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THE ART & SCIENCE OF THE LEO SATELLITE LICENSE GAME

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Abstract

The model in this paper focuses on the process by which the FCC determines the magnitude of the hurdles for companies wanting a license to operate a low earth orbit satellite system. The FCC faces pressure from at least three groups, GEO satellite companies, LEO satellite companies, and consumers. The FCC's optimal strategy is shown to require balancing pressures from various groups so that, at the margin, all groups have the same sensitivity to a change in the fees. Because LEO satellite companies and their customers are unable to muster the influence that traditional GEO companies can, the FCC's rational policy requires setting LEO licensing fees high enough to evoke angry reactions from the LEO industry. Although the FCC appears to set policy to protect the interests of GEO companies, the Commission is acting in its own interest given the system of incentives currently in place. Solutions that give customers more weight in the process, such as educating consumers on the benefits of LEO systems, can shift the weights toward lower license fees. If the FCC does not worry about the funding of its operating expenses, hurdles to LEO satellite systems would be lower.

Introduction

With the rapid development of technology toward miniaturization and new techniques for launching satellites, the interest in small satellites has increased dramatically in the past five years. Although Motorola's IRIDIUM™ project has generated a great deal of controversy, IRIDIUM™ has succeeded in focusing attention and resources on developing small satellite systems in low earth orbit.

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The commercial focus of low earth orbit (LEO) satellite companies is a fundamental shift in a business that has a history of military orientation. Promises of a wireless revolution have attracted much consumer attention, and demand for new services such as cellular phones, wide area paging and messaging networks has skyrocketed. The prospect of a global personal communications system has significant appeal to consumers who have begun to appreciate the prospects on a small scale with cordless phones in the home. The competition between various segments of the communications industry has therefore become a heated battle at the initial stages of development. The heat especially focused on the regulatory proceedings that are the antecedent to offering services. WARC '92 validated the importance of the new LEO technologies by clearing the underbrush associated with frequency allocations for these systems.

Many obstacles to the offering of LEO satellite services remain, but the initial hurdle is the license to orbital and frequency allocations from the FCC. Rothblatt argues that the orbital slot allocation is really a frequency allocation which in any case requires the FCC to issue a license.[1] The FCC is the gatekeeper for entry to the marketplace, and therefore the licensing process constitutes a barrier to entry. LEO satellite companies must struggle with other LEO companies and with other interested parties (GEO companies, cellular providers, etc.) to wrest a license from the FCC. Each of the interested parties pressures the FCC to act on the licensing applications so that the interest of the pressuring group is served. The depth of emotion on these issues is apparent even in the public comments filed with the FCC. They contain a level of vitriolic discourse seldom encountered outside the studios of *Crossfire* or *Evans and Novak*. Nonetheless, economic models of regulatory behavior are applicable to the FCC licensing process for LEO satellites.[2,3,4]

The objective of this paper is to explain the process by which the FCC determines the height of the hurdles that companies must vault in order to receive a license. The licensing game is complex with requirements along many dimensions (legal, financial, and technical) that are codified in Part 25 of Section 47 of the Code of Federal Regulations. Although many aspects of the licensing game for LEO companies should be investigated, we

focus on the direct and indirect costs of acquiring an operating license.[5] Here we construct a stylized model of the process by concentrating on a single dimension of the process - the cost of acquiring a license. In the sense that all the requirements impose a cost on the applicants (direct filing fees, indirect costs of time, lawyers' fees, and costs associated with modification of the technical specifications), we may focus on a cost variable without loss of generality.

The FCC faces pressures from three (special) interest groups in the model: GEO satellite companies, LEO satellite companies, and consumers of the services of LEOs. The paper shows that the optimal strategy for an FCC Commissioner is to balance the influences coming from those sources and from the effects of the Commission's limited operating budget. The FCC's optimal fee schedule should be structured to evoke much louder complaints from LEO companies than GEO companies, i.e., the fees for LEO licenses should be viewed by LEO firms as "too high." We show that the FCC and GEO companies, each acting in their own interests, are allied in opposition to LEO companies and consumers (if they exist and can be influential). The more established GEO companies exercise more influence in the process, and although the FCC appears to protect GEO companies, the Commission is meeting the FCC's needs. Economies of scale in processing applications at the FCC should play an important role in determining the ultimate costs of acquiring a license.

A number of reforms and the potential evolution of the game are explored. For example, forcing the FCC to charge its marginal cost of processing applications produces lower license costs for LEOs. Procedures that allow LEO companies greater influence than currently attainable will reduce license costs. As LEO firms mature and as GEO firms see the LEO market as an opportunity rather than a threat, the fees for licenses should come down. Therefore, one objective of LEO companies may be to convince more of the larger, traditional satellite companies to enter the LEO market. Thus the model identifies the effect of reforms on the relative magnitude of barriers to entry.

The paper is organized as follows. First, the current explicit fee schedule and the regulatory environment for satellite operators are described. A brief review of the literature on the decisions of government and regulatory agents is presented. This is followed by a section describing the construction of the stylized model of FCC decision-making and the role of interested parties to the process. The solution for the optimum cost structure for satellite firms is then described, and the effects of changes in various parameters of the process are discussed. In the final section, results are summarized, and policy prescriptions for the reform of the licensing game are explored.

Background

LEO satellite companies first compete publicly with GEO companies in the regulatory arena. LEO companies must file for licenses with the FCC and face opposition from other companies -- the companies already established in geostationary orbit as well as other potential LEO companies. The process of getting a license to construct satellites is tortuous and costly. Not only must filing and license fees be paid, but the cost of preparing filings, comments on other companies' filings, and responses to their comments/objection can be very high. The time delays in the process can themselves be costly for companies. They lose market share if others can offer services from other platforms. In the extreme, they can even be excluded from the process of getting a license (as for example, LEOSAT Corp. has found). All those costs (which we will refer to simply as the "licensing fee") for applications by LEOs can substantially limit their development. The FCC has instituted a pioneer preference license policy to give innovators an opportunity to experiment with their technology after a less costly and demanding application procedure. However, LEOs still face very stiff competition from each other and from other companies who are experienced and knowledgeable about the FCC's procedures. Those firms can exert influence on the commission in ways that are not readily accessible to newer companies.

Cost of LEOs Applications

The current and proposed schedules for direct application fees for LEOs generate a lot of complaints from the industry.[6] According to the suggested fee schedule in the legislation HR1674, the Federal Communications Commission Authorization Act of 1991, passed by the House in September 1991, the application fee for authority to construct the first low-earth orbit satellite in the system will be $10,000. Each additional application per satellite will be $500. For the launching and operating application, the first satellite for the first orbital plane will be $100,000. Each additional plane will be $50,000; each additional satellite will be $2750. Each of the remaining spacecraft will be charged $4000.[7] Given the large number of small satellites involved, developers of small satellite systems feel the 1991 Act only modestly decreases the application fees for constructing and launching satellites relative to the current fees of $2,030 per satellite construction and $70,000 per launch.[8] These application fees are still an impediment to the emerging small satellite industry. Moreover, under the proposed schedule, an additional $30,000 annual payment to FCC will be required for each commercial satellite in orbit. Each ground antenna

will be charged $75 annually.[9] This will also apply to satellites that are currently in geosynchronous orbits. Currently, GEOs do not pay any annual fees to the FCC.

Interviewed by *Space News*, Alan Parker, president of Orbital Communications Corp., a subsidiary of Orbital Sciences Corporation, considers such application and annual fees as "additional financial barriers" and "penalties" on the small satellite industry." [10] The OrbComm system uses a total of twenty-two satellites to provide two-way messaging services. Six satellites will be placed in each of three low earth orbits along with two spare satellites reserved on the ground. Under the proposed fee schedule, the OrbComm system will cost $19,500 for applications for construction, and $249,250 for launch and operation of the spacecraft. For a typical geostationary system of two orbiting spacecraft and one ground spare, the cost is $11,000 for construction applications and $154,000 for launch and operation applications. Thus, in a system of many small satellites, the application fees are substantially larger than for GEOs even though similar services can be provided.

The fee burden is especially heavy for the IRIDIUM™ constellation of seventy seven small satellites developed by Motorola Satellite Communications. Groups of eleven satellites will be deployed in seven separate orbits. They will pay $48,000 for satellite construction and $592,500 for launches. In *Space News*, Rob Frieden, Motorola's Deputy Director for international relations in Washington, claimed the fee proposal to be "discriminatory" against low earth orbit systems.[11] An FCC attorney, interviewed by *Space News*, explains that the FCC has not issued similar licenses for spacecraft in the low earth orbits, and these fees are based on cost projections.[12]

Even though there may be additional concerns about coordination issues with many small LEO satellites in different orbits, fees applicable to GEOs are viewed by some petitioners as not appropriate for the LEOs. Many people believe a greater economy of scale for the LEOs relative to GEOs occurs in the processing and reviewing of applications. As Rob Frieden expresses in *Space News*, "the number of satellites doesn't equate to the amount of staff needed to review and coordinate."[13]

Pioneer Preference Policy

Recognizing the stress on the developers of emerging technology such as commercial LEO systems, the FCC instituted a "pioneer preference" policy in April, 1991. It is intended to foster the development of new services or a substantial enhancement to an existing service by reducing the delays and risks of the allocation and licensing process. Realizing that financing is difficult without an FCC license, the FCC "permit(s) the recipients of pioneer preference to file a license application without being subject to competing applications."[14] Some argue pioneer preference gives an advantage to start-up ventures for future satellite licenses to innovative concepts early in the lengthy regulatory process. The new policy does greatly improve the pioneers' chance of financing projects and reducing costs. Although the transfer of a preference as a sale of object is not permitted, multiple preferences will be granted if more than one innovator meets the standard. Such an "Open Skies" policy of allocating spectrum to a number of companies to "experiment" will certainly help to stimulate technology and avoid the mistake of just picking one and prohibiting the others.

However, there are foreseeable problems with the policy. On one hand, it would be difficult to establish what qualifies a pioneer, on the other hand, denied competing ventures will challenge the FCC decisions in court which may further delay the process. In addition, Rodney Small, an economist for the FCC's Office of Engineering and Technology, who helped develop the new procedure, says in *Space News* that "for satellites, it will be difficult to get preference ... The FCC will be reluctant to grant pioneer's preference for nationwide satellite services because the procedure is designed to help assist entrepreneurial programs that serve local markets."[15] Thus, even with the pioneer preference policy, LEOs' position has not been substantially enhanced.

Literature

Models of the interaction of competing interest groups in such regulatory games are developed in the literature with Stigler's article considered the seminal work in this area.[16] The economics and public choice literature on industry influence on regulation has grown substantially since Stigler's seminal article, but the discussion of this topic has a long history back at least to Herring.[17]

Stigler argues that regulatory officials are captured by the regulated industry as a result of a number of factors impinging on the process. The act of setting up a regulatory apparatus invites activities on the part of the regulated industry to exercise control over the structure of the industry. In fact, Stigler argues that regulatory agencies are established at the urging of the regulated industry in order to enforce industry-wide agreements such as price fixing and reduced output. Such agreements are characteristic of cartels organized to benefit the industry with higher profits at the expense of other groups. Stigler presents empirical evidence on the trucking industry to support his views.

Becker takes a more expansive approach, modeling the pressure exerted by various groups interested in the regulatory process by virtue of either their paying taxes or their receiving government subsidies.[18] The group with the greatest individual stake in the process and the group that can best organize its influence on government prevails. Becker disagrees with Stigler regarding the effect of the size of the influence group. Becker believes that, although larger groups will have more resources to devote to regulatory pressure and will in the aggregate have more to gain, larger groups face severe "free rider problems" with the coordination and contribution of the diverse individuals in the group. Small groups, therefore, have a net advantage in pressuring the government for subsidies.

Evans and Garber focus on utility regulators and the evidence that regulators allow practices such as "gold plating" to occur.[19] They point out that regulators are only human and will respond to the pressure exerted by the utility companies and consumers in predictable ways. They argue that much of the operation of the existing system that appears irrational, for example the persistence of rate of return regulation that produces gold plating behavior, is attributable to the normal responses of rational, economic regulators.

Empirical evidence on the economic influence view has been largely indirect with the exception of studies of voting records of Congress. Eckert presents interesting evidence on specific regulatory agencies including the FCC and the influence of competing parties in the regulatory process.[20]

According to Eckert, "service on a commission is clearly a stepping stone to private sector jobs related to the related industry."[21] Of the 142 ex-commissioners, almost 51 percent took related private sector jobs. He suggests that such jobs could be a "reward for the votes on the bench that were favorable to the industry or a particular firm."[22] This indirectly indicates that the FCC and other commissioners are greatly influenced by the industry as opposed to other interested parties.

Competition between segments of the industry, for example, GEOs and LEOs, should also produce efforts to influence regulators as Stigler notes. GEO companies have been in the industry for a much longer period of time while LEOs are newly emerging. GEOs are more experienced in regulatory proceedings and are more entrenched than LEOs. We assume, therefore, that GEOs have a competitive advantage in regulatory proceedings. For example in Eckert's context where jobs are the reward, LEO companies are at a big disadvantage. LEOs are just at the start of their business life, and many of the LEO firms will not survive. Even though future jobs in LEO firms may be very lucrative, upsetting the well-established GEO firms by lowering barriers to entry for LEOs is very risky. LEO companies are typically small, start-ups with few current job opportunities and very risky prospects for future jobs.[23]

Model

Our model is structured similar to Becker's model. The FCC commissioner maximizes expected utility subject to a budget constraint. Expected utility is a function of the pressure exerted on the commissioner because more pressure causes greater stress for the commissioner.[24] The FCC decides the cost of applying for a license which we refer to as the "licensing fees." This is realistic because the FCC sets the rules that determine the dollar costs and time delays for applying, and the FCC provides the Congress with the fee schedule that is contained in the legislation setting the explicit fees. This has been in place since the Omnibus Budget Reconciliation Act of 1989 in which the Congress mandated the fee schedule.[25]

The model has two decision variables: licensing fees for GEOs and for LEOs, f_G and f_L respectively. A subscript "L" will refer to LEOs and subscript "G" will refer to GEOs in this paper. Whether there will be a difference between the fees depends, in part, on FCC's costs of processing these two types of applications and depends on the pressure from the groups that are affected by the fees. Because LEO systems usually deploy many more similar satellites to orbits than GEO firms, if economies of scale exist in the processing of applications, the cost of processing for LEOs on a per satellite basis is lower than for GEOs. This economy of scale factor in processing is formalized as e(q), where q is the number of satellites in each firm's system. Typically, GEO systems involve a single satellite so no economies of scale would result. LEO systems, however, could experience economies of scale given values of q such as 24 or 77. Thus $e(q)=q^*(1/q)$ reflects, in the extreme, such scale economies.

A number of factors affect the companies' application costs. These would include fees charged by the FCC for the license, the time it takes for FCC to respond to the applications, lawyers' fees for filings, and the complexity of the application process. Title 47 of Federal Regulations, Part 25 contains the legal, financial and technical requirements for the applicants. We use the license fees to represent all the costs and obstacles encountered by the applicants in our model. All the costs are assumed to be common to all applicants.

To maximize its expected utility function, the FCC considers the effects of influence of three counteracting groups: GEO firms, LEO firms and the customers. That is, the FCC's objective is to:

$$\underset{f_L, f_G}{\text{MAX}}\ EU(I_G, I_L, I_C)$$

A subscript "C" stands for customers in this paper. Each individual group influences the FCC decision to benefit group, and each group's suppliers and customers support its positions. To simplify and to avoid a bias toward any group in this paper, we assume that all three groups will have the same marginal influence on the FCC. That is,

$$EU_1' = EU_2' = EU_3' < 0$$

where primes denote derivatives take with respect to the i-th variable given as the subscript, and the FCC's utility will be negatively affected by influence from any group. No matter which group exercises influence, the commission is buffeted by the publicity and must take action to consider the filings and comments of any group exercising its right to petition/influence the Commission. The more influence is expected, the greater the disruption and aggravation for the Commission, and therefore the more disutility is experienced. The disutility is assumed to be greater at the margin for higher levels of influence so U" < 0.

Influence of the industry groups is a function of the groups' profit, the number of firms in the group, and how entrenched the group is in the industry. That is,

$$I_G = I_G(\pi_G, n_G, \varepsilon_G)\ ;$$

$$I_L = I_L(\pi_L, n_L, \varepsilon_L)\ .$$

The older and more established a group is, the better the network it has for affecting the regulatory and legislative process. The better informed it is about the process, the more experienced it is in the process, and the more influence it has on the FCC. Thus, we designate the following:

$$|\varepsilon_G| > |\varepsilon_L|\ ;$$

$$I_3' < 0$$

Stigler argues that the larger the number in the group, the more votes it will be able to get, but the larger the free rider problem will be.[26] Becker states that "small groups have certain political advantages that may swamp any adverse effects of fewer votes. They may control more easily free riding and shirking by members."[27] Consistent with Becker, we assume:

$$I_2' < 0.$$

In general, the number of companies in the industry will be affected by the size of the application fees which act as a barrier to entry for the industry. This is particularly relevant for companies considering entering with a LEO system. However, GEO companies are already in business, and the number of GEO companies are presumably not greatly affected by the size of fees in 1992. Thus, we have,

$$n_L = G(f_L),$$

but n_G is not a function of fees. This asymmetry in the model reflects the asymmetry of the established GEO companies versus the start-up LEOs.

The lower the profit, the more dissatisfied the group, the more likely that it will exert influence to change the fees. Wealthy companies may have more discretionary funds to influence the FCC's decision, but even firms that are not profitable have the resources (through borrowing and equity) to influence the FCC. (Even the high cost of filing applications does not deter unprofitable firms from filing.) Firms whose survival is most precarious will exert more influence on the FCC than if it were more successful/profitable. In other words, we have,

$$I_1' < 0$$

However, the degree of entrenchment affects the responsiveness of influence to profit. That is, for the same level of profit, the more entrenched firms exert more influence. Thus, we have,

$$I_{G1}' = \varepsilon_G < \varepsilon_L = I_{L1}' < 0.$$

The new LEO firms influence the regulatory process, but we argue that the effect of profits on the influence exerted is far weaker for LEO firms than for

GEO firms. LEO companies typically do not have the experience and "credibility" with the FCC. For example, LEO companies are relatively unable to catch the attention of the FCC as a result of the riskiness of the LEOs and the uncertainty of post-FCC employment of commissioners and staff (if Eckert's evidence is valid). Furthermore, the FCC's attention is likely to be less toward firms that are less likely to survive and continue to play in the regulatory arena.

Profit of the firms is a function of the costs, including total applications fees charged by FCC, (f times q times n), and the revenues (R) of the all firms involved in the industry which in turn, depend on the degree of competition in the industry. The elasticity of demand affects the interaction between competition and revenues. LEO systems typically emphasize low cost to customers, and apparently perceive demand to be elastic. Thus, lower LEO application fees will induce more competition, a higher demand and more revenues to the industry as a whole. (A full discussion of the role of demand elasticity is beyond the scope of this paper.) The degree of competition in turn depends on the number of companies in the industry. As stated above, at this point in the life cycle of GEO firms, the number of GEO companies is unaffected by the magnitude of GEO application fees. Thus, the impact of the change of fees on competition will only affect the number of LEOs. Thus, for simplification, we have,

$$\chi = \chi(n_L).$$

So far, we have the profit functions as follows,

$$\pi_G = g\{f_G\ q_G\ n_G,\ R(\chi(n_L))\},$$

$$\pi_L = h\{f_L\ q_L\ n_L,\ R(\chi(n_L))\}.$$

Similarly, the influence exerted by customers is a function of the costs of service to customers which also depends on the degree of competition. The more competitive the industry is, the lower the costs of service. So, we have,

$$I_C = I_C(C),$$

$$\text{where } C = F[\chi(n_L)],$$

$$\text{and } C' < 0.$$

Customers include individual consumers and the companies that consume services provided by these satellite firms. LEOs' customers will predominantly be individual consumers given the emphasis on personal communication applications, but other customers such as the trucking industry and those who must transport hazardous materials are also targeted as customers. However, LEO companies do not yet have many commercial customers given that no satellites have been launched by those companies to date.[28] Although the military has used LEOs successfully, little information is available to the public at large about the capabilities of LEOs in commercial applications. Presently, GEOs have a larger customer base than LEOs. Potential LEO customers' have an interest in pressuring the FCC to keep the fees on LEOs low. However, by their nature LEO systems are global (in contrast to GEOs) and thus have a world-wide customer base. The FCC is justifiably more sensitive to the interest of US customers thereby diluting the influence of the total customer base for LEOs. Despite the newness of the LEO markets, customers may be effective as a potential factor similar to the notion of "potential competition" in anti-trust considerations. A decision that will not upset the customers would certainly make life much easier for the Commission given that influence occurs also through customers' agents-- the Congress and the President. So customers' influence can be non-negligible but is likely to be low relative to influence from other sources. The higher the costs of service, the louder the customers' voices, the more influence they will exert on the FCC. So we have:

$$\varepsilon_c = I_c' > 0.$$

Meanwhile, the FCC has a fixed budget to operate. The inflexibility of the budget was clearly demonstrated when despite the skyrocketing of cellular phone applications, the FCC did not get any new resources to deal with the deluge. A significant tool that the FCC has for limiting the number of applications and controlling the effects of the budget constraint is the licensing fee schedule. The FCC could construct fees

high enough to cover the administrative expenses of processing the applications and/or to severely restrict the demand for FCC services. A budget constraint means that they must choose their actions carefully. To simplify, the constraint is expressed as: total licensing fees that the FCC gets from the industry must be at least equal to the administrative costs of processing the applications. (Including a dollar budget granted by Congress does not alter the economics of the decisions.) Processing costs depend on the demand for licenses, i.e., the number of applications, on the economies of scale and therefore on the licensing fees. High licensing fees, on one hand, increase the FCC's revenue and thus reduce the budget constraint and on the other hand, limit the number of applicants. The latter effect is imbedded into the function for the number of LEOs per system as described earlier. Therefore, the budget constraint will be as follows:

$$(n_G\ q_G\ n_G) + (n_L\ q_L\ f_L) > K\ [e(q_G)\ n_G,\ e(q_L)\ n_L]$$

where K denotes the cost of processing as a function of any economies of scale related to the number of applications processed.

Optimum Interaction and Comparative Statics

By taking the first order condition with respect to f_L, we will get:

$$\frac{\partial EU}{\partial f_L} = EU'(I'_{G1})\ \frac{\partial \pi_G}{\partial f_L}$$

$$+ EU'[(I'_{L1})\ \frac{\partial \pi_L}{\partial f_L} + (I'_{L2})\ \frac{\partial n_L}{\partial f_L}]$$

$$+ EU'(I_c'\frac{\partial C}{\partial f_L})$$

$$+ \lambda\ (q_L n_L + q_L f_L\ \frac{\partial n_L}{\partial f_L} - K_2'\ e(q_L)\ \frac{\partial n_L}{\partial f_L}) = 0$$

Recognizing each dollar cost decreases the profit by the same amount, we have:

$$g_1' = h_1' = -1.$$

Substituting the value of λ that we get from the first order condition for f_G enables us to cancel all EUs, and we get:

$$\varepsilon_G(g_2'R_G'\chi'G') + \varepsilon_L[h_2'R_L'\chi'G' - (q_L n_L + q_L f_L G')]$$

$$+ I'_{L2}G' + \varepsilon_c F'\chi'G'$$

$$+ \varepsilon_G[q_L n_L + q_L f_L G' - K_2'e(q_L)G'] = 0.$$

The first term,

$$\varepsilon_G(g_2'R_G'\chi'G'),$$

represents the change of GEO companies' influence with respect to change of LEO license fees. Lower license fees make GEO companies more unhappy, and they will exert more influence on the FCC. This decreases FCC's expected utility. Thus, the first term is negative.

Similar logic applies to the second term,

$$+ \varepsilon_L[h_2'R_L'\chi'G' - (q_L n_L + q_L f_L G')]$$

$$+ I'_{L2}G'.$$

The two components represent the change of LEO influence on the FCC with a change of LEO license fees. While the first is related to the profit function, the second one reflects the free-rider aspects of the LEOs' efforts to influence the FCC. The effect of fees on LEO company costs is[29]

$$q_L n_L + q_L f_L G'.$$

The effect on LEO revenues due to a competitiveness effect is

$$h_2'R_L'\chi'G'.$$

A decrease in the LEO license fee reduces the costs to LEO companies. This direct cost effect is presumably larger than the indirect competitive effect. Thus, the

term has a positive sign. That is, lowering the fee decreases the pressure of LEO companies on the FCC and thereby increases the FCC's expected utility. The next term has the same effect on the FCC, as the previous term.

The customer term in the first order condition,

$$\varepsilon_c F' \chi' G',$$

has the same positive sign as the LEO influence term. As low fees permit a more competitive environment, the costs to customers are low, too. Thus, customers will exert less influence on the FCC.

The last term,

$$\varepsilon_G [q_L n_L + q_L f_L G' - K_2' e(q_L) G'],$$

is derived from the budget constraint. It represents the FCC's position. As noted previously,

$$q_L n_L + q_L f_L G'$$

is positive and in this case it represents the revenue to the FCC.

$$K_2' e(q_L) G'$$

represents the marginal administrative cost to the FCC of processing license applications. Lower LEO license fees on one hand, decrease the FCC revenues; on the other hand, they permit a larger number of LEO companies in the market. The more LEO companies exist, the more LEO applications there are, the greater are the FCC's administrative processing costs. Thus, both the decreases in revenues and increases in costs lower FCC's expected utility and so this term has a negative sign.

The FCC does not always want high LEO license fees to increase revenues. When there are a large number of LEO applications, the economies of scale play a more significant role in reducing the administrative costs than a higher fee. Thus, under such circumstances, increasing the fees induces a much larger revenue loss than the gains from lower administrative costs. Therefore, increasing LEO fees will not always solve the problem of the budget constraint.

In order to have an internal solution, G' and χ' cannot be zero in our model. In other words, license fees must be a significant factor determining the number of LEO companies in the market (if the free rider factor is small), and the number of firms in the market must affect the competitive level among the group. In the absence of an effect on the number of companies and competition in the market, fees will be as high as the FCC can set them and no LEO firms will enter the market (unless some external constraint is imposed on the FCC). This is an important result from the model because those who argue that the fees and obstacles to filing are not a significant factor in the competitiveness of the market are arguing for a corner solution. The process collapses under that assumption and the LEO market is not viable. A competitive effect is critical to the process.

In addition, we make the following reasonable assumptions:

a) The utility function is concave (i.e. U" < 0).

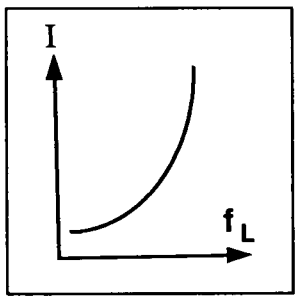

Figure 1: Convex Influence Function

b) The LEO influence function is convex with respect to LEO fees as shown in Figure 1. An increase of LEO fees when fees are already at a high level upsets LEO companies (and customers) much more than when the fees are low.

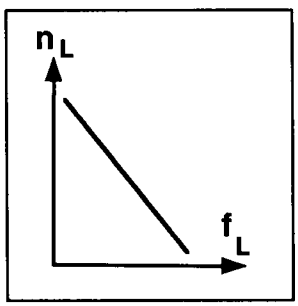

Figure 2: Concave Cost Function

c) The cost function is concave with respect to number of LEO companies as in Figure 2. That is, we allow for economies of scale, $e(q_L) < 1$. The cost of processing an additional satellite application for a given company's filing goes down as the number of satellites already processed gets high.

d) For simplicity and in the absence of strong evidence to the contrary, the number of LEO companies is a linear function of LEO fees as shown in Figure 3. A $1,000 increase in fees causes the same decrease in the number of companies at all levels of fees.

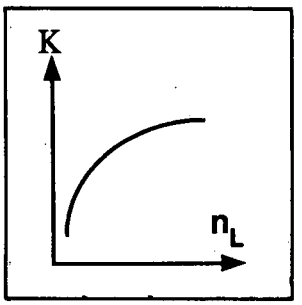

Figure 3: Fees Effect on Number of Firms

e) Profit π_L is concave in f_L (i.e., $h_2'' < 0$)

f) The GEO influence function is concave with respect to the number of LEO companies.

g) Free-rider problems are more significant in larger groups but the incremental effect is smaller for larger groups.

The above assumptions are necessary to satisfy the second order conditions for a maximum. Before turning to discussing the optimal fees under different scenarios, note that the results for the optimum fees are not a function of the specific utility function of the Commissioner. The optimal fee is invariant to the degree of the Commissioner's "risk aversion."

Role of Various Influence Groups

As described above, the GEO companies' term and the FCC term in the first order condition have the same sign. Thus, GEO companies and the FCC are aligned favoring LEO fee increases while LEO companies and customers are on the other side urging lower LEO fees. The FCC commissioner chooses the LEO license fee that makes the sum of those factors equal to zero. Thus, the Commissioner balances the forces reflected by positive terms against those reflected by negative terms. This Solomonic balancing of the various forces is optimal in the sense of giving the Commissioner the highest level of utility attainable under the conditions of the regulatory license game described here.

Notice that when $|\epsilon_G| > |\epsilon_L|$, the LEO firms are less able to exert influence for a given level of profits, and therefore, the Commissioner will need to evoke much greater anguish (marginal effect on profitability) from LEO companies. The greater injury inflicted on LEO firms produces influence that at the margin balances the influence of other more effective (but less perturbed) pressure groups. This effect could be mitigated if the LEO companies had strong allies, but the plight of start-up companies is a lack of customers, and, particularly in the personal communications industry, the influence of a large group of diverse customers is difficult to organize.

Increase of LEO Companies' Entrenchment

As time passes, LEO companies will acquire more regulatory experience. The pressure to decrease fees will increase. We would expect the FCC to decrease LEO license fees to induce more complaints from GEO companies to push the balancing game back to equilibrium.

Change of FCC Policy/Budget

Suppose FCC charges license fees at their marginal administrative costs. That is,

$$q_L n_L + G'q_L f_L = K'G'e(q_L)$$

Effectively, this is the same as dropping FCC's own concerns from the model. Thus, there is more pressure to lowering LEO fees than described above. To balance this, the FCC decreases LEO license fees inducing GEO companies' to exert more influence for a high LEO fee pleasing LEO companies and customers so that they exert less pressure.

Suppose the FCC is given a larger budget. This would mean that the budget constraint is less binding than previously, FCC can either charge a lower GEO license fee and/or a lower LEO license fee, because either of these actions will lower the pressure from the customers and the respective group. At sufficiently higher revenues, λ will equal zero because the constraint is not binding. Thus, the FCC term again disappears. This means the FCC lowers LEO license fees to induce higher pressure from GEO companies to balance FCC's disappearance from the first order condition. Thus, in our model, LEO fees are decreased when there is slack in the budget.

Summary and Implications

Interest in the communications applications of low earth orbit satellite systems has increased substantially in just the past two years as the cost of the technology has declined. The success of recent military applications has also brought attention to this new technology. The regulatory process, however, has not evolved as rapidly as the companies who can provide services to commercial users. Applicants for licenses to construct,

launch, and operate such satellite systems face many hurdles and high costs for entering the market. A substantial hurdle for LEO companies is the regulatory process for licensing the systems.

In this paper, we construct an economic model of the interactive behavior of various parties to the FCC's procedures for licensing low earth orbit satellite systems. We characterize the LEO licensing game as an interaction between the FCC, companies who provide geostationary satellites, companies who want to provide low earth orbit satellite systems, and customers of the LEO companies. The FCC determines the cost of entering the market for the two types of companies. We adopt the framework from the literature on regulatory decision-making wherein various groups influence the regulator's decision according to the objectives of the group. Regulators then respond by choosing the licensing fee that maximizes their expected utility. One benefit of the analysis is the realization that competitive effects of the fee schedule must be included in a model of the process. Without recognizing that license costs act as a barrier to entry affecting the level of competition in the market, unrealistic corner solutions to the licensing process are produced.

The results of the model show the optimal fees that a regulator should impose on firms who apply for licenses under the current regulatory regime. The regulator should balance the influence of each of the parties against one another so that their marginal influence is equal. This produces an alliance between the FCC and GEO companies opposing LEO companies and consumers. The FCC takes that position not in an effort to protect GEO companies from competition, though their actions may appear to be motivated in that way, but in an effort to correctly account for the budget constraints under which they operate. At the equilibrium, the fees charged to LEO companies should evoke substantial discontent from LEO companies.

We relate these characterizations of the FCC's policy to actual events and find a reasonable correspondence between theory and practice. We emphasize that the ethical conduct of FCC Commissioners is not questioned here. The results indicate that under the current structure of the regulatory system, the kind of behavior exhibited by the FCC is consistent with rational analysis of the application process.

If changes in behavior are desired, changes in the system or parameters in the system must occur. Although the model does not make a value judgement about the social desirability of the policies, fees on the order of $1.5 million per year do not appear to be in the interests of consumers who have little influence in the process.[30] Their interests seem better served by allowing more competition, stimulating innovation with the commensurate lowering of product prices. High barriers to entry are unlikely to be in their interest.

If one desires to change the system so that more weight is given to the public interest, the model provides an appropriate tool to examine effects of various alterations to the system. One aspect of the system that could be altered is the FCC's budget constraint. Although the model does not contain a budget appropriation from the Congress, an additional source of revenue produces a less binding constraint and therefore reduces the FCC's incentive to impose high fees on LEOs. This may also lower GEO fees somewhat, but lower LEO fees are the main effect because the experienced and more mature GEO firms already exercise substantial influence to keep their fees low. LEO companies and their customers are the main beneficiaries of a bigger operating budget for the FCC.

LEO firms might also move toward making GEO companies into allies instead of adversaries in the regulatory process. The model characterizes GEO companies as having little interest in providing services through LEOs. Currently, this is an accurate description, notwithstanding Hughes' financial interest in Starsys. If GEO companies were more convinced that this was an opportunity and that their revenue stream would not be damaged via competition from the LEO market, the GEO companies would exercise less influence toward high LEO fees. The balance would therefore tip toward LEO companies' interests.

In addition, a program of public awareness about the types of services that LEO technology can offer would empower customers and enhance their ability to support the LEO companies in their quest to hurdle the barriers to entry now erected. Expecting the FCC to undertake such a program is naive. The FCC has no incentive to do so except to forestall an ultimate wave of recrimination once consumers are offered LEO services.

This paper leaves many issues for future research. We hope that topics relating to other dimensions of the regulatory process such as auctioning of licenses can be approached with the technology we develop here. Including other participants in the process such as cellular phone companies, RBOCs, and others would present a richer description of the process but probably will not alter the main conclusions. Further research into the role played by assumptions about the sensitivity of the degree of market competition to application costs and the role of the elasticity of demand for LEO services could reveal interesting interactions between the different segments of the LEO industry. We hope that this paper opens the opportunity to pursue those topics with a more rigorous analysis and a more highly calibrated instrument for examining alternatives.

Endnotes

1. Rothblatt, Martin, The Satellite Slot Machine: A Game of Skill and Chance, Via Satellite, 38-42 (July 1991).

2. Stigler, George J., The Theory of Economic Regulation, 2 Bell Journal of Economics and Management Science, 3-21 (1971).

3. Becker, Gary S., Public Policies, Pressure Groups, and Deed Weight Cost, 28 Journal of Public Economics, 329-347 (1985).

4. Evans, Lewis and Steven Garber, Public-Utility Regulators Are Only Human: A Positive Theory of Rational Constraints, 78 American Economic Review, 444-462 (June-December 1988).

5. Determining whether an auction of licenses or fiat allocation of licenses is the most desirable method is important but requires the development of the model here for significant progress. So we must leave those questions for future research.

6. Marcus, Daniel J., Small Satellite Firms Claim FCC Procedures Stifle Market, 2 Space News 17 (May 13-19 1991).

7. The Communications Act of 1991, U.S. Congress, House of Representatives H.R. 1674, 102nd Congress, 1st Session, 13.

8. 47 CFR § 1.1102, 216.

9. *Supra* note 6 at 11.

10. Marcus, Daniel, House Committee Approves Modest Drop in Satellite Fees, 2 Space News, 16 (August 19-25 1991).

11. *Id.*

12. *Id.*

13. *Id.*

14. Gen. Docket No. 90-217, 6 FCC Rcd., 3492 (1991).

15. Marcus, Daniel and Renee Saunders, Pioneer's Preference Sparks Satellite Contest, 2 Space News 22 (July 8-14 1991). Indeed, last August, Motorola was denied its request for a Pioneer Preference for its global system.

16. *Supra* note 2.

17. Herring, E. Pendleton, Federal Commissioners: A Study of Their Careers and Qualifications (1936). Wilson, James, Q., The Politics of Regulation, Basic Books: New York (1980).

18. *Supra* note 3.

19. *Supra* note 4.

20. Eckert, Ross D., The Life Cycle of Regulatory Commissioners, 24 Journal of Law and Economics, 113-120 (1981).

21. *Id.* at 118.

22. *Id.* at 120.

23. A Commissioner is not violating any ethical code of conduct by considering these factors. In fact Spiller, argues that Congress allows and encourages consideration of post government employment opportunities as additional compensation to offset the below market wage that is paid to government employees. Thus, we characterize the LEO companies as less influential with the Commission relative to GEO companies. Spiller, Pablo T., Politicians, Interest Groups, and Regulators: A Multiple-Principal Agency Theory of Regulation, or 'Let Them Be Bribed,' 33 Journal of Law and Economics, 65-101 (April 1990).

24. *Supra* note 3, 4.

25. 47 CFR § 1.1101, 104-5.

26. *Supra* note 2.

27. *Supra* note 3 at 99.

28. By Fall 1992, some LEO companies (OrbComm and NACLS/Starsys) anticipate having experimental LEO satellites in-orbit to provide early market penetration and proof of concept. Some companies use GEOSATs as interim service providers until the LEOs can be deployed.

29. Assuming that marginal cost for LEOs is positive and increasing guarantees $(n_L + f_L G') > 0$.

30. The $1.5 million is based on 48 satellites and the $30,000 per satellite fee included in HR1674 passed by the House in 1991.