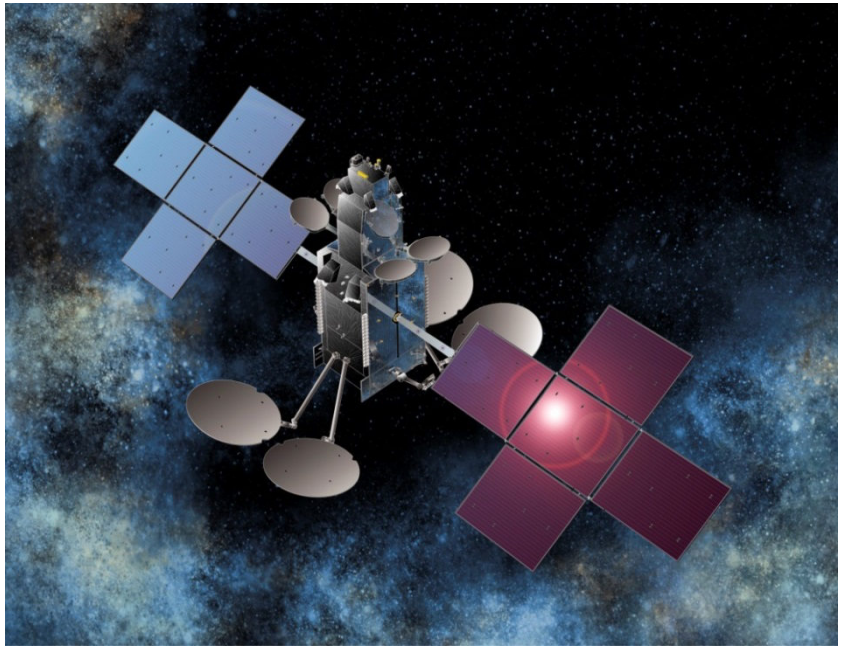
Telecom market

KTH Space Rendez-vous, Oct 2016
Folke Brundin
RUAG Space AB



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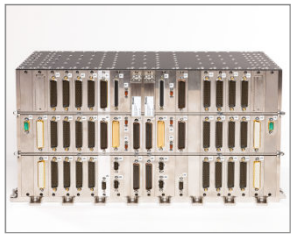
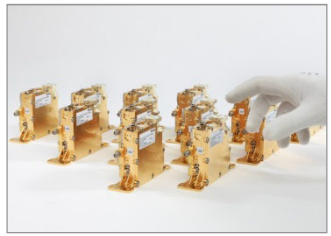
RUAG Space Sweden

Gothenburg

Linköping





RUAG Space, Operations in Sweden

Sales (2015): 775 MSEK (~92 MUSD)

Employees (2015): 400 (Gothenburg 325, Linköping 75)

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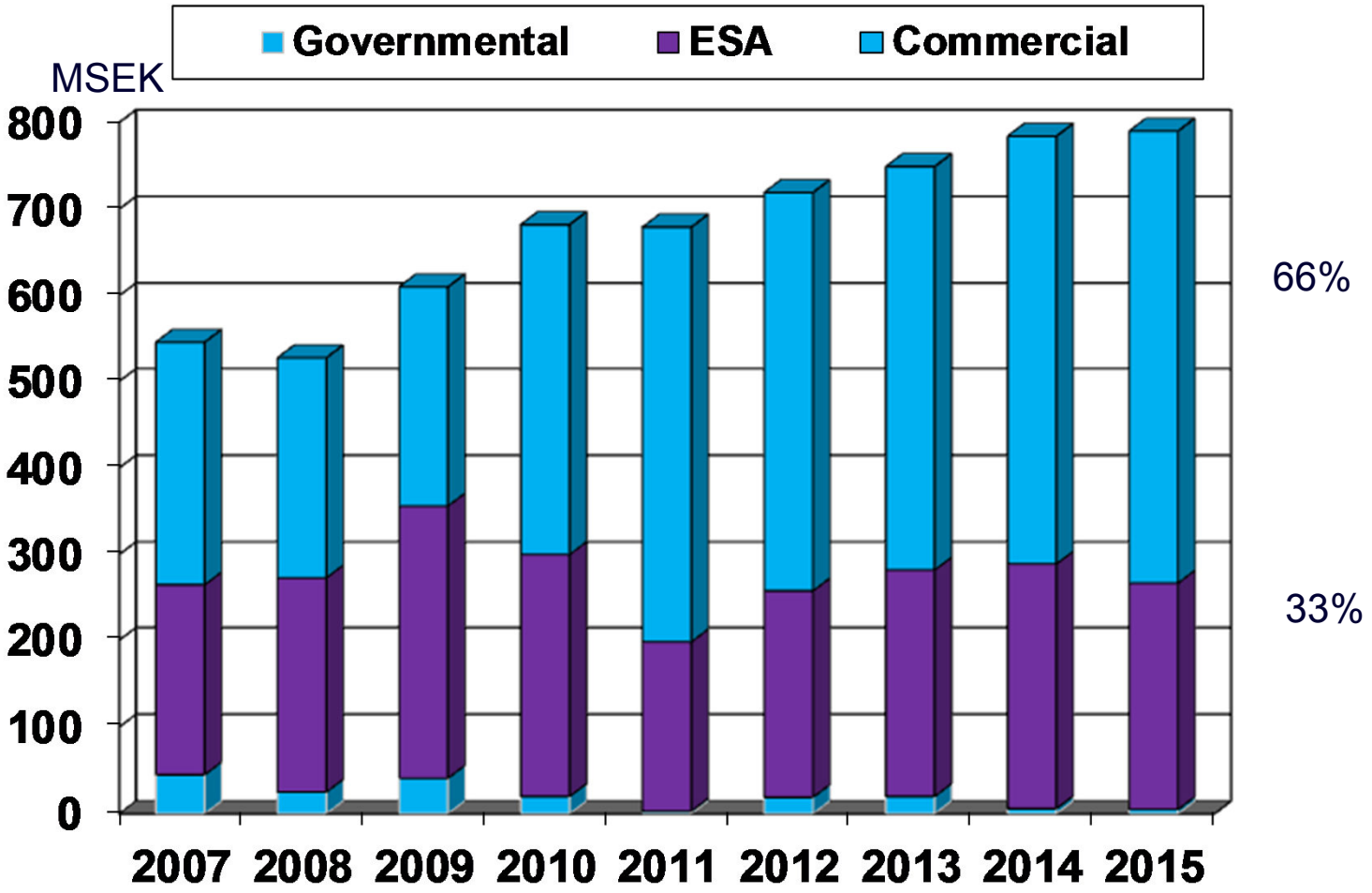
Our Customers

North America	Europe	Asia
Boeing	Airbus	ISRO
International Launch Services	Arianespace	Mitsubishi
Jet Propulsion Laboratory	Dutch Space	NEC Space Systems
Lockheed Martin	ESA/Estec	Hanwha Thales
MDA	Khrunichev	
NASA	Mier	
Northrop Grumman	Norspace	
Orbital Sciences	OHB	
Sea Launch	RSC Energia	
Space Systems/Loral	SSTL	
SpaceX	SIS/Land Launch	
United Launch Alliance	TESAT	
	Thales Alenia Space	

Sales development over time

RUAG Space AB



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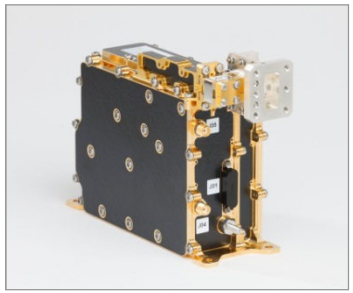
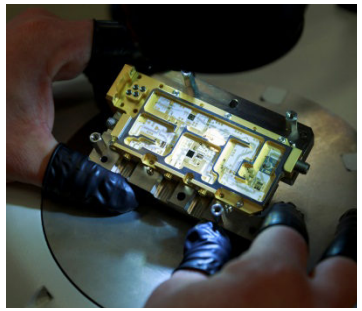
Example: Supply of Microwave electronics

Supplier of frequency receivers to world largest telecom satellite prime contractor, SSL in Palo Alto.

10-50 equipment per satellite, depending on service offered, 1-5 MUSD value



- Success factors
- ➢ Use of technology developed at/with Chalmers University
- ➢ World-class MMIC chips – GaAs, GaN
- ➢ Product development and qualification in ESA programs
- ➢ Niche product – broad customer base - high market share



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Example: Supply to Iridium Next

Supplier of Payload Interface Unit to Iridium Next,
10 kg electronics per satellite.

Constellation of 80 satellites, mobile communication.
Customer Thales Alenia Space, France.

- Success factors
  - ➢ Use of COTS technology, innovative design choices
  - ➢ COTS technology proven in ESA feasibility study
  - ➢ Fault-tolerance state-of-the-art heritage, based on 40 years of cooperation with Chalmers
  - ➢ Industrialisation for series production

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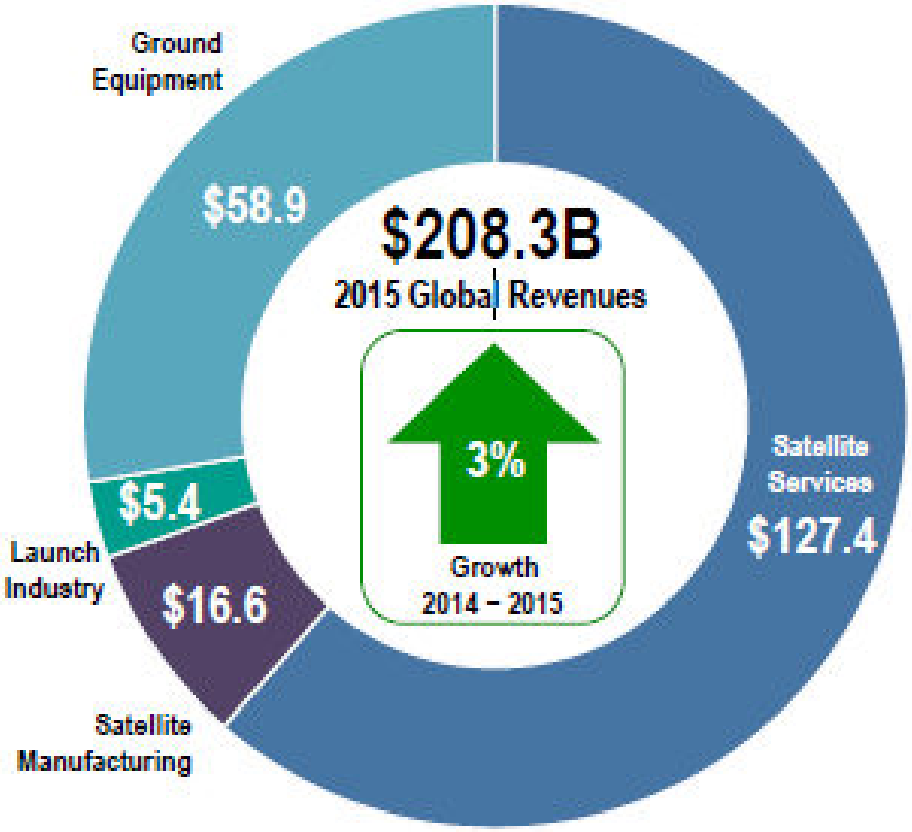
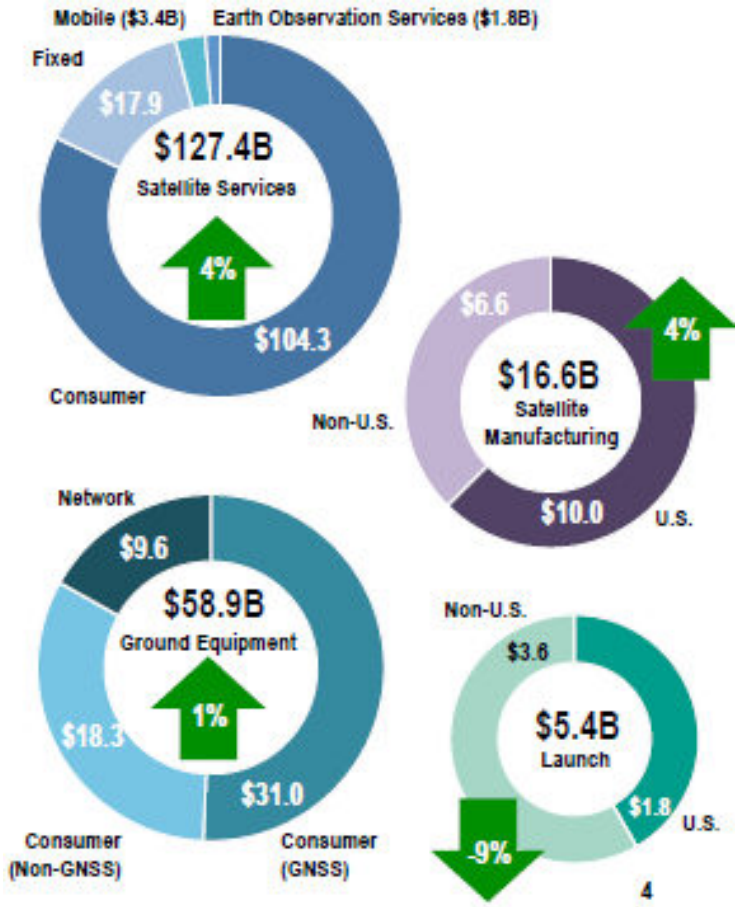
World Satellite Industry Revenues by Segment





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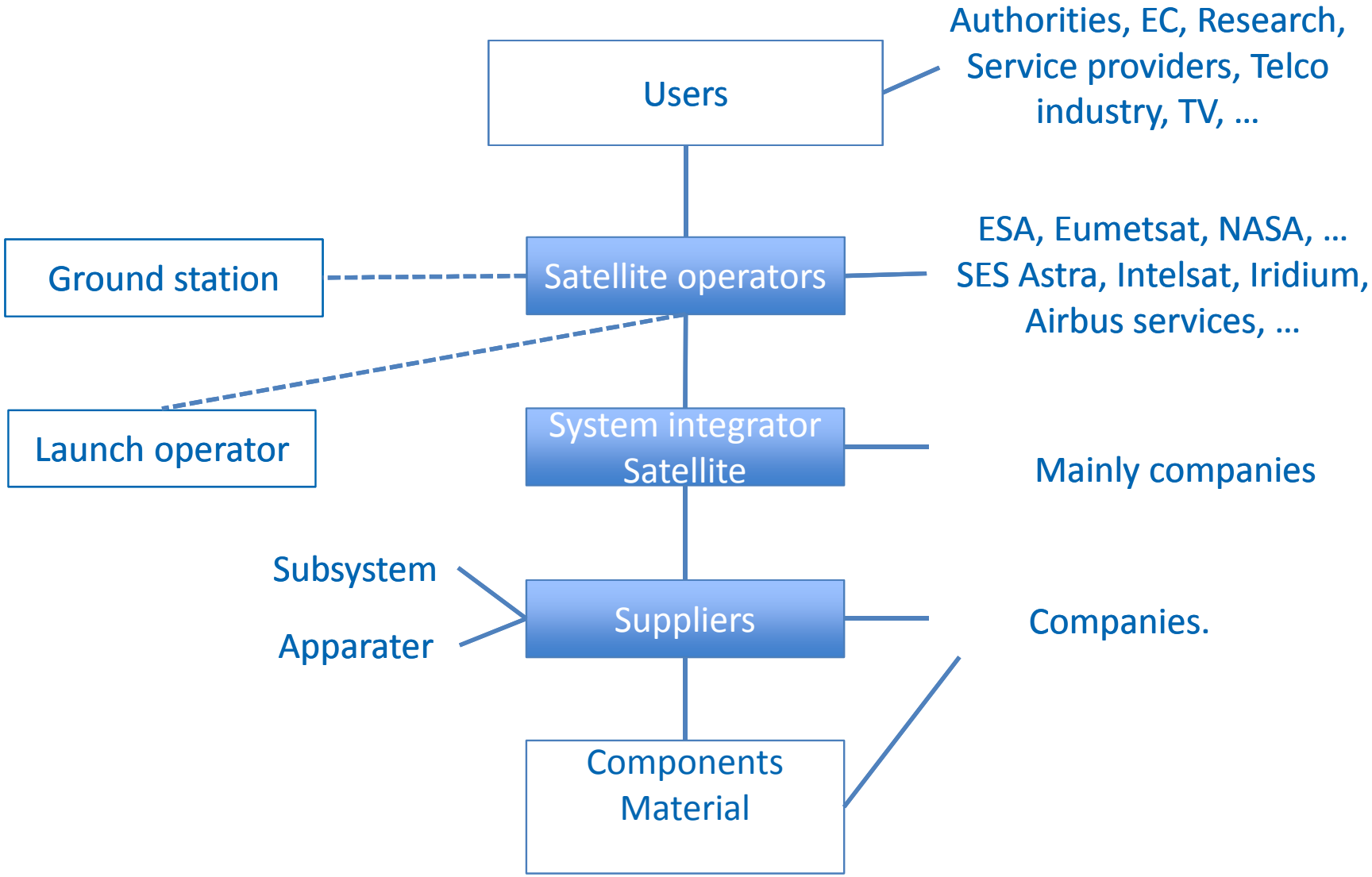
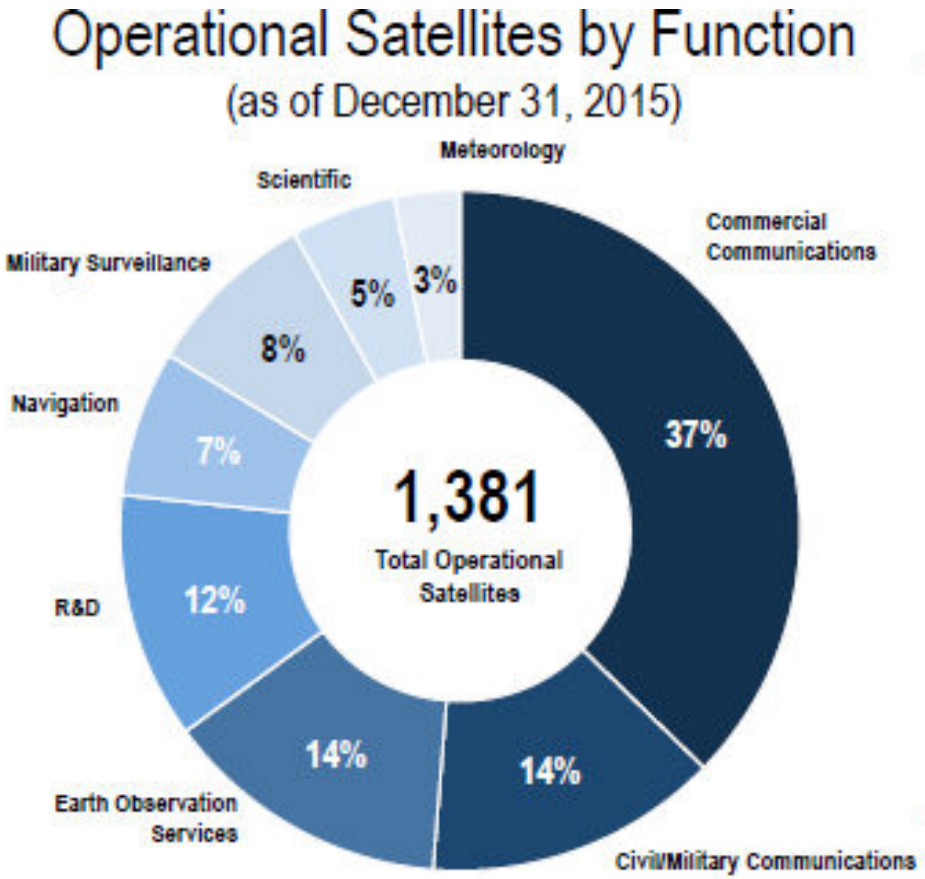
Space market - satellites

swedish aerospace industries

Structure and actors



Geo Telecom Satellites



- Number of satellites increased 39% over 5 years, compared to 986 reported in 2011
  - » Average number of satellites launched per year in 2011-2015 increased 36% over previous 5 years
  - » Small and very small satellites deployed in LEO contribute to this growth
  - » Average operational lives of certain satellite types (such as GEO communications satellites) are becoming longer
- 59 countries with operators of at least one satellite (some as part of regional consortia)

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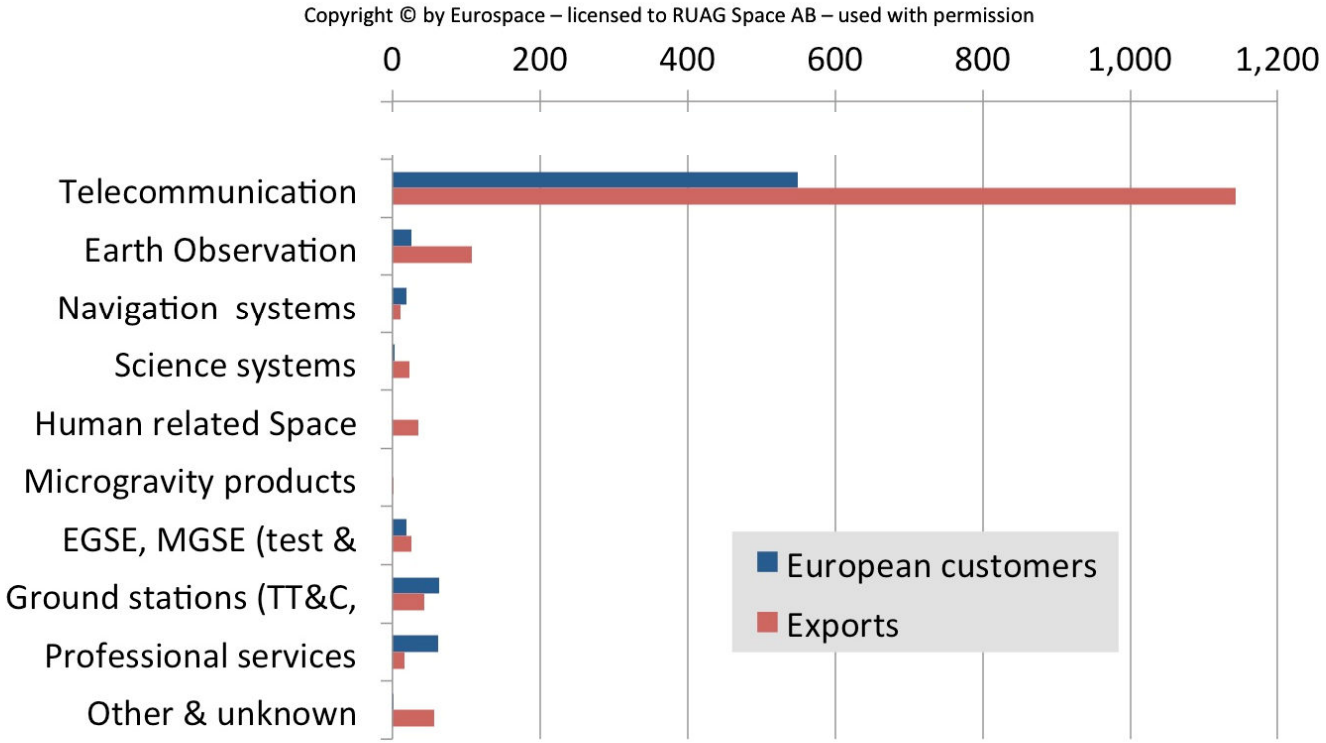
European satellite manufacturing

Focus: Sales on the commercial market by system (M€)



Telecom is dominating.

Megatrends Affecting Commercial Telecom

Trends	Implications
■ Everything is becoming IP-based ■ Web TV, video on demand, VoIP, ...	■ FSS/BSS services will be replaced by high-throughput satellites (HTS)
■ Internet of Things (IoT) – everything is becoming an IP device, producing, sending and receiving data	■ Requirements for bandwidth will continue to increase dramatically
■ Mobility is increasing	■ Satellites must reach mobile users
■ The developing world is connecting	■ Need to get bandwidth into everywhere

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Market trends

- Growth moving from video distribution to HTS (High through-put)
  - Video flat in developed regions, growth in developing world
  - HTS growing to meet demand for broadband access
  - Fully connected world; People and objects

- Broader range of satellite sized from small to large driven by
  - Sizing the satellite to the market and available CapEx
  - Greater range in launch vehicle options
  - Increasing number of regional operators

- Growth in mobility, especially aeronautical (In-Flight Connectivity) and maritime
- LEO & MEO HTS constellations moving forward; OneWeb, LeoSat, Telesat, SpaceX, Spacebelt, LaserLight, BSS, EightyLEO, etc.
- Terrestrial competition driving focus on launched cost per GB

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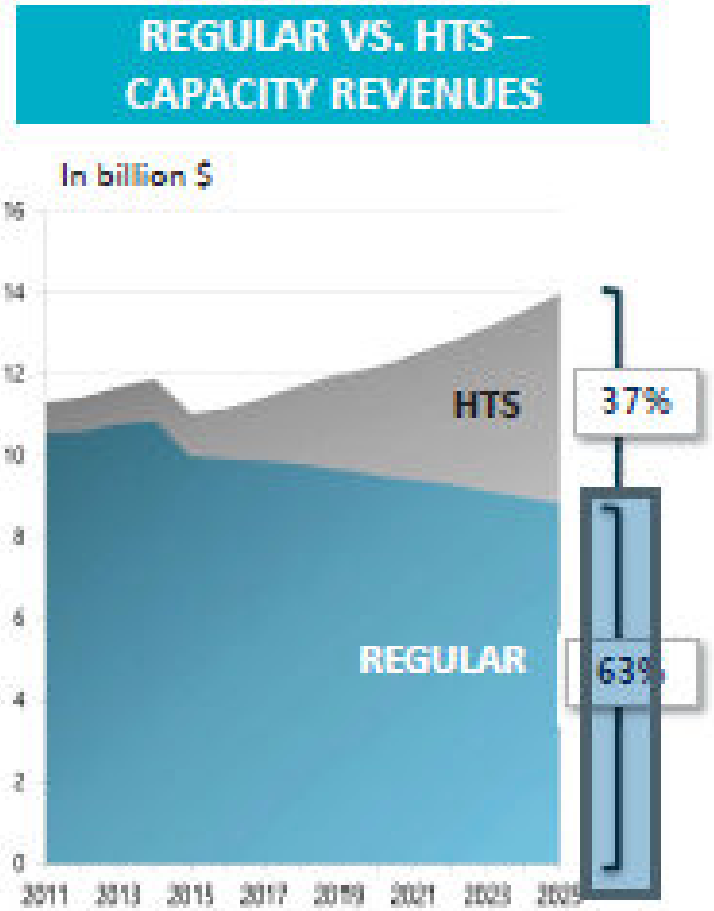
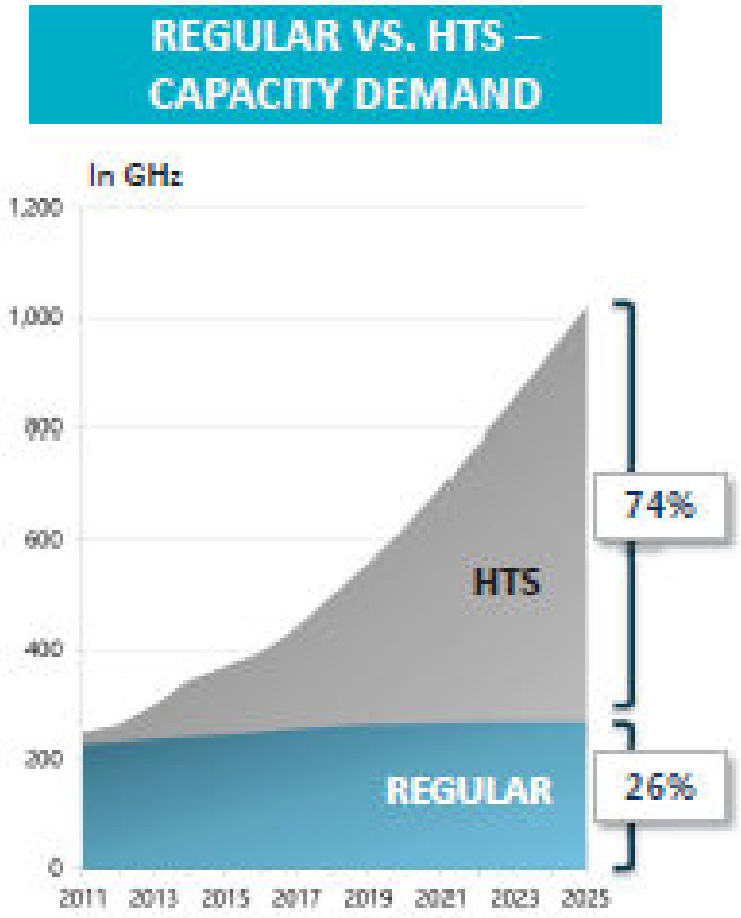
Revenue vs. Capacity Usage





Source : Euroconsult

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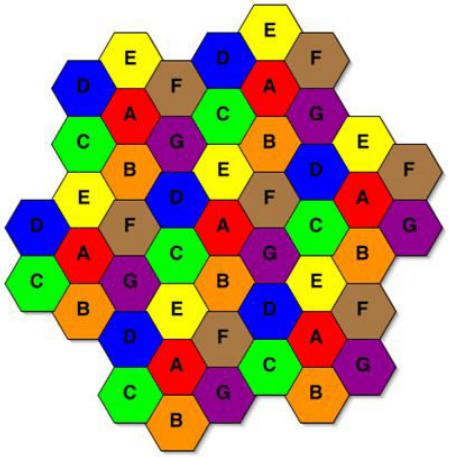
HTS – High-throughput satellites Enabling Technologies for Large GEOs (e.g. ViaSat)

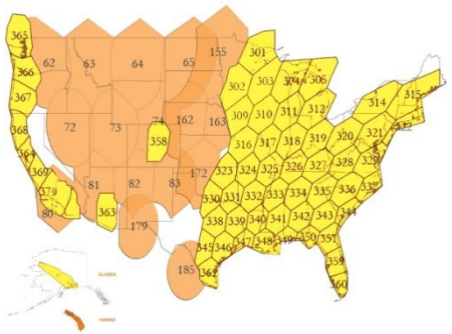
- 3 parameters affecting capacity (in order of impact):
  - C/I (beam-to-beam interference)
  - EIRP (transmit power)
  - G/T (receive antenna gain)
- So, enabling technology 1: Better antennas
  - Smaller beams ⇒ more frequency reuse ⇒ more total capacity
  - E.g., with 2 GHz spectrum, «7 color» reuse (see figure), if you cover an area with 100 beams vs. with 50 beams, you get 28.6 GHz into the coverage are vs. 14.3 GHz
  - To make this happen, one approach is a phased array or array fed reflector
  - Combined with flexibility, this may mean digital beamforming

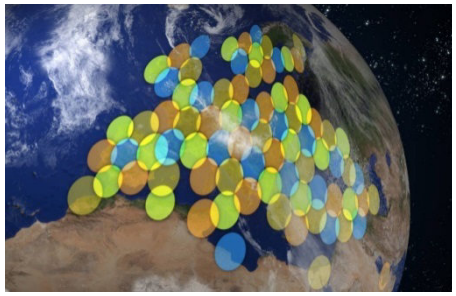


Q-/V-Band: The Idea

- High-throughput satellites (HTS) typically operate at Ka-band with two types of beam: user (traffic to and from users) and gateway (to route traffic to terrestrial internet infrastructure
- Today there are two approaches to cover gateways:
  - Re-use Ka-band spectrum over gateways (e.g., KA-SAT)
  - Put gateways in a location with no user beams (e.g., ViaSat-1)
- Both approaches sacrifice user capacity (up to 25%)
- The idea is to use new spectrum (Q-/V-band) to cover gateways

ViaSat-1 eliminates user beams where there are gateways





KA-SAT re-uses same Ka-band spectrum for gateways

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LEO constellations hot topic

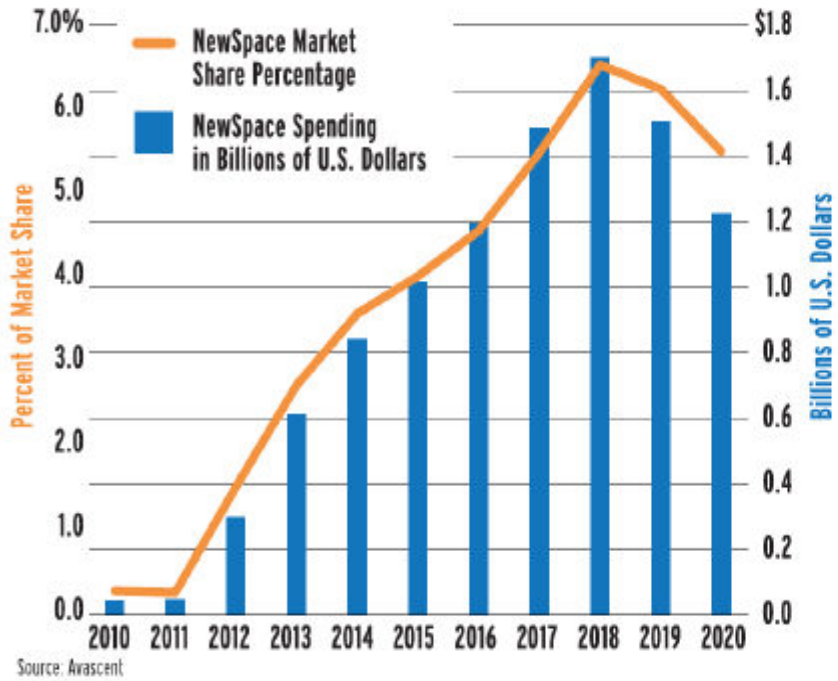
- FSS operators are assessing this solution
- New paradigm in manufacturing
- Interference concern with existing Ku-band GEO satellites
- Possible increase of orbital space debris a concern
- Today, 20% of applications are according to one operator latency dependent i.e. for most applications 25 ms delay is not a big deal.
- Terminals are biggest concern for LEO systems

NewSpace

Sure, NewSpace is a big deal

But don't make too much of the numbers

NewSpace accounts for thin slice of satellite market



Even if the NewSpace slice of the satellite manufacturing market doubles in the next decade, it will remain a tiny portion of an industry dominated by massive communications satellites.

Between 2010 and 2013, the market for satellites weighing less than 300 kilograms designed for commercial remote sensing, communications and meteorology missions in low Earth orbit climbed from one percent to two percent of the overall market, according to data compiled by Avascent. In the next decade, the NewSpace portion of that market should continue to expand.

"We don't forecast that it will drive growth, but we see it doubling," said **Lori Hammer, Avascent senior product manager.**

Avascent expects the overall spacecraft manufacturing market to grow one to two percent annually between 2016 and 2025. "If you account for inflation that is basically flat," Hammer said.

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HTS – High-throughput satellites
LEO versus GEO

- Why go to large LEO constellations vs. much smaller GEO constellation?
  - Reduce latency
  - Provide polar coverage
  - Access to NGSO spectrum
  - Ability to make each satellite much cheaper (COTS)

- Analysis:
  - Most internet usage is not latency-critical (except VOIP, e.g.)
  - There are very few users on the poles
  - GEO systems have waivers to use NGSO spectrum
  - Do economics really favor large LEO constellations vs. a small number of very powerful GEOs?

Main Technology Trends Affecting the Space Industry

- Automation
- Additive manufacturing
- New semiconductor technologies (GaN and graphene)
- New composites technologies (carbon nanotubes)
- Multifunctional materials
- COTS
- Software defined radios

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