EPIC Lecture Series
All Electric Propulsion Satellites
on GEO Telecom Market
Electric Propulsion History Key Dates

Commercial Telecom Market Quick Overview

Interest of Electric Propulsion for Geostationary Telecom Platforms

Technology Trade-Off for Electric Transfer

All Electric Platform Architecture Overview

Electric Propulsion Next steps
Electric Propulsion History Key Dates
1906: R.H. Goddard first technical note on EP potential
1950: Start of developments in US
1959: First Ionic Thruster (H. Kaufman)
1964: 2 ionic thrusters for the first time on SCOUT (SERT1&2 programs) and first PPT in orbit (Zond-2)
1971: Meteor embarks 2 Russian SPT-60
1994: First Arcjet used on TELSTAR 401 (Martin Marietta)
1998: First XIPS Xenon thrusters on PAS-5 (Hughes)
1998: Exploration satellite DS1 with ionic NSTAR thruster
2001: European Artemis satellite with ionic thrusters (RIT10 &UK10) and Stentor satellite with plasma thrusters (SPT100)
2004: Airbus first commercial platform with SPT100
2015: Boeing first all electric satellite with XIPS thrusters
2017: Airbus first large all electric satellite with SPT thrusters
Commercial Telecom Market Quick Overview
More than 60 Telecom Satellite Operators active worldwide

Cyclical commercial market, 22-25 satellite orders p.a. expected over next 5 years

New growing cycle from 2018 supported by the next replacement cycle and business growth on new services
Between 2004 and 2015, about 30% of GEO Telecom satellites were equipped with EP Electric Propulsion is more and more used and expected mid term predictions are as follows:

- 1/3 of the market for full chemical satellites
- 1/3 of the market for satellites with chemical transfer and electric station keeping
- 1/3 of the market for full electric satellites
Interest of Electric Propulsion for Geo Telecom
The 3 Types of GEO Telecom Satellites

- **GTO Orbit**
  - Typical launcher injection

- **Earth**

- **Full Chemical**
- **Chemical for transfer**
- **Full Electrical**

**Launchers**

- **Ariane 5**
- **Sea Launch**
- **Proton**
  - 6000 kg class launchers
- **Falcon 9** (27°)
  - 4850 kg
Full Electrical Satellites

GEO Orbit

GTO Orbit

4850 kg dry mass

< 1N

1800 s

6 months

< 0.3 N

1800 s

15 years

4850 kg dry mass

Full Electrical

Chemical for transfer

Electrical on-station

Full Chemical

Confidential
Resulting Operator Trade-Off for Electric Station Keeping

- Full Chemical
- Chemical for transfer
- Electrical on-station

**Electric Propulsion Subsystem**

**VERSUS**

- +10 Transponders (cost and add revenues)

**OR**

- Launch Mass Saving: (-600kg, cost/kg)

- 4850 kg dry mass
- 4850 kg dry mass
- 4850 kg dry mass

Full Electrical
Chemical for transfer
Electrical on-station
Full Chemical
Resulting Operator Trade-Off for Full Electric Satellites

**Propulsion Subsystem Upgrade**

**AND**

3/6 Months Transfer: (with associated cost)

**VERSUS**

+30 Transponders (cost and add revenues)

**OR**

Launcher Change: Ariane 5 to Falcon 9

- Full Electrical
- Chemical for transfer Electrical on-station
- Full Chemical

Confidential
### Full Chemical Satellites
- **2 Full Chemical Satellites**
  - Full Chemical Satellite: 5700 kg, 11 kW C/U (Astra 5B)
  - Full Chemical Satellite: 2900 kg, 5 kW C/U (Amazonas 4A)

### Full Electrical Satellites
- **1 Full Electrical Satellite**
  - Full Electrical Satellite: 3500 kg, 11 kW C/U (Eutelsat 172B)

### Full Chemical Satellites
- **2 Full Chemical Satellites**
  - Full Chemical Satellite: 5700 kg, 11 kW C/U (Astra 5B)

### Full Electrical Satellites
- **2 Full Electrical Satellites**
  - Full Electrical Satellite: 5300 kg, 15+ kW C/U (SES-12)
Technology Trade-Off for Electric Transfer
Electric Propulsion Types and Performance Overview

The image shows a graph comparing the specific power (W/m^2) and specific impulse (s) for different electric propulsion types. The graph includes categories such as Arcjet, Ionic Thruster, FEEP, HET, PPT, and Colloid. The graph also indicates TRL (Technology Readiness Level) with colors ranging from 1 to 9, with 9 being the highest. The specific impulse and specific power scales range from 10 to 100,000 and 0.1 to 1,000, respectively.
Electric Propulsion for Transfer (1/3)

DEFENCE AND SPACE

\[ F = m \cdot V \]

\[ \text{Isp} = \frac{F}{m \cdot g} \]

\[ \text{Eff} = \frac{g \cdot F \cdot \text{Isp}}{2 \cdot P} \]

F = mV

\text{Isp} = \frac{F}{m \cdot g}
Electric Propulsion for Transfer (2/3)

\[ M_f = M_i \exp(-dV/g/I_{sp}) \]

\[ dT = M \cdot dV/F \]
HET $\rightarrow$ 0.57 kg/day/kW (1800s)

GIT $\rightarrow$ 0.40 kg/day/kW (3000s)
All Electric Platform Architecture Overview
Adaptation for Transfer

E3000

PPU A
TSU

PPU B
TSU

PPU C
TSU

YM

YP
Electric Propulsion Next steps
DEFENCE AND SPACE

NEXT STEPS (1/2)

EUROSTAR E3000
- 10 S/C IN ORBIT
- 13 YEARS
- 35 000 H

EUROSTAR E3000E
- UP TO 16 kW
- 4.5 kW HET
- EOR IN 2017

EUROSTAR E3000 NEO
- UP TO 25 kW
- ALL ELEC
- LOWER COST
DEFENCE AND SPACE
NEXT STEPS (2/2)

**Key EP Characteristics:**
- 15-25 KW THRUSTERS, ALTERNATIVE PROP, DUAL MODE, HIGH THROUGHPUT, NEW POWER MANAGT SUBSYSTEM...

**Low Power Range**
- Key EP Characteristics:
  - 200-700 W THRUSTERS, ALTERNATIVE PROP, SIMPLIFIED OPERATIONS AND ELECTRONICS, COMPACT...

**High Power Range**
- Key EP Characteristics:
  - 3-5 KW THRUSTERS, DUAL MODE, FULLY OPTIMISED OPERATIONS, SIMPLIFIED ELECTRONICS...

**Key EP Characteristics:**
- 200-700 W THRUSTERS, ALTERNATIVE PROP, SIMPLIFIED OPERATIONS AND ELECTRONICS, COMPACT...
In Electric Propulsion we thrust.