Why take insurance?
Why Take Insurance?
Why Take Insurance?
Why Take Insurance?
Introduction to Space Missions
Typical Space Missions

- Mobile Satellite Services
- Fixed Satellite Services
- Remote Sensing
- Navigation
Telecom GEO mission

Fixed Satellite Services
Examples of Remote Sensing Missions

Optical (GeoEye)

Radar (TerraSAR)

Mobile Telecom (Globalstar)
Examples of MEO missions

Navigation (GPS)

Mobile Communications (ICO F series)

Broadband (O3b)
Introduction to Satellite Architecture
General Satellites Architecture

- The satellite is an autonomous object which needs to fulfil a specific mission over a long period of time.
- Its architecture is directly driven by the mission and the specific constraints of the space environment.
- Every satellite is essentially composed of:
  - A payload (instruments or communication module) dedicated to the mission.
  - A platform which provides all elements necessary to the payload over the satellite lifetime.
- The satellite must cope with specific space environment constraints:
  - Energy (i.e. full autonomy including during sun eclipses).
  - Thermal (-160°C in the shadow of the Earth; + 150°C in direct sunlight).
  - Electromagnetic (Earth radiation belts, solar storms).
  - Mechanical (acceleration, acoustic and vibrations constraints during launch).
  - Mass (with respect to the launcher capability).
Telecom Satellites
Telecom Satellites Architecture

Example: Spacebus 4000B2, source: ESA
Telecom Satellites Subsystems

- **Communications**
  - Transponders (reception, amplification & transmission)

- **Propulsion**
  - Orbit raising, attitude control

- **Power**
  - Solar panels & batteries

- **Structure**
  - Absorb chocks during launch phase

- **Thermal**
  - Temperature regulation within a specified range

- **Attitude**
  - Maintain specific position of satellite facing the earth

- **Telemetry & Command**
  - Control and maintenance of the satellite from the ground

---

**Payload**

**Platform**
Telecom Satellites Overview

Ex: Spacebus 4000B2, source ESA

- TTC Antenna
- Star Tracker
- Deployable Rx/Tx C Band
- Solar Panel
- Solar Array Drive Mechanism
- Apogee Boost Motor
- 10N thrusters
- Deployable Tx Ku Band
- Earth sensor
- Rx Ku Band
Telecom Satellites Transponder Principle
Telecom Satellite Footprint From GEO orbit

36 000 km
Telecom Satellites Capabilities

Equiv 24 Ku Tx
Ex: Spacebus, source: ESA

Equiv 100 Ku Tx
Remote Sensing Satellites
Remote Sensing Satellites

- Remote Sensing satellites vary according to the type of orbit they have and to the type of payload they carry (sensors, spatial resolution, spectral characteristics, swath, width, etc.)
- All these parameters are designed at the beginning of the mission definition depending on the application the satellite mission is targeting
Remote Sensing Orbit
Remote Sensing Satellites Types & Architectures

**Optical**

**Radar**

**Others**

*Ex: Nextar, source: NEC Satellite Systems*
Remote Sensing Satellites Mission Principle

- The mission principle of an imaging satellite is to acquire images, store them onboard and finally downlink them back to a ground station.

- From a risk perspective two main criteria shall be taken into account:

  - Image Quality
  - Image Quantity
Launchers
Various Types of Launchers for various Types of Orbits

- **Low Earth Orbit (LEO)**
  - 500 – 2,000 km

- **Medium Earth Orbit (MEO)**
  - 2,000 - 35,000 km

- **Geostationary Orbit (GEO)**
  - 35,786 km above the equator

➡️ Different classes of satellites & launchers
Small Launchers

ROCKOT (107)

VEGA (137)

DNEPR (215)
Medium Launchers

- PSLV
- SOYUZ
- LONG MARCH 3B
Heavy Launchers

- FALCON Heavy
- FALCON 9
- LONG MARCH 3B
- ATLAS V
- PROTON
- ARIANE 5
Orders of magnitude of launchers lifting capabilities

<table>
<thead>
<tr>
<th>CLASS</th>
<th>Targeted Orbit</th>
<th>launcher</th>
<th>Launcher Mass (tons)</th>
<th>Payload to SSO 700km (kg)</th>
<th>Payload to GTO (kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small</td>
<td>LEO to MEO</td>
<td>Rockot</td>
<td>107</td>
<td>1,700</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vega</td>
<td>137</td>
<td>1,350</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dnepr</td>
<td>215</td>
<td>1,200</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>LEO to GEO</td>
<td>PSLV</td>
<td>295</td>
<td>3,250</td>
<td>800</td>
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<tr>
<td></td>
<td></td>
<td>Soyuz (CSG)</td>
<td>308</td>
<td>4,500</td>
<td>3,150</td>
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<tr>
<td>Heavy</td>
<td>Mainly GTO</td>
<td>Long March 3B</td>
<td>426</td>
<td>5,000</td>
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<td></td>
<td></td>
<td>Falcon 9</td>
<td>550</td>
<td>8,300</td>
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<tr>
<td></td>
<td></td>
<td>Proton</td>
<td>693</td>
<td>6,920</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Ariane 5</td>
<td>775</td>
<td>9,400</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Falcon Heavy</td>
<td>1420</td>
<td>26,700</td>
<td></td>
</tr>
</tbody>
</table>

Disclaimer: Indicated values are for illustration purposes only and may not reflect the actual rockets performance capabilities.
Ariane 5 Telecom Mission Profile (source: Arianespace)

Mission duration: around 30 minutes
Proton Telecom Mission Profile 1/2 (source: ILS)

Mission duration: around 9 hours
Proton Telecom Mission Profile 2/2 (source: ILS)
Vega Sun-Synchronous Orbit Mission Profile

Typical ascent profile (two AVUM boosts mission profile / up to five possible)
S/C Separation ~ 1 hour following lift-off
Soyuz Sun-Synchronous Orbit Mission Profile

Typical ascent profile
(3-stage ascend phase and 2 Fregat burns)
S/C Separation ~ 1 hour following lift-off
Flight Events important re Space Insurance

- **Intentional Ignition**
  - Is defined as the point in time of intentional ignition of any rocket motor on the first stage of the Launch Vehicle for the purpose of launching a Satellite
  - Terminated Ignition is possible

- **Lift-off**
  - Is the point in time, following Intentional Ignition, when the Launch Vehicle is physically separated, under its own power, from all mechanical and electrical connections to the launch pad
  - “Point of no return”
Flight Events important re Space Insurance

- Ascend Phase and Injection
- **Satellite Separation**
- Deployment of solar array and antennas

- Satellite Orbit raising
- Satellite In-Orbit Testing
- **Satellite Acceptance**
Space Industry Risks Overview
Space Industry

**Ground Equipment**
- Network Equipment
  - Gateways
  - Control stations
  - VSATs
- Consumer Equipment
  - Direct Broadcast Services (DBS) Dishes
  - Mobile terminals (including sat phones)
  - Digital Audio Radio Services (DARS) equipment
  - Global Positioning System (GPS) hardware

**Satellite Manufacturing**
- Satellite manufacturing
- Component and subsystem

**Satellite Services**
- Consumer Services
  - TV, Radio, Broadband
- Fixed Satellite Services
  - Transponder Agreements
  - Managed Network Services
- Mobile Satellite Services
  - Data, Voice
  - Remote sensing/imaging Services
  - Space Flight Management Services

**Launch Industry**
- Launch Services
- Launch Vehicles

*Source: Satellite Industry Association (SIA)*
<table>
<thead>
<tr>
<th>Space Industry Risks</th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Satellite Operator</td>
<td>Asset, revenues,</td>
<td>Asset, revenues,</td>
</tr>
<tr>
<td></td>
<td>expenses, Liability</td>
<td>expenses, Liability</td>
</tr>
<tr>
<td>Satellite Manufacturer</td>
<td>Manufacturing, Transit,</td>
<td>Manufacturing, Transit,</td>
</tr>
<tr>
<td></td>
<td>Incentives, Liability</td>
<td>Incentives, Liability</td>
</tr>
<tr>
<td>User</td>
<td>Revenues, Expenses,</td>
<td>Revenues, Expenses,</td>
</tr>
<tr>
<td></td>
<td>Investments</td>
<td>Investments</td>
</tr>
<tr>
<td>Investor / Lender</td>
<td>Loss of Investment /</td>
<td>Loss of Investment /</td>
</tr>
<tr>
<td></td>
<td>Loan</td>
<td>Loan</td>
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<tr>
<td>Launch Services Agency</td>
<td>Relaunch Guarantee,</td>
<td>Relaunch Guarantee,</td>
</tr>
<tr>
<td></td>
<td>Liability</td>
<td>Liability</td>
</tr>
</tbody>
</table>
Phases of a satellite programme

Satellite

Rocket

Manufacturing

Transit

Pre-launch

Launch

Post Separation

In-Orbit life
Pre-launch

**Risks**
- Transportation
- Force majeure
- Political
- Program / Technical
- Currency fluctuation

**Major exclusions**
- War risk
- Radioactive contamination
- Financial insolvency
- Terrorism…

**Financial Exposures**
- Asset Value
  - Spacecraft & GSE
- Third Party Liability
- Contract Obligations
- Program Delay
  - Debt service
  - Operating expenses
  - Extra expenses
  - Revenue loss
Launch & Commissioning

Risks

Launch Vehicle
- Total failure
- Underperformance

Spacecraft
- Transfer orbit & Deployment
- Commissioning
- Mission Performance
- Lifetime

Space environment

S/C Control Center

S/C Operator

Financial Exposures

Asset Value
- Spacecraft cost
- Launch Vehicle cost
- Insurance & other capital interest

Third Party Liability

Manufacturer Incentives

Contract Obligations

Business Interruption
- Operating & extra expenses
- Loss of revenue

Exclusions
In- Orbit

Risks

Spacecraft
• Mission Performance
• Lifetime

Space environment
• Collision / Debris

S/C Control Center

S/C Operator

Exclusions

Financial Exposures

Asset Value
• Spacecraft cost
• Launch Vehicle cost
• Insurance & other capital interest

Third Party Liability

Manufacturer Incentives

Contract Obligations

Business Interruption
• Operating & extra expenses
• Loss of revenue
Coverages available by phase

- **AIT**
  - Manufacturing
    - All Risk
    - (Ground Markets)

- **Transit**
  - Transit & Pre-Launch
    - (Marine Markets)

- **Pre-launch**
  - (Space Markets)

- **Launch**
  - Launch and In-orbit
  - (Space Markets)

- **In-Orbit**
  - Third Party Liability
  - (Aviation Markets)

- **De-Orbit**
  - Third Party Liability
  - (Aviation Markets)
AIT, Transit and Pre-launch
Insurance characteristics by phase

**AIT**
- Large accumulation at plants or Test Centres (various satellites in the same clean room)
- Industrial and Engineering Risks (different treaties, different capacities)
- Deductible compulsory and high impact on rate
- No interference with Space Treaties

**Transit**
- No accumulation between satellites
- Deductible not compulsory and lower impact on rate
- No interference with Space Treaties

**Pre-launch**
- Main accumulation at the Launch Pad with launcher, launch pad, possible co-passenger, with increased risk of explosion from filling of launcher tanks up to Lift Off
- Deductible compulsory and high impact on rate
- Inter-Party Waiver of Liability on Launch Site
Premiums & deductibles by phase

**AIT**
- Rates usually applicable to the amount of works at end of the AIT phase
- Typical Rates: 0.30%-0.55%
- Usual Deductibles: $25,000 to $250,000

**Transit**
- Rates usually applicable to the replacement value of the transported items
- Typical Rates: 0.12%-0.20%
- Usual Deductibles: $25,000 to $250,000

**Pre-launch**
- Rates usually applicable to the replacement value of the Satellite at the moment of Launch
- Typical Rates: 0.315%-0.45%
- Usual Deductibles: $25,000 to $500,000
The Loss occurred at the Manufacturers Plant in 2003.

The Repairing Costs were $135 million
Third Party Liability
Space Liability: the 1967 Outer Space Treaty

● Provides basic legal framework for International Governance of Outer Space
  – Benefit to all the peoples
  – Maintain international peace
  – Prohibit the use of nuclear weapons and weapons of mass destruction in space

● Provides legal framework for international liability of States party to the Treaty
  – Governance of national activities carried out by governmental and non governmental entities (authorization and supervision)
  – Liability for damage to other States party to the Treaty if launch or procurement of the launching of an objet in space

● As of January 2016, 104 States have ratified, and an additional 25 have signed
Space Liability: the 1972 Liability Convention

- Expands on the liability rules created in the 1967 Outer Space Treaty
  - Elaboration of effective international rules and procedures
  - Ensure prompt payment of a full and equitable compensation to the victims
- Introduction of the term “Launching State”
  - A State which launches or procures the launching of a space object
  - A State from whose territory or facility a space object is launched
- Introduction of the liability regimes applicable to Launching States
  - Absolute liability for damage caused on the surface of the earth or to an aircraft in flight
  - Liability for fault for damage caused elsewhere than on the surface of the earth
  - Joint and several liability of multiple Launching States
- As of January 2016, 92 States have ratified, and an additional 21 have signed
Application of the Liability Principles

- The 1975 Convention of Registration of space objects
  - Mandatory central registration of objects launched into outer space
  - Launching States shall furnish all information to Secretary General of the UN
  - As of January 2016, 62 States have ratified, and an additional 4 have signed

- National Space Rules and Legislations
  - Provide regulation and licensing control of national space activities
  - Facilitate compliance with all International Obligations including registration of space objects
  - Clarifies risk sharing between the State and the private entities
  - Provide indemnification to Governments
  - Limits the exposure of private entities by imposing a ceiling of liability

Space Liability Insurance
Space Liability Insurance

● Definition
  – Indemnification of all sums that the Insured shall become legally obligated to pay for Bodily Injury and/or Property Damage to Third Parties arising out of the pre-launch, launch and in-orbit operations of spacecraft

● Insured and additional insureds
  – List of Additional Insureds is as broad as possible & includes Launching States

● Coverage Periods available for up to 12 months
  – But policy periods available for up to 3 years for declaration policies

● Coverage on an Occurrence basis
  – Claims only paid for occurrences taking place during the coverage period

● No cover for liabilities between participants in a space project
  – Requirement from insurers of waivers of recourse and hold harmless agreements

● Policies may be subject to single annual aggregate limit
Space Liability Insurance buyers

- Launch Services Providers
  - Compulsory requirements from most Launching States
    • Imposed through National Laws, Regulations, Licensing
  - Riskiest phase of a space project
    • Launch failure rate > in-orbit failure rate
  - Maximum known insurance requirement: USD500M
    • Today’s Market provides ample capacity at affordable prices
    • However the Market is very volatile and could even easily disappear
  - Complex launch procurement contracts
    • Interparty Waivers of Liability and hold harmless agreements
Space Liability Insurance buyers (cont’d)

- Satellite Operators
  - National regulations are less common for In-orbit liability insurance requirements
  - Many satellite operators do not procure in-orbit liability insurance
  - The ones who buy are mostly
    - Global Operators in GEO
    - LEO operators
The issue of space debris

- No definition of space debris in International Space Law

- Space debris includes:
  - Objects or fragments of objects both in-orbit and re-entering to earth
  - Debris from launchers and stages which either explode, do not reach orbit or re-enter to earth
  - Debris from satellites that return through air-space to earth

- Identification of space debris is difficult but possible
  - In-orbit detection threshold is currently 10 cm

- Third Party Liability Claim can be successfully filed if identification is possible
  - In case of in-orbit collision a third-party is entitled to file a claim against any or all of the responsible launching States
A new type of claim situation
Space Risk Management
It is a management discipline

Protect the assets and profits of an organization

By reducing the potential for loss before it occurs

By financing, through insurance and other means, exposures to catastrophic loss
Satellite Operators Problematic

Long Term Business Model
Limited Operational Flexibility
No return of S/C
Repositioning of S/C

Large Upfront Investments
Quality & Reliability
No access to asset in-orbit

International Business
Spectrum is the Lifeblood
Orbital slots & frequency rights
Impact on Risk Management Strategy

Management Level

High Impact Decisions

Financing Business Cost

Completeness

Global Approach

All risks scanned
What if scenarios
Back-up plans

Robustness

Financial Security

Full coverage
Insurers ratings
Long term protection
Risk Mapping Analysis: Road to Risk Management Plan

Risk Mapping

Diagnosis → Control

Risk Management

Risk Management → Insurance
Risk Mapping Analysis: Next Steps

- **Risk Mapping**
  - **Risk Reduction**: Technical Analyses, Quality Control
  - **Risk Avoidance**: Satellites & Launch Vehicles contracts
  - **Risk Mitigation**: Incentives, Sparing, other contracts
  - **Risk Transfer**: Insurance, Non-Insurance 3rd Parties

- Residual high impact risks
Step 1: identify and categorize risks

**Risk Register**

<table>
<thead>
<tr>
<th>Scenario 1</th>
<th>Scenario 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Significant reduction of state funding</td>
<td>Discontinuation of state funding</td>
</tr>
</tbody>
</table>

**Possible causes**
- Adverse change in political context (2011 election) and/or social environment (national, regional or global economic crisis) affecting the financing of the satellite program
- Decision triggered by a major failure in the satellite program

**Possible remedial actions**
- Report to alternative financing partners

<table>
<thead>
<tr>
<th>Assessment</th>
<th>Impact</th>
<th>Likelihood</th>
<th>Margin for improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderate</td>
<td>Moderate</td>
<td>Limited</td>
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</table>

<table>
<thead>
<tr>
<th>Prioritization</th>
<th>Priority Level</th>
<th>Risk Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>3</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Prioritization</th>
<th>Priority Level</th>
<th>Risk Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>3</td>
</tr>
</tbody>
</table>

**Risk Area**
Finance / Funding

**Risk Owner**
N C
Step 2: visualize risks and focus attention

Risk Maps

Risk Management Plan

Risk Transfer
Risk Mitigation
Risk Avoidance
Risk Reduction
Step 3: simulate risks and optimize cost

Risk Modeling

- Design the optimum space insurance programme based on specific constraints
- Challenge these constraints and perform trade-off between insurance and self insurance
- Measure self insured risk exposure
- Analyse sensitivity to main assumptions

Design of Insurance programme including loss formula
Satellite Procurement

- **Transfers after Completion of IOT or Acceptance or Designated Period**
  - Bought by Satellite Manufacturer (option for customer to purchase insurance)
  - Bought by Satellite Manufacturer

- **Transfers at Intentional Ignition or Lift-off**
  - Bought by Satellite Owner/Operator
  - Bought by Satellite Owner/Operator (with or without LRG)

- **Title & Risk of loss**
- **Launch Insurance**
- **Launch Services**

**In-Orbit Delivery**

**Ground Delivery**
### Key Contract Clauses

<table>
<thead>
<tr>
<th>Clause</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definitions</td>
<td>Identify how key terms are to be interpreted (Launch, Constructive Total Loss, Failure, Successful Mission..)</td>
</tr>
<tr>
<td>Delivery / Acceptance</td>
<td>Identify how and when contractual responsibilities will be fulfilled</td>
</tr>
<tr>
<td>Transfer of Title / Risk of Loss</td>
<td>Clearly identify all points/conditions of transfer for integration with insurance or other risk treatment options</td>
</tr>
<tr>
<td>Indemnification</td>
<td>Identify rights or obligations as indemnitee or indemnitor. As indemnitor, identify nature and extent of risk accepted under such provision</td>
</tr>
<tr>
<td>Insurance</td>
<td>As relates to indemnification provisions, contract may require various forms of insurance protection (i.e. property, liability..)</td>
</tr>
</tbody>
</table>
## Key Contract Clauses

<table>
<thead>
<tr>
<th>Clause</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Force Majeure</td>
<td>Conditions which can affect delivery schedules and liquidated damages</td>
</tr>
<tr>
<td>Delay / Termination</td>
<td>Conditions which create delay/termination rights, and financial penalties</td>
</tr>
<tr>
<td>Warranties</td>
<td>Understand nature of warranty if other than a “best efforts” contract</td>
</tr>
<tr>
<td>Incentives Payments</td>
<td>Understand extent to which incentive payments are at risk</td>
</tr>
<tr>
<td>Inter-Party Waivers</td>
<td>Identify obligations and assumptions under these required conditions</td>
</tr>
</tbody>
</table>
Origin of In-Orbit Delivery Contracts

No desire to be involved in the launch process

OK to pay a premium to the manufacturer in order to pass on launch responsibility

New Satellite Operators

Simple,
Involvement free,
Most beneficial solution
In-Orbit Delivery (single procurement)

Satellite Operator
(Final Customer)

Satellite Manufacturer

Satellite, Ground Control & other items

Launch Services Provider

Insurance Broker

1 Contract

Subcontractor

Subcontractor

Subcontractor

Subcontractor

Subcontractor

Subcontractor

Insurer

Insurer

Insurer

Subcontractor
Ground Delivery (separate procurements)

Satellite Operator
(Final Customer)

3 contracts
(or more)

Satellite Manufacturer
Satellite, Ground Control & other items

Launch Services Provider

Insurance Broker

Subcontractor
Subcontractor
Subcontractor

Subcontractor
Subcontractor

Insurer
Insurer
Insurer

Subcontractor

Subcontractor

Subcontractor
Hybrid In-Orbit Delivery

Satellite Operator (Final Customer)

Satellite Manufacturer

Launch Services Provider (selected by the operator)

Insurance Broker

Satellite, Ground Control & other items

Subcontractor
Subcontractor
Subcontractor

Subcontractor

Subcontractor

Subcontractor

Subcontractor

Subcontractor

Insurer
Insurer

Insurer

Insurer

Insurer
In-Orbit Delivery

Pros

- Manufacturer arranges launch
- Limited technical demands until after hand-over
- Simplification of the process

Cons

- Lack of relationship and understanding of satellite industry and insurers
- Lesser control over key subcontractors
  - Launch Services
  - Insurance
  - Possible impact on cost
Ground Delivery

Pros

Offers greater choice
- Launch vehicle not chosen by manufacturer
- Greater management control over the risk

Build relationship and understanding
- with satellite industry
- with space insurers

Cons

Investment in expertise in every competence

Requires greater involvement at every stage
Contractual Risk Transfer Techniques

- **Launch Risk Guarantee**
  - Relaunch or Refund in case of Launch Failure

- **Performance Incentives**
  - Reduction of contract price in case of non-performance of satellite

- **Liquidated Damages**
  - The party compensates for late delivery of S/C or late launch
Launch Risk Guarantee

- Insurance
- Insurance
- Satellite & Other costs
- Launch Services costs

Launch Risk Guarantee

- Launch Phase
- Post Sep Phase
Performance Incentives

- Launch Phase
  - Insurance
  - Insurance
- Post Sep Phase
  - Insurance
  - Insurance

- Satellite & Other costs
  - Insurance
  - Performance Incentives

Launch Services costs
LRG & Performance Incentives

- Insurance
- Performance Incentives
- Launch Risk Guarantee
- Insurance
- Launch Phase
- Post Sep Phase
- Satellite & Other costs
- Launch Services costs
Space Insurance Market
History of Space Insurance

1965  1st satellite pre-launch and liability policy (Early Bird for Intelsat)

1968  1st Launch insurance policy for a series of 5 Intelsat launches with 1 launch failure deductible

1975  1st launch insurance policy without deductible
       1st in-orbit life insurance policy

1977  1st space insurance claim
Characteristics of Space Insurance

High Severity of Loss
• High Chance of Loss
• Losses often result in complete loss of satellite

Volatile Class of Business
• Only 20-25 insured launches per year
• Actuarially difficult to predict losses; no Law of Large Numbers
• Rates are highly unpredictable and can fluctuate dramatically

Highly Technical Underwriting
• Insure Satellite Technology – Underwriters typically satellite engineers
High Values at Stake

Large Sums Insured
• Total insured values can exceed USD 800,000,000
• Sophisticated risk transfer schemes

Syndicated Risk
• Many Underwriters (20+) needed to complete placement
• Non traditional markets available

Buyers use a specialized broker
• Risk management services
• International transaction
The Broker is the Trusted Advisor

Risk Management Services

International Insurance placement
Space Insurance Capacity

Monetary amount available to cover one event

- Syndication of risk between numerous insurers
- Varies from risk to risk
- Accumulation impacts available capacity (dual launches)
- Sensitive to external environment
- Theoretical capacity differs from Working capacity
2018 Insurer Capacity

Outer ring: Launch capacity (total USD 1,182.9 million)
Inner ring: In-orbit capacity (total USD 1,057.9 million)

* This chart does not include the considerable amount of Chinese space insurance capacity
## 2018 Insurer Capacity & Coverage

### Asia

<table>
<thead>
<tr>
<th>Underwriter</th>
<th>Launch Theoretical $Millions</th>
<th>In-Orbit Theoretical $Millions</th>
<th>Maximum Launch Coverage Period (Years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asia Capital Re</td>
<td>$10.0</td>
<td>$10.0</td>
<td>1.5</td>
</tr>
<tr>
<td>Elseco. (Dubai)</td>
<td>$120.0</td>
<td>$120.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Korean Re</td>
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<td>$4.2</td>
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<td>Mitsui Sumitomo</td>
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<td>New India Assurance</td>
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<tr>
<td>Sompo</td>
<td>$1.0</td>
<td>$1.0</td>
<td>1.5</td>
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<td>Tokio Marine</td>
<td>$20.0</td>
<td>$20.0</td>
<td>3.0</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>$180.2</strong></td>
<td><strong>$175.2</strong></td>
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### Europe excl. UK & France

<table>
<thead>
<tr>
<th>Underwriter</th>
<th>Launch Theoretical $Millions</th>
<th>In-Orbit Theoretical $Millions</th>
<th>Maximum Launch Coverage Period (Years)</th>
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<tbody>
<tr>
<td>AlfaStrakh</td>
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<td>Ingosstrakh</td>
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<td>LIFE</td>
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<td>SATEC</td>
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<td>Sogaz</td>
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<td>1.0</td>
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<td>Swiss Re</td>
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<td><strong>Total</strong></td>
<td><strong>$214.3</strong></td>
<td><strong>$164.4</strong></td>
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### UK

<table>
<thead>
<tr>
<th>Underwriter</th>
<th>Launch Theoretical $Millions</th>
<th>In-Orbit Theoretical $Millions</th>
<th>Maximum Launch Coverage Period (Years)</th>
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<tbody>
<tr>
<td>AIG</td>
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<td>$40.0</td>
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<td>AmTrust Space Consortium</td>
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<td>Atrium</td>
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<td>Beazley</td>
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<td>1.5</td>
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<tr>
<td>Brit</td>
<td>$55.8</td>
<td>$55.8</td>
<td>1.5</td>
</tr>
<tr>
<td>Elseco / ViVet</td>
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<td>$45.0</td>
<td>5.0</td>
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<tr>
<td>GIC Re of India (UK)</td>
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<td>$6.0</td>
<td>3.0</td>
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<tr>
<td>Global Aerospace</td>
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<tr>
<td>Hamilton Syndicate</td>
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<tr>
<td>Inter-Hannover</td>
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<td>$15.0</td>
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<tr>
<td>Munich Re Syndicate (Watkins)</td>
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<td>Sciemus</td>
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<td>1.5</td>
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<tr>
<td>XLCatlin (UK)</td>
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<td>$22.5</td>
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<td><strong>Total</strong></td>
<td><strong>$361.8</strong></td>
<td><strong>$351.8</strong></td>
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### South America

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<th>Underwriter</th>
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<th>In-Orbit Theoretical $Millions</th>
<th>Maximum Launch Coverage Period (Years)</th>
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<tbody>
<tr>
<td>IRB</td>
<td>$10.0</td>
<td>$5.0</td>
<td>1.5</td>
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</table>
# 2018 Insurer Capacity & Coverage

## USA

<table>
<thead>
<tr>
<th>Underwriter</th>
<th>Launch Theoretical $Millions</th>
<th>In-Orbit Theoretical $Millions</th>
<th>Maximum Launch Coverage Period (Years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assure Space</td>
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<tr>
<td>Chubb (ACE)</td>
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<tr>
<td>Elseco. (US) / ARES</td>
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<td>$35.0</td>
<td>1.0</td>
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<td>PartnerRe</td>
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<tr>
<td>Starr Aviation and Hallmark</td>
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<td>$38.0</td>
<td>LIFE</td>
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<tr>
<td>XL Catlin (US)</td>
<td>$22.5</td>
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<td>1.0</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>$180.5</strong></td>
<td><strong>$160.5</strong></td>
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## France

<table>
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<tr>
<th>Underwriter</th>
<th>Launch Theoretical $Millions</th>
<th>In-Orbit Theoretical $Millions</th>
<th>Maximum Launch Coverage Period (Years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allianz (Spaceco)</td>
<td>$40.0</td>
<td>$40.0</td>
<td>3.0</td>
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<tr>
<td>AXA CS Paris</td>
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<td>$25.0</td>
<td>1.5</td>
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<tr>
<td>Elseco. (Paris)/ARTI</td>
<td>$50.0</td>
<td>$50.0</td>
<td>1.5</td>
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<tr>
<td>Hiscox</td>
<td>$35.0</td>
<td>$35.0</td>
<td>1.5</td>
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<tr>
<td>Kiln</td>
<td>$26.0</td>
<td>$26.0</td>
<td>3.0</td>
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<tr>
<td>La Reunion Spatiale</td>
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<td>$10</td>
<td>1.0</td>
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<tr>
<td>SCOR</td>
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<td>5.0</td>
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<td><strong>Total</strong></td>
<td><strong>$236.0</strong></td>
<td><strong>$201.0</strong></td>
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## China – Chinese Risks

<table>
<thead>
<tr>
<th>Underwriter</th>
<th>Launch &amp; In-Orbit Theoretical $Millions*</th>
</tr>
</thead>
<tbody>
<tr>
<td>PICC</td>
<td>$20.0+</td>
</tr>
<tr>
<td>CPIC</td>
<td>$20.0</td>
</tr>
<tr>
<td>China Life</td>
<td>$20.0</td>
</tr>
<tr>
<td>Ping An</td>
<td>$20.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>$80.0+</strong></td>
</tr>
</tbody>
</table>

## China – Non-Chinese Risks

<table>
<thead>
<tr>
<th>Underwriter</th>
<th>Launch &amp; In-Orbit Theoretical $Millions*</th>
</tr>
</thead>
<tbody>
<tr>
<td>PICC</td>
<td>$2.0 - $8.0</td>
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<tr>
<td>CPIC</td>
<td>$1.5</td>
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<tr>
<td>China Life</td>
<td>$1.5</td>
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<tr>
<td>Ping An</td>
<td>$2.0 - $5.0</td>
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<tr>
<td><strong>Max. Total</strong></td>
<td><strong>$16.0</strong></td>
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</table>

*Specific restrictions may apply. Chinese capacity limit variable depending on risk.
Sum Insured & Insurance Premium

Sum Insured

Satellite Cost
Launch cost
Insurance Premium
Other capitalized costs
- Interest / Engineering

Insurance Rate

\[
\text{Premium} = \text{Sum Insured} \times \text{Insurance Rate}
\]
Insurance rate influencing factors

Market Conditions
- Recent claims
- Recent placements
- YTD claims ratio
- Launch manifest
- External events

Risk Assessment
- S/C Configuration
- S/C perf. margins
- S/C track record
- LV track record
- Type of coverage
- Loss Formulas
- Insured’s History

Sum Insured
- Vs available market capacity
- Vs accumulation (dual launches)
- Vs coverage type (launch / IO)

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Capacity and Rates

Theoretical Capacity and Rates

- Maximum Rate
- Minimum Rate
- Typical L+150/365 Rate

Aon Proprietary
Premium and Claims

Premium and Claims

- Premium
- Claims
- Gross Margin


USD Billions

-0.8 -0.6 -0.4 -0.2 0.0 0.2 0.4 0.6 0.8 1.0 1.2 1.4 1.6
Launch plus 1 Year Normalised Net Rate (5 years)
Satellite In-Orbit Rates per Annum (5 years)

Satellite in-orbit insurance rates per annum

1 Mar 13 1 Jul 13 1 Nov 13 1 Mar 14 1 Jul 14 1 Nov 14 1 Mar 15 1 Jul 15 1 Nov 15 1 Mar 16 1 Jul 16 1 Nov 16 1 Mar 17 1 Jul 17 1 Nov 17

Placement Date

NET Premium Rate

0% 1% 2%
Launch plus 1 Year Normalised Net Rate by Launch Vehicle Group
Rate vs Sum insured

USD 700M
USD 600M
USD 500M
USD 400M
USD 300M
USD 200M

Insurance rate