Market Update

Chris Kunstadter, XL Insurance
SPACE INSURANCE: MARKET UPDATE

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Agenda

- Global economy
- Space industry
- Space insurance market
- Launch and satellite experience
- Unique threats
- Conclusion
The Global Economy

- Modest global economic growth
  - -1% to +4% per year by region
- Certain sectors evolving
  - Energy – *e.g.*, alternative sources
  - Technology – *e.g.*, “Internet of things”
  - Health care – *e.g.*, biosciences
- Insurance profitability steady
  - Modestly fewer cat losses in 2013
  - Meteorological phenomena increasing
  - Capital influx
- Exposure formation continues
  - Systemic
  - Specific
Top Ten Global Systemic Risks

- Fiscal crises in key economies
- Structurally high unemployment / underemployment
- Water crises
- Severe income disparity
- Failure of climate change mitigation and adaptation
- Greater incidence of extreme weather events
- Global governance failure
- Food crises
- Failure of a major financial mechanism or institution
- Profound political and social instability

Natural Catastrophes in 2013

Chelyabinsk meteorite impact
Russia, 15 February 2013

Source: Munich Re NatCat Service
State of the Space Industry

The good news
- New applications, technologies, operators, manufacturers, launch vehicles
- Infrastructure build-out continues
- Privatization is working
- Satellite orders remain stable
- Small satellites increasingly popular
- Commercial human spaceflight on the horizon

The not-so-good news
- Government support waning
- Some new markets slow to develop
- Satellite and launch delays affect income
- New technologies pose challenges
- Environmental factors unresolved
Space Activity Metrics

- **81** launches to orbit in 2013
  - 3 launches failed (3.7%) + one or more anomalous launches
  - 38 launches were insured (46%) – 1 insured launch failure
- **209** satellites on the 81 launches
  - 88 of the 209 satellites were cubesats (42%)
  - 52 of the 121 non-cubesat satellites were insured (43%)
- **1,167** active satellites in all orbits
  - Most are civil, scientific, research or national security
  - 212 satellites are insured (18%)
- **1,396** objects in geostationary (GEO) orbit
  - 322 are active commercial satellites (23%)
  - 178 of these active commercial satellites are insured (55%)
Launch Attempts to Orbit

Insured and uninsured

“Other” in 2013 = Antares, Dnepr, Epsilon, Kuaizhou, Minotaur, Naro, Pegasus, PSLV, Rokot, Strela, Vega
Insured GEO Satellites Launched

By manufacturer

Number of satellites launched

Year launched

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Insured GEO Satellites Launched

By region of manufacturer

Percentage of satellites launched

- US & Europe
- Russia & Asia


- 2001: 13%
- 2002: 27%

Chart showing the percentage of Insured GEO Satellites launched by region of manufacturer.
Commercial GEO Satellites Launched

By manufacturer

- SSL
- Airbus
- Orbital
- Orbital
- TAS
- Russia
- Boeing
- LM
- CAST, ISRO
- Japan
- Israel

Launch date

Number of satellites launched
GEO Satellite Mass Progression

Separated mass, kg

Launch date

Separated mass (kg)

Cubesats Launched

Number and percentage of total

<table>
<thead>
<tr>
<th>Year launched</th>
<th>Number of cubesats launched</th>
<th>Percentage of all satellites launched</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>0</td>
<td>0%</td>
</tr>
<tr>
<td>2001</td>
<td>5</td>
<td>5%</td>
</tr>
<tr>
<td>2002</td>
<td>7</td>
<td>10%</td>
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<td>2003</td>
<td>10</td>
<td>15%</td>
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<td>2004</td>
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<td>20%</td>
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<td>2005</td>
<td>20</td>
<td>25%</td>
</tr>
<tr>
<td>2006</td>
<td>25</td>
<td>30%</td>
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<td>2007</td>
<td>30</td>
<td>35%</td>
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<td>2008</td>
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<td>40%</td>
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<td>2009</td>
<td>40</td>
<td>45%</td>
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<td>2010</td>
<td>45</td>
<td>50%</td>
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<tr>
<td>2011</td>
<td>50</td>
<td>55%</td>
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<tr>
<td>2012</td>
<td>55</td>
<td>60%</td>
</tr>
<tr>
<td>2013</td>
<td>60</td>
<td>65%</td>
</tr>
<tr>
<td>2014 (4 months)</td>
<td>100</td>
<td>100%</td>
</tr>
</tbody>
</table>
Satellites In Orbit

1,167 total

- Commercial communications: 467
- Remote sensing: 152
- Navigation: 93
- Meteorological: 35
- Scientific: 58
- Research & development: 140
- National security: 222
Commercial Space Lifecycle
An example
Characteristics of Space Insurance

- Small population of risks + high severity = volatility of results
  - One launch can generate 10% of annual premium
  - One loss can wipe out full annual premium

- Overcapacity in space insurance
  - Low price of entry, short tail, high cash flow, losses settled quickly, uncorrelated with other lines of insurance
  - Several new markets in 2014
  - Very soft insurance market in general

- Unique underwriting challenges
  - Rapidly-evolving technologies, generic anomalies, environmental hazards, …
What Keeps Us Up At Night

- **Operations**
  - Environment – debris, solar activity, interference
  - External threats – intentional and unintentional
  - On-orbit servicing – prox ops
  - Hosted payloads – liability, cross-impact
  - Commercial human spaceflight
  - *Cyber* – *unbounded risk*

- **Systems**
  - Technology insertion
  - Test and analysis
  - *Workforce*
  - Counterfeiting

- **Commercial**
  - *Global economy* – *shifting alliances*
  - Market weakness and volatility
  - Capital allocation
  - Emerging risks
Space Insurance Metrics

- $775,000,000 net space insurance premium in 2013
- $806,100,000 potential insured losses from 6 events (104% loss ratio)
- $645,300,000 peak launch value (1.2x coverage ratio)
- $492,100,000 peak in-orbit value (highest in-orbit value ever)
- $406,200,000 peak claim (largest space insurance claim ever)
- 80% of premium was launch, 20% was in-orbit
- 0.02% of total worldwide insurance premium

- 40+ companies worldwide provide direct, international space insurance
  - Launch capacity (working): $750,000,000
  - In-orbit capacity (working): $550,000,000
Space Insurance Capacity

Launch capacity, by region

Total launch capacity $750,000,000

- US $110m
- Asia $93m
- UK $240m
- France $157m
- Rest of Europe $150m
- Asia $93m

$750,000,000
Space Insurance Capacity

Composition by type of insurer (company vs. MGA)

- **Company (new*)**
  - $28m

- **MGA (new*)**
  - $83m

- **MGA (>2 years)**
  - $110m

- **Company (>2 years)**
  - $529m

In past 2 years:

- 15% total capacity increase
- 43% MGA capacity increase

*“new” means in business for less than two years*
Commercial GEO Satellites In Orbit

By operator, insured and uninsured

322 satellites among 45 operators

- 29 operators have ~20% of the in-orbit fleet = 63 satellites (53 insured = 84%)
- 8 operators have ~20% of the in-orbit fleet = 58 satellites (36 insured = 62%)
- 5 operators have ~20% of the in-orbit fleet = 66 satellites (24 insured = 36%)
- 3 operators have ~40% of the in-orbit fleet = 135 satellites (65 insured = 48%)

6 of 45 operators buy little or no in-orbit insurance (13% of operators, 31% of in-orbit fleet)
Insured Satellites In Orbit
By manufacturer, GEO and LEO

- Airbus: 42 insured satellites
- SSL: 35 insured satellites
- TAS: 35 insured satellites
- LM: 27 insured satellites
- Orbital: 24 insured satellites
- Boeing: 13 insured satellites
- Other: 36 insured satellites

Total: 212 insured satellites
Insured GEO Satellites by Orbital Slot

In 10° longitude increments

Aggregate exposure

$3,000,000,000

$2,000,000,000

$1,000,000,000

$0

Americas

EMEA

APAC

+ $1.9b in LEO
(30 satellites)

Location of libration points (positions of stable drift orbit) = 105W and 75E

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Market Insured Satellites In Orbit

Aggregate exposure and unit count, by quarter

Number of satellites

Aggregate exposure ($ billions)

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Market Insured Satellite In Orbit
As of April 2014

212 satellites
Average: $139.4m
CV*: 81.3%

* Coefficient of Variability = standard deviation / average
Market Annual Average Rates

Launch + 1 year coverage

In-orbit coverage

Year placed

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Market Coverage Ratio

Net premium vs. peak insured value

Market Premium vs. Peak Insured Value

Year | Market Premium | Peak Insured Value
--- | --- | ---
2001 | $500,000,000 | $250,000,000
2002 | $750,000,000 | $500,000,000
2003 | $1,000,000,000 | $750,000,000
2004 | 2.9x | 1.2x
2005 | $1,000,000,000 | $750,000,000
2006 | $750,000,000 | $500,000,000
2007 | $500,000,000 | $250,000,000
2008 | $250,000,000 | $0
2009 | $250,000,000 | $0
2010 | $250,000,000 | $0
2011 | $250,000,000 | $0
2012 | $250,000,000 | $0
2013 | $250,000,000 | $0

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Market Leverage Multiple

Ratio of aggregate exposure* to net premium

Exposure : Net premium

* Average annual exposure of all satellites in orbit, whether under launch or in-orbit policies
Market Premium Flow
2008 - 2013

Net earned premium

$0
$250,000,000
$500,000,000
$750,000,000
$1,000,000,000

2008
2009
2010
2011
2012
2013
Market Insured Losses by Cause

Launch vehicle vs. satellite

Percentage of incurred claims

- 0%
- 25%
- 50%
- 75%
- 100%

Launch Vehicle

Satellite

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Launch Vehicle Success Progression

All launches of current GEO launch vehicles

Launch vehicles included \textit{(not shown in this order)}: Ariane 5 ECA/ES, Atlas 5, Delta 4, Falcon 9, H-2A/B, Long March 3A/B/C, Proton M / Breeze M, Zenit 3SL/SLB

Average $\sim 94\%$
Launch Vehicle Failure Rates

Current GEO launch vehicles

Launch vehicles included *(not shown in this order)*: Ariane 5 ECA/ES, Atlas 5, Delta 4, Falcon 9, H-2A/B, Long March 3A/B/C, Proton M / Breeze M, Zenit 3SL/SLB

Average 5.6%
Insured Satellite Failure Rates

By manufacturer, first year in orbit, since 2000

Manufacturers included (not shown in this order): Airbus, Boeing, CAST, ISRO, Lockheed Martin, MELCO, Orbital, Russian (Energia, ISS, Khrunichev, Lavochkin combined), SSL, TAS

Average 5.3%
Insured Satellite Annual Failure Rates

By manufacturer, 2nd and subsequent years in orbit, since 2000

Manufacturers included (not shown in this order): Airbus, Boeing, CAST, ISRO, Lockheed Martin, MELCO, Orbital, Russian (Energia, ISS, Khrunichev, Lavochkin combined), SSL, TAS

Average 1.5%
Market Insured Losses by Phase

Phase of operations, launch and first year, since 2000

- Launch vehicle flight: 45%
- 3rd through 12th months: 13%
- First 2 months in orbit: 42%
Satellite Loss Progression

Loss frequency vs. satellite age, insured population

92 losses (42%) in first two months
Satellite Loss Progression

*Loss quantum vs. satellite age, insured population*

See next chart
Satellite Loss Progression

Loss quantum vs. satellite age, first two months

Satellite age (months)

Loss Quantum

0%
25%
50%
75%
100%
Satellite Loss Progression

Losses by subsystem based on age at anomaly

Satellite Loss Progression

Losses by subsystem based on age at anomaly

Age of satellite at anomaly (years)
Tracked Space Objects
As of December 2013

Red: Spacecraft (operational & retired), Yellow: Orbital stages,
Blue: Fragmentation debris and mission-related objects

Source: ESA
## Widely-Reported Space Debris Events
### Last 20 years

<table>
<thead>
<tr>
<th>Year</th>
<th>Type</th>
<th>Satellite 1</th>
<th>Satellite 2</th>
<th>Pieces</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>Breakup</td>
<td>Pegasus HAPS rb</td>
<td>713 pieces</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>Breakup</td>
<td>Long March rb</td>
<td>343 pieces</td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td>Breakup</td>
<td>PSLV rb</td>
<td>370 pieces</td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>Intentional</td>
<td>FY-1C</td>
<td>&gt;3,300 pieces</td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td>Intentional</td>
<td>USA 193</td>
<td>174 pieces</td>
<td></td>
</tr>
<tr>
<td>2008</td>
<td>Breakup</td>
<td>Cosmos 2421</td>
<td>509 pieces</td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>Collision</td>
<td>Iridium 33 / Cosmos 2257</td>
<td>&gt;2,200 pieces</td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>Breakup</td>
<td>Breeze M rb</td>
<td>111 pieces</td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>Collision</td>
<td>BLITS / FY-1C deb</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>Collision?</td>
<td>NEE-01 Pegaso / Tsyklon rb</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- In addition, many (typically minor) satellite anomalies reported to space insurers are blamed on space debris, e.g.:
  - Solar array string losses
  - Attitude disturbances
A Bad Day In Space
Chelyabinsk Meteorite

- 15 Feb 2013, 0320 UT
- Estimated initial size
  - 19m diameter
  - 12,000 tonnes
- Impact energy ~440 kT TNT
- >1,600 people injured
  - Most from broken glass
  - No fatalities
- >7,000 buildings suffered broken windows
- Largest known earth impactor in over 100 years
- In 2013, at least 25 other earth-impacting meteorites observed

Source: NASA, Astronomical Institute of the Academy of Sciences of the Czech Republic
Conclusion

- Space insurance market has been profitable over the long-term, but margins are increasingly thin.

- Competitive space insurance market demands even more diligent underwriting.

- New applications and technologies, emerging risks, and increasing hazards in the space environment will stress satellite operators, manufacturers, launch providers, end-users and insurers.
Space for new ideas...

...new ideas for space