big LEO" satellite constellations. The FCC participated in the development of the U.S. Government's 1995 Interagency Report on Orbital Debris, and in subsequent years participated in the U.S. Government's development of debris mitigation guidelines.

In 1999, the FCC proposed for the first time, in connection with developing rules for a new type of satellite service, to adopt a requirement that applicants for authorizations in that service disclose debris mitigation plans, including any casualty risks that

might result from disposal of satellites by atmospheric reentry. The proposal was adopted the following year. In a series of actions over the following three years, the FCC adopted the same requirement for most new services.

The FCC has also issued decisions, with increasing frequency, in individual licensing cases. In one case, the FCC approved the end-of-life disposal plan for spacecraft in the Iridium low-Earth orbit (LEO) constellation. In another, the FCC granted a request to increase the orbital altitude of a portion of Orbcomm's satellite constellation, but required Orbcomm to take steps to reduce the orbital lifetime of those satellites, following end of life, to no more than 25 years. The FCC has also issued a number of decisions discussing and analyzing information submitted pursuant to disclosure requirements.

4. FCC DEBRIS MITIGATION RULES

The 2004 debris mitigation rules consolidate earlier disclosure requirements, and provide more detailed guidance to applicants concerning information that should be submitted. The new rules also for the first time adopt operational requirements concerning debris mitigation, specifically in connection with end-of-life disposal.

At the risk of some over-simplification, the new disclosure and operational requirements can be placed in three categories. The first category is disclosure concerning avoiding collisions with other large objects during normal operations. The second category is disclosure and operational requirements concerning post-mission disposal. The third category is disclosure concerning assessments and analyses designed to prevent the spacecraft becoming a source of debris, either through planned operations or through spacecraft system failures during normal operations. Spacecraft shielding to prevent loss of control due to collisions with small debris, efforts to minimize explosions, and control of debris released during normal operations all fall into this third category.

4.1. Collisions with large objects

The FCC required that applicants indicate that they have assessed and limited the probability of a spacecraft becoming a source of debris by collisions with other operational spacecraft or large debris. The FCC observed that, given the relatively low spatial density of large objects, this objective is likely to be readily obtainable. It indicated, however, that three specific scenarios may warrant more detailed

discussion of methods that will be used to limit collision risk.

The first scenario involves proposals to co-locate multiple satellites at a single geostationary orbital location. Any entity requesting an assignment of a GEO orbital location must assess whether there are any known satellites located at, or reasonably expected to be located at, the requested orbital location, or assigned in the vicinity of that location such that the station keeping volumes of the respective satellites might overlap. If so, the entity's orbital debris mitigation statement must include a statement as to the identities of those parties and the measures that will be taken to prevent collisions. This statement should address any FCC-licensed systems, or any systems applied for and under consideration. The statement need not address every filing with the International Telecommunication Union (ITU) that meets these criteria. The operator should, however, assess and address any systems reflected in ITU filings that are in operation or that it believes may be progressing toward launch, for example, by the appearance of the system on a launch vehicle manifest.

The FCC observed that there are a number of cases in which operators have successfully located multiple satellites at a single location, and within the same station-keeping volume. These arrangements require real-time coordination. Where the satellites are not operated by a single company, such coordination may present logistical or cost considerations that render it undesirable as a first choice for preventing collisions. Furthermore, in cases where operators coordinate operations, it is particularly important that they use common methods of calibrating measurement of satellite positions, or rely on a third party to provide that service.

The FCC stated that it will require entities that indicate that they plan to rely on coordination with other operators at the same orbital location to disclose the manner in which that coordination will be effected.

The second scenario is one in which a system will be operated at a low-Earth orbit that is identical, or very similar, to an orbit used by other systems. The FCC indicated that in such cases, an operator should submit an analysis of the potential risk of collision between the LEO systems and a description of what measures the operator plans to take to avoid in-orbit collisions. If the operator is relying on coordination with another system, the operator must indicate what steps have been taken to contact, and to ascertain the likelihood of successful coordination of physical operations with, the other system.

The third scenario involves inhabitable orbiting objects. The FCC concluded that it did not have sufficient information to specify a minimum separation from manned spacecraft, but required that entities seeking approval for LEO operations should address in their disclosure statements any measures, such as coordination of maneuvers, that will be taken in connection with inhabitable orbiting objects.

4.2 Post-Mission Disposal

The new FCC rules require, for all licensed spacecraft, that unless prevented by technical failures beyond the operator's control, the operator must discharge all stored energy sources on the spacecraft at the spacecraft's end of life.

The FCC also adopted additional requirements for geostationary and non-geostationary spacecraft.

For geostationary spacecraft, the FCC adopted a requirement that spacecraft be disposed of to an altitude derived from the formula in the Interagency Space Debris Coordinating Committee (IADC) Space Debris Mitigation Guidelines and in the essentially identical ITU recommendation concerning environmental protection of the geostationary orbit. Another rule also granted operators the authority for radiocommunications necessary to undertake the disposal maneuvers, without the need for obtaining prior FCC approval, so long as such maneuvers achieve the required minimum altitude.

The FCC concluded that a disposal requirement for geostationary spacecraft is necessary because economic incentives alone may not be sufficient to result in disposal practices that limit long-term collision risks in and around the geostationary orbit. The FCC observed that operators may face short term incentives, such as the desire to generate additional revenue, or to bring into use an orbital location for purposes of preserving priority in the ITU satellite network registration process. The FCC also indicated that the effects of an inadequate disposal will potentially impact not only the location an operator uses, but a large number of orbital locations, and have effects that will extend beyond the timeframe of an operator's planned business activities.

The disposal requirement applies to geostationary spacecraft already launched. This caused some concern among commercial operators because of its financial impact. As compared to disposal to an altitude of 150 kilometers above GEO – the minimum perigee increase previously targeted by some

commercial operators – a perigee increase under the new requirement would use more fuel, in an amount that would otherwise be sufficient for two to three months of station-keeping. This two to three months represents slightly less than two percent of a 15 year operational life, and, consequently, a commensurate loss in revenue expected over the lifetime of the satellite. Based on this potential financial impact, and with no evidence before it that a continuation of U.S. operators' current practices, for a finite number of satellites, would substantially increase collision risk, the FCC decided to "grandfather" geostationary spacecraft launched prior to March 18, 2002, the date on which the FCC first proposed to adopt spacecraft disposal rules. Spacecraft disposed of under the "grandfathering" provision must apply for and obtain prior approval for end-of-life operations.

The FCC also adopted disclosure requirements concerning post mission disposal of geostationary spacecraft. An applicant for a new authorization must detail the post-mission disposal plans for the spacecraft. The statement must disclose the altitude selected for a post-mission disposal orbit and the calculations that are used in deriving the disposal altitude. It must also include the quantity of fuel that will be reserved for post-mission disposal maneuvers, as well as the methodology used to derive that quantity, including the methods used to determine and address fuel gauging uncertainty.

For non-geostationary spacecraft, the FCC received a number of proposals for operational requirements, particularly for LEO spacecraft, as part of the "notice and comment" procedure used to adopt the rules. Those proposals included: 1) limiting micro-satellite constellations of 100 or more spacecraft to altitudes from which they will reenter the Earth's atmosphere within five years; 2) limiting micro-satellites to orbits with perigees below a certain altitude, such as 625 kilometers; 3) requiring satellites lacking propulsion to incorporate inflatable drag enhancing devices. These proposals arose from concerns about the reliability of individual spacecraft disposal mechanisms, particularly for large constellations, and the limited disposal options for spacecraft lacking propulsion. The FCC decided not to adopt specific operational requirements, and instead indicated that it would continue to evaluate end-of-life disposal plans on a case-by-case basis. The FCC indicated, however, that in cases involving satellite designs having known and significant failure rates, or where a satellite system has been designed with an acceptable failure rate for individual satellites that is well below industry norms, reliability may be relevant to both assessment of whether the satellite will meet end-of-life goals, and to assessment of whether

the purported public interest benefits arising from its activities will, in fact, be realized.

The FCC also indicated that it will require disclosure of the details of proposed end-of-life plans for non-geostationary spacecraft, and that it would examine such disclosures based upon the IADC recommendation that spacecraft at end of life remain in the LEO region for no longer than 25 years.

All three of the operational communications satellite systems licensed by the FCC for LEO operations were fielded prior to adoption of the IADC 25 year guideline. One system, the Iridium system, was designed and has been authorized to follow a maneuver strategy for its 79 currently operational spacecraft that would result in removal of each spacecraft from orbit within approximately two years after it reaches end of life. Another system, the Orbcomm system, lacks significant propulsion capabilities. The 36 Orbcomm spacecraft are expected to exceed the 25 year guideline, by perhaps as much as 15 to 25 years. A third system, the Globalstar system, which operates at approximately 1414 kilometers altitude, was designed with a disposal strategy of raising satellites by 100 kilometers. Globalstar recently revised its end-of-life strategy to restate the 100 kilometer goal as a minimum and to adopt a strategy which appears likely to result in some of its 51 currently active satellites being removed entirely at end of life from the LEO region, i.e., to an altitude above 2000 kilometers. The FCC recently approved this modified strategy.

The FCC rules specifically require, for disposal plans involving atmospheric reentry of the spacecraft, that the applicant provide a casualty risk assessment. This assessment should include an estimate as to whether the spacecraft will survive re-entry and reach the surface of the Earth, as well as an estimate of the resulting probability of human casualty.

The FCC's staff has also provided additional written guidance concerning the information that must be included in such disclosures. Casualty risk assessments must include a statement as to whether the atmospheric re-entry of the satellite will be controlled or uncontrolled. For controlled re-entry, the assessment must include the projected geographic region of the debris field of the surviving components/fragments, if any, and any measures taken to forewarn people who are likely to be in the geographic region during the time period of the re-entry. For uncontrolled re-entry, the assessment must include: 1) an estimate of the number of components/fragments, and their estimated dimensions and mass, likely to survive to the Earth's

surface; 2) an estimate of the probability of human casualty resulting from surviving components or fragments of the satellite; 3) a full description of the assumptions and parameters used in developing the estimates. In the event information on satellite design characteristics, satellite components, and satellite ground track during re-entry are not yet known, the applicant must provide information based on assumptions and parameters of a "worst-case" scenario.

The FCC staff also provided a sample methodology for estimating the probability of human casualty resulting from components/fragments that survive satellite atmospheric re-entry, and references to relevant documents, software tools, and data sources.

4.3 Other required disclosures

The rules require disclosure concerning control of debris released during normal operation, efforts to minimize spacecraft explosions, and spacecraft shielding to prevent loss of control due to collisions with small debris. The FCC noted that most commercial communications spacecraft do not release debris during normal operations. The FCC also observed that economic incentives are likely to be sufficient in most cases to ensure that operators will avoid explosions, loss of a spacecraft resulting from collisions with small debris, or other similar events that extinguish the revenue-producing activities of spacecraft. The FCC concluded that, in most cases, these disclosure requirements can be addressed by a brief statement indicating that no operational debris will be released, and that the operator has assessed and limited the likelihood of loss of control due to small debris, or explosions.

The FCC retains discretion in any case to request additional information.

5. INSURANCE AND LIABILITY ISSUES

The FCC decision also discussed liability and the role of insurance in debris mitigation.

With respect to liability, the FCC stressed that its examination of debris mitigation and post-mission disposal plans is restricted to an inquiry as to whether a space station operator has integrated debris mitigation measures into the design and operation of its spacecraft and as to whether such designs and operations might raise obvious public interest concerns. The FCC stated that its review of debris mitigation plans, or grant of authority to dispose of spacecraft at end of life, does not address, and is not intended to alter, any liability of

any private company in connection with the commissioning, operation, or de-commissioning of a satellite system.

In connection with its decision to “grandfather” the disposal practices of certain geostationary satellites, the FCC also noted a judicial decision. That decision assessed private liability for a loss at sea during a storm, because the ship in question had not adopted the safety practice, adopted by a number of other ships, of carrying new radio equipment that provided improved weather information. The court assessed liability even though the new safety practice was not required by a specific statute or regulation.

With respect to insurance, the FCC concluded that there may be cases in which requiring operators to obtain insurance would not be unreasonable. The FCC specifically mentioned cases involving use of atmospheric reentry for spacecraft disposal, particularly those in which there is a risk that portions of the spacecraft will strike the surface of the Earth. The FCC also noted that certain risks, such as third party liability resulting from collision risks for a disposed spacecraft that has an extremely long orbital lifetime, may not be easily amenable to insurance. The FCC declined to adopt a specific insurance requirement, and instead indicated that it would proceed on a case-by-case basis.

6. SCOPE OF THE FCC RULES

The FCC licenses both space stations (the ITU term for a radio station on board a satellite) and earth stations (terrestrial radio stations used to communicate with or through a space station). As commercial satellite communications have become increasing international in scope, applicants seeking authority from the FCC for an earth station often request to communicate with a space station that is not licensed by the FCC, but instead by a non-U.S. administration. The FCC requires the submission of technical information concerning such satellites and has adopted streamlined procedures to facilitate consideration of that information. The new orbital debris disclosure rules will apply in such cases.

In the case of remote sensing satellites, Congressional legislation specifically grants the U.S. Commerce Department’s National Oceanic and Atmospheric Administration (NOAA) authority for licensing the remote sensing operations of the satellite, and in ensuring end-of-life disposal “in a manner satisfactory to the President.” The FCC, however, licenses the radio-frequency aspects of remote sensing satellites. The FCC concluded that, for remote sensing satellites,

it will examine any debris mitigation issues not addressed by the NOAA licensing process.

The FCC’s operational and disclosure requirements do not apply to launch vehicles, which in the U.S. are regulated by the Federal Aviation Administration. The FCC indicated, however, that it would retain discretion, in the case of spacecraft launched by foreign launchers, to address any debris mitigation concerns, in the unlikely event such concerns are brought to the FCC’s attention. The FCC indicated, however, that it would continue its current practice of not routinely requiring information about the launch vehicle used to launch an FCC-authorized space station.

The FCC’s disclosure requirements apply to regular commercial operations, as well as experimental satellite communications and U.S. amateur satellites.

7. CONCLUSION

The FCC’s new debris mitigation rules provide a comprehensive framework for review and regulation of the debris mitigation practices of commercial spacecraft operations. The FCC’s rules and policies incorporate the latest recommendations of the IADC and ITU. The FCC’s established licensing process will ensure public disclosure and review of mitigation practices, including any new practices or recommendations that may be developed. The FCC’s ultimate goal in taking such actions is to protect the public interest in the continuity, reliability, and safety of satellite operations.

8. REFERENCES

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*FCC decision documents are indexed and available at:
<http://www.fcc.gov/ib/pdocs.html>