Risk Management of a Large Fleet

Lindsay Pattinson
Director of Satellite Operations, Eutelsat

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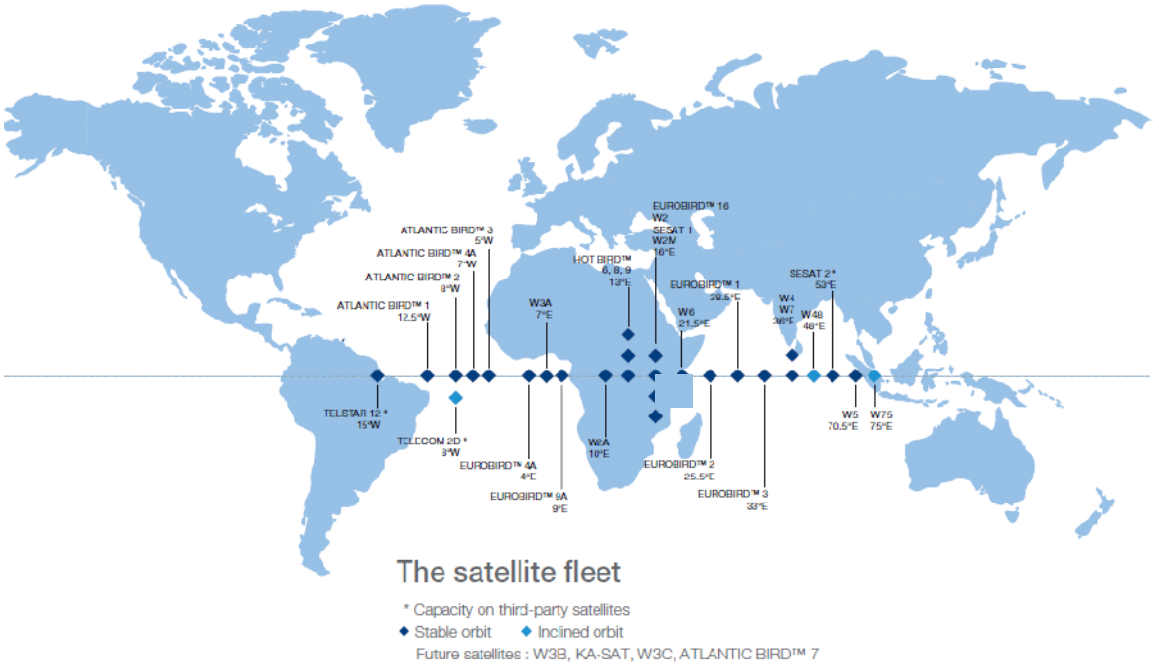
Eutelsat as operator of a large fleet

- More than 30 years experience in satellite operations, 40 satellites procured
- At March 2010, the operational fleet is 27 (24 fully owned) satellites, with four satellites to launch



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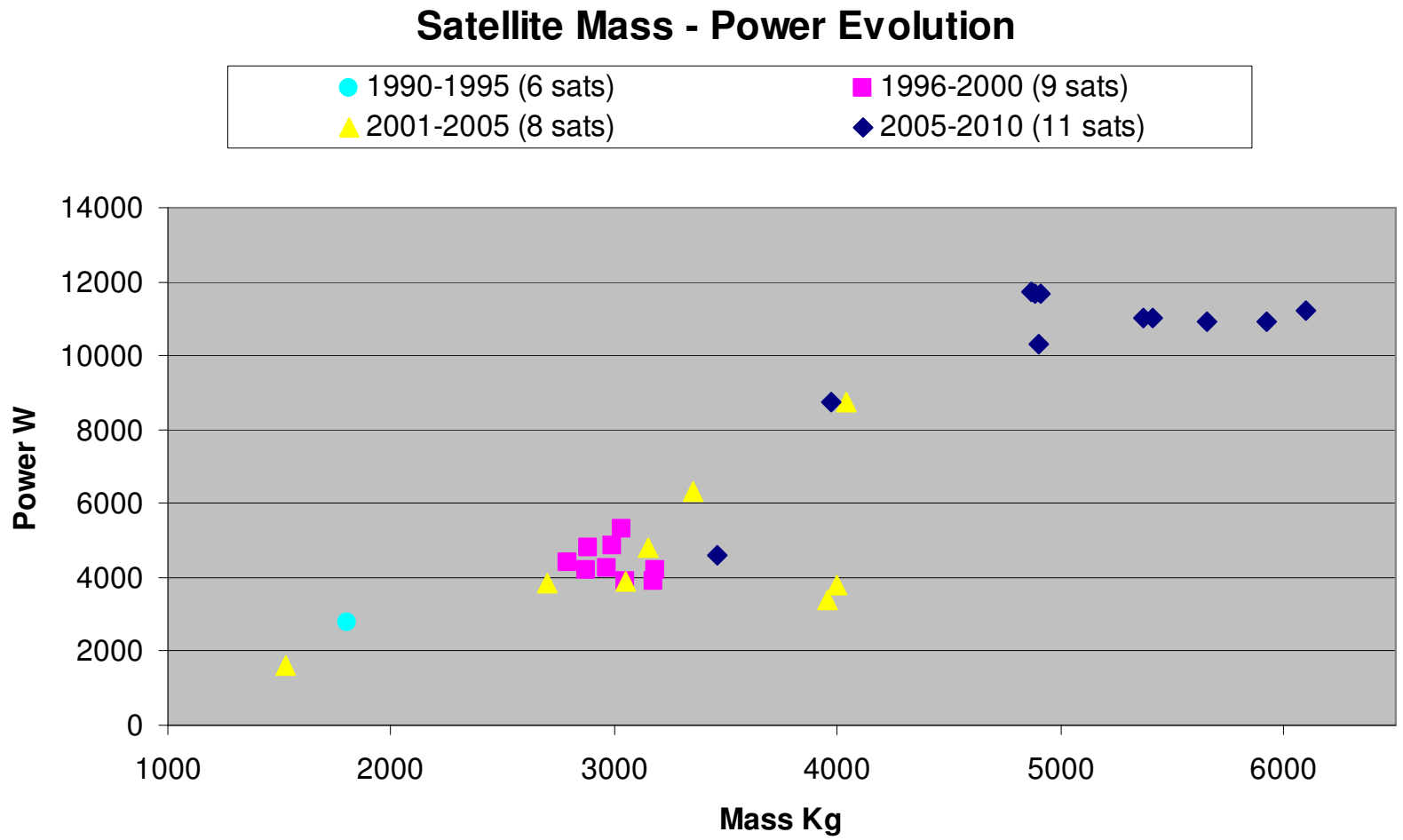
Eutelsat satellites procured

Supplier	Platform	No of S/C	Launch period	Launch Mass (kg, +/-)	Payload Power (W, +/-)
BAe/MATRA	Eurostar 1000	5 (1 lost at launch, 4 re-orbited)	1983-1988	1000	1000
TAS-F	SB2000	6 (1 lost at launch, 5 re-orbited)	1990-1995	1800	2800
EADS-Astrium	Eurostar 2000+	6 (1 lost at launch)	1996-2000	3000	4500
TAS-F	SB 3000B2/B3	6xB2, 3xB3	1998-2006	3000-4000	4000-6000
ISS-Reshetnev	MCC-727	1	2000	2500	3000
Alenia	Italsat/Sicral	1	2001	3000	4000
BSS	376HP	1	2003	1500	1600
EADS-Astrium	Eurostar 3000	6	2004-2011 (2 to be launched)	4000-5000	9000-12000
EADS-Astrium/ISRO	I3K	1	2008	3500	4500
TAS-F	SB 4000	4	2009-2011 (2 to be launched)	6000	11000

Eutelsat fleet – mass & power evolution



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Satellite procurement risks

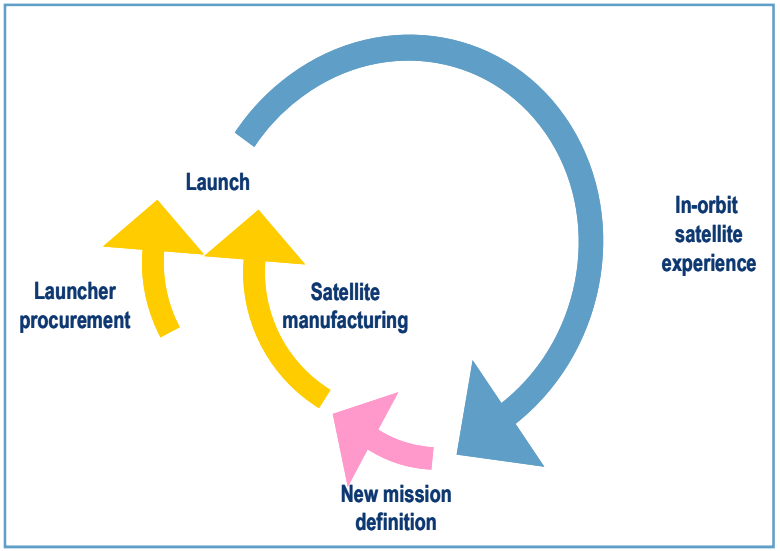
Risk origin	Related affected factor	Mitigation and prevention actions
➢Design change/upgrade ➢Modifications to original mission specification	➢Quality	➢Re-use as much as possible (successful) recurring designs ➢Use new technologies only after sufficient in-orbit experience (e.g., LiOn batteries, AsGa solar cells…) ➢Experience, lessons learnt, feedback
➢New technologies and non-recurring equipment ➢New or stretched designs to handle increased power demand ➢Trade-off of satellite performance/power capability against reliability	➢Quality ➢Procurement schedule	➢Quality Plan in all procurement contracts ➢Specific qualification and testing plans with strict monitoring ➢Select manufacturers with adequate visibility access ➢Alert processes agreed with suppliers.
➢Programmatic issues ➢Damage of equipment ➢Underestimate of manufacturing and integration sequences	➢Procurement schedule	➢Programme milestone review process ➢Order (when possible/convenient) satellite series rather than individual satellites

In-orbit satellite anomaly risks

Risk origin	Related affected factor	Mitigation and prevention actions
➢Minor loss of function or performance of on-board satellite equipment	➢Quality of Service (outages)	➢On-board redundancy
➢Major on-board failures and malfunctions ➢Serial anomalies	➢Quality of Service ➢Lost of assets (total or partial)	➢Introduce corrective measures on satellites in orbit and not yet launched ➢Feedback of conclusions into manufacturing and design processes ➢Incentives to industry during satellite lifetime ➢Industry support in case of satellite anomaly ➢Alert process with manufacturers to be kept informed of component failures or anomalies on other operators satellites. ➢Operational mitigations, where possible.
➢Incorrect definition or implementation of operations procedures	➢Quality of Service (outages)	➢Update of nominal and contingency procedures for each individual satellite ➢Staff training

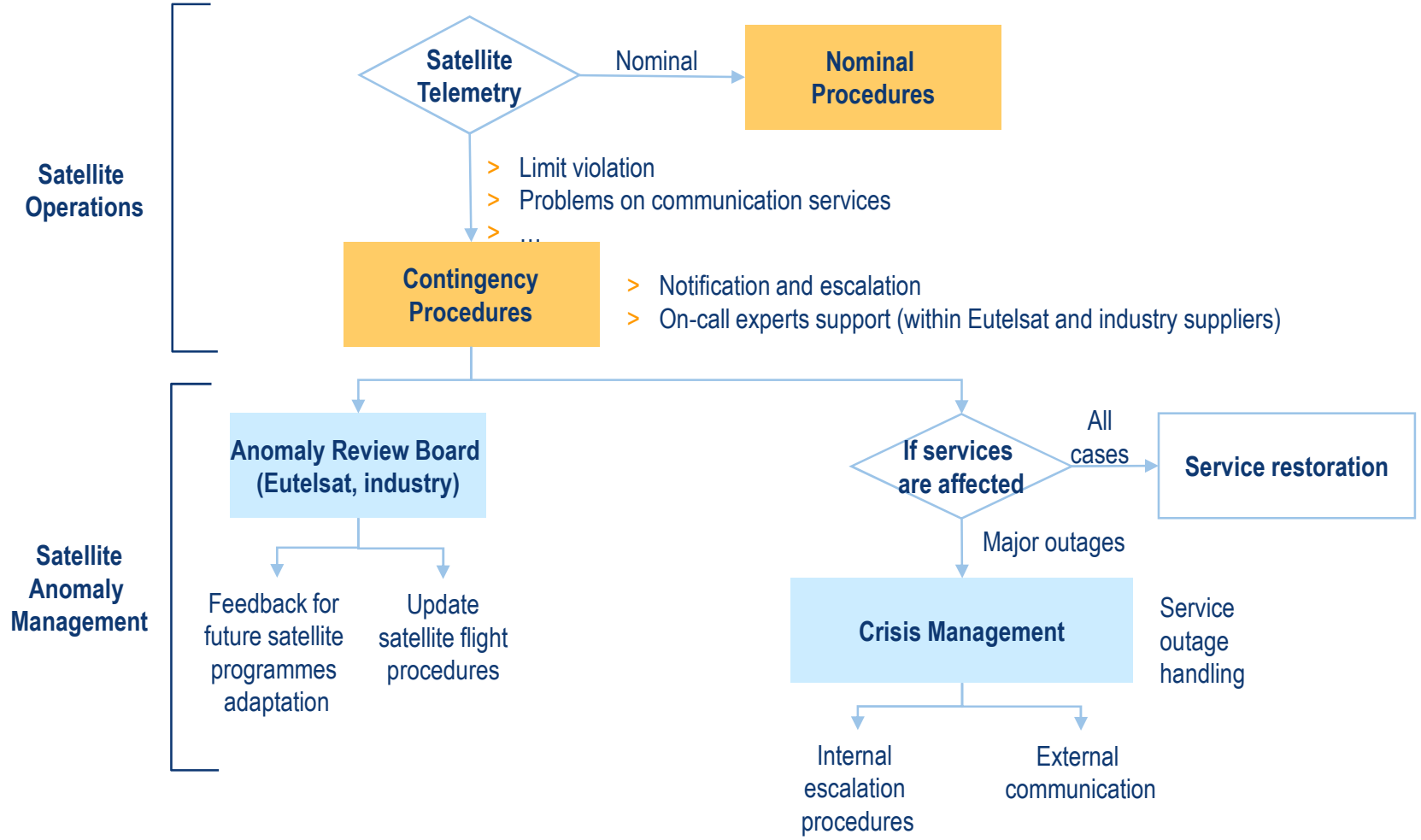
Procurement and operations feedback

- Procurement and management of in-orbit anomalies processes are under constant review and improvement.
  - These processes are related and constitute a loop where experience gained and lessons learnt from Eutelsat and other operators are incorporated.
  - There is a continuous interaction with industry to improve quality and reliability

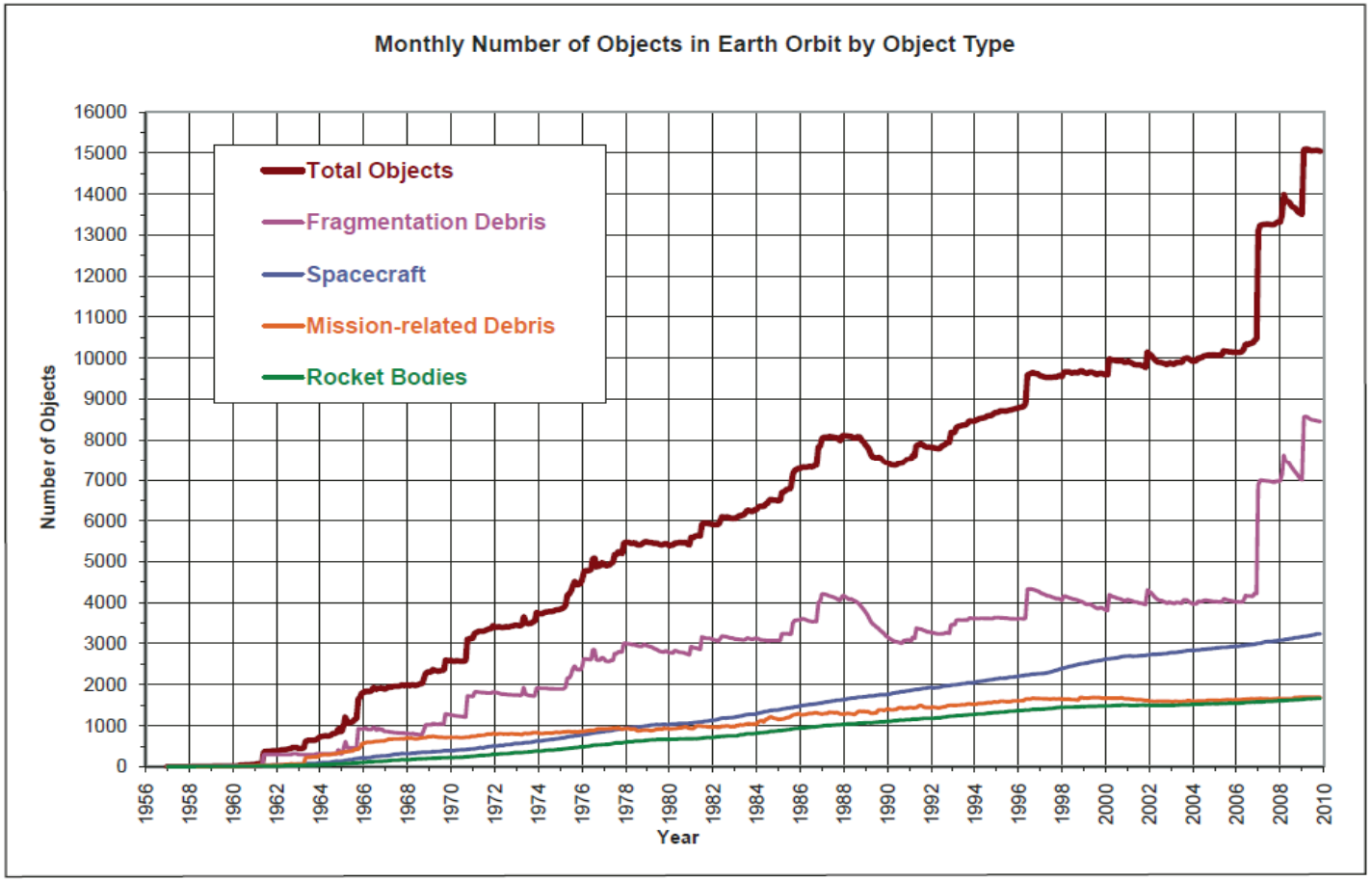


- Key Performance Indicators
  - Satellite procurement: on-time satellite delivery, quality (in-orbit anomalies)
  - Launch service procurement: on-time availability of launcher, flexibility
  - In-orbit anomalies and their impact on quality of services.
  - Satellite availability-for-services (availability) statistics
  - Monitoring of anomalies and performance across industry (external data sources)

Management of in-orbit satellite anomalies



Space debris



Monthly Number of Cataloged Objects in Earth Orbit by Object Type: This chart displays a summary of all objects in Earth orbit officially cataloged by the U.S. Space Surveillance Network. "Fragmentation debris" include satellite breakup debris and anomalous event debris, while "mission-related debris" include all objects dispensed, separated, or released as part of the planned mission.

Space debris risk

- **In addition to controlled satellites:**
  - Spent stages of launchers.
  - Satellites not sufficiently re-orbited or re-entered into earth atmosphere.
  - Explosions and collision fragments, either accidental or intentional destruction of satellites in the LEO region by missile.
- **Risks**
  - Collision probability is extremely low, though increasing. (Events are subject to enormous publicity.)
  - Could affect satellite launches, and during initial perigee raising.
  - Possible loss of mission, and cascade effect in case of collision.
  - Military satellites often removed from tracking databases.

Space debris – risk mitigations

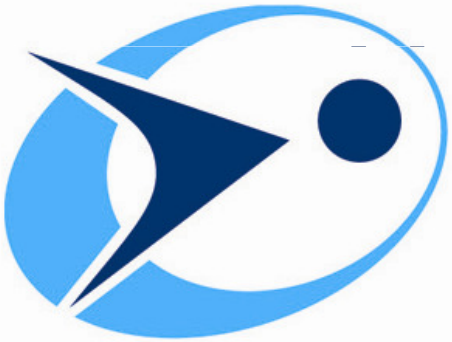
- **Risk mitigation**
  - Mechanical protection: very costly and only protects against low-energy impacts.
  - Application of appropriate recommendations and legislations aimed at avoiding growth of debris density. Eutelsat participates to various groups: UN COPUOS, CNES/IADC, French Space Law, ESA, etc.
  - Satellite design to avoid generation of particles or debris (paint flakes, explosive pyro devices)
  - Disposal of objects at end-of-life e.g. for GEO missions to move outside the “protected region”, which extends +/-200km from GEO. Eutelsat has successfully re-orbited all 9 GEO satellites so far removed from the GEO ring. Discharge all energy sources to avoid explosions or release of debris.
  - Improve accuracy in space tracking. US SSN operates the largest worldwide network of ground and space surveillance system, but has low accuracy and allows limited risk assessment.
  - Active coordination with other operators in case of passage of satellites.
  - Military satellites: Eutelsat is actively involved in information exchange with other operators, e.g. US military via the JSPOC arrangement.

- **Good practices are required by all space users to ensure sustainable use of the resource.**

Space weather

- **Events**
  - There are very few known cases of loss of control due to space weather.
  - Olympus satellite, total loss in 1993 following a Perseid stream
  - Cosmos 539: hit by micrometeoroid
  - Meteosat 8: probably hit by a micro-meteoroid
- **Micro-meteoroids and charged particle flux**
  - May cause problems due to mechanical effects in case of collision, or electrical effects in case of vapourisation on impact.
  - Leonids (between 1999 and 2002), from the Temple-Tuttle comet (every 33 years).
  - Perseids: associated with the comet Swift-Tuttle (each year, but very low particle flux)
- **Risks**
  - Equipment damage or total mission loss, random electrostatic events.
- **Risk mitigation / risk transfer**
  - Use of predictions from IMO, ESA and other sources
  - Leonids, Perseids, passage: the probability of collision is reduced by orienting the solar panels parallel to the flux.
  - Design and test of satellites to be tolerant to electrostatic phenomena.

Thank you



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Lindsay Pattinson, CV

Director of Satellite Operations, Eutelsat, Paris, France.

Having gained a PhD in Fluid Mechanics at the University of Newcastle upon Tyne, UK in 1983, employment was taken with British Aerospace, Space and Communications, as a Satellite Operations Engineer.

Moving to Eutelsat in 1988, in-orbit operations of the Eutelsat fleet became the main responsibility. Experience gained has been both wide and deep, covering satellite design and procurement activities, LEOP operations and the operational services phase through to end-of-life satellite disposal. This current position also involves chairmanship of the Eutelsat Anomaly Review Board, interfacing with operations and procurement within Eutelsat, and with industry, as well as entities involved in debris-related activities and situational awareness.

Eutelsat, Introduction

About Eutelsat Communications

With capacity commercialised on 27 satellites that provide coverage over the entire European continent, as well as the Middle East, Africa, India and significant parts of Asia and the Americas, Eutelsat is one of the world's three leading satellite operators in terms of revenues. At 30 June 2009, Eutelsat's satellites were broadcasting almost 3,300 television channels and 1,100 radio stations. More than 1,000 channels broadcast via its HOT BIRD™ video neighbourhood at 13 degrees East which serves over 123 million cable and satellite homes in Europe, the Middle East and North Africa. The Group's satellites also serve a wide range of fixed and mobile telecommunications services, TV contribution markets, corporate networks, and broadband markets for Internet Service Providers and for transport, maritime and in-flight markets. Eutelsat's broadband subsidiary, Skylogic, markets and operates services through teleports in France and Italy that serve enterprises, local communities, government agencies and aid organisations in Europe, Africa, Asia and the Americas. Headquartered in Paris, Eutelsat and its subsidiaries employ 615 commercial, technical and operational employees from 28 countries.

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