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ECON INCORPORATED

FEDERAL GOVERNMENT PROVISION OF THIRD-PARTY LIABILITY INSURANCE TO SPACE VEHICLE USERS

Final Report

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Summary

This study examines the provision of third-party liability insurance by the Federal Government to commercial users of space. It is assumed that the nation has decided that it is in the national interest to develop the space frontier and to make commercial use of this frontier. The nation has also decided that it is in the best interest of the peoples of the earth and the private organizations engaged in commercial space activities that space activities be insured against third-party liability in the amount of $500 million individually (single payload), or $750 million collectively (multiple payloads) when launched by a single flight of the Space Shuttle.

The purpose of a requirement for third-party liability insurance is twofold: (1) in the event of a loss, it ensures that those suffering the loss will receive some compensation, and (2) it protects the private entity conducting the space activity against catastrophic liability loss, thus improving the chance of continuation of an otherwise beneficial space activity after a mishap. Given that the determination has been made that commercial space development is in the national good, the Federal Government may choose to provide third-party liability insurance to certain space users when such insurance is not otherwise available from commercial insurance sources at a "reasonable" price. Such provision may be made when it is determined that a space activity is in the national interest. Criteria recommended for this determination are as follows:

1. The activity does not impose undue risk to persons or property on earth or in space.
2. The activity does not adversely impact the environment, nor does it impose undue risk to the environment, either on the earth or in space.
3. The activity is not in violation of international law or treaties to which the United States is a signatory.
4. The activity is not in violation of domestic law or the Constitution.
5. The activity does not threaten national security, nor does it impose undue risk to Government property, nor does it seek to overthrow the Government by force.
6. The activity does not infringe on basic human rights.

It is recommended that (with respect to the provision of third party liability insurance) determination of whether a space activity is in the national interest not include measures of the economic or financial worth of the activity insofar as such determination would be subject to a variety of imperfections, and may not be adequately made by an agent of the Federal Government, as opposed to a member of the sponsoring organization. It should be noted that the current JEA program does not require measures of economic or financial worth.

If the Federal Government chooses to provide third-party liability insurance to those space users that meet criteria such as the above, a determination of "reasonable" premiums must be made, and a structure for Federally provided insurance must be established. Determination of reasonability of rates is both difficult and subjective. From the point of view of the user,

the most reasonable rate is zero. Any payment higher than this is less reasonable. Surely another measure is necessary. Three possible measures are (1) historical rates, (2) the cost of alternatives, and (3) the financial impact on an activity. A common determination of the reasonability of a price is a comparison of the price to historical prices for the same good. If the price has remained relatively constant, most buyers will consider it "reasonable." Another measure of reasonableness is the comparison of alternatives. Any price for insurance would be considered unreasonable if, for example, a comparable launch on Ariane sans insurance requirements, were available at a lower cost than a launch on the Space Shuttle. Finally, reasonability could be defined in terms of the ultimate effect of insurance costs on the rate of space commercialization. No doubt, higher costs will impede the conduct of otherwise marginal activities. But, given the current rates, the impact of this effect could be quite small, unless prices increase drastically. None of these measures is totally satisfying, nor is there a basis for choosing one over the others. Thus, reasonability of premiums is largely subjective.

Unfortunately, the case for reasonability from the point of view of the insurers is not much better. For risks such as life insurance, actuarial data can be used to determine reasonability. But inadequate data are available for this method of determining "reasonable" premiums for third-party liability insurance for commercial space activities. In this case, the best measure of reasonability appears to be a comparison of premium-setting

practice in the space-insurance area with "standard practices" in other segments of the industry. The key consideration in making this comparison is the manner in which insured risks are diversified. It is apparent that space-liability risks are diversified in a manner that is quite favorable to the insured, in comparison to other areas of insurance. Thus, using the criteria of standard practice, current space-liability premiums appear quite reasonable. And using historical rates as a basis for judging reasonability from the point of view of the user, it could be said that the premiums will remain reasonable if they do not increase significantly.

Insurance serves the purpose of diversifying risks. Expected liability takes into account the likelihood of events and their potential magnitudes. It is the average liability over a large number of trials. Estimating an expected liability precisely is very difficult, but appropriate calculations can be done using relatively simple models, and, from such a model, it appears that the expected liability that the entire Space Shuttle fleet will generate over its lifetime is less than $500,000. Consequently, it is highly likely, but not certain, that premiums on the order of $100,000 per insured activity—approximately the current rate—will provide an adequate set aside for liability claims that may arise. However, expected value is only a statistical measure, it is only achieved over a large number of events. Liability damages will either be 0 or high, but since probabilities associated with an accident causing damages are extremely low, the expected liability is small.

Each insured entity pays a premium that, if properly

calculated, is higher than the expected liability that the insured activity would generate. The excess between the premium and the expected liability provides for overhead, profits, fees, etc. of the insurers, and it provides a cushion against statistical variations from averages. The maximum liability that a space activity could conceivably generate is equal to the face value of the insurance policy (typically $500 or $750 million). Over time, insurers must set aside a sum of money that could make such a payment if required. One method of setting a premium, when insufficient actuarial data is available, is to choose that premium that would set aside enough revenues to cover a maximum liability event within a reasonable period of time—typically 1 to 5 years.

These considerations of reasonability provide the basis of a structure for the provision of third-party liability insurance by the Federal Government. Since any test for reasonableness is arbitrary (from insurer's point of view reasonableness may imply increases in premiums from the current $100,000 level to $500,000 to $1 million, in order to maintain a reasonable relationship with other forms of liability insurance), an alternative to avoid such a test would be for the Federal Government to provide Federal insurance at a rate somewhat above what is likely to be encountered in the free market. This could ensure that insurance will be available and at a reasonable rate, if not on the private market, then from the government. It is suggested that such a structure seek to accomplish the following objectives:

1. It should not present an impediment to commercial space

activities, rather it . ld complement them.

2. Its conditions should not be subject to interpretation or negotiation.
3. It should not interfere with the provision of third-party liability insurance from commercial insurance sources.
4. It should not impose a burden on the United States Treasury.

Given these considerations, the following structure is suggested for the provision of third-party liability insurance by the Federal Government and should be studied further.

1. Establish a Space Liability Trust Fund that is independent of the General Fund, and which receives monies from premiums paid, those monies providing for management of the Fund and liability payments that be made by the Fund.
2. Provide for qualified space users to purchase th d-party liability insurance from the Fund at a price established by the Fund, and set so as not to encumber potential space activities nor to inhibit the continued provision of such insurance from commercial sources.
3. Establish a premium schedule in advance of sales, such premiums to apply for a period of at least one year. Premiums should not be subject to negotiation, but they could be subject to revision on a yearly basis, as dictated by actuarial data.
4. Establish a premium schedule that is tied to the launch fee. For example, for Space Shuttle flights, the pre-

mium could be 1 percent of the launch fee. The exact percentage could be adjusted periodically, if necessary.

By proportioning the insurance premium to the launch fee, the Fund acknowledges that small payloads would not be as likely as large payloads to contribute to potential mishaps. Further, the premium burden would be shared by the Space Shuttle users according to their "use" of the Space Shuttle. And such a premium structure would not impose an undue burden on small payloads that are likely to represent much smaller financial investments than large payloads. The use of the launch fee as a parameter for determining premiums is simple and objective: it accounts for size and mass of the payl , and it is an easily determined parameter that is readily available to the Federal Government.

If a trust fund is set up in accordance with the above structure, it could assure that all potential space users would have access to third-party liability insurance at a price that does not unduly inhibit commercial space activities. It could, therefore, remove this potential barrier to commercial space activities. On the other hand, it would not prevent the insurance industry from continuing to provide such insurance to the limit of its capacity to do so, at rates comparable to current rates, or higher if actuarial data indicate. Finally, given a rate structure wherein premiums exceed those currently charged by commercial insurance sources, it is extremely unlikely that such a fund would impose a burden on the United States Treasury, at least in the long term.

1. INTRODUCTION

In 1972 the United States became a party to the U.N. "Convention on International Liability for Damage Caused by Space Objects."[1] The treaty provides that the launching state of a space object, that is, the state from whose territories a space object is launched, is absolutely* liable for any damage caused to any other state by the object. No limit is placed on this liability. Without a liability limit, private enterprise would hesitate to make use of space. Thus, to promote commercial space activities, the Federal Government has agreed to indemnify all space users against liabilities exceeding $500 million. The first $500 million of liability has, however, remained an issue.

Since the late 1970's, the National Aeronautics and Space Administration (NASA) has required users of space vehicles to obtain insurance to protect the Federal Government from potential tort liability resulting from injury to third parties (those not a party to the launch agreement).[2] Initially, the required level of insurance was set at the amount that was available from private sources.[1] Users of expendable launch vehicles have been able to procure liability insurance in amounts up to $500 million per launch. More recently, however, for payloads carried aboard the Space Shuttle, difficulties have been experienced in obtaining this amount of insurance when there have been two or more payloads on the same flight because the required insurance capacity of $1 billion or more ($500 million per payload) has not

* "Absolute" liability means that there is no need to prove fault.

always been available. (Flights have been insured for up to $1.5 billion,[2] but recently there have been problems in finding sufficient capacity to insure up to $1.0 billion per flight.)

Faced with the unavailability of insurance, the government may choose one of four courses of action:

1. Continue to require all Space Shuttle users to purchase $500 million third-party liability insurance ($750 million combined total per flight).
2. Waive the insurance requirement under certain circumstances, such as when it is unavailable, or not available under reasonable terms and conditions or for reasonable premiums.
3. Provide insurance, backed by the Federal Government, to those users that cannot or choose not to obtain it from commercial sources.
4. Perform added research and development to make the system "safer," and to demonstrate such safety, so that insurance will be more readily available.

Insofar as insurance might not be available to all potential space users, the first option could impose a significant obstacle to commercial space activities. Even if insurance is usually available, the threat of its unavailability could impose unacceptable risks to some commercial space activities. Implementation of the second option could create incentives for private industry to try to fail to obtain insurance, and it would not provide any compensation to the Government to cover potential losses. This option would also create the possibility of a

lengthy approval process. The government would have to decide whether terms and conditions and premiums were "reasonable." Measures of reasonableness are, as will be discussed, unsatisfactory, and depend on the user. A reasonable premium for Comsat may not be reasonable for SBS or Microgravity Research Associates. The government would have to continually survey the price and availability of insurance. The third option places the Government into the insurance business but, if done with care, could meet the desired criteria. This course of action would expose the Government to substantial potential liabilities, but not more than the second option, and some compensation would be provided. If structured carefully, Federally provided insurance would be available as a back-up to private insurance, and not in competition with it. This would ensure that adequate insurance is always available for a reasonable premium, if not from the private sector then from the government. The final option is not really viable. The cost of research and development to demonstrate improved reliability of the Space Shuttle would undoubtedly be more than the maximum liability that could occur if the Government indemnified all users against all liability losses.

By the authority provided in Section 308 (1979) of the National Aeronautics and Space Act of 1958, the NASA Administrator may "provide liability insurance for any user of a space vehicle to compensate all or a portion of claims by third parties for damage resulting from activities carried on in connection with the launch, operations or recovery of a space

vehicle." The users are to reimburse the Administration to the maximum extent "practicable" for this insurance. Subsection (b) of Section 308 states that, "taking into account the availability, cost and terms of liability insurance, any agreement between the Administration and a space vehicle user may provide that the United States will indemnify the user against third party liability claims resulting from activities carried on in connection with the launch, operations or recovery of the space vehicle to the extent that the claims are not compensated by the liability insurance of the user."[3]

Section 308 was implemented under Executive Order No. 12291, a nonmajor, final regulation titled "Insurance and Indemnification of NASA Space Vehicle Users (14 CFR Part 1214 Subpart 1214.13)."[4] The regulation states that all users of a NASA space vehicle, with the exception of those flying small self-contained payloads, and users providing payload specialist services for NASA missions must obtain insurance protecting themselves, the U.S. government, and other parties identified in the launch agreement. However, this insurance requirement may be waived for a particular user or flight if it is determined that such action is in the "public interest." The amount of insurance and the terms and conditions of insurance must be agreed to by NASA and the user, taking into consideration the insurance available in the world market at a "reasonable premium." If NASA determines that adequate third party liability insurance is not available on reasonable terms and conditions or at a reasonable premium on the private market, or that the availablility of insurance prevents an orderly and equitable allocation of

liability risk, NASA will provide adequate liability protection for users and the U.S. government.[5]

Recent discussions between NASA and the Office of Management and Budget[4] have stressed the need for NASA to further define its insurance-related role and clarify the conditions under which it will indemnify or provide Federal insurance for space vehicle users, and the potential magnitude of the U.S. Treasury's liability if Federal insurance is provided.

The objective of this study is to provide information to support decisions concerning the provision by the Federal Government of third-party liability insurance for commercial space activities. The practices associated with third-party liability insurance in the marine, aviation, and electric utility (nuclear power) industries in addition to those industries associated with space missions have been reviewed. Results of this review are presented in Section 2. Theoretical considerations of rate setting are discussed in Section 3 and a methodology to determine the period of time over which the insurers of each industry intend to set aside reserves to recover from a maximum liability loss should one occur is introduced. Data have been developed (Section 4) for the above industries, including premiums, claim statistics, annual revenue generated and payouts, and industry assets relating to the ability to insure. The data were analyzed (Section 4) to determine the set-aside period in each industry, and to suggest standards of reasonableness from the insurer's point of view. Criteria for Federal provision of insurance are discussed in Section 5, which

presents public interest arguments, an interpetation of the Price-Anderson Act, determinants of the availability of commercial insurance, potential insurer liability, and measures of reasonableness for premium rates from the user's point of view. Section 6 presents options available to the government regarding third party liability protection. Conclusions and recommendations are provided in section 7.

2. LIABILITY INSURANCE IN FOUR INDUSTRIES

A review of practices associated with third party liability insurance in the nuclear power, marine, aviation, and space industries is presented.

2.1 Nuclear Power Industry

Nuclear power has associated hazards that have characteristics unlike most other hazards and related potential losses that are covered by insurance policies. The probability of occurrence and the maximum possible magnitude of damages is unknown. In the worst possible case the losses could be catastrophic. In the late 1950's, the Nuclear Regulatory Commission concluded that hypothetical property damage from a nuclear incident might range from half a million dollars to a worse case limit of $7 billion. The latter figure would be due mostly to contamination of land with fissionable products.[1] Later studies estimated damages far greater. For instance, according to NRC's Reactor Safety Study [1975], damages from a major accident could reach $17 billion.[2] Although the probability of occurrence of such catastrophic nuclear incidents[1] is thought to be extremely low (one study estimated the probability of a serious nuclear plant accident to be as low as one chance in a billion reactor operating years[3]), it is desirable that insurance be available to provide for such an eventuality. A unique system of setting aside funds for the remote possibility of a large financial loss has been established in the nuclear industry, and it is governed by the Price-Anderson

Act. [4]

The Price-Anderson Act of 1957 amended the Atomic Energy Act of 1954. The Act was intended to apply only to licenses issued through 1967, but was twice extended to apply to licenses issued through 1977 and then through 1987. Major objectives of the Price-Anderson Act were (1) to overcome industry reluctance to participate in nuclear power generation due to fear of the possibility of catastrophic, uninsured claims from a nuclear accident and (2) to avoid delay or failure to provide compensation to the public in the event of a nuclear incident [5]. Price-Anderson protects the public if an incident were to occur by assuring the availability of funds to satisfy public liability claims. [3]

Price-Anderson requires a nuclear power reactor operator to submit proof of financial protection, covering liability claims for bodily injury or property damage losses caused by nuclear materials,[6] to the Nuclear Regulatory Commission (NRC) before he can receive an operating license. Financial protection may be supplied through "private insurance, private contractual indemnities, self-insurance, other proof of financial responsibility or a combination"[7] of the above. Electric utilities that choose to purchase insurance are required to buy all nuclear liability insurance that is available from private insurers or else provide an equal amount of financial protection.[4] Initially the maximum amount of private insurance available per facility was $60 million; over time, it has risen to $160 million--the maximum applied to production facilities

having a rated capacity of at least 100,000 kilowatts.[8]

To date, each nuclear operator has elected to purchase a liability policy from one of two insurance pools. The amount of financial protection required and the fee for government indemnity are based on authorized operating levels of thermal power.[8] In 1957, when the original version of the Act was passed, liability insurance in the private market was $60 million and the government agreed to be liable for $500 million[3,9]. The rationale behind the $500 million limitation on government indemnification was that $500 million would not significantly disturb the Federal budget.[10] The Act limited each nuclear facility's maximum liability to $560 million: the amount then available from the private market plus the $500 million the government would indemnify in case of loss exceeding private market capacity. The $500 million limitation on government indemnification, Congress agreed, could be subject to upward revision in any particular incident, if after further congressional study Congress decided more appropriations were in order. Changes in the Act would be considered by Congress in light of the particular incident.[1]

This was the first time that any such protection had been offered by the Federal government for any particular industrial hazard and the amount of protection it allowed was unprecedented in the history of liability insurance covering a commercial activity.[8] Reactor operators had to pay an annual fee to the government for this extra protection from the government.[11,6] During the years that the Act has been in force the government has collected $21 million in indemnity fees.[9] Industry

coverage under private insurers grew to $160 million per facility by 1979.[12]

The maximum amount of liability insurance available per nuclear incident is shown in Table 2.1 for the period 1957-1982. In an analysis of the Price-Anderson Act, the General Accounting Office spoke with representatives of the nuclear pools to gain an understanding of the basis for available liability coverage and the possibility of increasing the coverage. Pool representatives stressed that coverage is based on each company's willingness to invest its money in nuclear insurance, and not on any actuarial basis. Even the Three Mile Island accident did not provide enough data for an actuarial base. In the absence of any type of actuarial base, various insurance companies are forced to make decisions regarding nuclear power versus other investments where the actuarial base is better known and the profit potential is better. Pool representatives felt that even if premiums were raised substantially, insurance capacity would not be

TABLE 2.1 HISTORY OF MAXIMUM LIABILITY COVERAGE AVAILABLE FROM THE NUCLEAR POOLS (THOUSANDS OF CURRENT YEAR DOLLARS)

YEAR	LIABILITY COVERAGE
1957-65	$ 60,000
1966-68	$ 74,000
1969	$ 82,000
1970-71	$ 82,000
1972-73	$ 95,000
1974	$110,000
1975-76	$125,000
1977-78	$140,000
1979-84	$160,000

SOURCE: THE PRICE-ANDERSON ACT, THE THIRD DECADE

increased.[10]

The maximum limitation on liability has remained fixed in current year dollars (it recently reached $585 million with the growth of a secondary level of insurance, which will be explained below). Thus, using the consumer price index $560 million in 1957 dollars translates into $1.8 billion 1982 dollars. Similarly, the $60 million private insurance, available in 1957 would have a value of $200 million in 1982 dollars. Thus, the actual value of insurance has been reduced (in constant dollars relative to 1957) by a factor of approximately 3 to 4.

Subsequent amendments modified the Price-Anderson Act. A 1966 amendment stipulated that insurance claims be made on a no-fault basis. Under this provision the liability protection of the nuclear plant covers claims against any other individual who might be liable under ordinary tort law principles, such as architects, engineers, contractors and suppliers.[13] The nuclear operator waives almost all legal defenses in incidents determined by the Atomic Energy Commission (AEC) to be an extraordinary nuclear occurrence (ENO). Limiting the waiver to ENO's would prevent the filing of small spurious claims and nuisance suits against nuclear reactor operators. An ENO was defined in the amendment to be an event"causing a discharge or dispersal of source, special nuclear, or by-product material from its intended place of confinement in amounts offsite, or causing radiation levels offsite, which the Commission determines to be substantial and which the Commission determines has resulted or probably will result in substantial damages to persons offsite or property offsite."[8]

This "channeling" of responsibility for liability claims is intended to simplify and speed the claim process. Claimants only have to prove personal injury or property damages were caused from radioactive materials released in a nuclear incident and show monetary amount of loss, but they do not have to establish the nuclear plant owner's liability.[6,8,9] This ensures the public will be able to establish liability for a nuclear accident which will be backed by solid financial resources and allows the insurance industry the stable premium base required to spread the risk of a nuclear disaster over an extended time period.[12] If a number of potential defendants had to have liability insurance, the total amount of insurance would be spread out among many potential defendants. In the case of a judgement against any one of them there would be a reduced amount of insurance available for payment of claims than would otherwise be the case.[13] Consistent with the no-fault provision, standard property and liability policies such as automobile, homeowners and commercial property and liability policies contain exclusions or limitations on losses stemming from radiation hazards.[8] The amendment also stated that government indemnity would be reduced to the extent that private financial protection increased beyond $60 million.[9]

Another amendment in 1975 required the creation of a secondary level of financial protection that would be provided through payments of retrospective premiums ($5 million per large operating reactor) when and if a nuclear catastrophy occurred at one of the plants that exhausted the primary level of financial

protection.[5] In the event of a nuclear accident causing liability damages in excess of $160 million, each operator of a nuclear plant will be billed by the nuclear pools (nuclear pools are discussed below) up to $5 million for each incident for each reactor (not to exceed $10 million for each reactor in a calendar year). The intention was to phase out government indemnification [11] and this has actually occurred as the financial protection now available from private sources is $585 million ($160 million primary and $425 million secondary - 85 power plants provide $5 million each of retrospective premium).[12,14] Under the amendment the maximum liability limit floats upward to meet the amount of protection both primary and secondary available from private sources[6] (from $560 million to $585 million). If losses should ever exceed the maximum limit on liability, Congress has obligated itself to review the situation and take appropriate action to protect the public.[4,6]

Most insurance practices operate by "spreading the risk" or distributing the large losses of a few to a large number of insureds who each pay a small premium.[15] This "interpersonal loss spreading" works well when accidents are common to a large number and the size of loss is moderate. The probability of a nuclear catastrophy are very low yet the potential damages if one does occur are extremely high.[12] Nuclear liability insurance uses the technique of "intertemporal loss spreading" which, rather than spreading the risk over individuals spreads the risk over time. Intertemporal loss spreading involves spreading over several accounting periods the impact of a large loss that might take place in a particular year.[3]

The capacity to underwrite such a loss must be available, but is beyond the means of any single insurance company.[3,6] Nuclear risks are concentrated and pooled and the insurance industry insures the entire nuclear industry.[12] In order to fulfill its licensing requirement each nuclear facility has purchased a liability policy from the nuclear insurance pools,[6] as mentioned above. Pools are groups of insurance companies that combine resources to allow them to insure risks of a size that would be beyond the capacity of any single firm [11]

Two pools provide nuclear energy insurance -- the American Nuclear Insurers (ANI) and the Mutual Atomic Energy Reinsurance Pool (MAERP).[3,6,16] Liability insurance is underwritten by ANI,(which also underwrites property insurance), and which counts 140 insurance companies as members,[17] and the Mutual Atomic Energy Liability Underwriters (MAELU) which is affiliated with MAERP and consists of six member companies of MAERP.[3,5,6,16] Two pools were established in 1957: MAERP was organized as a mutual corporation and the Nuclear Energy Liability Insurance Association (which eventually became ANI-after consolidation with the Nuclear Energy Liability-Property Insurance Association and subsequent name change) was organized as a stock corporation. ANI operates five separate nuclear pools covering nuclear property and liability insurance inside and out of the U.S. As of September 1982, 112 ANI member companies participated in the nuclear liability pool.[5]

The pools use identical policy forms, rates and rating procedures and carry out inspection of risks and handling of

claims jointly.[8] Consistently 77.5% of coverage has come from ANI and 22.5% from MAELU sources for both primary and secondary coverages.[5] Foreign nuclear insurance companies reinsure about 50% of the liability insurance available.[8,18]

Under the Industry Credit Rating Plan, the pools provide for retrospective downward adjustments of premiums ten years after payment. Seventy percent of each annual liability premium is set aside in a reserve fund to be used for loss or loss expense payments. After ten years a portion of the funds not used to pay losses are refunded to the insureds. The Plan was developed because of the lack of an experiential base upon which to set premium rates or any reserve fund to support the insured risk. Table 2.2 indicates the amount of refunds made to the nuclear industry and the percent of premium income the refund represents.[8,19]

In 1984 the maximum liability coverage available from the nuclear pools is $160 million for each insured facility (there are currently 85 facilities).[8,12] The coverage available from the pools is the primary level of protection and is supplemented by a secondary level of protection which is furnished by the operators of nuclear power plants under the retrospective premium plan as noted above.[3,12] This retrospective rating plan is provided under a basic policy issued by the nuclear pools that covers "excess losses," defined as losses from bodily injury or property damage in excess of sums paid or payable under all applicable primary financial protection. This secondary level of financial protection has reached $425 million (85 power plants operate under this system). [6,12]

TABLE 2.2 NUCLEAR LIABILITY PREMIUM REFUNDS		
YEAR	AMOUNT OF REFUND ($1000)	PERCENT OF PREMIUM INCOME*
1967	46	66%
1968	241	67%
1969	477	67%
1970	784	67%
1971	1,017	68%
1972	1,167	67%
1973	1,393	68%
1974	1,434	68%
1975	1,468	70%
1976	1,681	70%
1977	1,951	70%
1978	2,156	71%
1979	2,054	61%
1980	849	20%
1981	1,653	29%
1982	2,301	35%
1983	3,250	39%

SOURCE: NUCLEAR INSURANCE FACTS AND FIGURES 1984, AMERICAN NUCLEAR INSURERS REPORTS

*CORRESPONDS TO PREMIUM INCOME FOR YEAR TEN YEARS PRIOR TO REFUND DATE.

As part of the secondary level of financial protection program, ANI and MAELU are making available $30 million of contingent liability that will cover the possibility of default on retrospective premium by any of the reactor operators.[16] These retrospective premiums are only payable when the liability costs exceed funds available from primary insurance coverage.[1] The secondary level of protection is a form of interpersonal loss spreading.

Two forms of nuclear energy liability policy (NELP) coverage are available from the liability pool. The facility form covers licensees of nuclear production or utilization

facilities for liability for injury to the public or damage to the public's property caused by the nuclear energy hazard. The nuclear energy hazard is defined as "the radioactive toxic explosive or other hazardous properties of nuclear material."[3,11,20] Insurance is applicable only to nuclear material at the nuclear facility described in the declarations, accidently discharged from the facility, or while being transported to or from the facility and away from another facility.[3] The facility form includes three coverages. Under coverage A the insurer promises to defend insured and pay legal obligations of insured for damages. Coverage B, is first party insurance which allows the insured to collect from the insurer for damages to its property that are not at the nuclear facility, but that may be damaged by a nuclear incident at the facility. A supplier to facility which sustained damages to its property from a nuclear incident at the facility would also collect under Coverage B. Coverage C is known as "Subrogation—Offsite Employees," and responds to claims of a contractor's worker compensation insurer.[3,21]

The second form of coverage is the suppliers and transporters policy. Although suppliers and transporters to a nuclear facility are insured under that utility's facility form for damages arising from their activities on behalf of the utility this second form provides them with additional coverage. It also covers suppliers and transporters who are subject to nuclear exposure but who are not performing a service for a named insured under a facility form.[3,22]

2.2 Ocean Marine Industry

The ocean marine liability risk is characterized by potentially large liabilities. The 1978 wreck of the Amoco Cadiz caused a massive oil spill off the coast of Brittany which has generated over $2 billion in damage suits. Amoco had $50 million pollution liability coverage at the time of the accident.

Legal liability policies in the marine industry are written to protect ship repairers, stevedores, terminal operators, and marina operators.[1,2] These policies offer protection to an insured with the property of others in his care when there is waterfront exposure or a watercraft risk. Practices associated with shipowners' liability, however, is more analogous to space liability, and will be examined in more detail in the following paragraphs.

A shipowner's liability due to negligent navigation includes any incident involving his vessel in contact with all floating or fixed objects. There may be liability without contact, as when damage is caused by wash due to a vessel's excessive speed. When the negligence of two or more vessels are found to have caused damages then liability is proportionately allocated among the two according to comparative degree of their fault (before 1975 liability was equally allocated but in a Supreme Court decision in 1975 the principle of proportionate liability was adopted).[3] Shipowners are covered for legal liability under protection and indemnity insurance and under a third party liability provision covering collisions that may be included in the hull policy.

In the following paragraphs protection and indemnity (P&I) policies are considered.

At least 90% of all shipowners' liability is insured through P&I clubs. There are approximately 20 international clubs, worldwide. In the U.S., the American Club is the only mutual non-profit P&I club. Non-Americans began joining the American Club in 1980.[4] The American Club includes 35 shipowner members[5] (as of 9/82) and is the only active U.S. liability market for oceangoing fleets.

The clubs, which are non-profit are similarly organized. Each club appoints a board of directors from its shipowner membership, which hires managers to run daily operations.[6] P&I members, who must be shipowners, pay an annual premium based on ship size, crew, claims experience and management fees. When each member renews, the club underwriters try to adjust the premium rating for that member so it reflects the risks to the club of claims for that member, taking into account the member's premium and claims record and other factors. In a mutual association, the premiums are paid in the form of advanced calls during the currency of the policy year. These form a basic fund out of which the claims and other outgoings are met.[7] If there are losses during the year, the club issues extra calls, while if there is a surplus the club may pay refunds to the members.[6,8] An appropriate premium rate is usually expressed in terms of "per gross tons."

The Federal Limitation of Liability Act (1851), designed to protect vessel owners from catastrophic losses, not caused with

owner's privity or knowledge, limited the liability of owners for damage to property arising out of a collision[2,3] to the value of the vessel if the owner didn't cause and wasn't previously aware of circumstances that caused the loss. Court interpretations changed over the years. The purpose of the Act was to encourage growth of the maritime industry. Early litigation set the value of the vessel at its value at the end of the voyage (obviously in major losses this value was low) plus the freight actually earned on the voyage. The judicial climate began to change in the late 1930's when the owner was often judged to be with privity and knowledge, and thus not subject to limitation. The Sirovich Amendment set a maximum limit of $60 per gross ton of vessel when loss of life or personal injury on seagoing vessels was involved.[2]

Changes in state or federal laws or the enactment of new laws may change the vessel owner's responsibilities and potential liabilities under P&I coverage. Changes may also result from judicial interpretations.[2]

Two types of P&I limits are often referred to: primary and excess. Usually primary P&I limits are equal to the vessel's hull value, and excess limits are limits that exceed that amount.[2]

It is difficult to find one underwriter who will take the entire risk of P&I limits which are often in millions of dollars. Coverages are thus often written under a number of policies arranged in layers, so the underwriters can spread their risk. Since risk is higher at the lower layers of coverage, higher premiums are charged for the lower layers of protection than for

the upper layers where risk is lower. Underwriters would only be involved if the losses were within their layer of coverage.[2] For instance, protection provided through a British club may be layered as follows. The shipowner's club covers the first $750,000 of damages. Between that and $6 million the clubs share the reinsurance based on the size of each club and its premium income. Losses above $6 million are reinsured in Lloyd's and other markets up to $375 million, damages beyond which the pool would share, or the club might cover.[6] British P&I clubs often provide unlimited protection, but the American club offers up to $375 million of protection.

The American Club and underwriters generally provide coverage under two standard protection and indemnity policies (British P&I clubs each have their own rules.)[9] The standard policy includes a general clause under which the club agrees to "indemnify the assured against any loss, damage or expense which the assured shall become liable to pay and shall pay by reason of the fact that the assured is the owner (or operator, manager, charterer, mortgagee, trustee, receiver or agent, as the case may be) of the insured vessel and which shall result from the" liabilities, risks, events, occurrences and expenditures as set out in the policy.[3,10] Coverage is indemnity and not direct liability: the insured must have been legally liable to pay and have paid the loss, damage or expense before P&I underwriter is liable under the policy.[3] There are innumerable clauses available to add, modify or delete coverages. Standard policy 38 covers the legal liability of the assured for loss of life,

injury and death, crew medical and other expenses, damage or expense in connection with any fixed or movable object or property, removal of wreck of insured vessels when compulsory by law, fines and penalties except resulting from lack of due diligence, and legal fees and defense costs resulting from a liability or alleged liability of assured covered by the policy. Coverage excludes direct damage to vessels named in policy, loss of use, monetary loss, demurrage, claims regarding vessels in tow, cargo on board named vessels, claims under Longshoremen's, Harbor Workers' Compensation Act or any Workers Compensation Act, contractual liabilities, war risks and claim, loss, damage or expense collectable under a Hull Policy.[9,11]

The second policy, Standard Policy 23 covers, in addition to the above coverages, cargo legal liability on the insured vessel including passenger, baggage and personal effects, excess (that is not covered by the hull policy) collision liability for loss or damage to another vessel, liability for damage to another vessel not caused by collision, third party liability to fixed and floating objects,(except another vessel or craft) and liability for oil and hazardous substance spills.[2,3]

The provision that covers fixed and floating objects protects for third party liability damages to piers, docks, bridges, jetties, harbor, breakwater, structure, beacon, buoy, lighthouse, cable and other fixed objects or movable objects (except another vessel or craft or property on board another vessel or craft) whether owned by the assured or not.[10] When a vessel comes into contact with stationary or moving objects, other than another vessel, the vessel is almost always liable for

damages. Just the fact that the vessel was moving is often regarded as prima facie evidence that the vessel was at fault. The best defense for the vessel owner would be to prove that control of the vessel was impossible although everyone on board extended their best efforts. Another defense would be to prove that improper marking or lighting led to the accident.[2]

The pollution portion of the P&I policy covers liability for spills of oil and other hazardous substances, whether arising from a collision or not[3] although pollution coverage may be excluded by endorsement and may be offered for an additional premium.[2]

There is a collision coverage under this policy for excess collision liability with vessels not covered by the Hull policy which covers liability to other vessels if insured's vessel caused a collision. The risks that would fall in this category of P&I coverage are expenses for which the assured is liable for removing, raising or destroying the wreck of another ship or vessel or its cargo, damage done by another ship or vessel to a harbor, wharf, pier, stage or similar structure as a result of the insured vessel being in collision with that vessel. Payments for damages to the cargo of the insured vessel by the non-carrying vessel involved in the collision and included by that vessel in her counterclaim against the insured or carrying vessel in accordance with American law are also included under this clause in the policy.[3]

As mentioned above, these last two coverages (liability for damage to fixed or movable objects and excess collision

liability) seem most analogous to third party liability arrangements for space vehicle users. Also the third party liability provision under the hull policy mentioned below that covers collisions is similar to the third party liability for space vehicles users.

A lay-up return provision clause is included, which does not appear on SP-38.[9,12] When a vessel is laid up (known as a port risk) shipowners pay significantly less than they pay to protect a navigating ship. If a ship that has been insured as an active ship is "laid-up" in port for longer than 30 days the owner may receive a return of part of the premium paid.[5]

According to the American Club the largest claim to date has been for $45 million, though maximum insurance coverage provided through the American club has now reached $375 million.[13] The club's standard limit is $100 million per incident.

Hull insurance policies include a third party liability provision that will cover collisions: if a vessel negligently strikes another vessel causing damage to that other vessel and her cargo, the hull insurance under its Running Down clause, of the offending vessel should cover collision damages to the vessel it struck. If the collision forces the vessel that is struck into collision with a third vessel, the vessel that caused the collision is also covered under its hull policy.[1,14] If the vessel that is collided with strikes a pier and damages it and injures persons, then damages are covered under the P & I policy of the vessel that caused the collision.[14]

Before 1970, pollution liability was a minor concern and the major concern was when oil damaged someone's property. Liability

for cleaning up an oil spill was first imposed with the International Civil Liability Convention (CLC) of 1969 (which was ratified by most maritime nations, although not by the U.S.) and the Water Quality Improvement Act of 1970, in the U.S. [3,9]

In 1969, a voluntary program was entered in to by international oil companies and tanker owners. The association, Tanker Owners Voluntary Agreement Concerning Liability for Oil Pollution (TOVALOP) deals with clean-up cost and not third party liability claims. Tanker owners agree to reimburse governments for their clean-up costs unless the vessel concerned can prove that no negligence was involved. Members are encouraged to instigate clean-up operations themselves, regardless of fault, and if they do the reasonable costs of such voluntary clean-ups are covered by TOVALOP. Limits covered under TOVALOP are $100 per gross ton (of the offending vessel) with a maximum of $16.8 million. The agreement is administered by the International Tanker Owners Pollution Federation and the liabilities and obligations under TOVALOP are insured by the International Tanker Indemnity Association (ITIA) in conjunction with the international Protection and Indemnity Clubs. [3]

Later another arrangement was introduced by the oil industry when it became apparent that the amount available for clean-up under TOVALOP would probably not be sufficient. The Contract Regarding an Interim Supplement to Tanker Liability for Oil Pollution (CRISTAL) has the objective of providing additional compensation to government or other third parties suffering pollution damage which they cannot fully recover from the owner

of the offending vessel because of the vessel's limit of liability. CRISTAL also seeks to encourage voluntary clean-up and will reimburse the tanker owner (or his P&I club) in respect of the owners own clean-up costs after other available remedies have been exhausted. Membership is limited to oil companies engaged in the production, refining, or marketing of oil. CRISTAL operates if the vessel carrying the oil cargo is a member of TOVALOP and the cargo carried is owned by a CRISTAL member.

It has been suggested that the voluntary associations were a public relations exercise and were intended to obviate the need for pollution legislation. However, maritime nations have introduced severe pollution laws.[3]

In the U.S. Federal legislation and implementing regulations have imposed and defined liabilities of vessel owners and operators in spills of oil and hazardous substances.[9] Legislation has set limits of liability when damages were not due to wilful misconduct or negligence within the privity and knowledge of the vessel owner or operator, and established funds to provide for claims. In addition to Federal legislation individual states have enacted regulations concerning oil pollution claims. Thus, a vessel owner may be liable to the Federal government for clean-up costs and to state and third party claimants also.[3]

The Water Quality Improvement Act of 1970 introduced the principal of strict liability whether or not there was negligence. Except when a spill from a vessel was the result of an act of God, an act of war, negligence by the United States, or an act or omission by a third party, the owner of the vessel is

liable for clean-up costs incurred by the U.S. government (private claims are not effected by this legislation). Originally the Act limited liability to $100 per gross ton up to a maximum of $14 million. The Clean Water Act of 1977 and 1978 amended the limits of liability. For inland oil barges the limit was the greater of $125 per gross ton or $125,000; for tankers the limit was the greater of $150 per gross ton or $250,000 and for other vessels it was $150 per gross ton with no floor. The previous $14 million ceiling on liability was removed. If the spill was caused by wilful misconduct within the vessel owner's privity and knowledge, the owner is liable for the full cost of clean-up without limitation.[3,9]

The Comprehensive Environmental Response, Compensation and Liability Act of 1980 [15], which has not yet been implemented set limits for liability for costs incurred by the U.S. government in removal or remedial action caused by incidents involving release of a hazardous substance.

The Trans-Alaska Pipeline Authorization Act (TAPA) provides a $14 million limit of liability to vessels loading oil from the Trans-Alaska pipeline. The Act covers all damages including clean-up costs, sustained publicly or privately. Strict liability shall not be imposed if damages were caused by acts of war and negligence of the government or the damaged party.[3,16] Actually, the Act states that strict liability for claims arising out of one incident shall not exceed $100 million. The owner and operator of the vessel is liable for the first $14 million of claims (financial responsibility for $14 million had to be

demonstrated before the oil was loaded). The remainder of the damages up to $100 million is to be paid by the fund (the Trans-Alaska Pipeline Liability Fund) provided for in the Act The fund could be used to pay for clean-up, resources, injuries, and third party claims. A 5 cent per barrel tax on oil passing through the Valdez terminal provides funding.[17]

The Deep Water Port Act of 1974 limits liability for damages and cleanup costs resulting from discharge of oil caused by vessels at deepwater ports. Liability is limited to $150 per gross ton or $20,000,000, whichever is lesser, except if the discharge was due to wilful misconduct or gross negligence within the privity of the owner and operator, in which case they are liable for full costs of cleanup and damages. The Act sets up a Deepwater Port Liability Fund of $100 million which shall be used if liability exceeds $20 million. The fund is raised by a 2 cent per barrel tax on oil handled by an deep water terminal.[17,18]

The Outer Continental Shelf Lands Act Amendments of 1978 established an Offshore Oil Pollution Compensation Fund (not to exceed $200 million) raised by imposing a per barrel fee on oil obtained from the Outer Continental Shelf. Liability limits are set for oil pollution damages caused by vessels operating in the waters above the Outer Continental Shelf or in the waters above submerged lands seaward from the coastline of a state and transporting oil directly from an offshore facility. Liability for damages caused by such vessel is limited to $250,000 or $300 per gross ton, whichever is greater, if the incident was not caused by wilful misconduct or gross negligence within the privity or knowledge of the owner.[19]

2.3 Aviation Industry

Aviation insurance was originally underwritten by insurers in marine and accident departments which still handle some insurance associated with air transport, such as air cargo (normally insured under marine policies) or personal accident policies protecting air travellers (handled by accident departments). However, in recent decades, a distinctive aviation market has developed to handle demand from the rapidly growing industry. Insurance companies that write substantial aviation business have set up specialist aviation departments or specialist aviation insurance companies.[1]

The three primary aviation markets, U.S. Aviation Insurance Group (USAIG) and Associated Aviation Underwriters (AAU) and the London market [2] work under a quota share environment whereby each underwriter takes a percentage of the limit and percentage of their share of the premium for certain lines of major airline business.[3]

Aircraft are classified for insurance purposes into air carriers (the airlines), and general aviation which includes private aircraft (personal enjoyment and business uses), corporate flying (aircraft owned and operated by corporations for transporting executives) and commercial flying (rental and charter work, student instruction and operation of aircraft for hire other than air carriers).[4] Liability policies are also written for other air transport related risks such as hangar keepers liability, airport owners' liability and fuelers' liability. Manufacturers' products liability risks constitute

another class of insurance.

There are three basic liability coverages that are included in aviation package policies: passenger bodily injury, bodily injury excluding passengers and property damage. Lloyd's aircraft liability policy for instance, defines six coverages. Through Coverage A the insurer agrees to pay legal obligations of the insured for damages for bodily injury caused by occurrence and arising out of the ownership, maintenance or use of the aircraft. Coverage B covers legal obligations of the insured due to property damage, Coverage C covers passenger bodily injury liability, Coverage D is single limit bodily injury including passengers and property damage liability, Coverage E is single limit bodily injury excluding passengers and property damage liability and Coverage F pays reasonable medical expenses, and funeral services for persons who sustain bodily injury sickness or disease by accident while in, entering or alighting from the aircraft.[5] Coverages A, B, and E appear to be analogous to third party liability coverage for space vehicle users.

In recent years, the trend has been towards the simplification of insurance programs. Up through the late 1960's an airline probably would have a separate hull, hull war, passenger liability, third-party liability, freight liability, mail legal liability and cargo liability policies. Now it is common for an insurer to issue only two policies; a combined hull and liability insurance covering in one limit of indemnity all types of liability risk and a separate hull war policy.[1]

The level of insurance required for some aviation risks

(such as liability) may strain the capacity of international insurance markets. ? · substantial potential liabilities require direct underwriters and reinsurers to spread the risk as widely as possible. Leading underwriters usually accept between 5 and 10% of major risks. National aviation pools and sharing agreements (reinsurance arrangements) have been used to spread risks and more effectively mobilize capacity.[1]

The Federal government sets minimum limits on liability coverage. Section 298.42 of the Civil Aeronautics Board (CAB) Economic Regulations Part 298 requires air taxi operators, engaging in air transportation to maintain aircraft accident liability insurance and specifies a required minimum limit of liability coverage. There is a limit for any one passenger of at least $75,000 and a limit for each occurrence in any one aircraft of at least $75,000 multiplied by 75% of the total number of passenger seats installed in the aircraft. The minimum limit on liability for bodily injury to or death of persons excluding passengers is $75,000 for any one person in any one occurrence and a limit of at least $300,000 for each occurrence. A minimum limit on liability for loss of or damage to property is set at $100,000 for each occurrence.[6]

U.S. air carriers are subject to part 205 of the CAB economic regulations. A U.S. or foreign direct air carrier must meet the requirements of part 205 to receive the right to engage in air transportation. The carrier is required to make available proof of insurance or self-insurance to the CAB. Th. .d party aircraft accident liability coverage for bodily injury to or death of persons including nonemployee cargo attendants,

excluding passengers and for damage to property must meet the minimum limit of $300,000 for any one person in any one occurrence, and a total of $20,000,000 per involved aircraft for each occurrence. In the case of accidents involving aircraft of fewer than 60 seat or 18,000 pounds maximum payload capacity the minimum coverage is $2,000,000 per involved aircraft per occurrence. The limits of liability apply separately for each occurrence. A minimum of coverage for bodily injury to,or death of aircraft passengers is $300,000 per passenger and a total per involved aircraft for each occurrence of $300,000 times 75% of the number of passenger seats installed in the aircraft.[7]

It is difficul to generalize about aviation insurance because in the U.S. aviation policies are not standardized. Premiums vary significantly, there are no published rate manuals, usually no filed rates, and most rates are taken from general guides or "off the top of the head".[8] Rates are based on criteria such as pilot qualifications, make and model of the aircraft, how the aircraft will be used, how the aircraft is stored, frequency and mileage of flights, type of coverage required, airfields that are frequented, and aircraft capacity.[5,9,10] There is no precise actuarial or scientific basis for the rate because of the relatively small number of units involved. Rates are based on past statistics and underwriters' risk assessments or judgement.[10] Liability premiums are often based on the number of revenue passenger miles flown.[5,9] In the case of passenger liability, the logic of charging per revenue passenger mile is obviously to secure an

increased premium in proportion to the greater exposure.[1]

Supply and demand influence rates. Activities and practices of the aviation pool members over the years seems to indicate that participation varies with the immediate past underwriting experience generated by all lines of insurance as opposed to underwriters surplus. Underwriters have been bold when loss ratios were low and have restricted commitments when loss ratios were high. Rates are susceptible to previous losses: when underwriters are faced with losses in excess of premiums they subsequently raise premiums to break even. For example, record losses suffered by aviation insurers in 1983 will amount to $700 million in hull and liability payments. The 1983 premium volume amounted to between $500 million to $550 million. According to one broker, rate hikes in the London market are averaging 37.5% for hull coverage and 23.5% for liability coverage. British Airways premium rate for liability insurance almost doubled from $3.53 million to $6.95 million, this year.[13] Pan Am paid significantly higher rates on hull and liability coverage and in addition has agreed to a $10 million aggregate deductible for hull and liability losses in addition to per occurence deductibles for partial hull losses.[14] A London underwriter expects that airlines with high loss records will be confronted with average overall renewal rate hikes of 40%.[11]

Skandia Insurance Company, Ltd. of Stockholm maintains a data bank of aviation statistics. Their data on airlines with a fleet value of larger than $20 million, indicates that liability rates in the U.S. market between June 1976 and May 1979 were substantially lower than the breakeven rates.[12]

2.4 Commercial Space Industry

Under traditional United States tort law, if the Shuttle and/or payloads contained within it were to cause damage to a third party, the U.S. government and users of the Shuttle would be potentially liable to the third parties, based on negligence or absolute liability (liability without proof of fault or negligence).

The United Nations' Convention on International Liability for Damage Caused by Space Objects, which the United States is a party to,[1] holds a launching State absolutely liable to pay compensation for damage caused by its space object on the surface of the earth or to aircraft in flight.[2] The launching State is charged with liability for all space objects launched from within its borders, regardless of satellite ownership, so a claimant only needs to file claim against the launching State regardless of the ownership of the object that caused the damage.[3] If damage is caused other than on the earth's surface to a space object, or persons on board that space object, of one launching State, by a space object of another launching State, the latter will be liable only if the damage is due to its fault or the fault of persons for whom it is responsible.[2] The Convention does not apply to damages caused by a space object of a launching State to the nationals of that State, or foreign nationals who are participating in the operation of that space object from the time of its launching until its descent, or when they are in the immediate vicinity of a planned launch or recovery area.[3] (Additional Articles in the Convention indicate liability when a

third State is involved, or when two or more States jointly launch a space object.)[2]

It has been NASA's policy since the late 1970's[4] to require commercial users of launch vehicles to obtain third party liability insurance that will protect the U.S. from potential tort liability resulting from injury to third parties and non-U.S. government users of expendable vehicles have been able to obtain at least $500 million worth of third party liability insurance per launch.[1,4]

The Shuttle Launch Agreement requires the customer to obtain, at no cost to NASA, insurance protecting the Customer and the U.S. Government from any third party liability for damage arising out of the performance of the agreement during the Risk Period defined in the agreement. The Risk Period begins at the start of the physical attachment of the Payload to the Orbiter and ends after the launch of a payload upon the landing of the particular Orbiter without causing damage to third parties, or if a payload is jettisoned, when the payload impacts the earth without causing damage to third parties, whichever occurs last. If third parties are damaged, the risk period ends immediately after all such damage occurs. Or the risk period ends prior to the launch of a payload upon completion of removal of the payload from the orbiter for any reasons.[5]

Under an amendment to the National Air and Space Act of 1958, NASA has been authorized to provide liability insurance and to indemnify a user of a space vehicle for claims for damages that may result from activities carried out in connection with

the risk period defined above. This amendment is section 308 of the NASA Act and is described in the following paragraphs.

The customer is also required to obtain, at no cost to NASA insurance protecting the customer and the U.S. Government from any third party liability for damage caused by a deployable payload element following deployment (not including a payload that remains tethered to the Orbiter).[5] NASA will not provide liability insurance or indemnify for damages arising during the period following deployment and after the Orbiter has landed. This coverage is required to be in force indefinitely [18] and is usually renewed every three years.[6]

The launch agreement also includes an interparty waiver of liability under which each party agrees not to bring a claim against or sue the other party or other customer and agrees to absorb the financial and other consequences of damages it sustains as a result of participation in STS operations whether or not such damage is caused by NASA, the customer, or other customers participating in STS operations, and regardless of whether such damage occurs through negligence or otherwise. This interparty waiver applies indefinitely to any party to a shuttle launch agreement, whether or not they are are the same shuttle flight. Each party therefore agrees to absorb the consequences (financial and other) of damage to its property.[5]

If a payload specialist sustains bodily injury, the individual or his estate may sue one of the parties to the launch agreement but the individual's employer may not sue any of the parties to the launch agreement because of the interparty waiver.[4]

This inter-party waiver is extended to other participants in STS operations, including contractors and subcontractors and other customers who are therefore protected from claims including product liability claims which otherwise might be pursued by the parties or their contractors or subcontractors, or other customers).[5]

For the first few launches, before the interparty waiver came into effect (prior to December 1982), a Shuttle contractor such as Rockwell carried liability insurance for each launch to protect against claims by Shuttle users for damage to the user's property (third party risks were also covered, but potential third party damages were considered remote). Premiums for each launch were $1.4 - $1.5 million. To the extent that NASA's funds were used to reimburse contractors and subcontractors, payment of such high premiums were considered to be to the detriment of NASA's space missions. NASA then agreed to indemify NASA contractors under Public Law 85-804 for claims or losses resulting from use or performance of products or services defined in the agreement (including space transportation system, components, cargo flight elements or ground support, repair, modification, and overhaul support to the STS).[4, 7]

The customer also agrees in the launch agreement, not to make a claim against the U.S. Government and the U.S. Government's contractors and subcontractors, for damage or relief for any delay in provision of any aunch and associated services or for non-performance or improper performance of launch and associated services.[5]

The amendment to the National Aeronautics and Space Act of 1958, referred to above, adds a new Section 308 (which is part of Public Law 96-48 sec.6) to the Act (and renumbers the previous 308 to 309),[11,13] which authorizes NASA to provide liability insurance and to indemnify a user of a NASA space vehicle for claims of third parties that may result from activities carried out in connection with launch, operations or recovery of the space vehicle.[8]

Subsection (a) of Section 308 authorizes the Administration on such terms, and to the extent it may deem appropriate, to provide liability insurance for any user of a space vehicle to compensate all or a portion of claims by third parties for death, bodily injury, or loss of or damage to property resulting from activities carried on in connection with the launch, operations or recovery of the space vehicle. Appropriations available to the Administration may be used to procure such insurance, but users must reimburse NASA to maximum extent practicable by users under reimbursement policies established pursuant to section 203 (c).[9,10]

Subsection (b) of Section 308 authorizes NASA at its discretion to enter into agreements with a user of a space vehicle which would provide for the indemnification of that user against claims by third parties for damage resulting from activities carried out in connection with the launch, operations or recovery of the space vehicle, to the extent that such claims are not compensated by liability insurance of the user. The Administrator must issue implementing regulations which take into account the availability, cost and terms of liability insurance

before entering into any such agreements. The indemnification may, at NASA's discretion, be limited to claims other than claims resulting from users' actual negligence, wilful misconduct, or both. Payments may be made from funds available for research and development not other wise committed, or from funds appropriated for such payments.[9,10,11]

A "user" is defined as anyone who enters into agreement with NASA to use all or part of a space vehicle, who owns or provides property to be flown on the vehicle, or who employs a person to be flown on the vehicle.

A "space vehicle" is defined as an object intended for launch, launched or assembled in outer space, including Shuttle and other components of the Space Transportation System, and includes elements of STS such as Spacelab and upper stages in addition to the payload to be flown on the Shuttle for a user.

Third party is defined as any person who may bring a claim against a user for death, bodily injury or loss of or damage to property (a claim for any damage sounding in tort). Third party usually does not include users contracting with NASA for launch services, as per the inter-party waiver mentioned above.[9]

Section 6 of Public Law 96-48 is implemented in 14 CFR Part 1214. According to 1214.13(c) of this rule NASA requires each user to obtain insurance in an amount not in excess of $500 million dollars, but recognizing that there does not seem to be the insurance capacity to insure a single shuttle flight for more than one billion dollars, the Agency will accept that there may be Shuttle flights with payloads of several users that are

insured under one policy for not in excess of one billion dollars. This is acceptable during the flight, however, each user is expected to insure their deployed payload for $500 million dollars. The rule states that NASA will indemnify users flying small self-contained payloads and users providing payload specialist services for NASA missions under a NASA contract for third party liability to the extent that such claims are not compensated by the liability insurance of the particular user. These users will not be required to obtain insurance.

In addition NASA has indemnification agreements with those it has Joint Endeavor Agreements (JEA) with. Under the JEA, NASA provides free launch service while the company provides experiments to or other payloads to NASA. NASA does not require insurance for the Shuttle flight and indemnifies during research flights. Foreign users are not required to purchase third party liability insurance, but NASA does not agree to indemnify them.[4]

All other users of a NASA space vehicle must obtain insurance protecting themselves, the U.S. Government and other persons or entities identified in the launch and associated services agreement entered into by NASA and the users for third party liabilities. The amount of insurance and the terms and conditions of the insurance shall be agreed to by NASA and the user depending on the insurance available in the world market at a reasonable premium. The Associate Administrator for Space Flight, with agreement of the General Counsel and Comptroller, may waive this requirement for a particular user and/or flight if he or she determines that to do so would be in the public

interest. Agencies of the U.S. Government (defined in 5 U.S.C.) 102 and 105 will not be required to obtain such insurance.

NASA may indemnify each user (with the exception of other U.S. Government agencies) for liability incurred by the user in excess of the NASA approved insurance policy of the user subject to terms, conditions and exceptions contained in the indemnification agreement. A user will not be indemnified for payments that fall within the deductible of the user's policy, or aren't covered due to exclusions in the policy except for the maximum dollar limitation stated in the policy or standard exclusion agreed to by NASA for shuttle-caused pollution or interference with radio frequencies, or for payments to contractors or subcontractors for liability incurred by them, or settlement payments unless agreed to by the U.S. government. If NASA determines that adequate third party liability insurance is not available on reasonable terms and conditions or at a reasonable premium in the commercial insurance market or if NASA determines that the availability of third party liability insurance prevents an orderly and equitable allocation of the risk of liability NASA will try to provide adequate liability protection for users and the U.S. government choosing one of the following three options.[8]

The first option would be to have a user(s) chosen by NASA be authorized to purchase an insurance policy protecting all uninsured users on the flight, the U.S. Government, and other persons or entities party to the launch and associated services agreement between NASA and the users. The premium would be

allocated among all the users with the exception of a small self-contained payload user, or U.S. Government agency.

A second option would allow NASA to obtain an insurance policy and equitably allocate the premium among the users on that flight, again except for self-contained payload users and government agencies.

Under the third option NASA would indemnify uninsured users for a premium that will be put into an indemnification pool that NASA would use to indemnify users or to offset equitably premiums of other users. This option would be chosen by NASA only when it determines that adequate insurance is not available at a reasonable premium and on reasonable terms and conditions in the commercial insurance market.[8]

Under these provisions NASA may provide liability insurance to users at its discretion on "such terms and to the extent it may deem appropriate," to compensate users for claims by third parties. Thus, NASA may provide insurance to some users and charge those users for the insurance, or it could exempt other users from the requirement of obtaining or paying for third party liability insurance at all. Under this section the Administrator may use appropriated funds available to NASA to purchase third party liability insurance for a number of shuttle flights. The Administrator would seek reimbursement to the maximum extent practicable from users under general Shuttle reimbursement policies, by charging users a fixed price for insurance based on an estimate of the cost of insurance, number of Shuttle flights and users to be protected by the insurance policy and other factors. Other reasonable methods of collecting

from users for insurance may be adopted by NASA according to their experience and the insurance that is available.[1]

NASA is not expected to use appropriated funds to protect the U.S. Government from liability, but Subsection (a) is broad enough to include even that.[9,11,12]

NASA and International Technology Underwriters (INTEC) have a Memorandum of Understanding in which it is recognized that INTEC will establish and administer an "underwriting facility" to provide third party liability insurance for users who choose to insure through the facility. The facility will support only the U.S. launch program. INTEC will attempt to increase capacity of third party liability insurance to $750 million and if possible $1 billion per flight, and obtain the insurance at the lowest possible premium rate and, as administrator will equitably allocate the premium among users on the same flight, in addition to providing coverage on an individual basis.[13]

The insurance policy put together by INTEC covers a period commencing with the attachment of payload by bolt to the Shuttle and ending 36 months later unless the user's payload is jettisoned, in which case the policy period will end for that user when the payload impacts the Earth without causing damage to third parties.

A limit of liability, if there is one user identified in the Schedule of User's and Payloads, is $500,000,000 for all damage arising out of any one occurrence during the risk period defined in the launch agreement.[14] So far, INTEC has been able to obtain up to $750 million of capacity to insure one single

shuttle launch.[6] The limit of liability may be used to satisfy the legal liability of one or more of the insureds identified under the policy for any one occurrence. If the limit of liability has been reduced or exhausted because of payments of liability claims of some of the users insured by the policy then other users under the policy may seek alternative protection including indemnification by NASA as described in the launch agreement. Despite the number of users insured under the policy the limit of liability for all damages is $500,000,000 for each insured payload for any one occurrence from the time each payload is deployed as defined in the launch agreement.[14]

Damages that are excluded under the policy include damage caused by radioactive contamination (except for liability for damage caused by a payload when proximate cause of damage is radiation naturally occurring in space environment;)damage arising out of conduct of another venture of which insured is involved and which isn't designated in declarations as an insured; act of war; radio frequency interference with another communications system; discharge, dispersal, release or escape of smoke vapours, soot, etc. unless such discharge, etc. is sudden and accidental; liability of any insured as manufacturer; obligation of insured to his employees or obligations for which insured (or any of his insurers) may be liable to his own employees under worker's compensation, unemployment, death or disability benefits law or any similar law; liability for damage to property of insured, claims for failure of insured's spacecraft to provide communications service(s).[14]

The Office of Management and Budget has questioned the

extent to which the government should provide or obtain insurance for non-federal users of space vehicles and has asked NASA to establish criteria to determine when Federal insurance is in the public interest. OMB objects to the lack of specificity concerning the conditions under which the Federal government should provide insurance to or indemnify a user of a NASA space vehicle. In particular OMB mentions the lack of clarity of the underlined terms in the statement "if NASA determines that adequate third party liability insurance is not available on reasonable terms and conditions or at a reasonable premium in the commercial insurance market or if NASA determines that the availability of third party liability insurance prevents an orderly and equitable allocation of the risk of liability." Also there is no indication in the rule of what information NASA will use to determine the availability of insurance in the commercial market. Another objection is that the public interest is not defined in certain sections of the rule that would allow NASA to waive insurance requirements for some users of space vehicles, nor does it provide criteria to be used in waiving the insurance requirements. OMB has requested that NASA clarify these ambiguities and identify the data as well as assumptions NASA will use in determining the amount of insurance available in the world market, how much insurance each user must procure and what could be the potential liability to the U.S. Treasury if the Federal government provided insurance to space vehicle users.[14]

2.5 Relevant Practices and Precedents

Several practices and precedents from the industries reviewed may be of relevance to issues concerning third party liability insurance for space vehicle users.

There is precedent for government involvement in private sector liability. The Federal Limitation of Liability Act of 1851 set a precedent, in that through it the government tried to encourage development of the shipping industry by limiting shipowners liability.

Designed to encourage development of the nuclear power industry, the Price-Anderson Act limited nuclear operators' liability and committed the government to indemnify nuclear plant operators for liabilities in excess of the commercially available insurance.

In the marine area, a number of Acts—Deep water Port Act, Outer Continental Shelf Act, etc.—limit liability of shipowners for damages caused by spills of oil and other hazardous substances and establish funds to pay damages in excess of the limitation.

The concept of layering is based on the fact that smaller claims are more likely than larger claims and therefore rates for covering lower layers are higher than rates for covering higher layers.

3. THEORETICAL CONSIDERATIONS OF INSURANCE RATE SETTING

There are many factors that contribute to the process of setting insurance rates: claim statistics, competitive market forces, corporate strategy, profitability and overhead are a few. Of these, one might expect claim statistics to be the dominant factor. And, indeed, there are cases when it might be--health insurance, life insurance, automobile collision insurance. But there are insured risks for which claim statistics provide little useful information. These include risks that have an extremely low probability of occurrence, but very high consequence and thus, high liability limits. Nuclear power plant liability is a good example. Hopefully, the risk of a catastrophic accident, resulting in high claims, is so low that such an accident will never occur. In fact, after some 800 reactor-years of experience, the worst accident has been the incident at Three Mile Island, with total liability claims just under $30 million. This is against an insured liability limit of $160 million. There exist no claims in the upper $130 million of coverage.

In a case such as this, how can rates be set? For one thing, mathematical models might be used to estimate risk. But the models could be misleading or, in fact, totally wrong and, in any event, would be difficult or impossible to validate. The insurer must take a more pragmatic approach. The following discussion outlines, in highly simplified terms, a method by which rates may be set for insurance against these types of risks.

First, it is helpful to observe that insurers always seek to diversify their risks so that laws of averages apply. As Figure 3.1 shows, there are three dimensions over which an insurer can diversify risk: the insured population, time, and across risks. The insured population comprises the set of insurance buyers—the insured—for a particular risk. In the cases of health insurance, life insurance, and automobile liability insurance, the insured populations each range into the tens of millions. Within these populations, "catastrophic" events are so common that yearly actuarial data reflect well the "cost" of providing insurance, and year-to-year trends provide a good indication of systemic changes. For these reasons, population is the preferred dimension for diversification.

Sometimes, as is the case with commercial aviation and marine liability insurance, the population—for instance, the number of commercial airliners—is too small to affect adequate diversification by population alone. In cases such as these, insurers tend to diversify over time. Diversifying over two years, in essence, doubles the population; ten years increases it by an order of magnitude. Insurers prefer to diversify across time when the population is too small to diversify across population alone because time-diversification still enables the insurers to treat each insured risk as a "product line." Insurers want to do this so that rates can be set for each risk that will assure profitability for each product line. And, of course, insurers want to cover a particular risk only if they can do so at a profit.

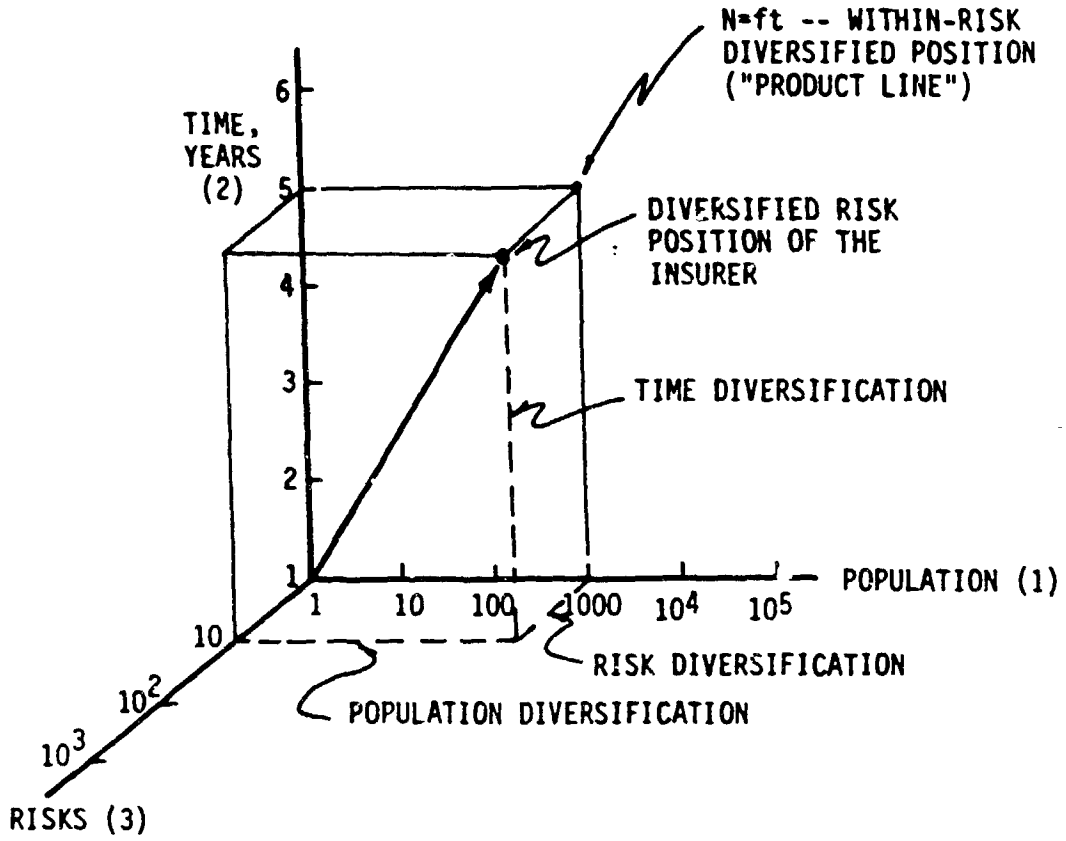

FIGURE 3.1 DIMENSIONS OF RISK DIVERSIFICATION

But, if insurers do resort to the time dimension to achieve adequate diversification, they want diversification to be accomplished in as short a period as possible—preferably two or three years, and in no case more than ten years. One way to look at time diversification is that the time needed to achieve diversification is roughly the minimum time necessary to assure profitability. Thus, it is possible to shorten the time period necessary for time diversification by raising rates. But raising rates is not always the best course of action.

As a last resort, insurers diversify across risks. Diversification by insurers, both companies and individual underwriters, across risks is a common practice, but not at the level of the industry as a whole. Elaborate practices, such as reinsurance, have been established to provide diversification for the individual, but the "industry" maintains its view of the product line as a means of rate setting. Thus, diversification across risks on an industry-wide basis can be expected only for those insured risks with so few activities that within-risk diversification cannot be achieved, even over a number of years. Third-party liability insurance for space activities might fall into this category.

A brief digression may shed further light on the process of insurance rate setting. Many people view the purchase of insurance as the placing of a bet—a bet by the insured with the insurer that some undesirable event will happen. But insurance is not a bet. A bet seeks to widen the range of possible futures for the bettor. For example, a person who could remain at his

status quo, but places a bet on a horse race, has broadened his range of futures to his status quo minus his bet on the low side (if the horse loses) to his status quo plus winnings on the high side (if the horse wins). The outcome of his bet is likely to be decided at an instant in time, and in the near term. Insurance does just the opposite: it narrows the range of possible futures, generally covering a range of time, and not necessarily in the near term.

In the undertaking of some activity—driving an automobile, launching a spacecraft, living—there are risks of undesirable outcomes. By buying insurance, the insured reduces his status quo by the cost of the insurance, but also reduces or eliminates altogether the impact of an undesirable event. The key is that the insurer serves as broker to diversify risk: he is in the business of buying and selling risks. To be specific, brokers do the buying and selling; underwriters hold diversified risks. Both these groups want an economic return for their activity. They use information where it is available, but they must also make decisions—buy and sell decisions—in the absence of information. Their method for making decisions in the absence of information has evolved over hundreds of years. It is unwritten and untaught, it is not based on mathematical rigor, but it is pragmatic and, over the long term, it keeps them in business.

Suppose the perpetrator of an activity that has never been conducted in the past wishes to insure some aspect of that activity. Potential insurers could simply refuse to provide coverage for reason of lack of actuarial data. But the activity could appear to be relatively "safe" (from the insured risks),

and failure to provide insurance would lose the insurer an opportunity for economic gain. But, to insure the risk, the insurer must pick a premium. One strategy for picking a premium is simply to decide on a premium that is high enough to set aside revenues to cover a maximum liability loss after insuring some number, N, of such activities. For example, if the set-aside period is ten activities, then the premium would be one tenth (1/N) of the insurance policy value.* To this premium can be added profit, overhead. etc. The question remaining is, simply, how to pick N. The answer, provided that sufficient within-risk diversification is possible, is to pick a value for N such that N activities involving the risk will be insured in a reasonable period of time—typically 1 to 5 years. For example,if an average of 20 commercial payloads per year were each insured for $500 million, the insurer would have to charge $5 million per payload to set aside enough reserves to cover a maximum liability loss after 5 years.

Once a risk is insured, experience is gained that can be used for adjusting future rates. If no claim experience occurs, the insurer could consider lowering his premium or issuing premium refunds as occurs with nuclear liability insurance premiums. But he would be likely to do so only if the frequency of the activity increases so that he can maintain reasonable time diversification, or after a period of insuring the risk during

*This was, in fact, the approximate rate and its method of determination for the insurance of communication satellites prior to the losses of early 1984.

which he manages to set aside reserves that would cover a maximum liability loss.

On the other hand, if claims are filed and insurance payments made, the insurer might choose to adjust his premium to reflect such payments. Consider the special case of third-party liability insurance for nuclear power plants. Some 105 claims have resulted in insurance payouts, for 62 of these claims, of $32 million. This total is well under the liability limit of $160 million for a single event, yet large enough that it could reasonably be expected to affect rates. With no other data or insights, the simplest thing to do is to assume that the historical rate of payout will be the future rate of payout, and use this to set the premium. This may be referred to as the actuarially determined premium, yielding an annual insurance rate, r_a, in premium dollars per insured dollar. But this would neglect the fact that insurance is being provided for a range of liability for which there is yet no experience. Thus, a simple strategy is to add a "catastrophic event" rate, 1/N, to the actuarial rate, r_a, to determine a total, unburdened rate, r. That is,

$$r = \frac{1}{N} + r_a$$

To this rate, overhead, profits, etc. may be added to determine the burdened rate. This notion is the basis of Figure 3.2, which is a plot of this equation.

An example may help in understanding this figure. Suppose a

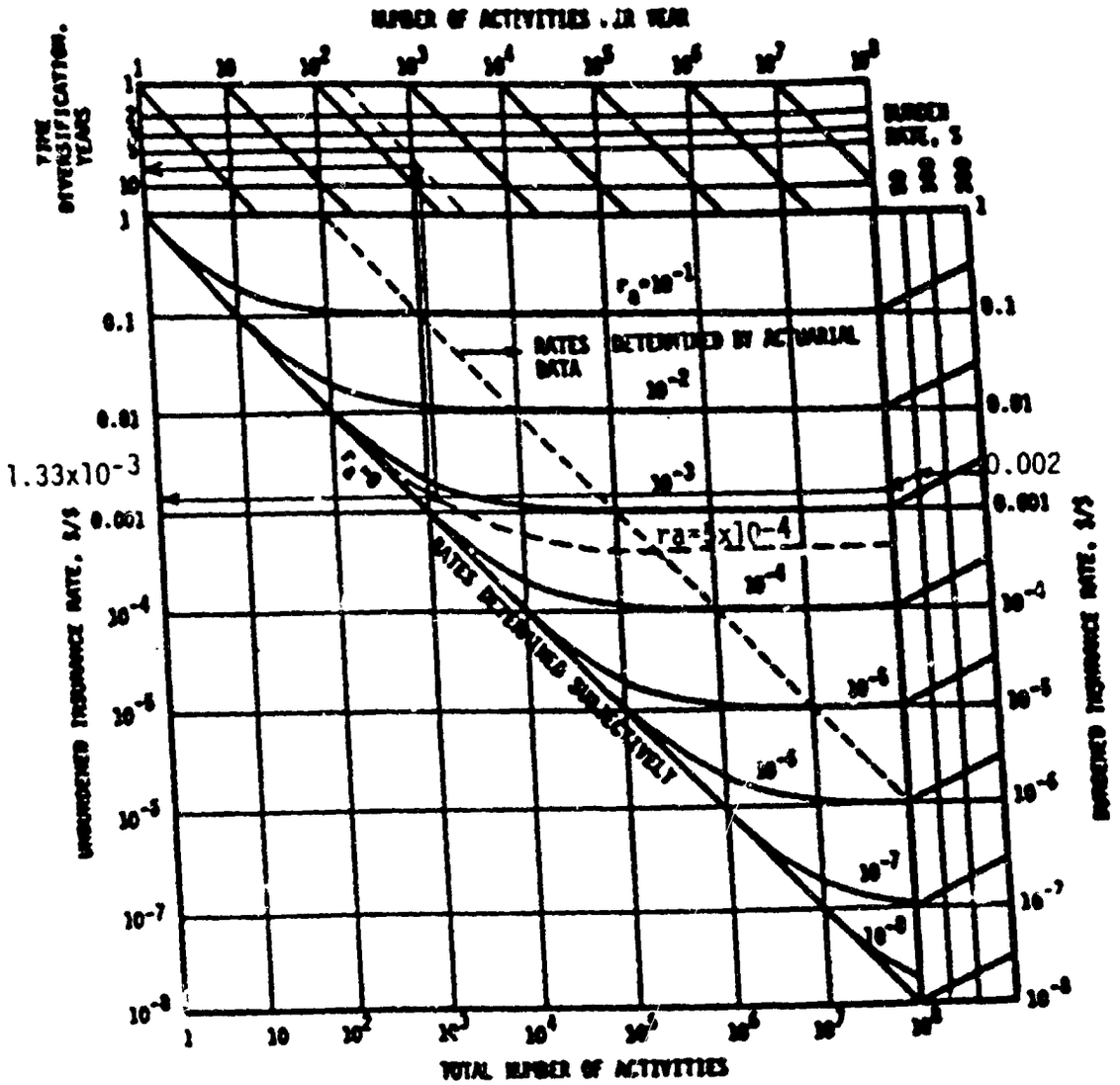

FIGURE 3.2 DETERMINATION OF INSURANCE RATES AND PERIOD OF TIME DIVERSIFICATION

particular risk is insured in the amount of $100 million. Further, suppose that 100 units (launches, reactor-years, etc.) have been so insured to date, and accumulated claims have resulted in payments of $5 million. Dividing claim payments by the number of insured-risk units (100) yields the actuarially expected liability per insured-risk unit, $50,000. Dividing this amount by the face value of the policy, $100 million, yields the actuarially determined unburdened rate, $r_a = 5 \times 10^{-4}$. Now, suppose that the insurance rate actually charged is 2×10^{-3} $/$, including burden, and that a typical burden rate for this type of insurance is 50 percent. The unburdened rate is determined from Figure 2.2 to be 1.33×10^{-3} $/$, and the intersection of the unburdened rate with the curve $r = 5 \times 10^{-4}$ gives a perspective on the extent to which the rate is subjectively, versus actuarially, determined. In the example shown, rates are largely determined subjectively. Finally, suppose that 200 such activities are insured per year. The "set-aside" time for risk diversification is therefore approximately 6 years. By plotting data for different insurance "product lines" on this figure, an understanding of "standard practice" can be obtained.

Another comparison that can be made using Figure 3.2 involves the time accepted for diversification of risk. Analyzing data presented in Section 4, it appears that diversification in the nuclear power plant industry, depending on the layer, takes place over a period of from under one year to eighteen years, in the marine industry about 2.2 years, and in the aviation industry about thirty-two years are provided for the diversification of a maximum-liability event. The space industry

to date appears significantly different. The time for within-risk diversification appears to be in excess of 100 years. This could mean (1) that insurers perceive that they are insuring against an "impossible" event or (2) that they are currently diversifying across risks as well as population and time. To the extent that the latter case is true, premiums may rise as space activities increase and space liability insurance becomes a "product line."

4. HISTORICAL DATA

Insurance provided to the four industries is effected by several commonalities. The maximum exposure in each industry is high and well above the $50 million that was the median limit of liability insurance (including excess and umbrella insurance) carried by respondents to the Cost-of-Risk Survey. In fact, only 5.7 % of respondents to the Cost- of-Risk Survey carried limits above $200 million. [14] Union Carbide , with $5 billion worth of assets, and facing $15 billion worth of damage suits from the recent disaster in Bhopal, India has only $200 million worth of umbrella protection. Relatively little actuarial data in the four industries is available and therefore the statistical analysis that is used by underwriters of high volume low unit exposure risks such as autos, life, or dwellings is inapplicable. Rates are set subjectively, and based on judgement.

4.1 Nuclear Power Industry [1,2]

An average nuclear power plant pays approximately $400,000 annually for nuclear liability insurance. The maximum amount of liability insurance per plant per incident is $160 million. If the average nuclear plant purchases a $160 million policy at an annual premium of $400,000 then the rate is $.0025 per dollar of insurance.

Cumulative liability premiums collected from 1957 through 1983 have amounted to approximately $260 million. Refunds made under the Industry Credit Rating Plan (described in Section 3.1, above) from 1967 through 1983 total approximately $24 million[1] Claims paid out for nuclear liability damages amount to about $32

million. Close to $30 million went to pay claims arising from the 1979 incident at Three Mile Island.[3] Table 4.1 and Figure 4.1 depict premiums, claims and refunds.

TABLE 4.1 NUCLEAR LIABILITY INSURANCE -- PREMIUMS, CLAIMS, REFUNDS (THOUSANDS OF CURRENT YEAR DOLLARS)

YEAR	LIABILITY PREMIUM	CLAIM EXPENSE AND/OR LOSS PAYMENT**	PREMIUM REFUNDS***
1957-1975*	$ 74,007*	$ 1,493	$ 8,031
1976	15,352	193	1,682
1977	17,533	444	1,951
1978	19,184	45	2,157
1979	20,316	29,452	2,055
1980	23,002	372	850
1981	27,521	7	1,653
1982	30,256	290	2,302
1983	33,100 (EST.)	-	3,250
TOTAL	260,271	32,296	23,930

SOURCE: NUCLEAR INSURANCE FACTS AND FIGURES 1984, AMERICAN NUCLEAR INSURERS REPORTS

*REPRESENTS GROSS WRITTEN PREMIUM FROM INCEPTION TO NOVEMBER 30, 1975. PREMIUM FIGURES REPORTED FROM 1976 THROUGH 1983 REPRESENT ANNUAL GROSS WRITTEN PREMIUMS.

**IN SEVERAL CASES THE SOURCE GAVE THE DATE OF INCIDENT AS A SPAN OF SEVERAL YEARS. WHEN THAT OCCURRED THE TOTAL CLAIM EXPENSE WAS CONSIDERED TO BE INCURRED IN THE FIRST YEAR OF THE TIME PERIOD GIVEN.

***PREMIUM REFUNDS ON PREMIUMS COLLECTED 10 YEARS PRIOR TO REFUND.

The premium charge per million of insurance, at each layer of insurance is presented in Table 4.2. Claims within each layer are indicated in Table 4.2 as well as the actuarial rate (r_a), the burdened rate (r), and the set-aside period. Nuclear insurance time diversification is illustrated in Figure 4.5.

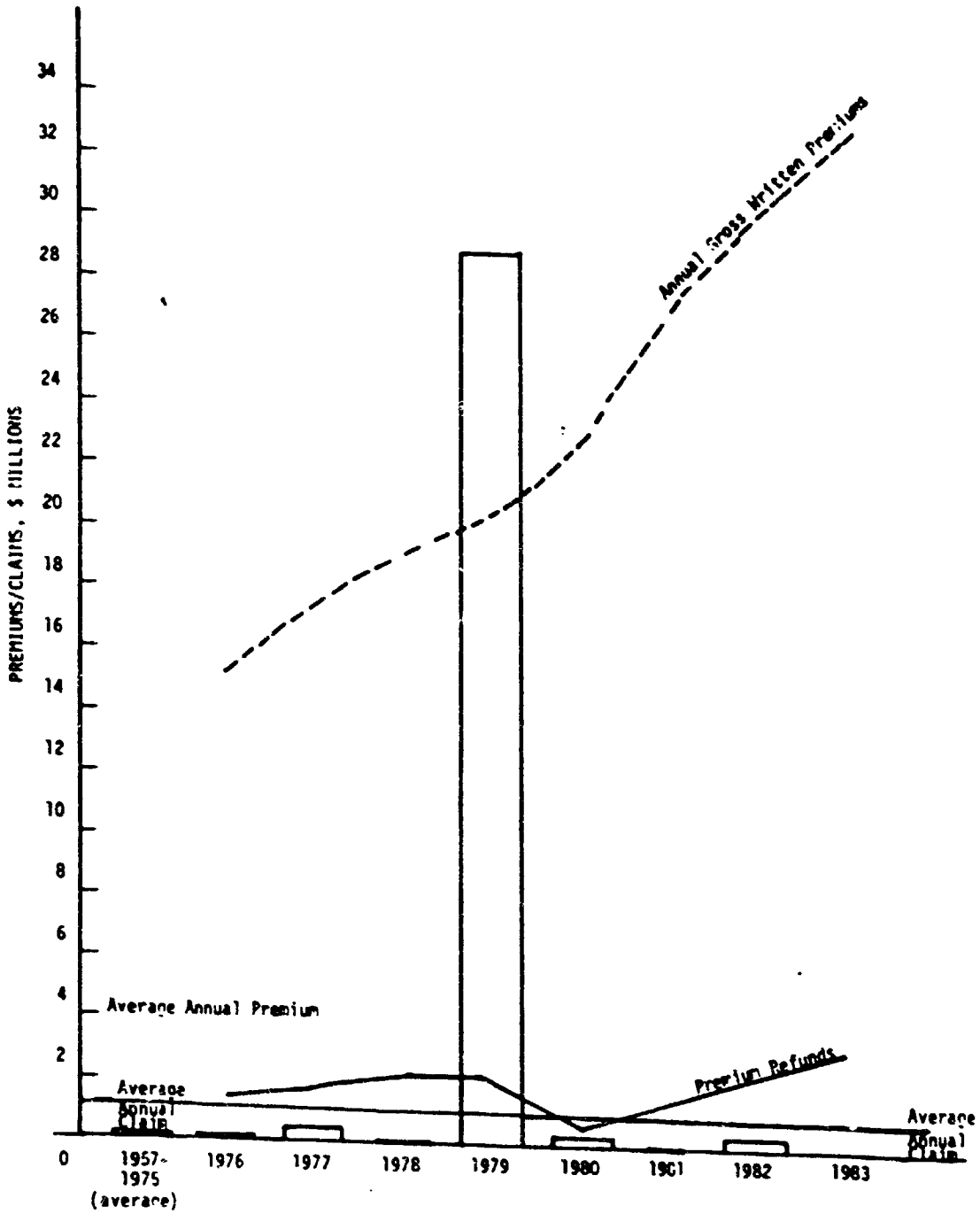

FIGURE 4.1 NUCLEAR LIABILITY INSURANCE - PREMIUMS, CLAIMS, REFUNDS

SOURCE: NUCLEAR INSURANCE FACTS AND FIGURES 1984, AMERICAN NUCLEAR INSURERS REPORTS

TABLE 4.2 RATES PER LAYER FOR NUCLEAR LIABILITY INSURANCE

Layer	Premium per Million ($ of coverage)	r	Claims (millions)	Claims per Unit*	r_a	Set-Aside Period
A $1 million	$48,500	.0485	$3,856	$4,645	.004645	3 mos.
B $2-5 million	$24,250	.02425	$4,000	$4,819	.001205	10 mos.
C $6-10 million	$12,125	.012125	$5,000	$6,024	.001205	1.7 yrs.
D $11-20 million	$ 5,820	.00582	$10,000	$12,048	.001205	4.4 yrs.
E $21-40 million	$ 2,410	.00291	$ 9,440	$11,373	.00057	8.5 yrs.
F $41-60 million	$ 1,123	.001123	0	0	0	16 yrs.
G $61-160 million	$ 970	.000970	0	0	0	18 yrs.

* Reactor operating year (830 reactor operating years to date in the U.S.)

4.2 Ocean Marine Industry[4]

Lloyds premiums and claims in marine insurance are presented in Table 4.3 and graphed in Figure 4.2. Net premiums written in ocean marine insurance in the U.S. is displayed in Table 4.4.

TABLE 4.3 LLOYD'S PREMIUM AND CLAIMS IN MARINE INSURANCE (MILLIONS OF CURRENT YEAR DOLLARS*)

YEAR	PREMIUMS	CLAIMS
1981	N/A	N/A
1980	2,670	N/A
1979	2,370	2,300
1978	1,830	1,670
1977	1,670	1,490
1976	1,530	1,350
1975	1,440	1,260
1974	1,450	1,360

SOURCES: 1983 INSURANCE REGISTER
LLOYD'S MARITIME YEARBOOK

*CONVERTED FROM POUNDS STERLING BASED ON $2.40 TO THE POUND.

TABLE 4.4 NET PREMIUMS WRITTEN IN OCEAN MARINE INSURANCE BY U.S. INSURERS (MILLIONS OF CURRENT YEAR DOLLARS)

YEAR	NET PREMIUMS WRITTEN	PERCENT OF TOTAL NET PREMIUMS WRITTEN IN U.S.
1983	$1,096	1.01%
1982	$1,101	1.06%
1981	$1,127	1.13%
1980	$1,065	1.11%
1979	$1,009	1.12%
1978	$1,000	1.22%

SOURCE: BEST'S AGGREGATES AND AVERAGES, 1984

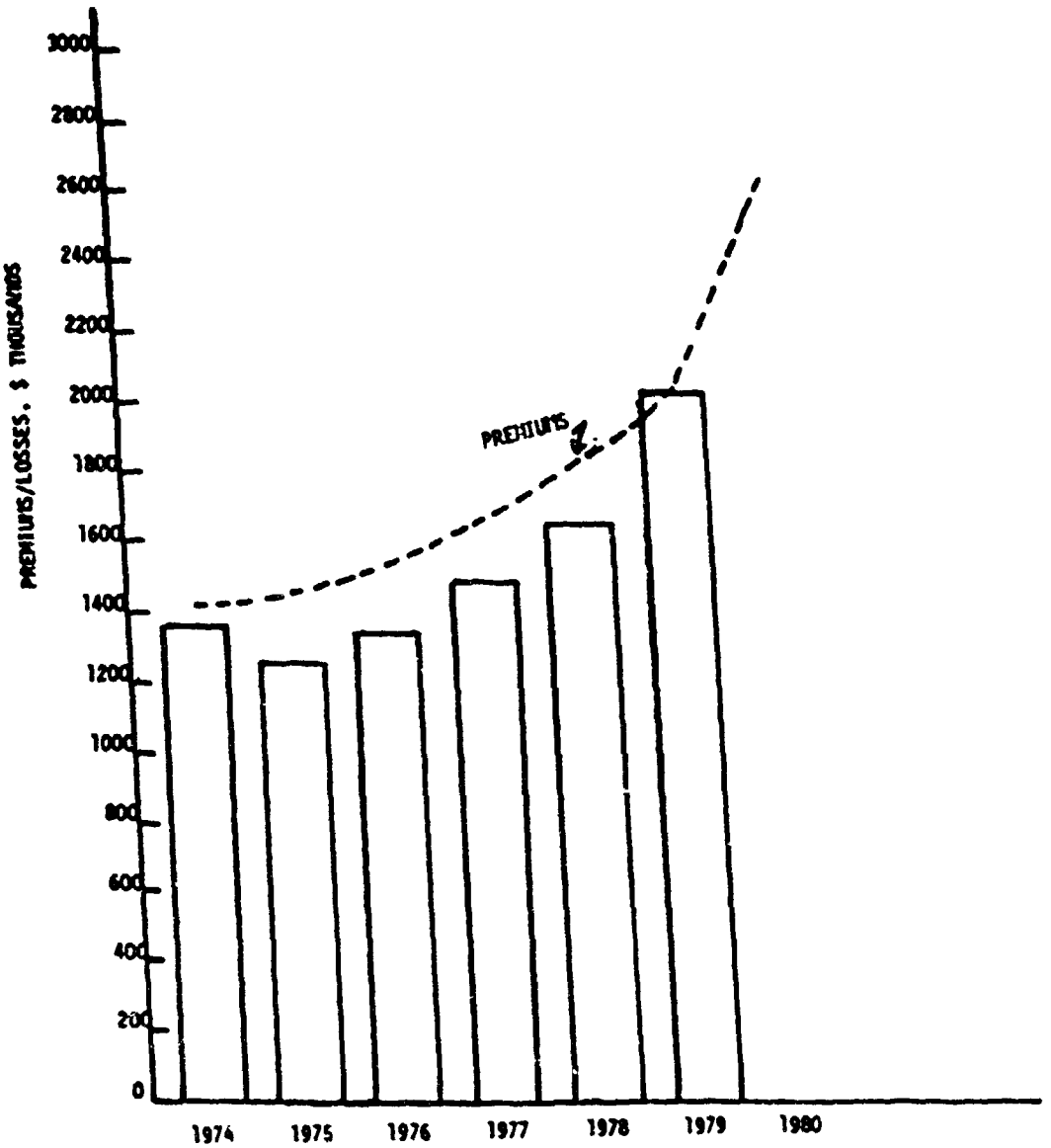

FIGURE 4.2 PF IIUM AND CLAIMS STATISTICS IN MARINE UNDERWRITING AT LLOYD'S OF LONDON

SOURCES: LLOYD'S MARITIME YEARBOOK
1983 INSURANCE REGISTER

The following is based on the annual report of the Standard, a British P & I club. The statistics are for the 1980/81 policy year.

Limit of insurance=$381,000,000
Total premiums=$41,120,753
Number of ships=1911
Premium per ship=$21,517
Premium per ship per million=$56

Premium by layer

First layer of $6,000,000

Total premiums= $41,120,753
minus reinsurance
premiums = $5,879,449
35,241,304 premiums for first layer of $6,000,000
Premium per ship=$18,441
Premium per ship per million=$3,074
Claims less pool and reinsurance recoveries= $20,801,503
Average claim per ship=$10,885

Second layer $375,000 excess of $6,000,000

Reinsurance Premiums=$5,879,449 premiums for second $375,000,000
Premium per ship=$3,077
Premium per ship per million=$8
Claims statistics=NA

Sufficient data were available for the first $6 million worth of coverage, however, claims statistics were not available for the $375 million in excess of $6 million layer. Therefore only the set-aside period for the first $6 million was computed. An important observation may be made by comparing premiums charged in the lower layer with premiums charged in the upper layer. Per ship premium per million dollars of coverage for the first $6 million amount to approximately $3,074. In the second layer of coverage the premium per ship per is $8. Most of the anticipated risk is in the lower layer of insurance.

Layer	Premiums in thousands	r	Claims in thousands	Claims per Unit	r_a	Set-aside Period
First $6 million	$35,241	.0031	$20,802	$10,885	.0018	2.2 yrs

The data is plotted in Figure 4.6.

4.3 Aviation Industry

The following data are worldwide aviation data.[5,6] Maximum exposure is estimated to be $380 million per event. In the U.S. airlines obtain liability policies of approximately $600 million. It is assumed that the limits on policies in other countries are somewhat lower because often the monetary value of human life in court settlements is lower in other countries. Thus an average worldwide figure is estimated at $380 million.

An estimate of the average number of departures has been based on the total long and short haul departures between 1974 through 1978.[5] An average premium of $19,000 per thousand departures is estimated by dividing the total liability premiums collected over the six years from 1978 through 1984 ($968,673 thousand) by the estimated number of departures in thousands over the period (51,000). The burdened insurance rate is then computed per dollar of insurance.

Average claims per 1,000 departures is estimated by taking total liability losses worldwide during the six years from 1978 through 1984 (576,007 thousand) and dividing by the estimated number of departures (in thousands) during that time period

(51,000). The actuarially determined rate r_a, is derived by dividing average claims per thousand departures, by total coverage.

TOTAL LIABILITY PREMIUMS* (000$)	r	CLAIMS* (000$)	CLAIMS PER UNIT**	r_a	SET-ASIDE PERIOD
$968,673	$5x10^{-5}$	$576,007	$11,294	$2.97x10^{-5}$	32 years

*over a six year period
**thousand departures

Plotting the data as in Figure 4.4 or computing N reveals that the set aside period is 32 years.

The data used are displayed in Table 4.4 and presented in graph form in Figure 4.4. Table 4.6 displays premiums and claims in aviation insurance written by Lloyds, Table 4.7 shows net premiums written in aviation in the U.S. and Table 4.8 shows premiums and losses in aviation liability insurance written by U.S. insurers.

TABLE 4.5 WORLDWIDE AVIATION STATISTICS

YEAR	PASSENGER KILOMETERS (BILLIONS OF KM)	NUMBER OF AIRCRAFT ACCIDENTS	TOTAL LIABILITY LOSSES[1] (THOUSANDS OF CURRENT YEAR DOLLARS)	TOTAL LIABILITY PREMIUMS (THOUSANDS CURRENT YEAR $)
1983	N/A	N/A	$ 87,028	$184,789
1982	1,144	23	204,941	175,471
1981	1,117	18	12,922	168,136
1980	1,089	21	38,175	152,570
1979	1,060	31	160,215	139,208
1978	936	25	72,726	148,499

SOURCE: SIGMA, ECONOMIC STUDIES, WORLD AVIATION AND AVIATION INSURANCE, NO. 61 JUNE 1984, SWISS RE

[1] TOTAL LOSSES: KILLED AND INJURED PASSENGERS INCLUDING LUGGAGE AND FREIGHT DAMAGE CAUSED BY AN AIRCRAFT ACCIDENT.

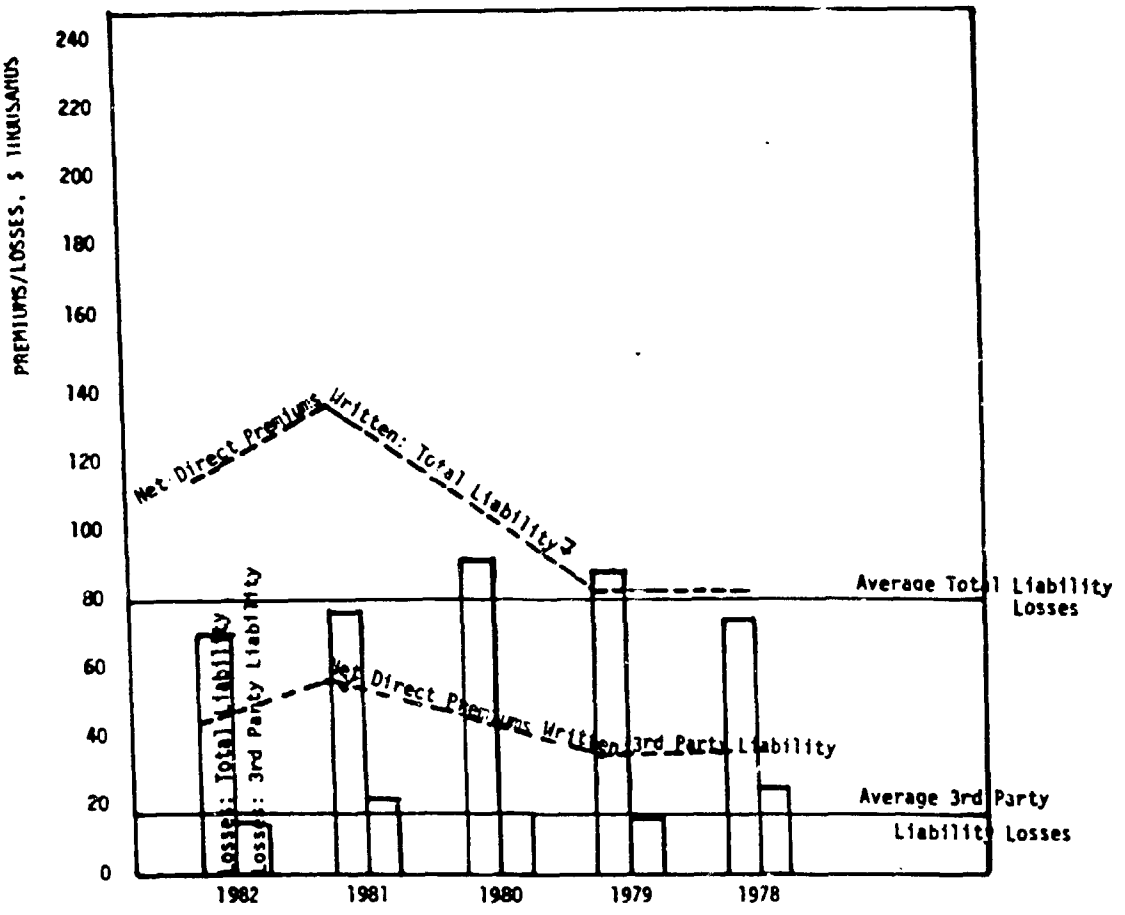

FIGURE 4.3 PREMIUM AND LOSS STATISTICS FOR ALL AVIATION CATEGORIES-U.S. INSURERS
LOSSES ARE INCURRED LOSSES INCLUDING ALLOCATED CLAIM EXPENSES
PREMIUMS ARE NET DIRECT PREMIUMS WRITTEN

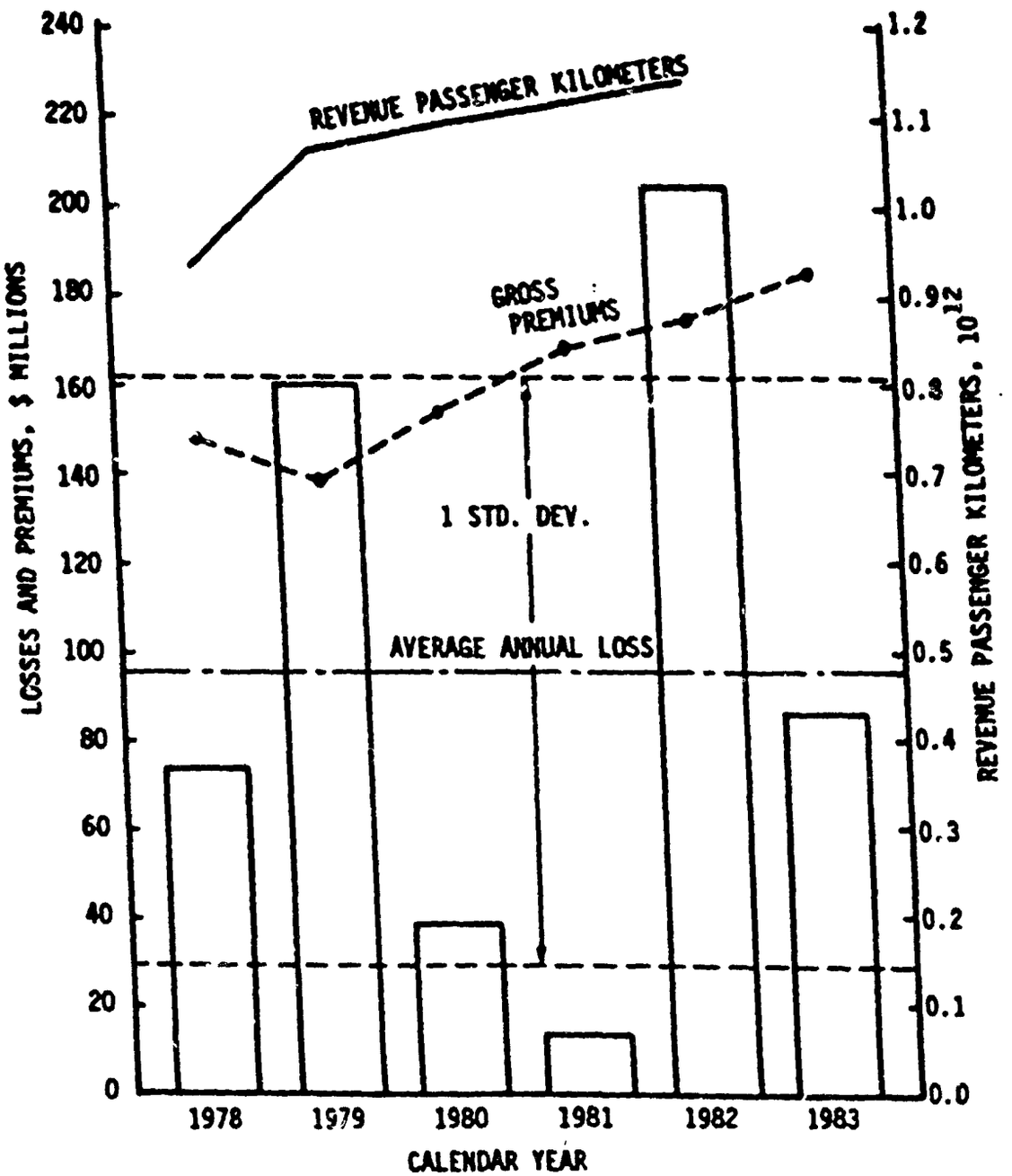

FIGURE 4.4 WORLDWIDE AVIATION STATISTICS

TABLE 4.6 LLOYD'S PREMIUMS AND CLAIMS IN AVIATION INSURANCE (MILLIONS OF CURRENT DOLLARS*)

YEAR	PREMIUMS	CLAIMS
1981	$309	N/A
1980	626	N/A
1979	559	564
1978	385	388
1977	349	346
1976	349	336
1975	319	309
1974	334	323

SOURCES: 1983 INSURANCE REGISTRY
LLOYD'S MARITIME YEARBOOK

*CONVERTED FROM POUNDS STERLING BASED ON $2.40 TO THE POUND.

TABLE 4.7 NET PREMIUMS WRITTEN IN AVIATION INSURANCE BY U.S. INSURERS (MILLIONS OF CURRENT YEAR DOLLARS)

YEAR	NET PREMIUMS WRITTEN	PERCENT OF TOTAL NET PREMIUM WRITTEN IN U.S.
1983	$302	.28%
1982	$254	.24%
1981	$209	.21%
1980	$171	.18%
1979	$147	.16%
1978	$156	.19%

SOURCE: BEST'S AGGREGATES AND AVERAGES, 1984

TABLE 4.8 PREMIUMS AND LOSSES: AVIATION[1] LIABILITY INSURANCE U.S. INSURERS (THOUSANDS OF CURRENT YEAR DOLLARS)

YEAR	NEW DIRECT PREMIUMS WRITTEN		INCURRED LOSSES INCLUDING ALLOCATED CLAIM EXPENSE	
	TOTAL[2] LIABILITY	THIRD PARTY[3] LIABILITY	TOTAL[2] LIABILITY	THIRD PARTY[3] LIABILITY
1982	115,095	45,578	69,779	14,433
1981	136,926	56,328	76,116	21,200
1980	114,691	48,156	91,651	19,024
1979	83,537	35,670	88,599	17,900
1978	83,819	36,728	74,189	25,108

SOURCE: AVIATION STATISTICS CLASSIFICATION RESULTS ON WRITTEN BASIS, POLICY YEARS 1978-1982, AVIATION INSURANCE RATING BUREAU

[1] INCLUDES SCHEDULED AIRLINES, INDUSTRIAL AID RISKS, FLYING SERVICE, MANUFACTURERS, AND PRIVATE PLEASURE RISKS.

[2] INCLUDES AIRCRAFT PASSENGER, PUBLIC AND PROPERTY DAMAGE LIABILITY.

[3] INCLUDES PUBLIC AND PROPERTY DAMAGE LIABILITY.

4.4 Space Industry

Each payload pays approximately $100,000 for $500 million of liability insurance. (This varies depending on the number of payloads on the flight.) Under the INTEC facility, the maximum liability for one payload is $500 million,[7] for more than one payload, maximum liability protection is $750 million.[8]

There is no claims data, so $r_a=0$ and the rate must be set entirely subjectively ($r=1/N$). The current rate per dollar of insurance is $.0002 (taking $100 thousand divided by $500 million), and the number of activities over which insurers will

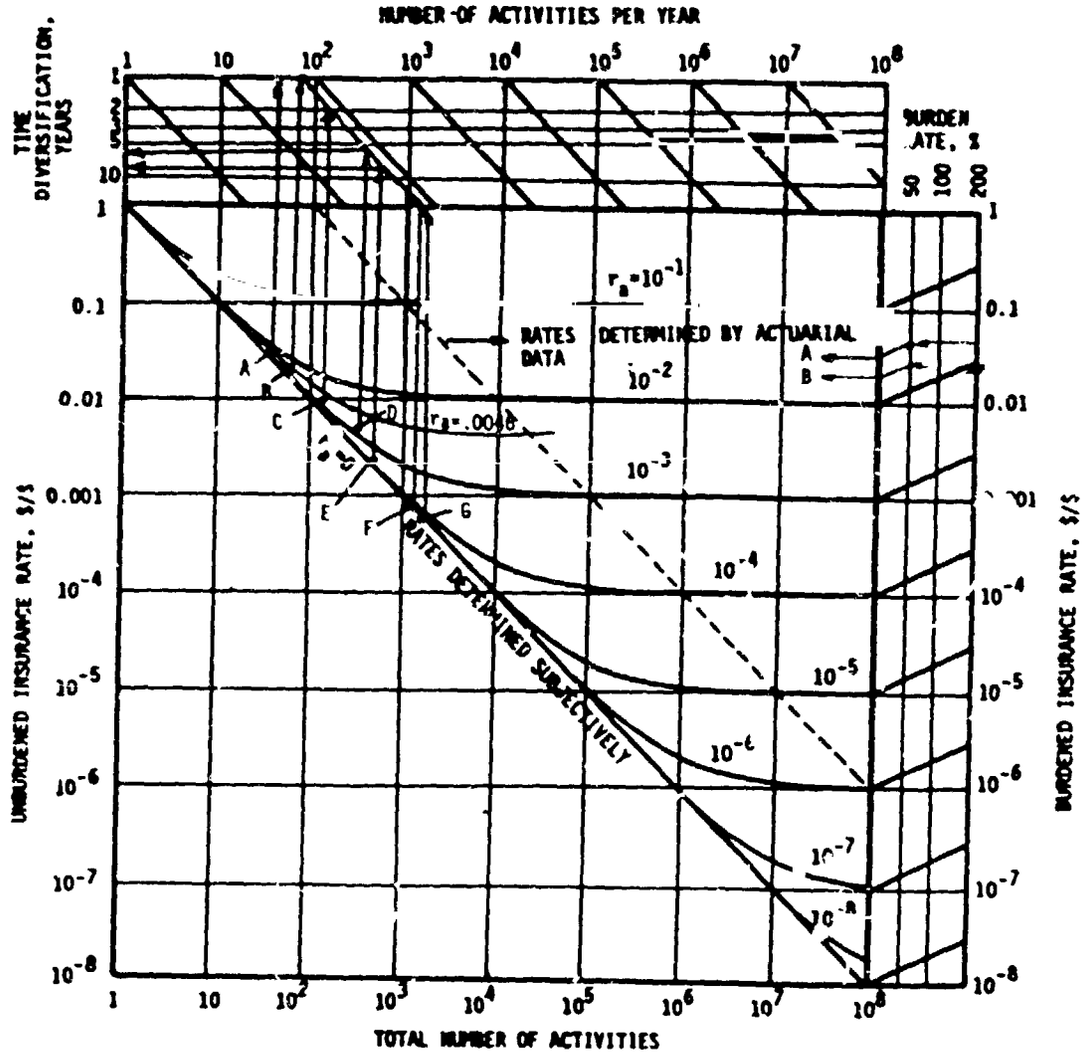

FIGURE 4.5 DETERMINATION OF NUCLEAR INSURANCE TIME DIVERSIFICATION

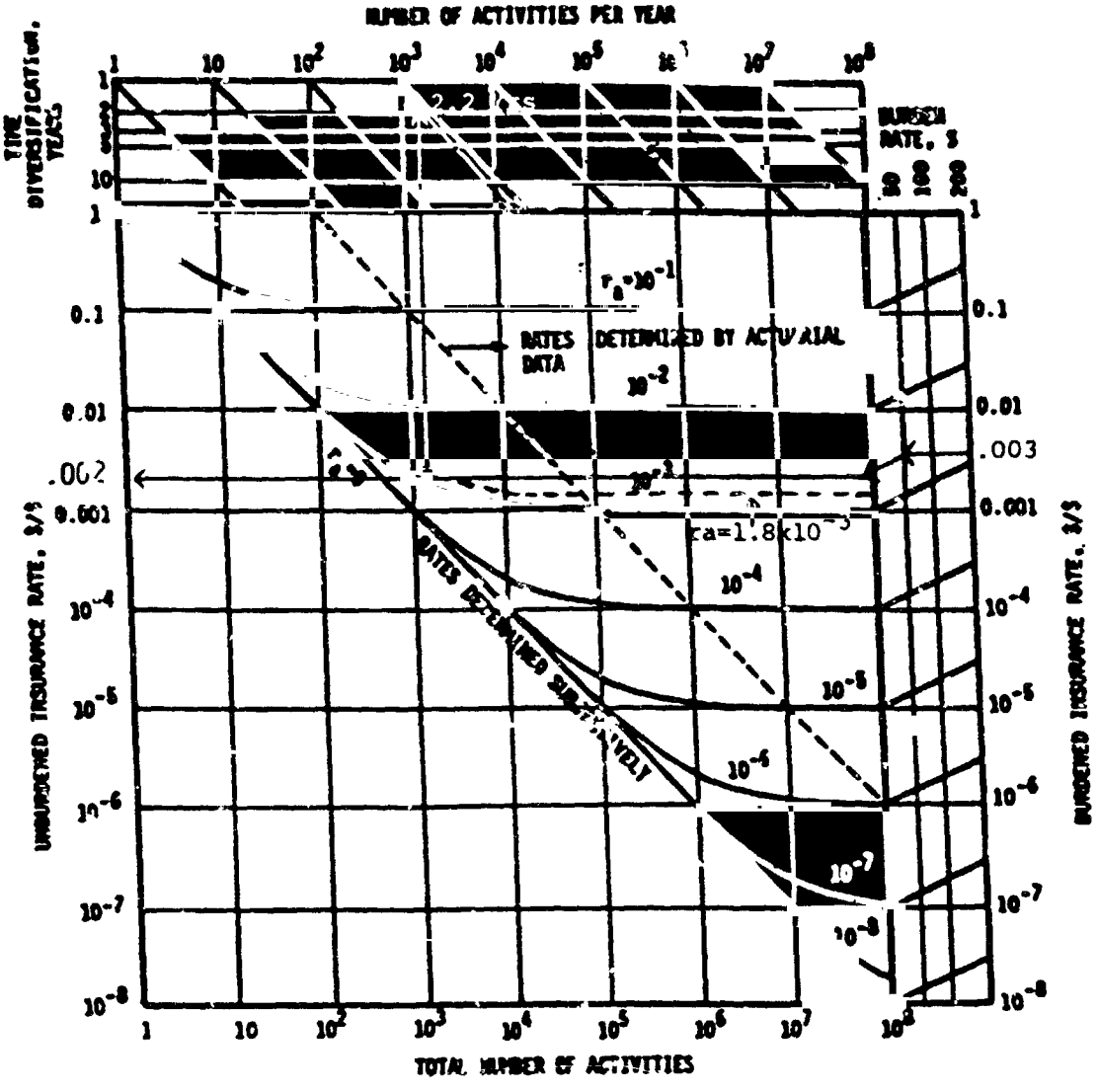

FIGURE 4.6 DETERMINATION OF MARINE INSURANCE TIME DIVERSIFICATION

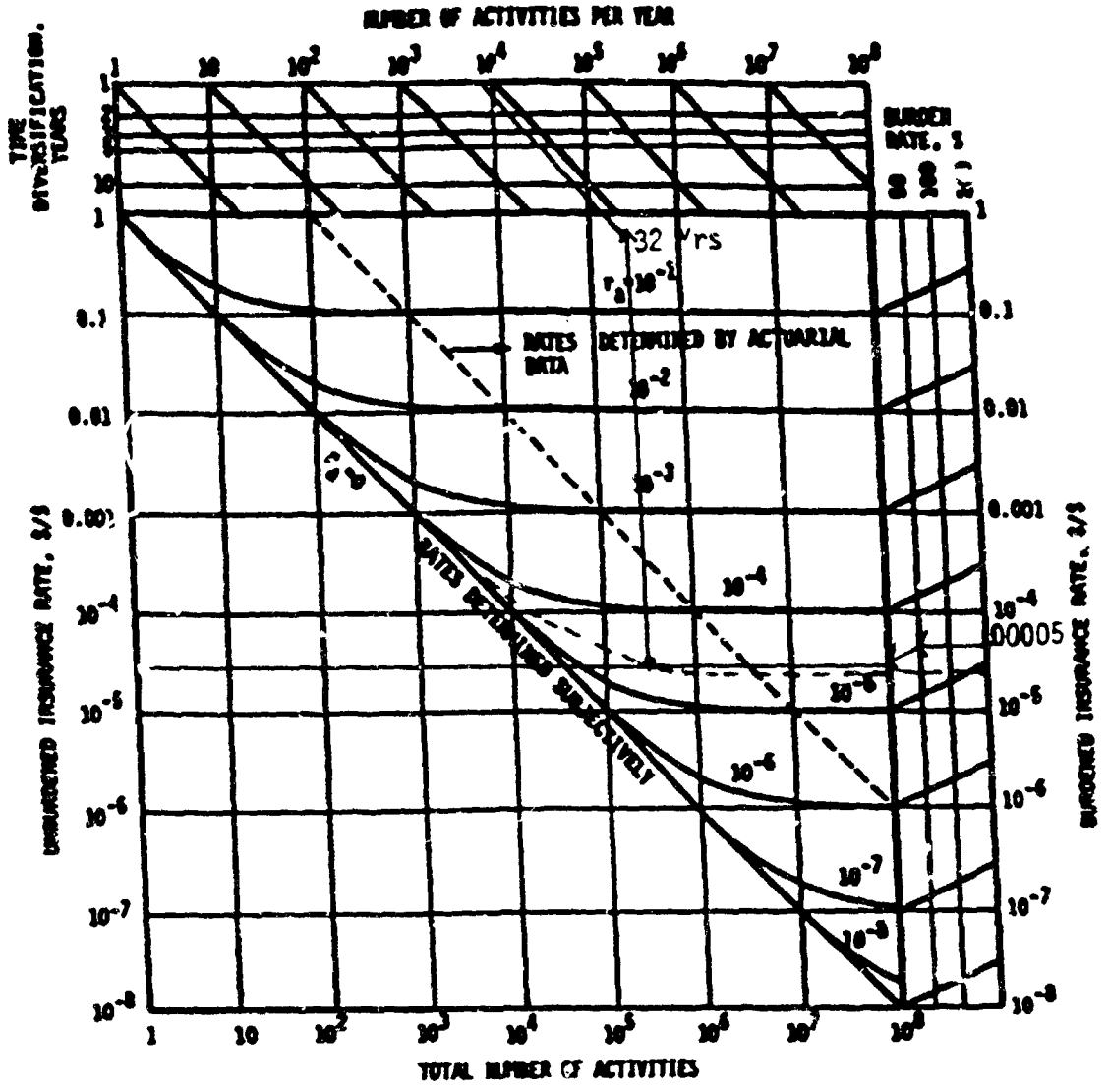

FIGURE 4.7 DETERMINATION OF AVIATION INSURANCE TIME DIVERSIFICATION

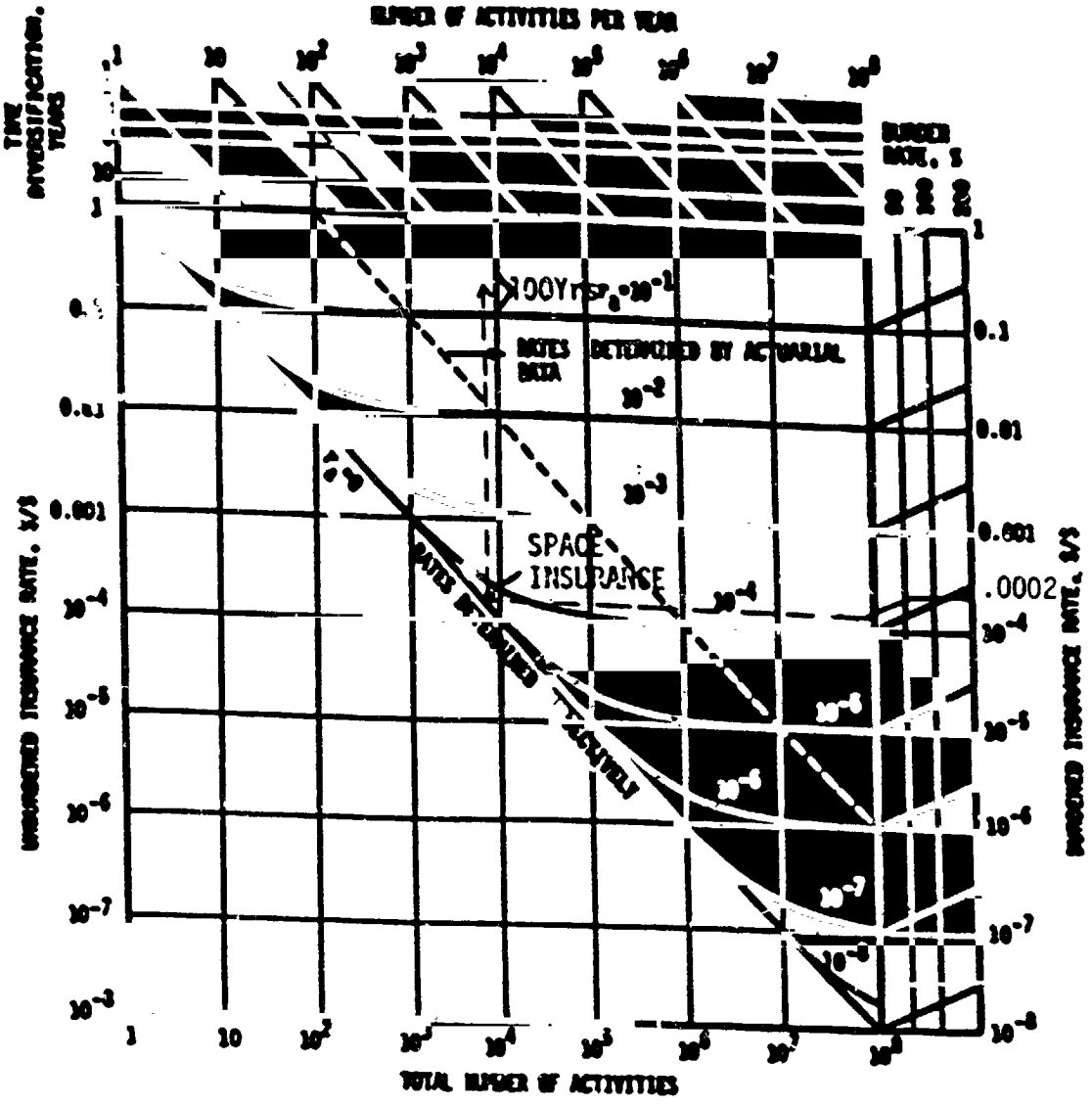

FIGURE 4.8 DETERMINATION OF SPACE INSURANCE TIME DIVERSIFICATION

set aside the amount of a maximum liability event is 7,500. Thus the set-aside period, if there are an average of 20 insured payloads per year is 375 years, if 50 payloads on average per year, the set-aside period is 150 years.

4.5 Industry Assets Related to the Ability to Insure

Policyholders surplus is the net worth of the insurance company and serves as an extra backup to a company's reserves so money will be available to pay catastrophic or unexpected severe losses.[9] Policyholders surplus may be considered a measure of industry assets related to the ability to insure because the limit to the amount of premiums an insurer will write is a function of its policyholders surplus. The exact relationship is often debated but an insurer is considered overextended it the ratio of its net written premiums to policyholders surplus is more than 3 to 1.[10] Theories have advanced the hypothesis that an optimum ratio for property insurers would be 2 to 1 and for casualty insurers 1 to 1.[11] Statistics from Best's Aggregates and Averages reveal that total policyholders surplus was $65,600,000,000 and the total net written premiums amounted to $108,983,000,000 at year end 1983 in the U.S.[12] The aggregate ratio of net premiums written to policyholders surplus then was 1.66 in 1983 in the U.S.

One insurance company typically insures many lines of business and draws in premium from each line. Policyholders surplus is available to back all these lines of business and is not necessarily distributed to each line. The company may maintain total net written premiums to policyholders surplus as a

whole at a certain ratio and not necessarily maintain this ratio over each line of business.

However, one may arrive at a rough approximation of policyholders surplus associated with the aviation and marine industries by assuming that these industries maintained the ratio that the insurance industry as a whole did-1.66- and calculating the policyholders surplus required to produce a ratio of 1.66. (Policyholders surplus = net premium / 1.66). According to Best's Aggregates & Averages net premiums written for ocean marine insurance totaled $1,096,231,000 and for aircraft totaled $301,584,000 in 1983. On the basis of these statistics it is estimated that policyholders surplus approximates $660,380,120 for ocean marine insurance and $181,677,000 in aircraft insurance. It must be stressed that net premiums written in each of these lines is a very small percentage of total net premiums written (net premiums written on aircraft were only .3% of the total net premiums written and net premiums written on ocean marine were 1% of total in the U.S.). In actuality the insurance industry has substantially more policyholders surplus available to claims, because the company's total policyholders surplus is probably much greater: the above is an approximation of policyholders surplus that might be associated with aviation or ocean marine.

Another measure of capacity, known as large line capacity, refers to an insurer's ability to provide a large amount of insurance on a single loss exposure. In some states, regulations prohibit insurance companies from writing net for its own account an amount of insurance in excess of 10% of its surplus to

policyholders on any one loss exposure. (One insurer may write a large line if it keeps its retention at 10% to its surplus and reinsures the balance.)[10] Applying this rule to the estimates of policyholders surplus above, indicates that approximately $18 million of capacity may be available for aircraft risks and $66 million for ocean marine risks for a single loss exposure from U.S. insurance companies. This also is a gross approximation and it must be noted in reality companies may be allowed 10% of total policyholders surplus (as opposed to the above estimated policyholders surplus targeted for aircraft or marine risks) but often take on exposure in amounts substantially less than 10% of policyholders surplus.[13]

5. CRITERIA FOR FEDERAL PROVISION OF INSURANCE

5.1 Public Interest Arguments

There are several reasons why the Federal government should be concerned with third party liability protection for private users of government facilities and private contractors to government. In the event of a catastrophic accident, private entities could be subject to devastating liabilities if it were judged that they were liable under actual (causal relationship between damage or injury and the acts or failures to act of a user is proven) or absolute liability (liability without proof of fault or negligence) standards.[1,2] To the extent that this possibility discourages the development of activities or industries considered to be in the national interest, a limitation of liability is in the public interest. Government reduction of the risk of investment in new technology is recognized as often necessary to encourage the development of such technology. Such was the rationale behind the limitation of liability set for the nuclear industry by the Price-Anderson Act. On the other hand, a limitation of liability that allows victims to go uncompensated is not in the public interest. Thus another Federal concern is that victims might go uncompensated for damages sustained, either if adequate protection is not available to those who might cause damage to third parties,[1] or if there is a limitation on liability without indemnity provisions for damages beyond the limitation. Averting either of those two possibilities may reasonably be considered to be in the public

interest. Therefore it may be considered in the public interest that NASA ensure adequate financial protection against the possibility of third party damages.

NASA now ensures adequate protection by requiring space vehicle users, with some exceptions, to purchase insurance to protect the U.S. government as well as themselves. Since private insurance capacity is limited, if there are damages that exceeded the level of private insurance available then NASA's promise to indemnify the space vehicle user beyond this amount is consistent with assuring the victim of compensation and protecting the user from disasterous financial consequences of its use of the space vehicles, both of which may be considered to be in the public interest. Without this agreement on the part of NASA to indemnify damages beyond the level of protection offered by commercial insurance, the space vehicle user might find the threat of disasterous damages, although remote, a deterrent to use of space vehicles.

However, if the cost of obtaining financial protection is high, the insurance requirement may itself pose a deterrent to space activity. If the cost of obtaining third party liability insurance would discourage space activity, it may be in the public interest, for the Federal government to provide insurance.

Space activity, in general, is considered to be in the national interest and thus the removal of any deterrent to space activity may be said to be in the public interest. It is not within the scope of this study to prove that space activity is in the national interest: however, the decisions of the U.S. government to date with regard to the space program have been

consistent with this premise. However, not all space activities are in the national interest. Space activites that fit the following criteria are not in the national interest:

> The activity imposes undo risk on persons or property on earth or in space.
>
> The activity adversely impacts the environment, or imposes undo risk on the environment, either on the earth or in space.
>
> The activity is in violation of international law or treaties to which the U.S. is a signatory.
>
> The activity is in violation of domestic (Federal and state) law and the Constitution.
>
> The activity threatens national security, it imposes undo risk on Government property, and it seeks to overthrow the Government by force.

Further, although measures of economic worth of an activity may provide quantitative data to aid in the determination of which activities are in the national interest, or the ranking of activities according to economic value, such measures would require a cumbersome case by case analysis and would be subject to different value judgements, opinions and political interests. It is recommended that determination of whether a space activity is in the national interest, for purpose of determining which parties receive federally provided insurance not include measures of economic worth.

In regard to assuring compensation to potential victims, it seems that the NASA requirement that insists on a user or users purchasing one policy to protect themselves and the Federal government regardless of who is at fault (except if contractor is at fault, in which case NASA will indemnify,[3]) will facilitate the claims procedure by reducing the number of parties

that could be sued.

5.2 Interpretation of Price-Anderson Act

The Price-Anderson Act is one excellent example of government policy that was intended to assure compensation to potential victims (at least up to the maximum limitation on liability of $560 million) and to encourage participation of private industry in the development of a new technology, nuclear energy, by reducing potential exposure to liability. By committing the government to provide indemnification for potential damages in excess of coverage held by the nuclear plants up to $560 million the government made certain that at least that much would be available to compensate victims. There is, however, an uncertainty as to who would bear the risk of damages in excess of the limit of liability, the victims or the federal government through the subsequent enactment of legislation. For claims beyond $560 million, Congress made a vague promise to take appropriate steps. Another advantage to the potential claimant is that, under the 1975 amendment, the claims procedure is simplified and the number of parties that may be sued is limited. By limiting liability of the nuclear plants to $560 million it protected the plants from the potential of disasterous financial liabilities. The limitation of liability and the possibility of indemnity have reduced financial risk to the nuclear utilities and thus might have resulted in a greater number of operating facilities than would otherwise be the case.[4]

Before 1954, the Federal government had an absolute monopoly

on atomic energy development. The Atomic Energy Act of 1954 was intended to encourage the development of atomic energy by the private sector. However, the private sector was not willing to invest heavily because of enormous potential liabilities. Indeed, testimonies in hearings on the Price-Anderson Act indicate that industry did not want to become involved in the nascent nuclear power industry without a commitment on the part of the government to limit liability and provide for indemnification.[5,6]

One frequently heard objection to the Price-Anderson Act on the part of critics of nuclear power was that the unwillingness of the industry to assume the full risk of liability was evidence that the operation of nuclear plants was inherently unsafe. Others contend that this unwillingness was not due to a lack of absolute conviction as to safety, but was consistent with a belief that there was an extremely remote possibility that an accident would occur, but that liability for the accident would be disastrous.[7]

It has also been suggested that the indemnification provision may have impeded growth in the primary level of insurance. By entitling nuclear utilities to indemnification for liability incurred but not insured in the primary or secondary layer, Price Anderson may have given utilities a disincentive to purchase more liability than required by the Act. In the same vein, insurers, who have not been enthusiastic about nuclear liability insurance in the first place, haven't offered as much nuclear liability insurance as they might otherwise, because the nuclear utilities haven't pressed them to increase the supply of

insurance.[4]

5.3 Availability of Commercial Insurance

Availability of insurance for any given risk is influenced by the rate, profitability of a given line, loss experience, and state of the insurance industry. Capacity is also influenced by perception of risk, which is itself influenced by the degree to which technical problems are understood and the exposures are clear.

The amount of space liability insurance would increase if more companies participated in providing insurance capacity and if each company took a larger exposure. With good loss experience, increased premiums or improved terms and conditions, available insurance would be likely to increase.

Without performing an extensive survey of insurance companies in the U.S. and in London it is impossible to determine the extent that insurance capacity will respond to increases in rates. However, discussions with underwriters suggest that insurance premiums would have to increase significantly before more third party liability capacity can be brought out.

Experience with space liability has to date been positive. With the exception of the Russian satellite Cosmos 954 [1] there have been no liability payments for damage caused by space objects to date. Over 4800 spacecraft are currently in orbit.[9] While it may seem there is a significant amount of experience that has borne out the safety of space launches, the premium volume in space liability insurance is small especially in relation to the size of the maximum liability exposure. So far,

in the U.S. no claims have been paid so experience is excellent, but at current rates it will be over a century before insurers will have collected enough premium to cover one maximum liability loss.

However, the availability of satellite liability insurance is influenced by more than simply the experience in the satellite liability market. Experience in the physical damage insurance will effect capacity that is available for liability and so will the current rate of profitability of the marine and aviation markets and experience in the insurance market in general and the liability market in particular.

It seems reasonable to suggest that shrinking capacity in the physical damage market that is resulting as a number of insurance companies close their satellite insurance departments is synonymous with decreasing capacity in liability insurance. To properly understand liability exposure the underwriter must understand the physical damage exposure. Reinsurers are dropping out of both the aviation and satellite market. U.S. insurance companies will not take risks without reinsurance. Companies that are withdrawing from the market in satellite physical damage (or those that have chosen not to enter), will not likely maintain an expertise in any aspect of space insurance.

Capacity appears to be shrinking in space liability insurance and rates increasing. One case in point is a recent policy covering in-orbit liability exposure. The premium for this policy increased 1,000% over the previous policy and the capacity was so constrained that the maximum available exposure

halved from $500 million to $250 million. The renewed policy covered one year instead of three. Recent losses in the physical damage area may have influenced perceptions of risk, causing insurers to question the extent to which technical problems are understood. Insurers may feel that uncertainty is higher than previously believed, and this could be causing many to drop out of both physical damage and liability insurance and causing others to reduce their lines and charge a higher premium. Higher premiums for liability insurance is in part an attempt to recover losses in the physical damage area.

In the U.S. there is a well developed "umbrella" liability market which provides coverage, and in fact, large amounts of coverage for the various liabilities of U.S. corporations and businesses. An umbrella coverage is intended to cover catastrophic events faced by business. Several U.S. companies can usually combine to provide up to $200 million in coverage. However, this capacity is not available to satellite users, due to exclusions in reinsurance treaties (for umbrella coverages) which exclude aviation risks. Hence even if umbrella underwriters were inclined to consider satellite coverages, they could not offer their usual capacity, only a net line, which would not be of much use. In addition, the current rates of satellite insurance would be too low. Regardless of the type of risk, the minimum premium per million dollars of exposure for umbrella coverage is $500. Some reinsurers have minimum premiums of $750 or $1000 per million. Present placements of satellite insurance are priced at approximately $200 per million.

Capacity and pricing for satellite coverage will also be

influenced by the current state of profitability of the marine and aviation markets. The logical potential sources of capacity in satellite insurance are the aviation and marine markets. The marine market is noted for its ability to respond to the needs of capacity type risks. In shipping, the marine market, led by underwriters at Lloyds of London, and the underwriters at British insurance companies, successfully put together the insurance coverage for the first large super tankers. When these were first introduced, they posed considerable challenges and problems both from technical and capacity standpoints. In addition to accepting capacity type risks, marine underwriting requires the exercise of judgement and recognition of different exposures, because of the many factors that marine underwriters consider in underwriting various risks. Marine underwriters consider the risk and whole environment in which the risk is placed. Factors influencing rate setting include mode of transport, number and location of stops the vessel makes, reputation of shipper, container, etc. A marine underwriter must constantly analyze the differences in the same overall class of account. This type of rigor in analyzing exposures sets marine underwriting apart from such insurance areas as homeowners, auto, or life, which use actuarial data to set rates. By their very training, marine underwriters have the inclination to move into new areas and to move into new exposures. They are used to considering different exposures every day.

Space liability insurance has been placed largely in the London market [10] while U.S. insurers generally consider the

current rates too low and have been reluctant to participate in this area. The intrinsic differences between the London and U.S. markets explain why capacity is more readily forthcoming from London. An overview of these differences is presented in Appendix A.

5.4 Potential Insurer Liability

Determining the maximum potential liability loss that a space vehicle could cause is not feasible because there really is no upper limit on potential damages. Accidents of untold magnitude are possible by a cascading of unlikely events. Other activities occur daily that also could under certain circumstances cause enormous damages.

According to estimates there is a remote possibility that an accident at a nuclear power plant could cause several billion dollars of damage. However, in over twenty-seven years, total damages from incidents at power plants have totalled $32 million. Commercial jetliners have an impressive safety record. In the five year period between 1974 and 1978, 33 total losses (excluding war and sabotage accidents) out of 9,500,000 departures of long-haul jets were recorded and 36 total losses occurred out of 31,450,000 departures of short-haul jets.[15] Even more impressive is the degree to which airlines have avoided the sort of damage which would result in third party claims. The reason that commercial jetliners carry large liability limits is due to the potential liability to passengers. The worst aviation disaster in history, (an on ground collision)[16] occurred in 1977 at Tennerife in the Canary Island and caused $161 million in bodily injury and material damages.[17] One of the worst

disasters involving damage to persons and property on the ground was the 1982 crash of a Pan-Am Boeing 727 in New Orleans. Liability damages amounted to $70 million.[18] Probably the worst marine disaster to date, the wreck of the Amoco-Cadez off the coast of France in 1978 has generated over $2 billion in lawsuits.

The Federal Government has exercised range safety control over all space vehicle launches emanating from the territories of the United States. The purpose of this control is to assure the safety of peoples and structures from risk of death, injury, or damage from "space objects" over the entire world. The steps taken to assure such safety are herculian, and include the evacuation of a safety zone—land, sea, and air—around all launch sites and in the downrange region of each launch, the planning of launches to avoid overflight of populated regions of the earth during ascent, and, as an ultimate mechanism, provision for total destruction of the launch vehicle should the launch go awry in a manner that threatens such safety. To date, the Government has achieved an excellent safety record.

Despite these precautions and the resulting safety record, however, there remain a variety of scenarios under which a launch system such as the Space Shuttle could cause extensive damage, including injury and death to humans. And, although most such mechanisms would be extremely unlikely to occur—indeed, they would be concocted from highly implausible scenarios—competent physicists could find mechanisms for their occurrence that would not violate physical laws. Thus, from the point of view of an

insurer, maximum liability events are "possible," and the maximum potential loss could be the face value of all future insurance coverage.

More limiting, however, and considering only that liability exposure related to the Space Shuttle fleet, the maximum exposure would be the liability limit per Space Shuttle flight, $750 million, times the number of Space Shuttles in the fleet, say 5, or $3.75 billion. The Space Shuttle fleet alone could not generate a third-party liability to insurers higher than this amount. Since the Federal Government has already agreed to indemnify losses beyond the available insurance, which is presently available up to $750 million a flight, the maximum liability to the Treasury if the Federal Government agrees to provide insurance, that is, take on the first $750 million of risk as well, would be the incremental exposure of $750 million per shuttle flight. The government is already exposed to liabilities in excess of $500 to $750 million a shuttle flight. But, surely, if one such catastrophic accident occurred, efforts would be redoubled to make the occurrence of a second such event even less likely. Thus, the possibility of third-party liability claims even approaching this amount is so remote that its consideration must be treated as an academic exercise.

It is more reasonable, and informative, to ask what expected value of liability might be generated by the Space Shuttle fleet. A precise computation of this value would be very difficult, but a simple model can provide adequate insights. Assume that liability might arise only if the Space Shuttle is lost in an uncontrolled accident. The probability of a liability loss on

any given flight would be the product of four probabilities: (1) the probability that the Space Shuttle will have an accident on any given flight, P_A, (2) the probability that the accident will occur in an uncontrolled manner (and thus cannot be diverted to an area where no liability damage would occur) given that an accident does occur, $P_{U/A}$, (3) the fraction of the earth under the orbital arc that is inhabited, f_I, and (4) the probability that a liability loss is incurred given that an uncontrolled accident occurs in an inhabited area, $P_{L/I}$. In addition, let $\overline{L}$ be the average or expected liability per accident that results in a liability loss. The expected liability loss per Space Shuttle flight (ELL_f) is, thus

$$ELL_f = P_A P_{U/A} f_I P_{L/I} \overline{L}$$

It is assumed that each Space Shuttle vehicle would be involved in only one accident and, further, that each vehicle has a useful life of n flights. The expected liability loss per vehicle (ELL_v) is, thus

$$ELL_v = [1-(1-P_A)^n] P_{U/A} f_I P_{L/I} \overline{L}$$

Assuming that no steps would be taken to prevent a second accident, given the occurrence of one accident, the expected liability loss for a fleet of N Space Shuttles (ELL_t) is

$$ELL_t = \sum \left\{ [1-(1-P_A)^n] P_{U/A} f_I P_{L/I} \right\}^i \quad (i\overline{L})$$

The parameters of this equation are not known. But reasonable values can be used, for illustrative purposes. Choosing values:

$$P_A = 0.01$$

$$P_{U/A} = 0.1$$

$$f_I = 0.05$$

$P_{L/I} = 0.2$

$\bar{L} = \$750$ million

$n = 100$

$N = 5$

Although these are arbitrarily chosen values, some reason could be expressed that they are probably on the conservative side, that is, they overestimate the expected fleet liability. For example, a 1 percent chance of an accident on any given flight is in concert with NASA design criteria. $P_{U/A} = 0.1$ is probably a gross overestimate of this probability. $n = 100$ assumes that every flight of each vehicle's expected life will carry a commercial payload. $N = 5$ assumes a full, five-orbiter fleet, and $\bar{L} = \$750$ million assumes that any incurrence of liability results in the maximum possible liability. Using these numbers, $ELL_t = \$476{,}000$. Thus, a premium of $100,000—approximately the current price of third-party liability insurance—is more than one-fifth of the expected liability generated by the entire Space Shuttle fleet over its lifetime!

This result is further evidence that insurance premiums are not determined by expected loss. This is an expected value that would never occur. In reality, the Space Shuttle fleet will generate either no liability loss at all, or a very large loss in the unlikely event that any loss occurs. (Of course, a small loss is possible, but even less likely.) To be safe, an insurer must set aside funds to cover a payment, should a loss be incurred. By this logic, premiums on the order of $100,000 are actually very "reasonable." Analysis of insurance rates in other industries indicate that the set-aside period in these industries

is significantly shorter than the set-aside period for space insurance. Judging by practice in other industries, if space insurance is to become a product line, it would not be unreasonable for premium rates to rise to a level 5 to 10 times higher than current rates.

Should the Federal Government choose to provide third-party liability insurance to Space Shuttle users, its liability exposure would be determined by the limits cited above, tempered by any liability assumed by commercial insurance sources.

5.5 Measures of Reasonableness

Judging the premium rate that could be considered unreasonable from the point of view of the user is a difficult and arbitrary task. From the user's point of view the most reasonable premium is zero; any premium above zero is less reasonable. Of course, a rate of zero would be unreasonable from others' perspectives, i.e. the insurance companies, which would not offer insurance capacity unless it could expect a reasonable rate of return.

Once the user accepts that some rate must be paid, he may judge reasonableness by historical costs, comparing rates with what he is used to paying. A sudden and substantial rate increase would likely be perceived as unreasonable to a user.

Rates that impaired the financial viability of a space activity would certainly be considered unreasonable. High insurance costs might cause the overall profitability of the space venture to become low relative to other commercial ventures and might result in a shift of investment out of space activities

and into terrestrial enterprises. Payment of liability premiums may effect competitiveness of a space venture by making it less attractive in relation to its competitors. One example would be if a venture such as Comsat had to pay insurance costs that made provision of its services less competitive in relation to competing terrestrial technologies like microwave or fiber optics. High insurance costs could make the venture itself untenable as could be the case in a small business situation that may be just starting up or a research and development venture that is not expected to generate revenues for several years.

One may consider the financial impact of several levels of premium on a typical satellite mission, by computing the impact of the higher costs of the missions (at higher premium levels) on the present value of net income of the missions, and the effect higher premiums might have on financial performance measures of the business entity such as per share earnings, rate of return on investment, return on assets, and net profit margin.

Since communications satellite missions make up the bulk of space missions subject to the liability insurance requirement, a communications satellite business example is considered in order to illustrate potential financial impacts. In particular, Comsat General Corporation and one of its planned satellite systems, the Comstar K system, is considered, and the effects of four liability premium levels are indicated..

The effect on several financial performance measures was estimated using data from Comsat's annual Report for 1983 and computing what each performance measure might be if Comsat had

paid an additional insurance premium of $.5 million, $1.0 million, $5.0 million and $10.0 million. Table 5.1 presents the results of the computations, assuming that the insurance cost increases are not passed on to the consumers.

TABLE 5.1 EFFECT OF VARIOUS PREMIUM LEVELS ON COMSAT'S FINANCIAL PERFORMANCE MEASURES

FINANCIAL VARIABLES	PREMIUM LEVELS (MILLIONS OF DOLLARS) $.5	$1.	$5.	$10.
RATE OF RETURN ON COMMON STOCK EQUITY	8.75%	8.7%	8.2%	7.8%
NET PROFIT MARGIN	11.3%	11.0%	10.6%	7.7%
RETURN ON ASSETS	4.8%	4.7%	4.5%	4.2%

BASED ON DATA FROM COMSAT, ANNUAL REPORT 1983

The financial data (Table 5.2) on the Comstar K mission is included in Comsat's FCC filing for that mission. The satellite system will include 2 satellites and one in-orbit spare. Costs and revenues are projected for the system.[11] Using a discount rate of 10% the present value of the net income is $15.63 million. This was compared with the present value which would result if premiums were to cost an additional $.5 million, $1.0 million, $5.0 million, and $10.0 million per satellite. At a $5 million premium the net present value was $6.58 million and at a $10 million premium the present value was -$2.44. (Table 5.3) However, calculations used the revenue forecast assumed under present premium levels.

TABLE 5.2 COMSAT GENERAL CORPORATION COMSTAR-K PROGRAM

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
TOTAL CAPITAL EXPENDITURES	1.00	45.57	78.17	96.79	78.06	13.91	-	-	-	-	-	-	-	-	-
TOTAL ANNUAL EXPENSE	-	1.26	1.26	1.26	18.84	35.61	42.17	43.32	44.02	44.77	45.57	46.43	47.35	48.36	37.30
REVENUE REQUIREMENTS	-	-	-	-	57.00	75.00	89.00	94.00	99.00	105.00	108.00	112.00	114.00	116.00	116.00

TWO SATELLITES WILL BE LAUNCHED IN 1988 AND ONE WILL BE LAUNCHED IN 1989

SOURCE: COMSAT GENERAL CORPORATION, IN THE MATTER OF THE APPLICATIONS OF COMSAT GENERAL CORPORATION, FOR AUTHORITY TO CONSTRUCT, LAUNCH AND OPERATE 12/14 GH_2 SATELLITE AND TO CONSTRUCT AND OPERATE RELATED TT&C EARTH STATION FACILITIES, NOVEMBER 7, 1983

TABLE 5.3 PRESENT VALUE OF NET INCOME AT VARIOUS PREMIUM LEVELS (millions of dollars)

PREMIUM LEVEL	PRESENT VALUE*
$ .5	$14.72
1.0	13.82
5.0	6.5
10.0	-2.44

*OVER 15-YEAR PERIOD USING A DISCOUNT RATE OF 10%

That would be valid if a communications satellite enterprise such as Comsat was faced with a unit elastic demand for its services. That is, if the same amount of revenue would be received at any price (if prices were increased revenue would remain the same because quantity demanded would fall by the same percentage), premiums of between $5 million and $10 million would threaten the viability of the mission, by causing the present value of net income to turn negative.

However, the cost of the satellite component is a very small percentage of total communications costs and very likely may be passed on to the consumers without causing too much concern. If this is the case, revenue would increase when consumers pay higher prices because when demand is inelastic, consumers do not cut back their demand significantly when prices go up. If the venture can pass on price increases to the consumer, the above negative impacts on the venture itself may not occur, or may only

negative impacts on the venture itself may not occur, or may only occur in the short run. If premiums were to increase and demand is price inelastic, the corporation would be able to pass the cost of the higher premiums on to its customers without materially affecting revenues, and the resulting financial performance measures.

The venture can pass costs on to users until the cost is pushed beyond the cost of the next best choice, which in the case of communication satellites would be terrestrial systems (microwave and fiber optics). If premiums were to cause costs to rise to a point which would make terrestrial communications less expensive than communication satellites, the viability of the communications satellites would be threatened.

Determining the impact of premiums on the financial viability of a mission is an unsatisfactory criteria for NASA to employ, however, in deciding when liability insurance should be provided by the Federal Government, because it would require a case-by-case analysis, which would be costly to administer and subject to numerous imperfections. Obviously premium effects on a venture's financial viability depends on the venture. A premium that may not impair Comsat missions may be too high for another venture and so there is no one "reasonable" premium, based on this criteria.

An alternative criteria could be the point at which launching via a U.S. system becomes significantly more expensive than a comparable launch on a foreign system. If insurance costs were so high that they made the cost of launching a payload via the shuttle more expensive than an Ariane launch, users would

consider premium charges unreasonable and NASA might lose potential business to its French competitors. Avoidance of this possibility would be in the national interest.

Presumably NASA has priced shuttle launches below cost to attract customers to the space transportation system. It may be necessary to examine NASA's rationale in pricing to determine why and to what extent additional costs may be unreasonable. Requiring users to pay high liability insurance costs, is counter to the original objective of maintaining low launch prices. Any increase in insurance premiums associated with the launch of payloads increases the cost of launching the payloads to the user and the cost of launching on the NASA system, relative to the cost of launching via a foreign competitor. The price of an Ariane (Delta class PAM-D) launch ranges from $25 - $30 million; the price of an equivalent shuttle launch ranges from $15 to $20 million. One may compare the two prices if third party liability insurance for launches on the U.S. system were to increase to $.5 million, $1 million, $5 million and $10 million. A strict comparison of launch prices may not be sufficient, however, since there are other variables affecting demand for each of the different launch systems.

Other measures of reasonableness may be used. A reasonable premium may be set as a percent of total revenue or a percent of payload cost or a percent of launch cost.

One approach to determining whether third party liability premiums are reasonable is suggested by a recent survey performed by the Risk Planning Group and Risk & Insurance Management

Society. This survey computed cost-of-risk (defined in the survey as net insurance premiums, unreimbursed loss costs, loss control, loss prevention expenses and administrative cost) as a percentage of revenue in 33 industry groups and found that it ranged from a low of 0.11% in the finance and banking industry to a high of 2.47% in the transportation industry (and averaged .48% over all industries).[12] Using these percentages as a criteria, it may be concluded that if the cost-of risk represented by the insurance costs of a particular mission were to exceed 2.5% of the projected revenues of that mission, then the cost of insurance is out of line with the highest percentage paid in other industries.

Table 5.4 sets out costs and revenues that are projected by the American Satellite Corporation (ASC) for a proposed mission.[13] (the system consists of two in-orbit satellites in 1986, three in-orbit satellites in 1987 and four in-orbit satellites and one ground spare in 1989). Insurance costs as a percentage of projected revenue are displayed on the last line, and range from .06% to 2.3%. Taking the years 1986 and 1987, when ASC plans to launch a satellite each year, the insurance level that would amount to 2.5% of projected revenues would equal $1 million in 1986 and $2.3 million in 1987. Projected insurance costs are $.8 and $1.87 million in years 1986 and 1987 respectively. An additional $.2 million in insurance costs in 1986 and another $.44 million in 1987 would bring the percentage of insurance costs to revenue in those years to 2.5%. Amounts beyond that level would result in insurance costs being more than 2.5% of revenues and thus greater than the maximum percentage of

TABLE 5.4 AMERICAN SATELLITE COMPANY SATELLITE SYSTEM REVENUE REQUIREMENTS

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
TOTAL COST IN PLACE	$212.09	$330.24	$330.24	$667.92	$667.92	$667.92	$667.92	$667.92	$667.92	$667.92	$667.92	$667.92	$667.92
Revenue Requirement													
Annual Charges & Expenses													
Fixed Charges	$ 1.33	$ 1.88	$ 1.88	$ 9.29	$ 9.66	$ 10.05	$ 10.46	$ 10.87	$ 11.30	$ 11.76	$ 12.23	$ 12.71	$ 13.22
Insurance	.80	1.87	2.48	2.63	4.06	3.94	3.13	2.33	1.64	1.12	.68	.36	.04
System Management and TT&C	1.70	2.00	2.16	2 43	2.64	2.85	3.07	3.32	3.59	3.87	4.18	4.52	4.88
Depreciation	24.18	37.73	37.73	73 25	73.25	73.25	73.25	73.25	62.10	44.61	38.26	25.60	11.06
TOTAL AC&E	$ 28.01	$ 42.41	$ 44.25	$ 87.60	$ 89.61	$ 90.09	$ 89.90	$ 89.77	$ 78.63	$ 61.36	$ 55.35	$ 43.19	$ 29.20
Provision for Return	$ 26.51	$ 41.28	$ 41.28	$ 83.49	$ 83.49	$ 83.49	$ 83.49	$ 83.49	$ 83.49	$ 83.49	$ 83.49	$ 83.49	$ 83.49
Revenue Requirement - Annual	$ 54.52	$ 83.69	$ 85.53	$171.09	$173.10	$173.58	$173.39	$173.26	$162.12	$144.84	$138.84	$126.68	$112.69
Projected Revenue	$ 40.00	$ 92.40	$110.90	$143.90	$177.00	$177.00	$177.00	$177.00	$177.00	$177.00	$140.00	$ 84.60	$ 66.10
Insurance as a Percent of Revenue	2%	2%	2.2%	1.8%	2.3%	2.2%	1.8%	1.3%	.9%	.6%	.5%	.4%	.06%

BASED UPON: AMERICAN SATELLITE COMPANY, AMENDMENT OF APPLICATION FOR AUTHORITY TO CONSTRUCT, LAUNCH AND OPERATE ITS THIRD DOMESTIC COMMUNICATIONS SATELLITE, FCC FILING

the survey.*

There are flaws with this technique. First it is based on a survey which is based on a limited data set. Secondly, it considers only insurance costs and revenues associated with a particular mission and not with the entire corporation itself, as does the Cost-of-Risk survey. It is not known what the ratio of insurance costs to revenues within the corporation are. Also it is based on projected cost and revenue data. Since the FCC filing was produced there is reason to believe that insurance costs will be much higher than was probably anticipated at the time the filing was written (especially in the physical damage area). Therefore there is probably less room for growth in the insurance costs before they become 2.5% of projected revenues.

Liability insurance cost may also be considered as a percentage of launch costs, or payload value. The preferred method would be to set a reasonable premium as a percent of launch costs since NASA can easily establish these costs and payload cost data could be manipulated by the prospective user. Charging a single premium rate for all payloads creates difficulties in allocating the liability risk in an orderly and equitable manner. Although CFES (Continuous Flow Electrophoresis System), flown by McDonnell Douglas and the Microgravity Research

* If insurance costs are depreciated over several years then it would be appropriate to estimate the increment that would bring insurance costs to 2.5% of revenues for the years over which the costs were depreciated. The sum of the increments would indicate how much of an insurance increase would bring insurance costs to 2.5% of revenue.

Associates (MRA) experiment do not pay launch costs under the Joint Endeavor Agreement, if they were required to pay, each launch of its payload would cost McDonnell Douglas approximately $1 million and MRA, approximately $300 thousand.[14] NASA also decided to waive liability insurance requirments in these cases, but if each had to pay for liability insurance at the current rate of $100 thousand, McDonnell Douglas would be paying 10% of launch costs and MRA, 33%. If a communications satellite launch costs on the order of $20 million: liability premiums are .5% of launch costs. If one may reasonably assume that marginal activities, those that are experimental and might be discouraged by high insurance costs, use smaller, lighter payloads, then setting premium rates as a percentage of launch costs would allow marginal users to pay a more moderate premium. Insurance costs would then be less of a barrier to marginal activities.

An important criteria then, for reasonableness of premiums is that the premium not be an important consideration in total mission costs. An arbitrary rule of thumb could be to chose 1% of the launch costs, beyond which premium rates would be considered unreasonable. In this case, McDonnell Douglas would have to pay $10,000, MRA $3,000, and the communication satellite owner, $200,000 for insurance.

6. GOVERNMENT OPTIONS

This section discusses options available to the government for the provision of third-party liability insurance to space users, if the government chooses to make such protection available. These options are viable because of two key factors:

1. The expected liability generated by most space activities is virtually nil. Thus, in the long term, premiums on the order of those currently paid will recover expected losses, and there is a great deal of freedom available for the structuring of rates.
2. There are several precedents for government provision of insurance, and these could provide models for the provision of third-party liability insurance to space users.

6.1 Organizational Structures for Federally Provided Insurance

Many different organizational structures are possible for Federally provided third-party liability insurance for space vehicle users. Because of this flexibility, choices should be made carefully and with due consideration of the results. It would seem reasonable that the chosen organizational structure should strive toward the following objectives:

1. It should not create a barrier to commercial space activities.
2. It should not be tied to Congressional decision making.
3. It should not constitute a burden on the Treasury.
4. It should promote availability of insurance to all qualified potential space vehicle users, large and small.

5. Rates should be as objectively determined as possible; such insurance should be administratively simple and require no case-by-case decisions.

6. It should not compete with the private insurance industry.

7. It should be stable in the long term.

A proposed organizational structure could be evaluated against these objectives. Five alternative structures are considered below.

1. Federal Space Insurance Trust Fund — Under this concept, the government would create a Space Insurance Agency (SIA) to provide liability (and perhaps other) insurance for space activities. The SIA would collect premiums for insurance provided. These premiums would be used to offset the cost of administering the SIA and to pay any claims that might arise. Excess premiums, those beyond administrative costs and claims, would be placed in a trust fund to cover potential future claims. The Treasury would be liable only for that portion of claims that might exceed the magnitude of the trust fund. As soon as the trust fund becomes large enough, potential liability to the Treasury would essentially be eliminated. At such time as sufficient funds are available, the SIA could reduce its premiums and/or provide an income to the Treasury.

2. Group Insurance — Under this alternative, the government would provide "group insurance" by purchasing a commercial policy covering its launches on an annual,

rather than a per flight basis. The cost of this policy would then be allocated across space users according to their use of the launch systems. The key advantage of this alternative is that such a policy may be obtainable at a lower premium than policies that are purchased for individual flights.

3. Layered Buy-Down — Under this concept, the insurance industry would be called upon to provide space user liability insurance, but in lesser amounts. Private insurance sources would provide the bottom layer of insurance, say $100 million per activity, with the government providing insurance for higher layers, say $100 million to $500 million. A premium would be charged for the upper layer of insurance, but as in the case of other layered insurances, the premiums for the upper layer would be substantially lower than that for the lower layer. Alternatively, NASA could retain the bottom layer of exposure for a fee, and obtain or require the user to obtain commercial insurance to cover the upper layers.

4. Self Insurance — Under this approach, users would self-insure by agreeing to pay a retrospective premium in case of an accident. This arrangement could be structured in a similar manner to the secondary level of insurance, of the nuclear industry.

5. Captive Insurance Company — Under this concept, the government would establish a captive insurance company similar to those which many shipping and oil companies

have set up. A "captive" run under the aegis of NASA would have the advantage of NASA's engineering expertise. It would be available to offer coverages much broader than that available from the regular insurance market. It would be available to play a key role in the event of a capacity crunch in the insurance market. It most likely would be able to offer more competitive premiums—and like all captives, would be able to take advantage of reinsurance arrangements on any risks that it might decide to take. It could also serve as a proving ground for U.S. underwriting expertise in space projects.

The second and fourth options are mentioned for completeness, but are not suggested because of their disadvantages, which include difficulty in setting rates and inability to identify who should make retrospective payments in the event of a claim. The use of a group policy would present difficulties unless all users were required to insure under the group policy. Otherwise, commercial coverage offered outside the group policy for lower premiums could lure some users away, increasing the premium for those remaining under the group policy or leaving the Government to pay some portion of the group policy costs. User self-insurance is not viable unless there is a substained population of users who regularly use the launch system. One can not expect users, who make infrequent use of the launch system to agree to pay a portion of liability damages of another user's launch.

The remaining alternatives appear, at least on the surface, to be viable. They seem to hold the potential for meeting the specified objectives, and they provide some protection to the Treasury against losses that it could incur without such provision.

6.2 Determination Of Insurance Premium Schedule

Given any of the above organizational structures, it remains to determine premium schedules for Federally provided insurance.

The structuring of an insurance premium schedule for Federally provided third-party liability insurance could seek to accomplish several objectives, such as the following:

1. It should be designed to promote, not inhibit commercial space activities.
2. Its conditions should not be subject to interpretation or negotiation.
3. It should not interfere with the provision of third-party liability insurance from commercial insurance sources.
4. It should not impose a burden on the United States Treasury.

It would be all too easy to structure a premium schedule that would inhibit commercial space activities. For example, if Federal premiums were substantially lower than commercial insurance premiums, but were available only to certain qualified users, it could force potential space users to engage in a lengthy approval process, thereby delaying or preventing altogether the activity. On the other hand, premiums that are high in relation to other costs of the activity could present a

barrier. A premium of, say, $100,000 may be negligible to a user launching a $50 million communication satellite, with a total launch cost in excess of $30 million. But to a user with a very small payload, say a $200,000 box with a $100,000 launch cost, a $100,000 insurance premium could be devastating. The premium structure should not inhibit potential users with very small payloads.

To facilitate the rapid approval of Federally provided insurance, the provisions of that insurance should be laid out as clearly and concisely, and subject to as little interpretation or negotiation, as possible. If, to accomodate the insurance of small payloads, premiums are to vary with payload size, then such variation should be based, to the maximum extent possible, on objective and easily measured parameters. Payload cost or financial status of the activity are not good measures. Both are subject to a wide range of "interpretation" and are subject to variabilities in accounting practices. Also, the administrative costs of using such parameters would be high. The Space Shuttle launch fee, on the other hand, is an easily determined parameter that is not subject to debate. It is simply the amount paid by the user to the Federal Government for launch services.

The premium structure should generate enough revenue to fully fund any claim payments that might have to be made, and it should not prevent the insurance industry from continuing to provide insurance up to its capacity to do so. Thus, at least for "larger" satellites, such as the PAM-D class communication satellites, the Federal insurance premium should be well above

current insurance industry premiums.

If the Federal Government uses a method similar to that used by the insurance industry for determination of rates, being sure that any premium is well above the expected liability, the rate should be high enough to set aside reserves to make payments against possible claims over a reasonably short time.

The above objectives appear to be achievable using a carefully structured premium schedule. It is suggested that such a schedule could be based on the Space Shuttle users fee and set so as not to compete with the private insurance industry, given its current rate structure.

7. CONCLUSIONS AND RECOMMENDATIONS

Several practices and precedents associated with third-party liability insurance in other industries may be used as a basis and rationale for structuring the Federal approach to third-party liability insurance for space vehicle users. A precedent for government commitment to indemnification of damages beyond commercially available insurance may be found in the Price-Anderson Act. Federal Acts, such as Price-Anderson and the Federal Limitation of Liability Act of 1851, limited private industry liability, with the objective of encouraging development of the industry. Other Acts applying to liability caused by spills of oil and other hazardous substances have limited liability and also established Funds to pay damages in excess of the liability limits. One practice that may be useful, if the Federal government chooses to provide some portion of liability insurance, is that of arranging coverage in layers.

Reasonableness of premiums depends on one's perspective. Rates must be reasonable to the seller and the buyer, otherwise the two groups will not do business. An analysis of rates in other industries suggests it would not be inconsistent with standard insurance industry practice if rates for space liability insurance were to rise significantly (perhaps to $500,000 to $1,000,000) if space liability insurance is considered a product line.

Several criteria are suggested to determine reasonableness

from the user's point of view, but reasonableness is subjective and varies with the user. Rates that may be reasonable to one user could be unreasonably high to another. Current rates are probably reasonable from many points of view but even they could impede small ventures. An alternative to the government determining whether adequate insurance is available at reasonable rates, would be for the government to make available Federal insurance as a back-up to commercial insurance and designed so as not to compete with commercial insurance.

Several viable alternatives are available to the government. If structured correctly the provision of third-party liability insurance through the Federal government could serve the goal of promoting space commercialization, could be self-supporting and would be highly unlikely to negatively impact the Treasury. Because the expected liability is low (in the case of the Space Shuttle estimated at $10,000 per shuttle flight), the government is not likely to be in a situation which would cause a drain on the Treasury. By charging a premium the government is putting aside funds to cover any damages that might arise.

If the government decides to provide third-party liability insurance careful study should be devoted to consideration of the structure and format of the Federally provided insurance. Once steps are taken precedents will be locked in for the future an wrong decisions can be costly. Further study should focus on the following:

* Impact of various premium rates on space commercialization.
* An evaluation of the insurance options available to the government.

* The organization of the entity that administers the insurance.

* Structure of the third-party liability provision.

* Determination of a premium schedule.

Specifically it is recommended that an analysis be performed of a government entity set up to provide third party liability insurance. The insurance options mentioned above should be evaluated and the organization and administration of the government entity should be studied. Various premium schedules should be evaluated. The long term and short term impact on both the private sector and the government should be considered.

GLOSSARY*

Absolute Liability: Liability without proof of fault or negligence.

Capacity: A measure of the amount of insurance which an insurance company is able or prepared to assume on particular risks.

Captive Insurer: An insurance company set up by a company or group of companies to insure their own risks or risks common to the group.

Earned Premium: The portion of a premium which is the property of an insurance company, based on the expired portion of the policy period.

Excess treaties: Provide for reinsurers to pay only the amount of any given loss in excess of the amount the primary insurer agrees to retain.

Facultative Reinsurance: A procedure by which insurance companies reinsure risks on an individual basis, with a reinsurer having the option to accept or decline each risk.

Hazard: Condition which creates or increases the chances of a loss.

Indemnity: To provide financial compensation for losses.

Insurance: A system under which individuals, businesses and other organizations or entities, in exchange for payment of a sum of money (a premium), are guaranteed compensation for losses resulting from certain perils under specified conditions.

Liability Insurance: Insurance covering the policyholder's legal liability for injuries to other persons or damage to their property.

Limit: The maximum amount of benefits that an insurer agrees to pay in the event of a loss.

Line: A type or kind of insurance.

Lloyds: Groups of individuals, called syndicates (not insurance companies), assuming liability through an underwriter. Each individual independently and personally assumes a proportionate part of the risk accepted by the underwriter.

Loss: The basis on which an insurance claim is submitted and/or paid.

*Source: Sharing the Risk, Insurance Information Institute.

Loss Ratio: The percentage of premiums (usually earned premiums) used to pay losses and loss adjustment expenses.

Loss Reserve: An insurer's estimated liability for unpaid insurance claims or losses that will have to be paid in the future.

Mutual Insurance Company: An incorporated insurance organization owned by its policyholders.

Negligence: Failure to use the degree of care which a person of reasonable prudence would use under given or similar circumstances. A person may be negligent by acts of omission or commission, or both.

Net Underwriting Profit or Loss: Statuatory underwriting profit less (or loss plus) dividends to policy holders.

Policyholders' Surplus: The sum remaining after all liabilities are deducted from all assets. Sums such as paid-in capital and special voluntary reserves are also included in this term. This surplus is an additional financial protection to policyholders in the event a company suffers unexpected or catastrophic losses. In effect, it is the financial base that permits a company to sell insurance.

Pool: An organization of insurers or reinsurers through which particular types of risk are underwritten with premiums, losses and expenses shared in agreed-upon amounts.

Premium: The sum paid for an insurance policy. Net premiums written represent premium income retained by insurance companies, direct or after reinsurance transactions. Direct written premiums are the amounts actually paid by policy holders.

Pro-rata Treaties: Also may be referred to as proportional reinsurance. The amount of insurance, the premium and losses are shared by the primary insurer and the reinsurer in agreed proportions.

Rate: The cost of a given unit of insurance, on which a premium is based.

Reinsurance: Assumption by one insurance company of all or part of a risk undertaken by another insurance company.

Retention: The amount of risk retained by an insurance company and not reinsured.

Retrospective Rating: A method permitting adjustment, subject to maximum and minimum limits, of the final premium for a risk on the basis of its own loss experience.

Risk: The chance of loss. Also used to refer to the insured or

to property covered by a policy.

Risk Management: Management of the varied risks to which a business firm or corporation might be subject. It involves analyzing all exposures to gauge the possibility of loss and determining how to minimize losses by such means as insurance, reduction or elimination of risk or the practice of safety and security measures.

Self-insurance: An arrangement through which some firms and individuals plan to assume all or a portion of their own losses. Self-insurers often establish special funds for this purpose, and purchase insurance to cover losses in excess of predetermined amounts.

Subrogation: The legal process by which an insurance company, after paying a loss, seeks to recover the amount of the loss from another who is legally liable for it.

Surplus Lines: (1) A risk or part of a risk for which there is not normal insurance market available. (2) Insurance written by non-admitted insurance companies.

Tort: A wrongful act, resulting in injury or damage, on which a civil action may be based. Does not apply to a breech of contract.

Treaty: A form of reinsurance agreement between insurance companies.

Treaty Reinsurance: A contract of reinsurance setting forth the conditions for reinsuring a class or classes of insurance.

Umbrella Liability: A form of insurance protection against losses in excess of the amount covered by other liability insurance policies; also protects the insured in many situations not covered by the usual liability policies.

Underinsurance: A condition in which not enough insurance is carried to cover the insurable value.

Underwriting: The process of selecting risks for insurance and determining in what amounts and on what terms the insurance company will accept the risk.

Underwriting Profit or Loss: The amount of money which an insurance company gains or loses as a result of its underwriting operations. A net gain or loss on underwriting operations represents a company's statutory underwriting result less any amount it may pay to its policyholders in the form of dividends.

Unearned Premium: The portion of a premium that a company has collected but has yet to earn because the policy still has unexpired time to run.

APPENDIX A

LONDON COMPARED WITH U.S. INSURANCE MARKET

London will be a leading force in satellite underwriting due to a number of recent developments, and its unique institutional arrangements.

First, as the premium statistics show, London, in general and Lloyd's in particular, are the worldwide centers for marine and aviation insurance. The first satellite insurance was placed in the three London aviation syndicates. London and Lloyd's, in particular, have been involved with the development of satellite insurance and place the bulk of satellite liability insurance.

Lloyd's has not been immune to the vicissitudes of the world underwriting cycle. In the marine area, they have been hit by declining risks of the worldwide shipping recession. Aviation underwriting results have been poor due to the financial woes of the airline industry. However, underwriters at Lloyd's were among the first to recognize the problem. Capacity has been greatly reduced in many problem areas. Reinsurance has tightened and unprofitable business, particularly treaty business has been cut back. These steps were taken a full year before U.S. insurance companies took similar steps. As such, many marine syndicates can expect to be profitable in 1984 and 1985

In the underwriting cycle, the marine market is always the first to turn, because it is smaller.

By structure many of the Lloyd's marine syndicates are also those most active in the aviation and satellite areas. This is

the result of historical development.

Lloyd's reputation for flexibility innovation and underwriting flair is well deserved. With many developments originating at Lloyd's -- such as insurance in oil rigs and jets --under the right set of circumstances Lloyd's might be able to develop a thriving satellite market.

Partly, Lloyd's innovation and flexibility is due to the specialization of 400 syndicates within the collective market. Lloyd's has leaders that specialize in certain types of insurance and the market will follow the recognized leaders. If two or three can agree on premium rates and terms and conditions for a particular risk, others often will follow suit and significant capacity becomes available.

U.S. insurance companies are expected to show a profit (overall) every year. The President and Chairman of the insurance companies thus can be expected to make short term decisions to satisfy stockholders and directors. Because marine and aviation premiums are a small part of any one company's book and hence a small part of the problem, if any, a marine department can usually avoid rash short term type actions, but not always. Thus while U.S. marine departments are not "closed down" for bad results, they may become risk averse and stop entertaining particular classes of the business, due to the intense short term need for profit from management.

But Lloyd's, in contrast to U.S. companies has a unique three year accounting year. Rather than operating on a twelve month basis, Lloyd's acts on a thirty-six month basis. The final accounting for a given year is not made and determined for two

years. This helps to even out the expected fluctuations in experience, so that a bad loss and an abnormal year can be taken in normal stride. Moreover, if underwriters know they've had a bad year, they still have two years in which to demonstrate that they can take corrective actions. As a result, the Lloyd's market while open to innovation, is also more open to considering risk. The Lloyd's market is far more receptive to charging high rates for tough risks that the U.S. insurance market will not insure for any price. By its accounting method and its composition as specialty syndicates, and its ability to spread large amounts of risk amongst all its members, Lloyd's is ideally suited for high risk capacity type accounts.

Added to these unique qualities of Lloyd's is a responsiveness to commercial needs and a penchant for innovation and for developing expertise. As such, Lloyd's is the center for marine activities and aviation insurance, and will for the forseeable future set the terms and conditions in the satellite industry. One might expect various facilities in the U.S. to offer limited capacity; these would be the largest aviation facilities and some of the more aggressive marine facilities.

However, in the present underwriting climate in the U.S., that is, with U.S. companies and reinsurers experiencing unheard of and unprecedented underwriting losses, there is little likelihood that U.S. insurance companies will see space insurance, either physical damage or liability as an attractive opportunity. Those U.S. companies which do see space as an attractive area in which to commence insurance activities will be

hampered in their efforts by a lack of reinsurance. They will not be able to line up reinsurance treaties. As such, capacity which is available in the U.S. will be very small. A broker may have to talk to seven U.S. underwriters to get capacity of $2,000,000. A broker in London on the other hand may approach three or four Lloyd's leaders and be able to line up $100,000,000.

Significant U.S. capacity perhaps could be gathered in one underwriting pool; however this capacity will not be forthcoming without some evidence of premium volume and, most importantly, profitable experience.

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