The Globalization of Space

Jonathan McDowell

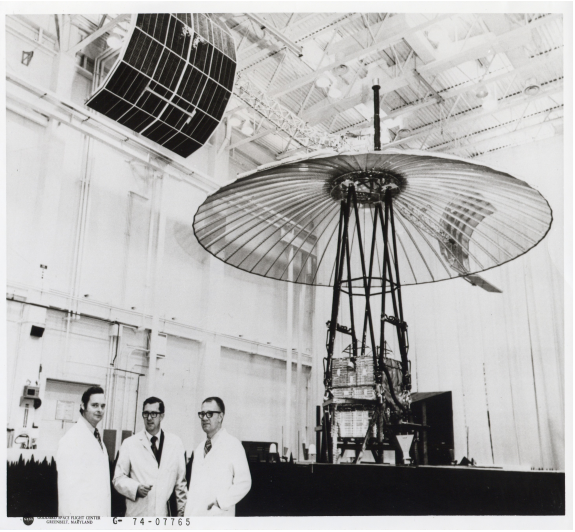
A quick introduction to satellites

About 1000 satellites currently operating
Some in low orbit skimming just outside the atmosphere, mostly going from pole to pole

Some In 'geostationary orbit' in a ring high above the equator

Communications

Earth Imaging

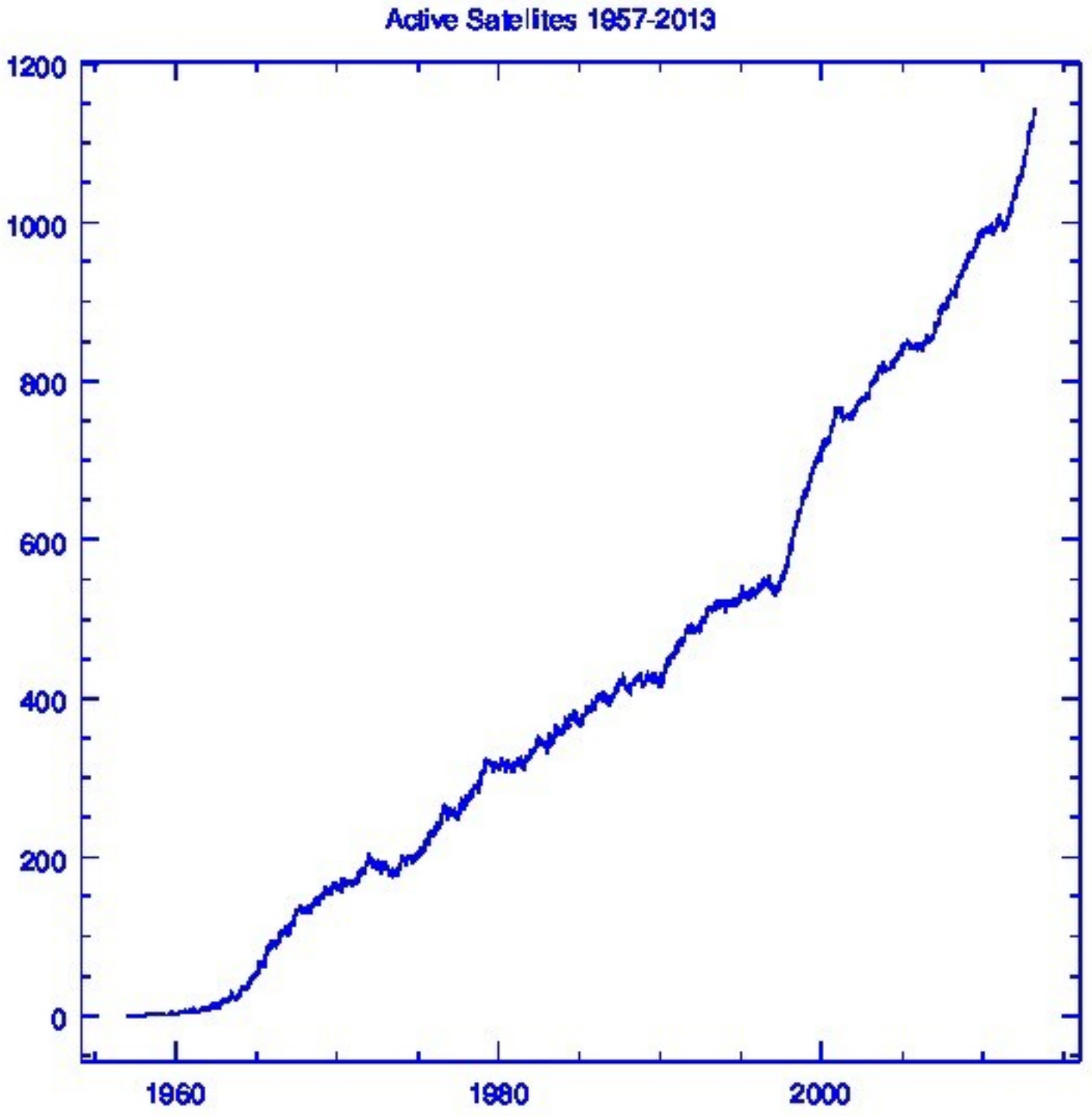


Signals intelligence

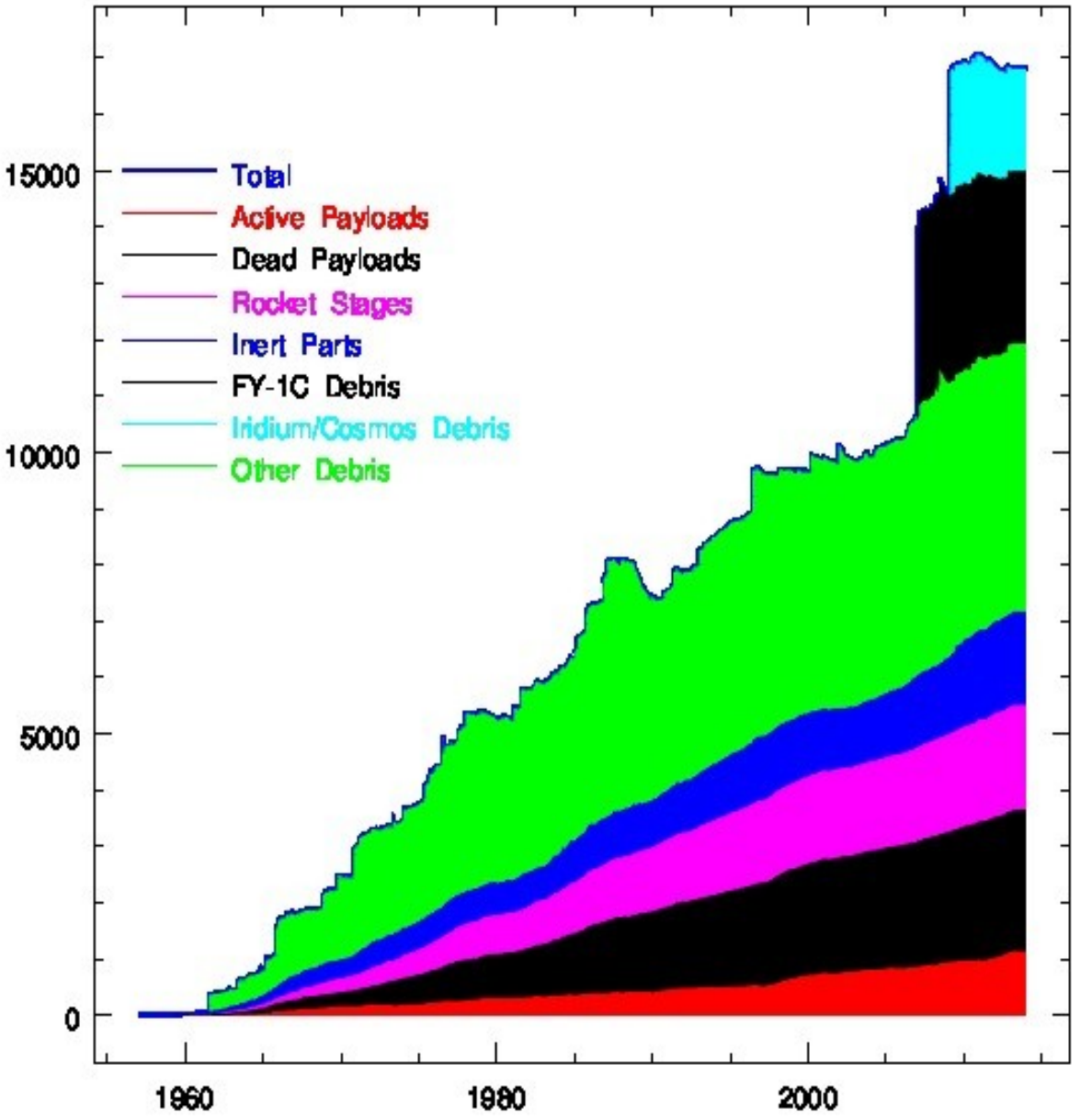
Navigation (GPS)

Science
(e.g. astronomy)

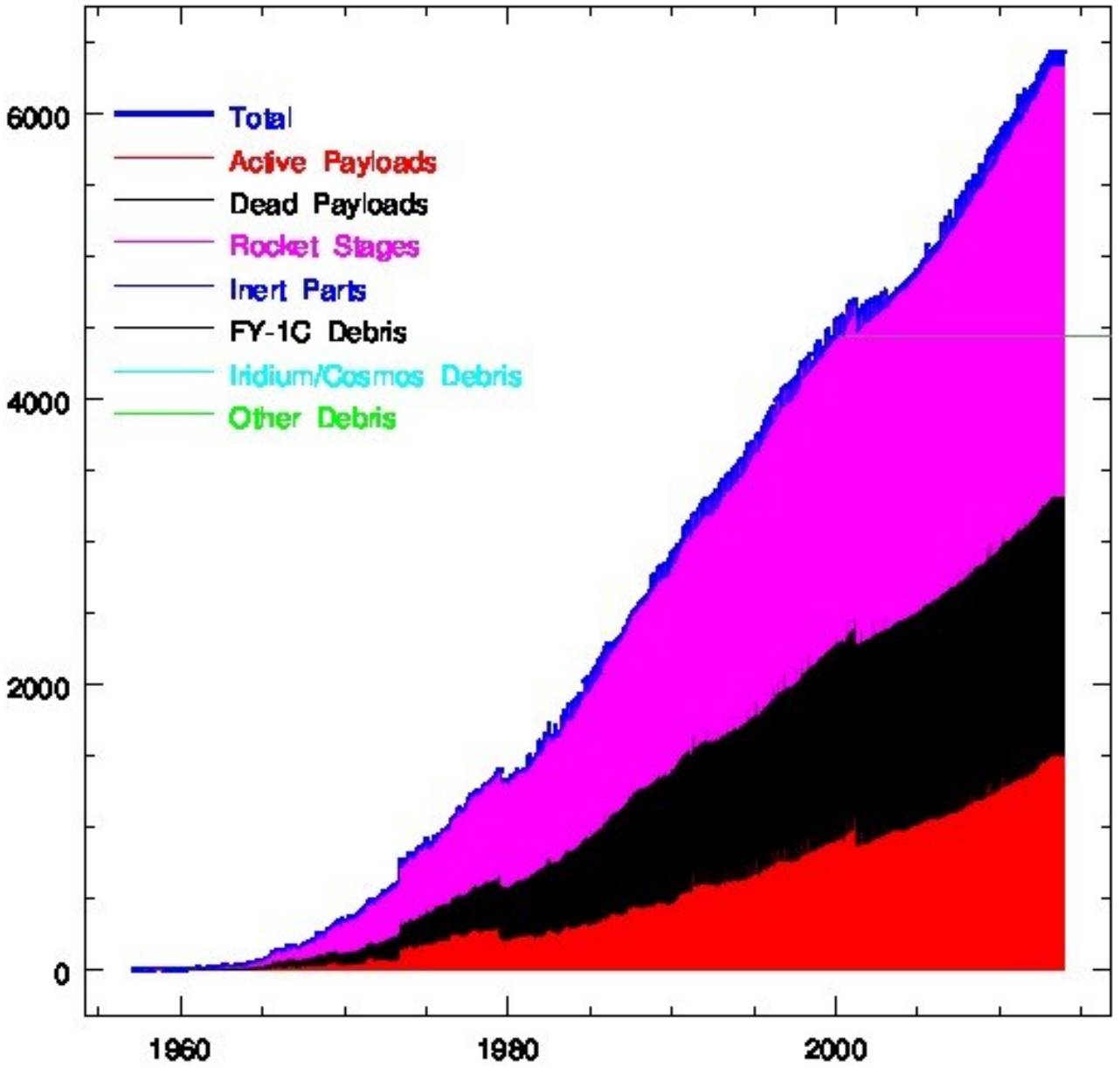
Human spaceflight

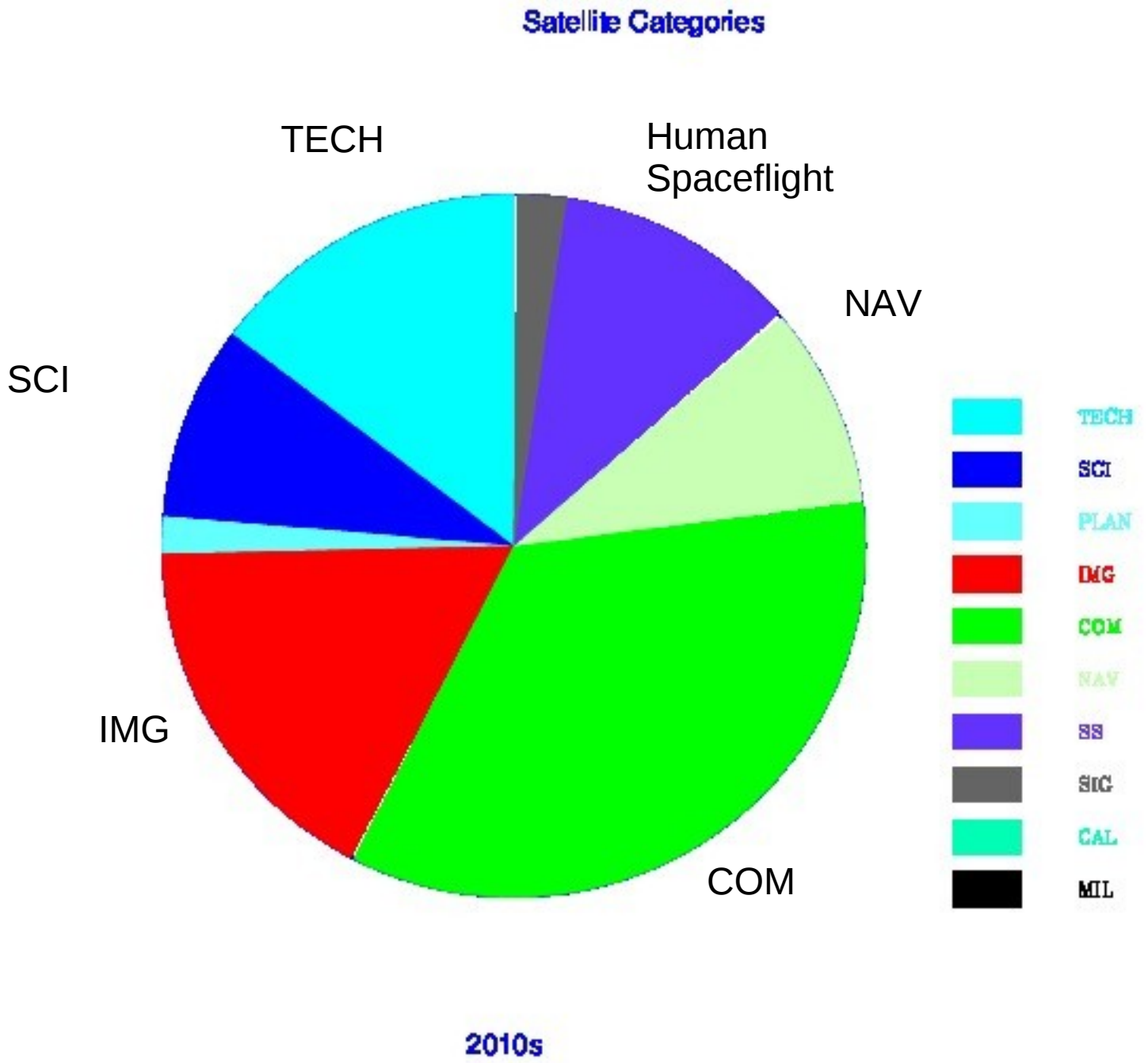

Active Satellites 1957-2013
1200
1000
800
600
400
200
0
1960
1980
2000

The Growth of Space Junk

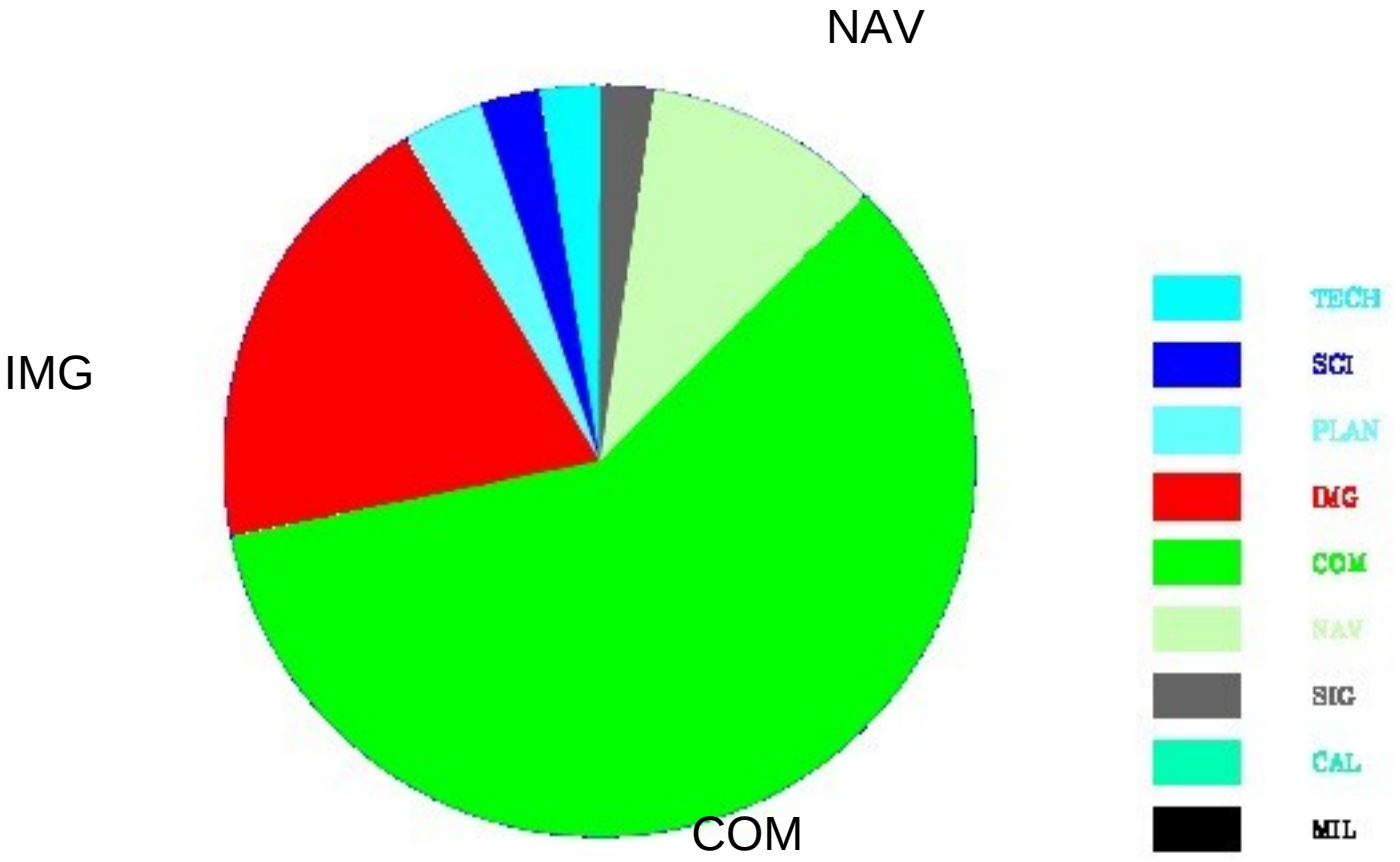


Space Junk - mass in metric tons




Satellite Categories
TECH
Human Spaceflight
NAV
SCI
IMG
COM
TECH
SCI
PLAN
IMG
COM
NAV
SS
SIC
CAL
MIL
2010s

Satellite Tonnage (excluding human spaceflight)

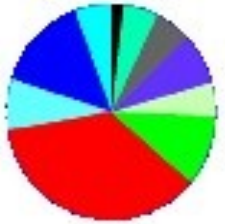


2010s

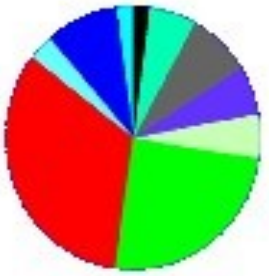
3-yr total 700 t robotic, 1000 t 6 x Shuttle + ISS/PRC

Satellite Categories

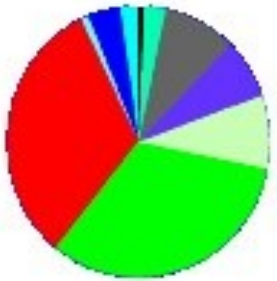
1950s



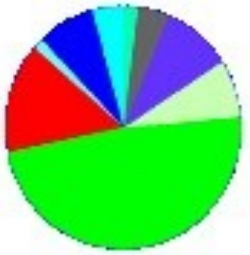
1960s



1970s



1980s

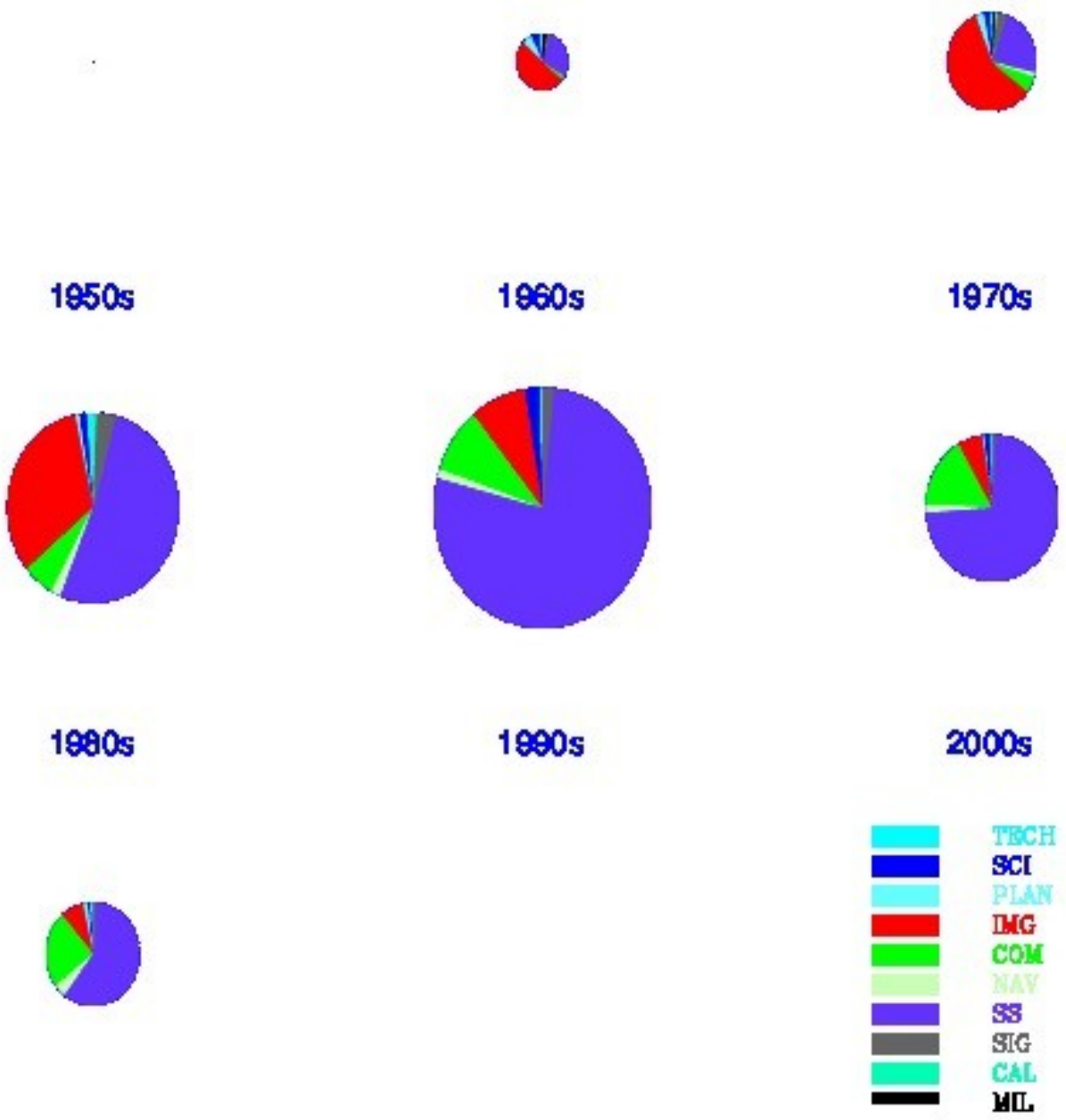


1990s

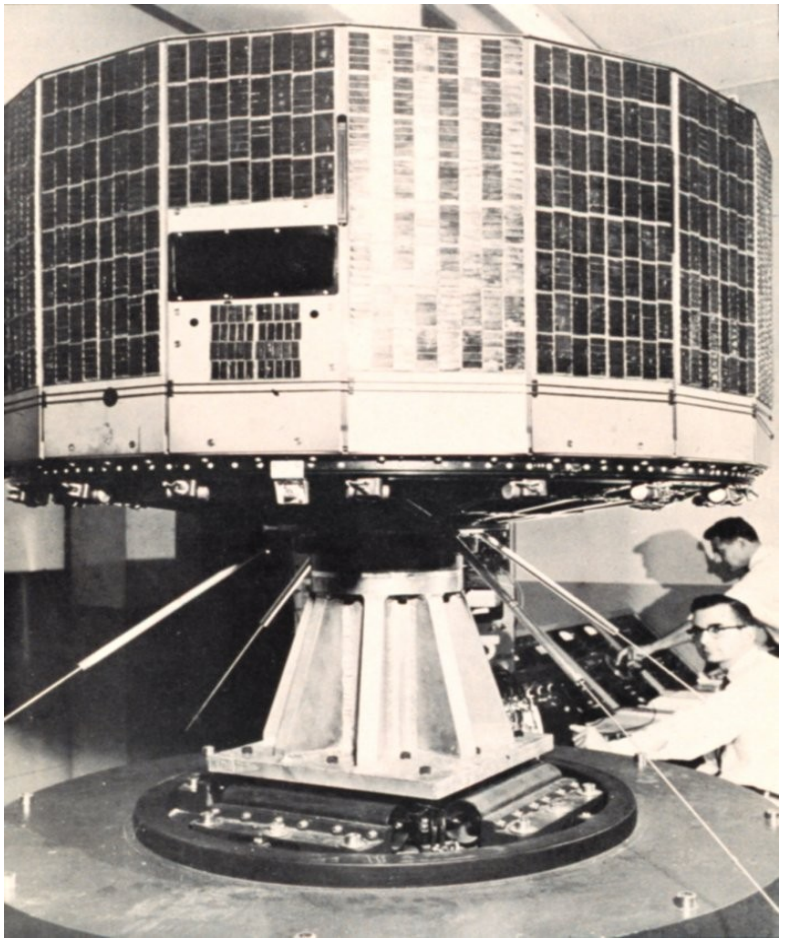
2000s

2010s

Satellite Tonnage



We still think of space the way it was in the 1960s

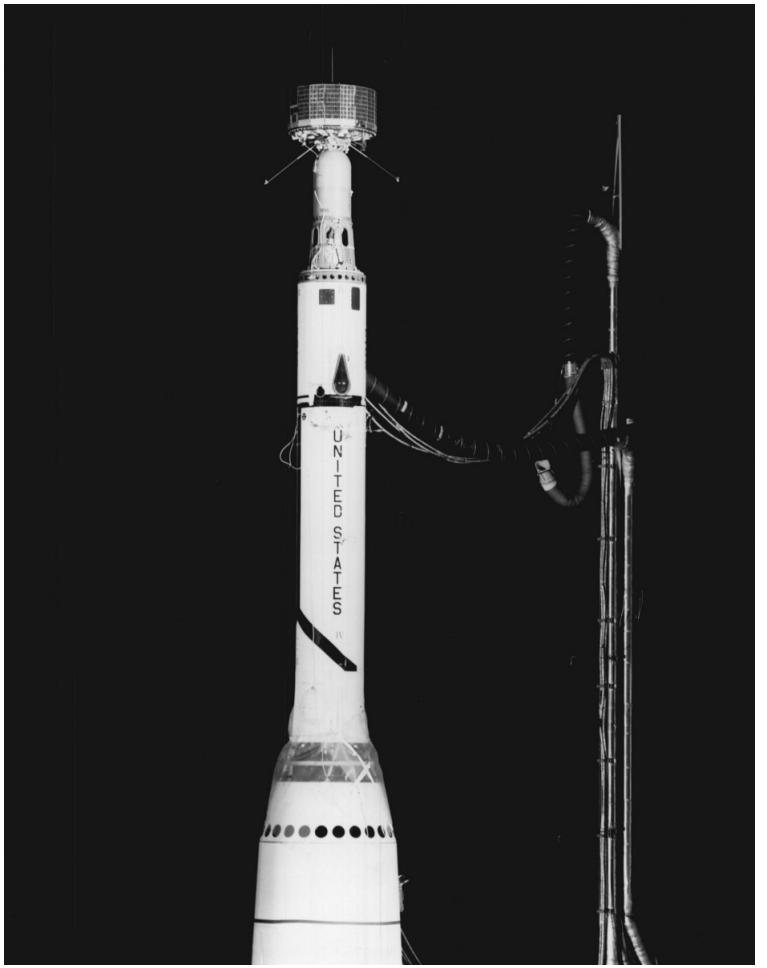


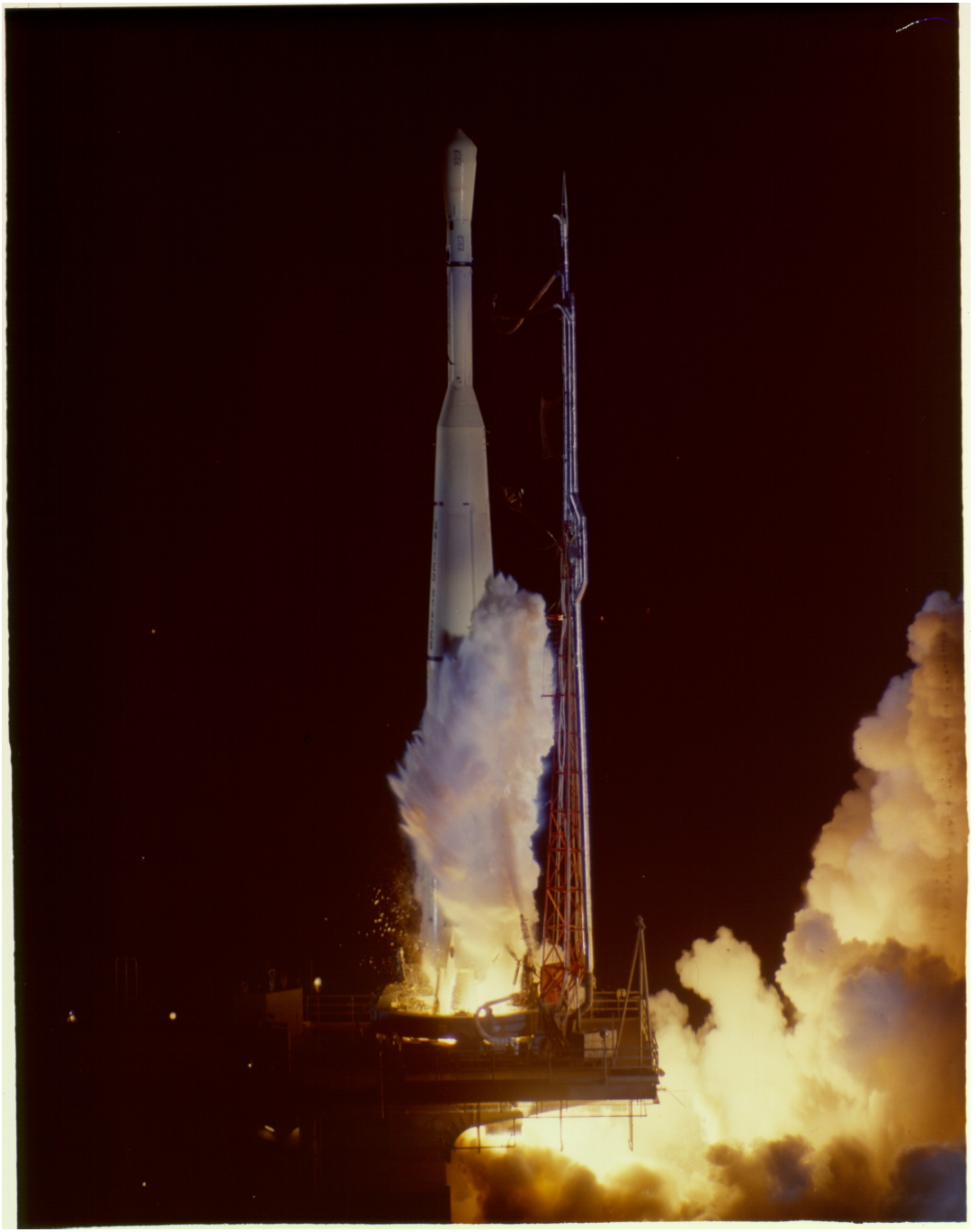
Here, the TIROS weather satellite is assembled by a US manufacturer – in this case, RCA in East Windsor, NJ

Another US company, Douglas Aircraft, builds the Thor Delta rocket.

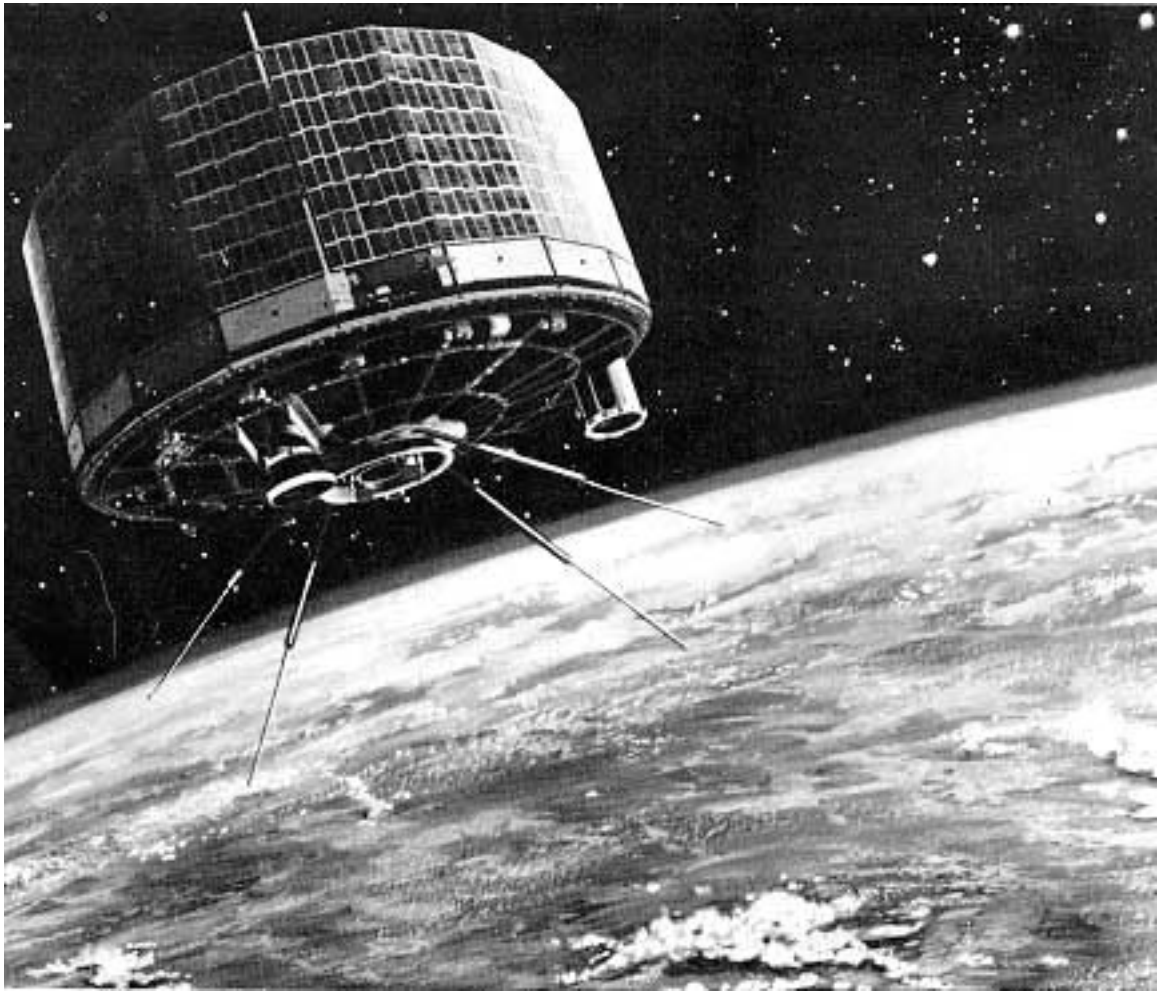
The satellite is delivered to its owner, the US civil space agency NASA, who also buy the rocket.

Here is TIROS 2 on top of the rocket before the nose cone is added





Here, the NASA Delta launches TIROS 2 into space from a launch site on US territory – in this case, Cape Canaveral, FL



And the satellite operates in orbit under the ownership of NASA, using a NASA mission control center in Greenbelt, MD

1962 – Ariel 1, a UK owned, US built satellite with UK instrumentation

(1964's Ariel 2 carried the first – and AFAIK so far only – Cambridge satellite experiment, for radio astronomy)

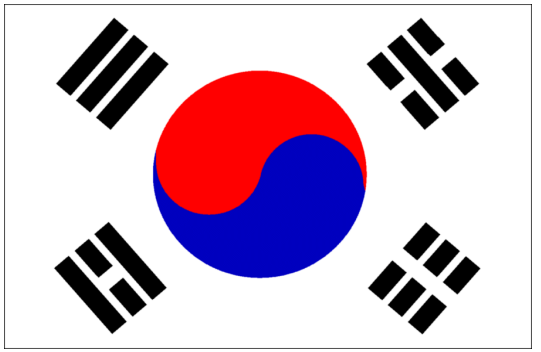
Later in 1962: Canada's Alouette 1 Canadian built and owned

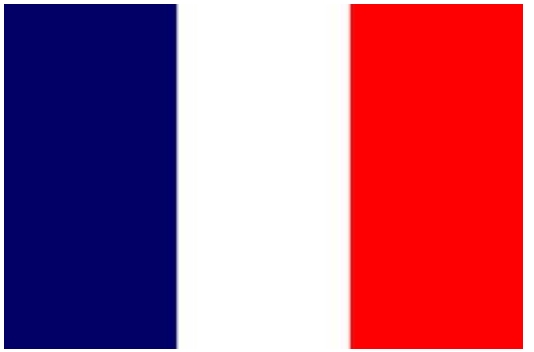
1965:
The first French satellite launch from the Algerian desert

France becomes the third country with orbital launch capability after the USSR and the USA

But it's not like that any more!

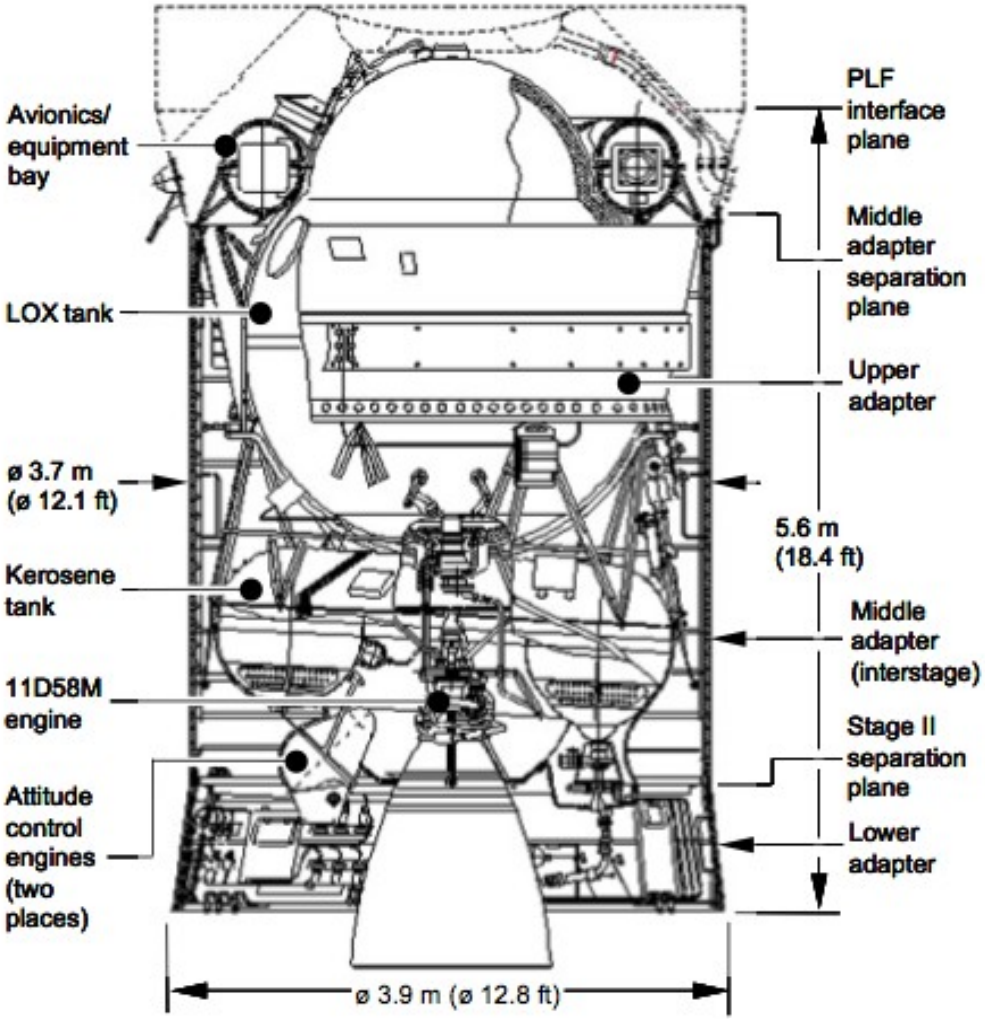
South Korea's Koreasat-5 satellite takes shape in the Thales Alenia factory in Cannes, in the south of France



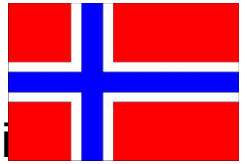


In the Ukraine, the Yuzhnoe company builds the Zenit-2S rocket

Block DM-SL (without interstage)



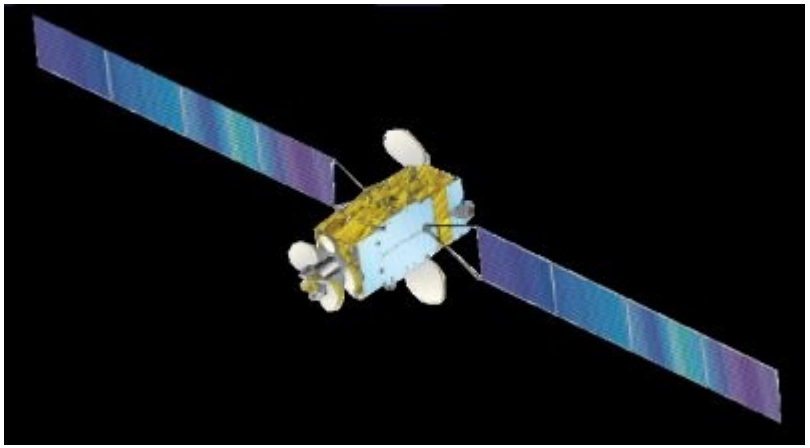
In Korolev, near Moscow, the Rocket Space Corporation “Energiya” builds the Blok DM-SL upper stage rocket

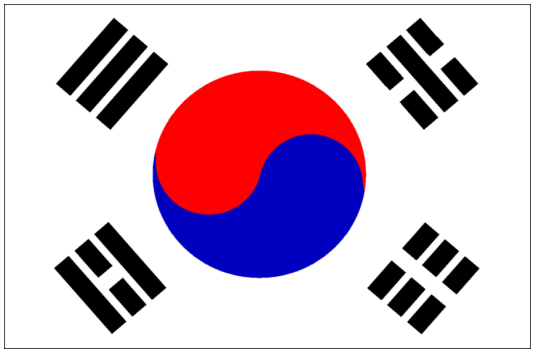


At Sea Launch home port in Long Beach, California, the satellite and Zeni rocket are loaded on the Norwegian-built floating launch platform

The platform then sails out in the Pacific to the Equator – in international waters

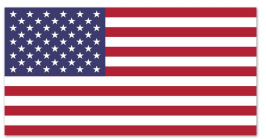
The Zenit rocket puts the Koreasat-5 in orbt
where it is operated via the mission control center in S Korea
with support from engineers in France

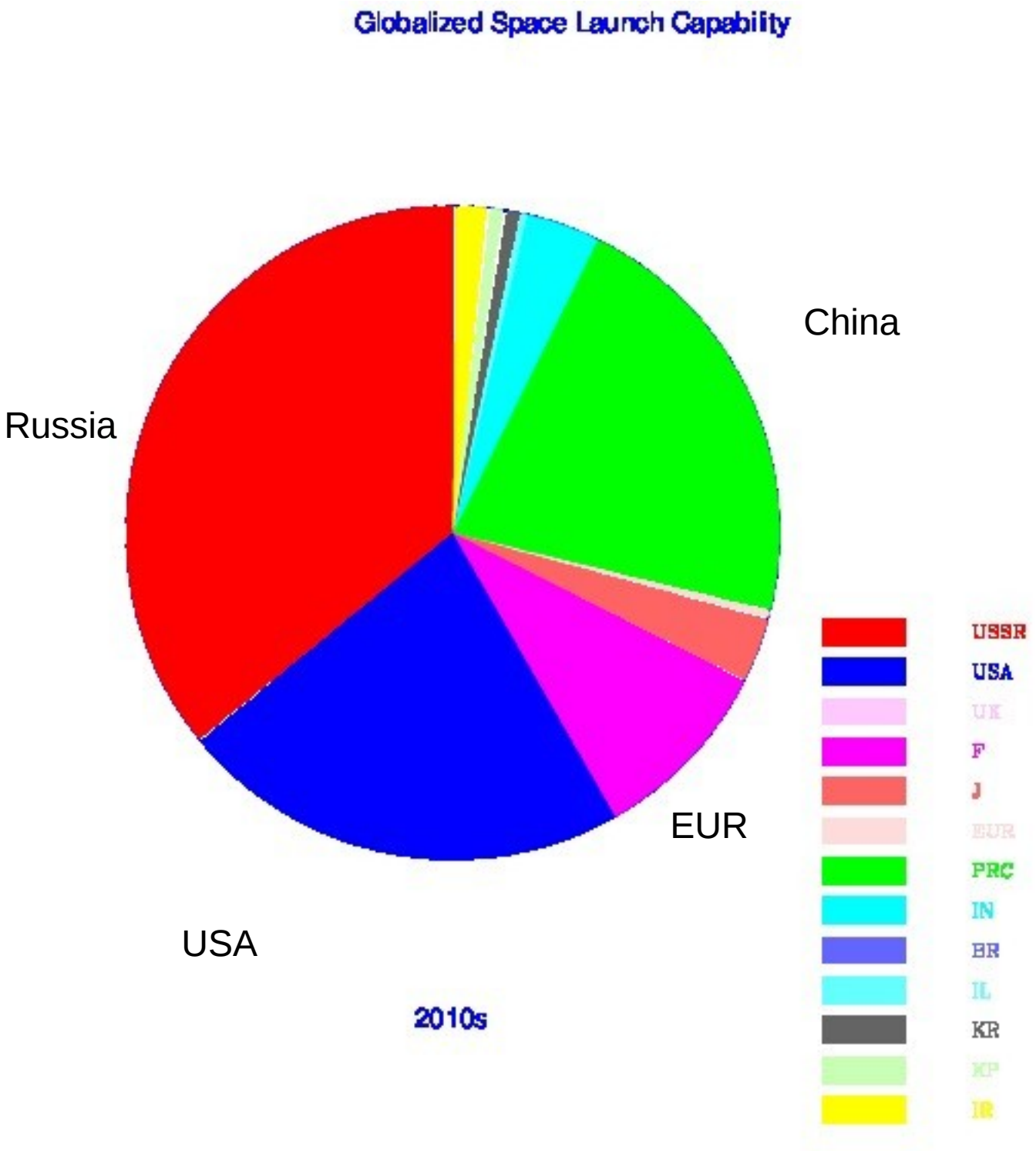




The rocket launch is carried out by Energia Logistics (US), a US subsidiary of RSC Energiya. The launch is sold to the satellite owner by Sea Launch AG of Bern

I count this as a US launch!





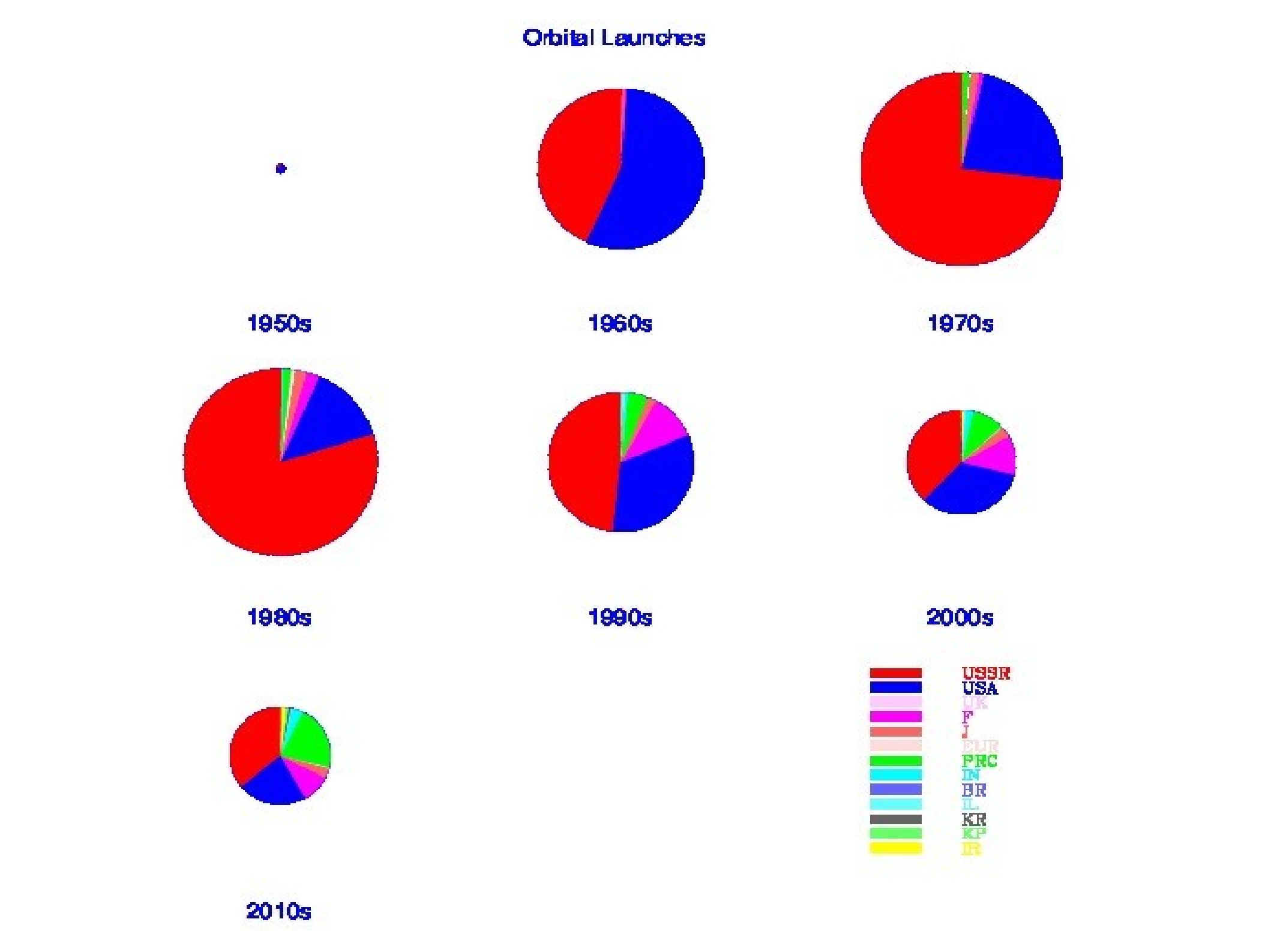
Today the space launch market has many more players

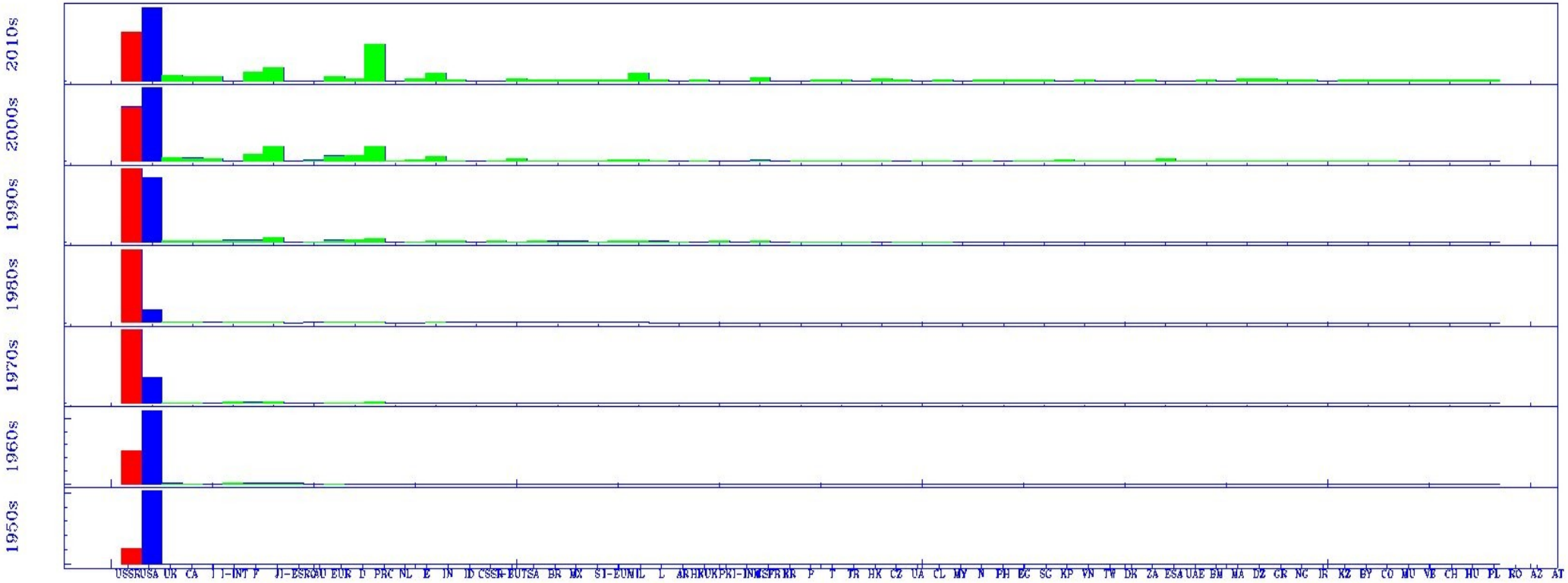
In 2012 China had as many orbital launch attempts as the US

12 countries plus ESA/Arianespace have launched satellites; Brazil has also tried but failed.

North and South Korea are the latest members of the club

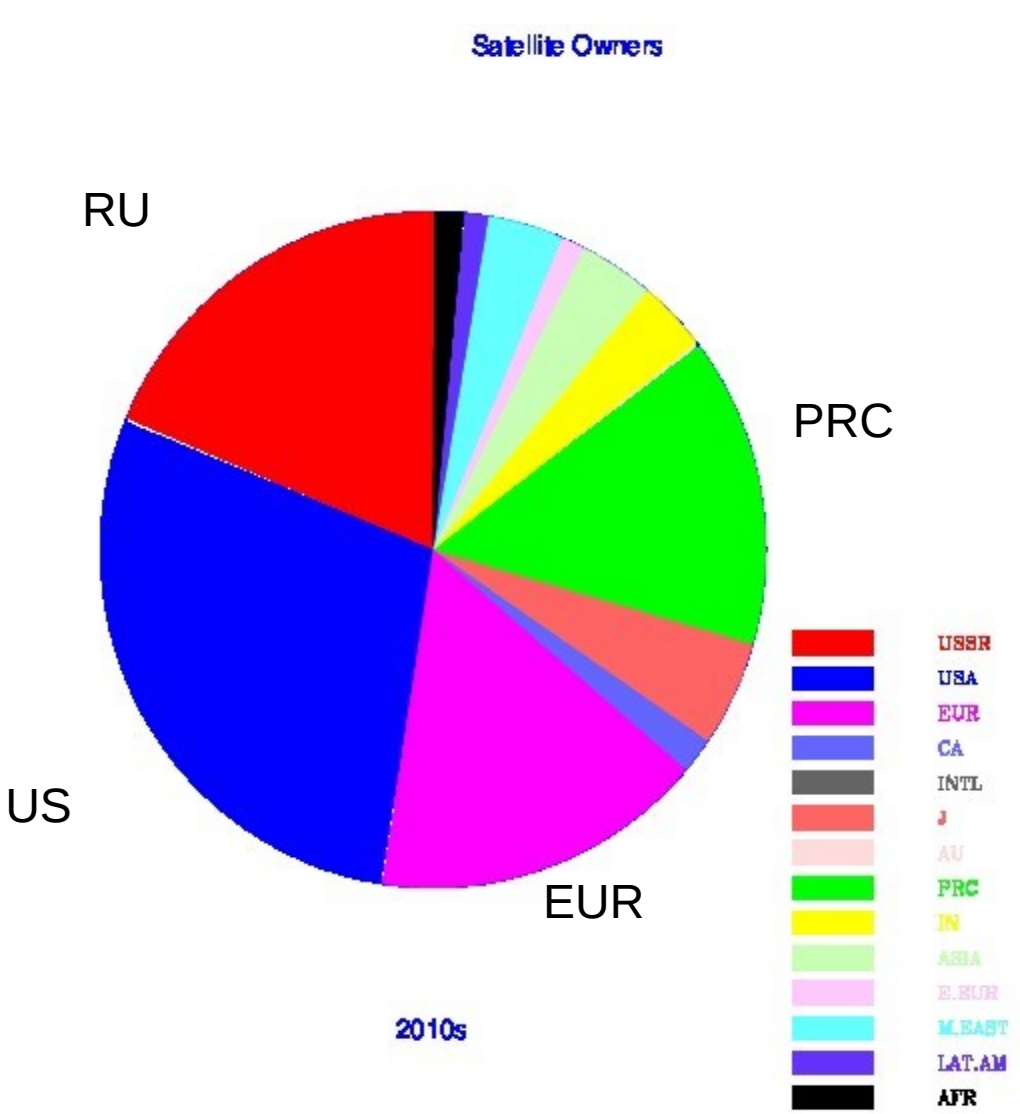
Orbital Launches

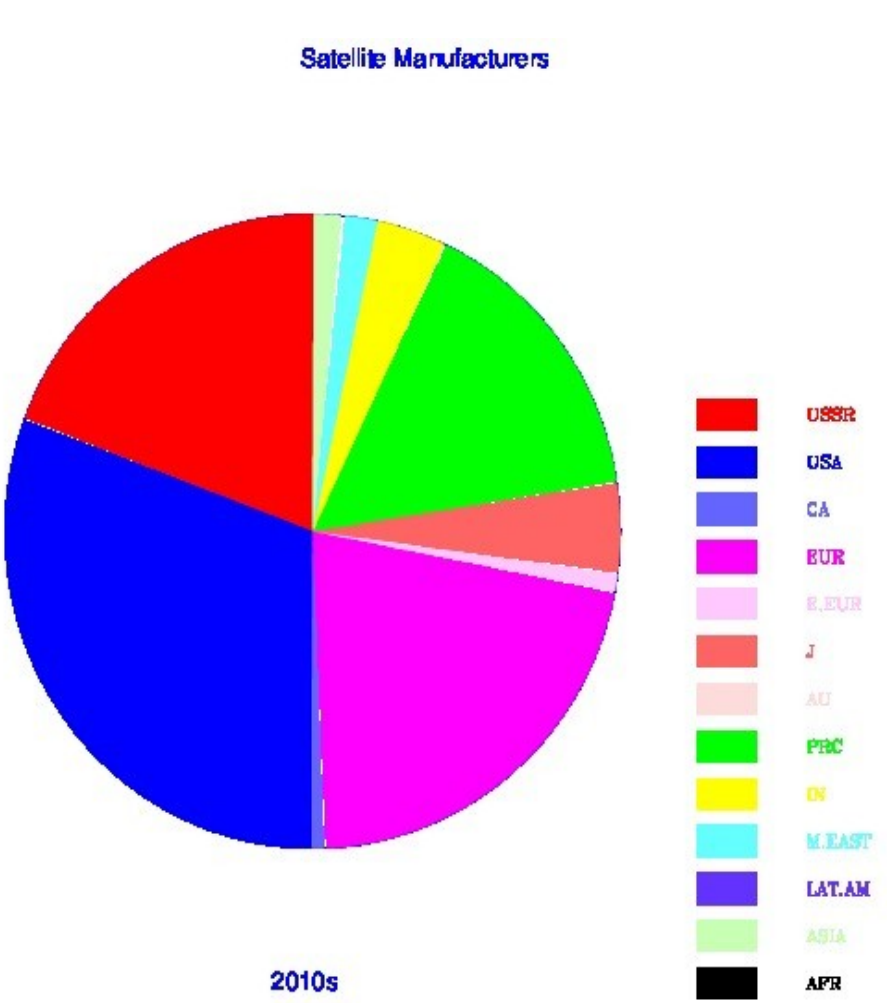




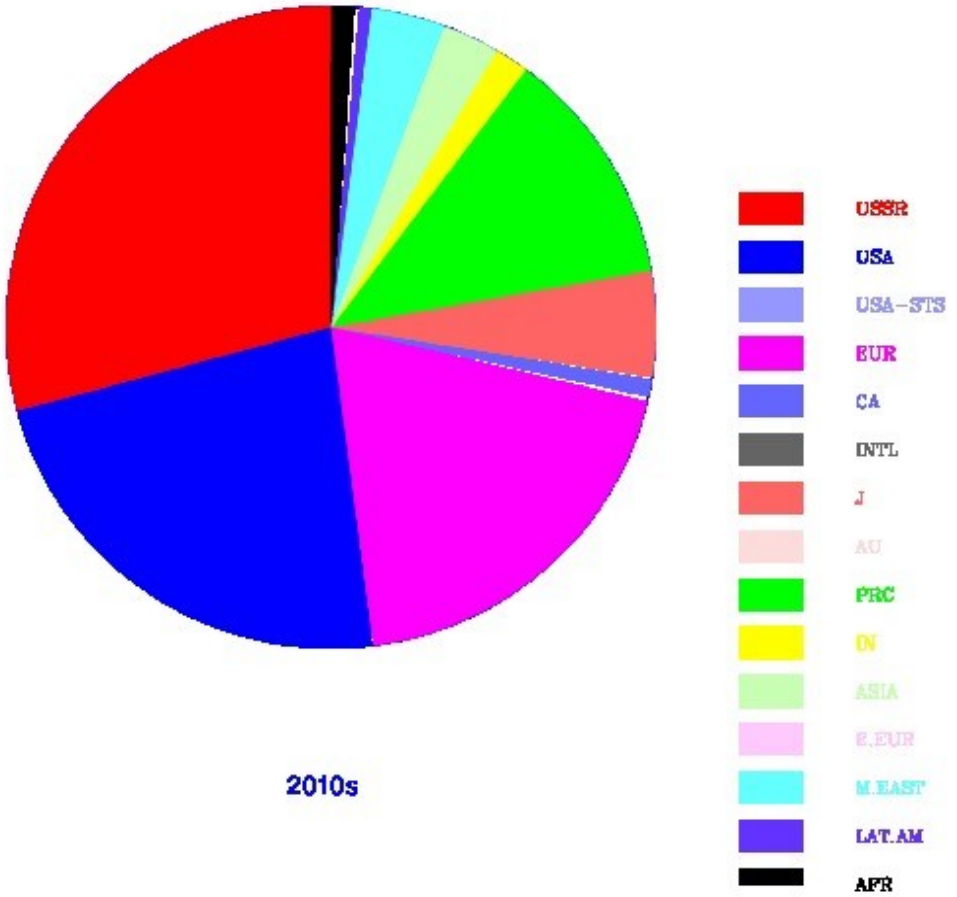
If we look at the 68 parent countries of satellite OWNERS, the pie chart doesn't cut it
Neither does this set of histograms really...

Instead, let's pick out the main players and lump the rest per continent


Satellite Owners
RU
PRC
US
EUR
2010s
USSR
USA
EUR
CA
INTL
J
AU
PRC
IN
ASIA
E.EUR
M.EAST
LAT.AM
AFR


Satellite Manufacturers
2010s
USSR
USA
CA
EUR
E.EUR
J
AU
PRC
IN
M.EAST
LAT.AM
ASIA
AFR

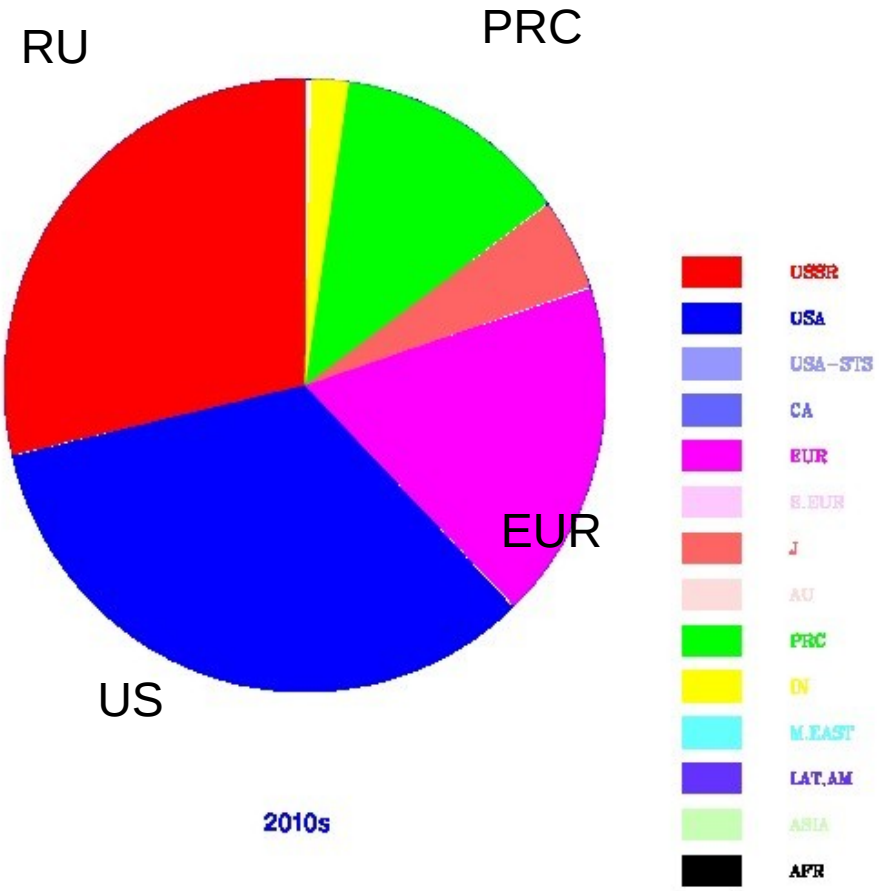
Satellite Tonnage by Owner Country



2010s

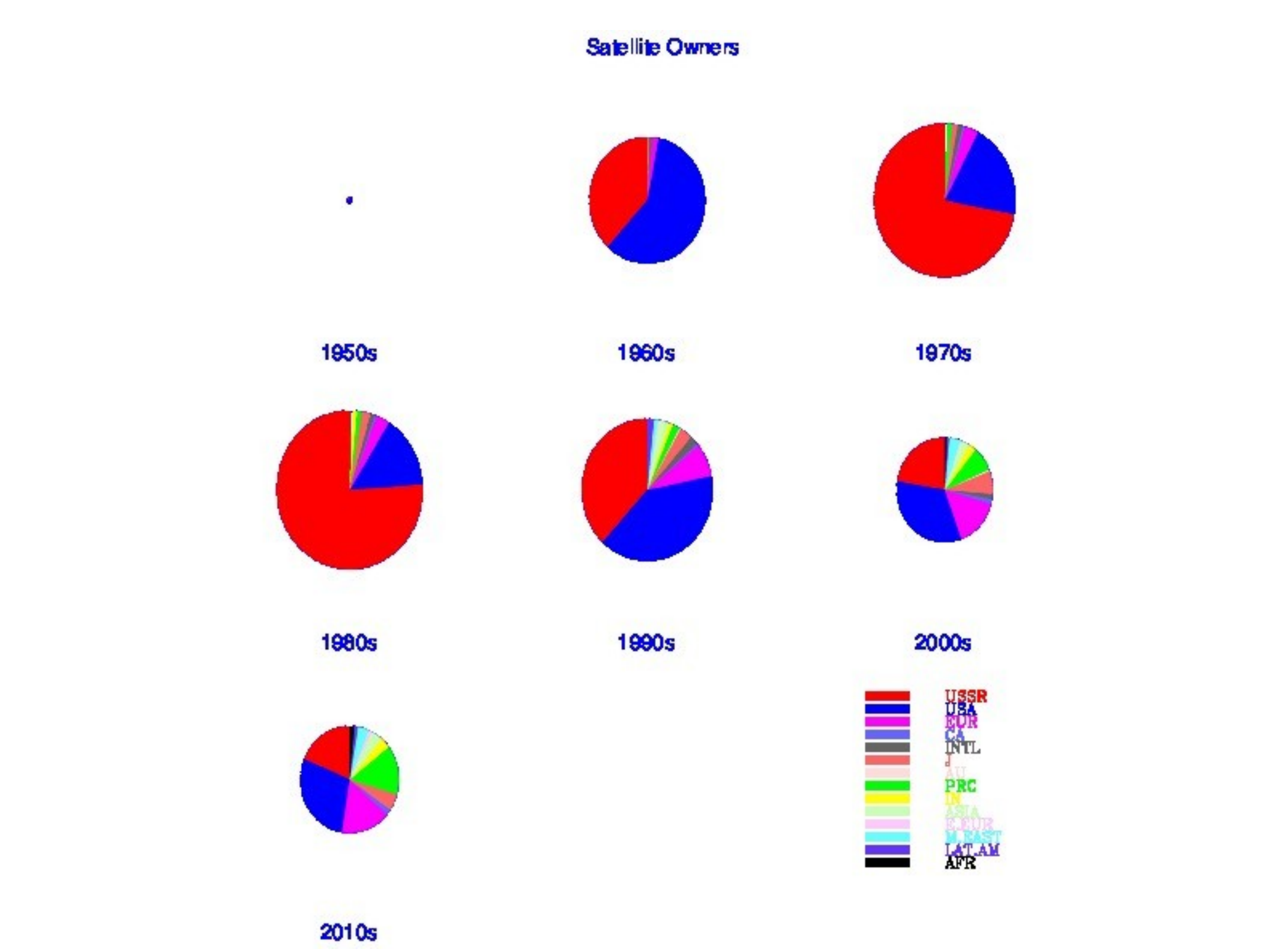
Excludes Shuttle

Satellite Tonnage by Manufacturer Country



2010s

Excludes Shuttle


Satellite Owners
1950s
1960s
1970s
1980s
1990s
2000s
2010s
USSR
USA
EUR
CA
INTL
J
AU
PRC
IN
ASIA
E.EUR
M.EAST
LAT.AM
AFR

The commercialization of space

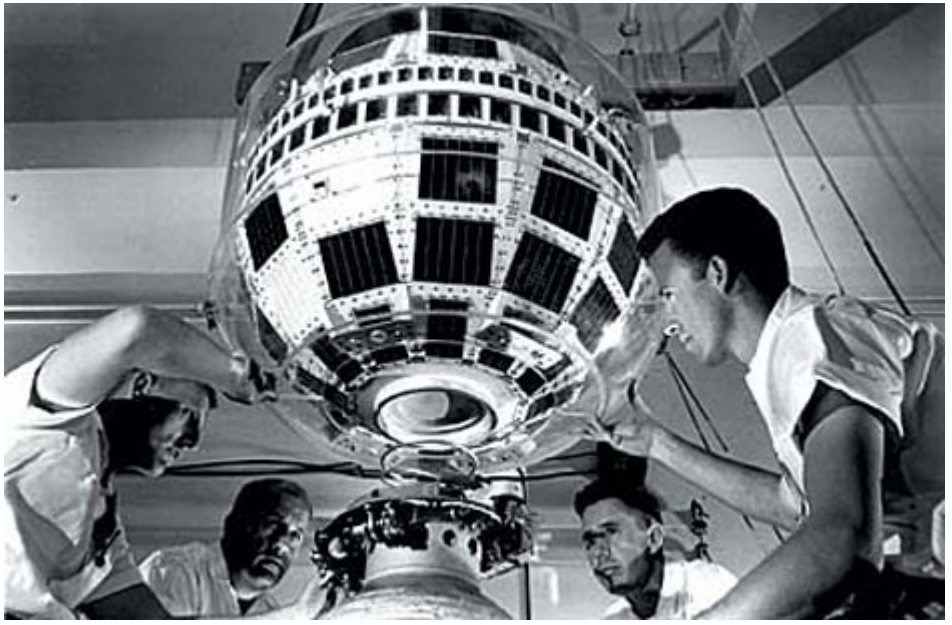
In the era of government space programs, commercial enterprises were involved early on as manufacturers (contractors)

In the USA, the early-lab built Explorer and Vanguard satellites from JPL and the Naval Research Laboratory were soon followed in 1959 by satellites built by Lockheed (CIA CORONA) and TRW (NASA/USAF Able Probes)
RCA, McDonnell, General Electric and Ball Brothers soon followed

The space rockets, like their military ballistic missile siblings, also moved from the Army-Huntsville and Navy-NRL workshops to the factories of Chrysler (REDSTONE), Martin (VANGUARD), Douglas (Thor) and Lockheed (Agena)

In the Soviet Union, the Design Bureaus of Korolev, Yangel and Chelomey acted in some ways like the independent corporations they would later become

When Europe and Japan arrived on the space scene, bolstering their respective aerospace industrial concerns was a priority
But for the most part the projects were initiated by and funded by governments - true “commercial space” came later



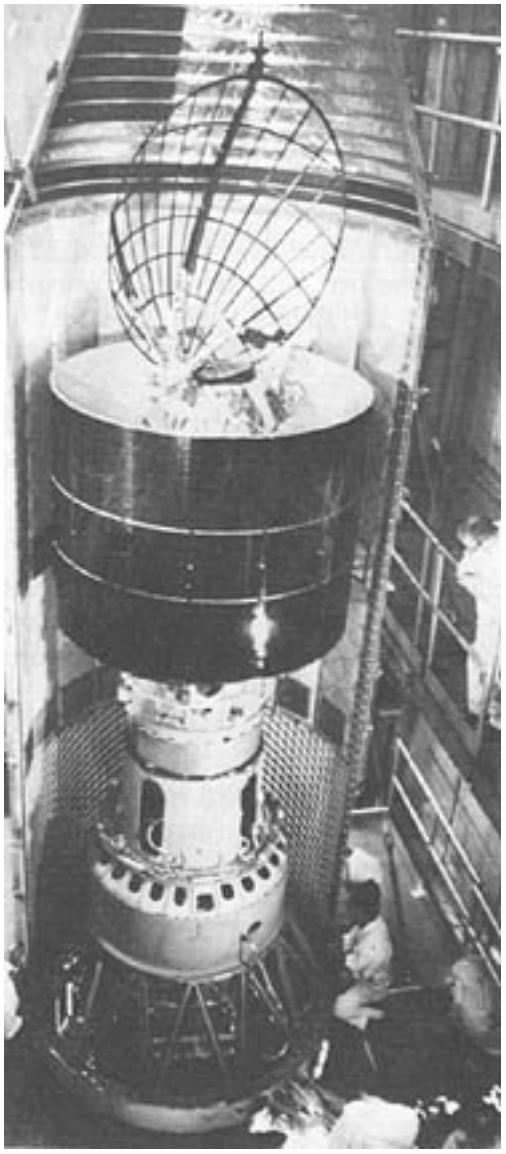
1939

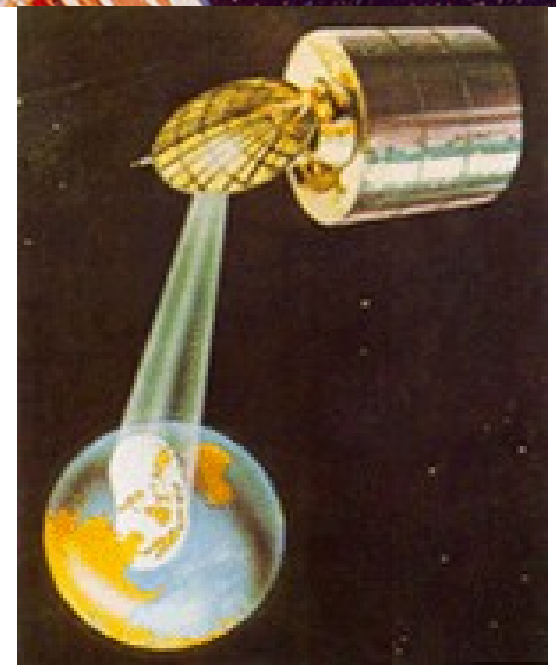
1962-1963

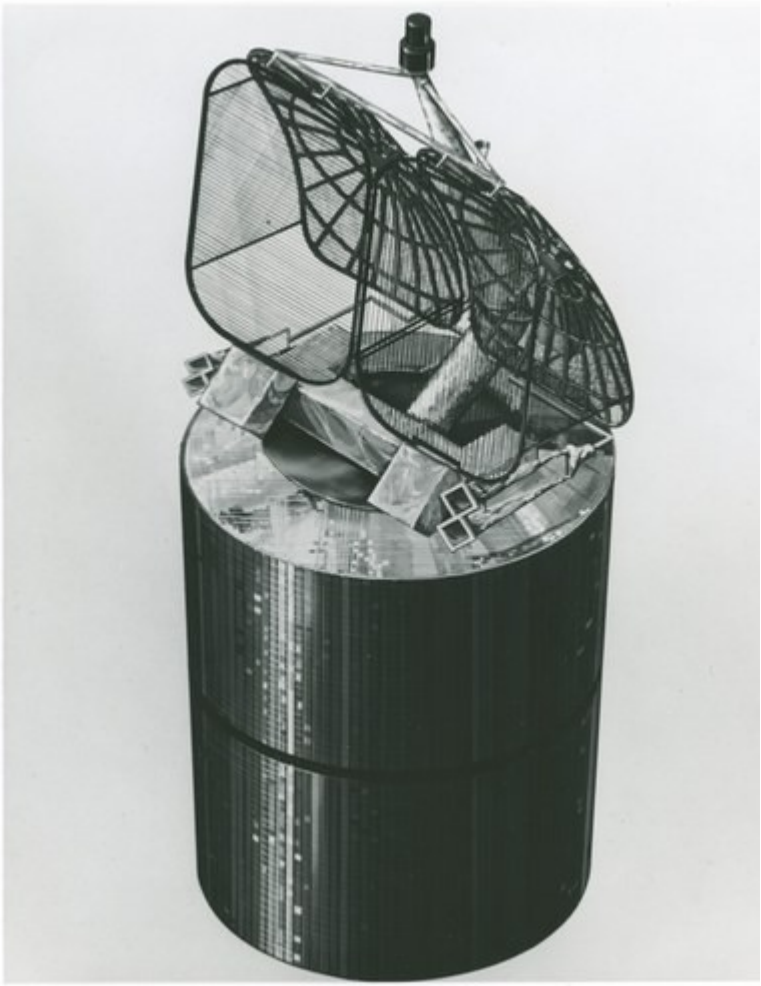
Telstar 1 and 2 – AT&T funded the first commercial communications satellites and paid NASA to launch them

Telstar was not followed up – the next commercial satellite system had to wait for geostationary satellites to be mature.

In 1972 the Canadian company Telesat was established as a commercial enterprise by the Canadian government
The `Anik' system was the first of a rush of first-generation commercial communications satlelites built by Hughes and RCA



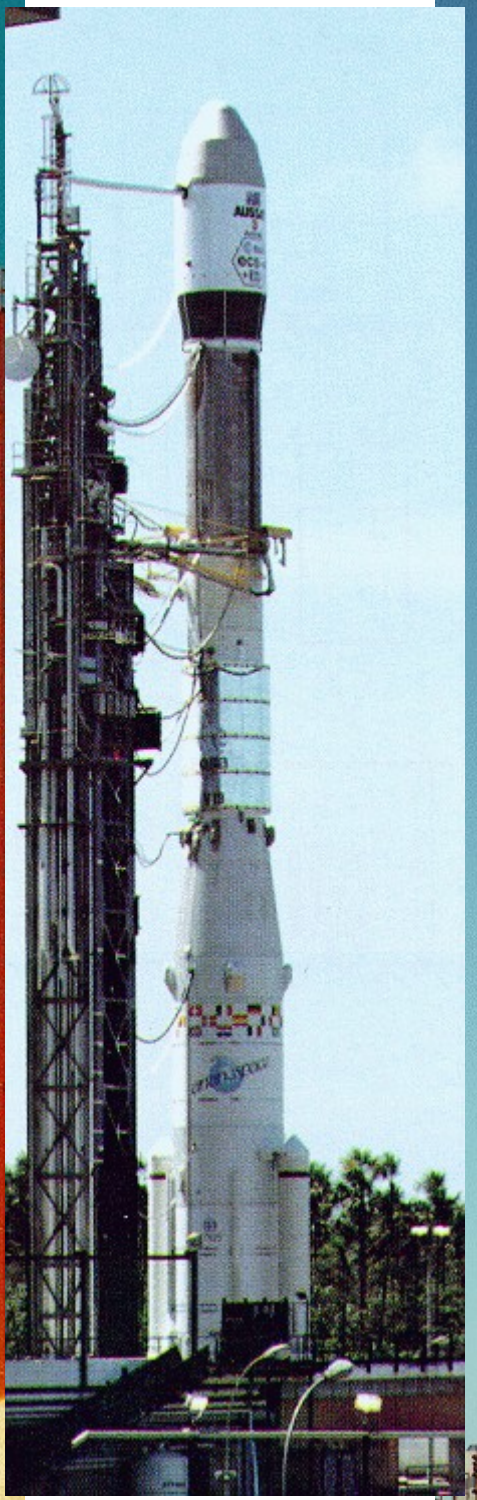




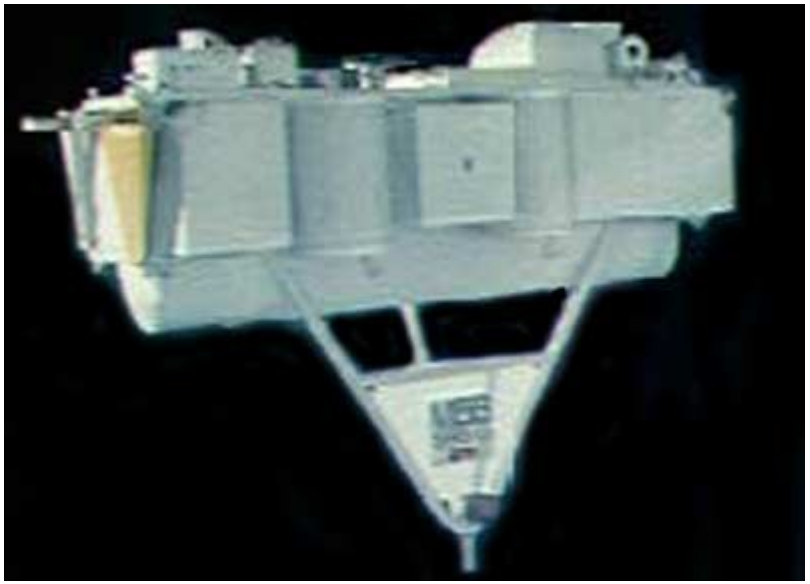
1974: Western Union's Westar
1975: RCA Globcom's Satcom
1976: Comsat General's Marisat and Comstar
1976: Perumtel of Indonesia's Palapa

In the 1980s government civilian orbital launches by NASA and ESA were replaced by commercial launch services by McDonnell Douglas (now Boeing), General Dynamics (now Lockheed Martin) and Arianespace

Apart from the Space Shuttle, NASA hasn't launched a satellite itself since 1994



In the 1990s a commercial microgravity market began but didn't really take off – hopes of industrial scale manufacturing in space remain a science fiction dream for now



German company MBB flew the SPAS experiment on Shuttle missions

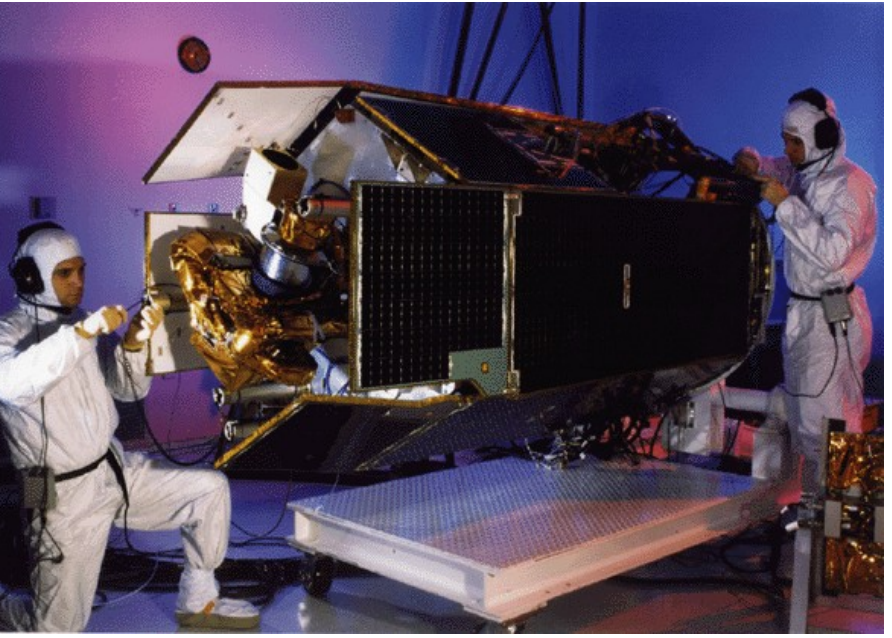
Wake Shield Facility – Shuttle payload

Foton – Russian recoverable microgravity satellite

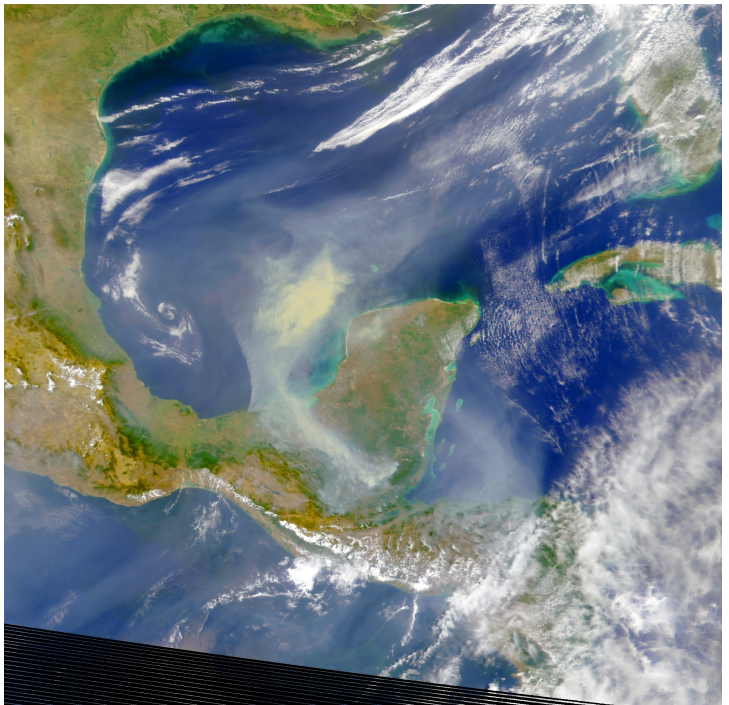
The US govt attempted to create a commercial imaging satellite market for many years

In 1985 operation of Landsat 4 and 5 was turned over to the private company EOSAT – although the govt. retained ownership

The French company SPOT IMAGE was created for commercial sales of the French space agency's imaging satellite SPOT 1



Commercial Earth imaging satellite – ORBIMAGE's Orbview-2/Seastar Launched 1997



Today commercial imaging satellites are familiar thanks to Google maps!

In the 2010s, commercialization began to extend to human spaceflight
SpaceX's latest Dragon cargo ship reached the Station on Mar 2

With the globalization of corporations, space commercialization becomes space globalization

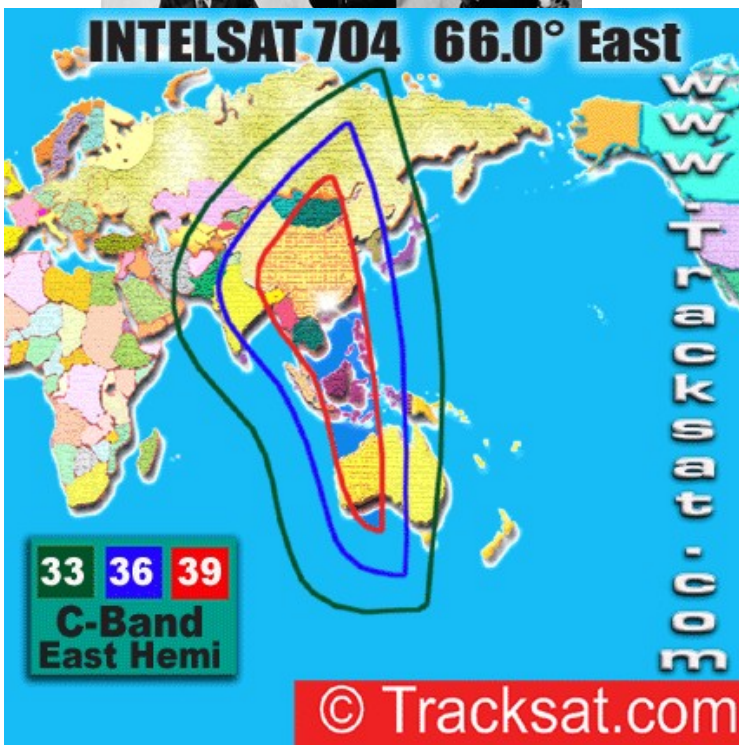
SES (Societe Europeene des Satellites)
- Based Luxembourg, 1985 (first satellite 1988)
- Absorbed RCA Americom (New Jersey) 2001
  (Absorbed GTE Spacenet 1994)
- Abosrbed GE Capital (Gibraltar) 2001
- Absorbed Nordic Satellite (Stockholm) 2005
- Absorbed New Skies (The Hague) 2006
  (spun off from INTELSAT in 1998)
- Stake in Nahuelsat (Argentina), Quetzsat (Mexico)
- Former stake in Asiasat (Hong Kong) and Star One (Brazil), etc.

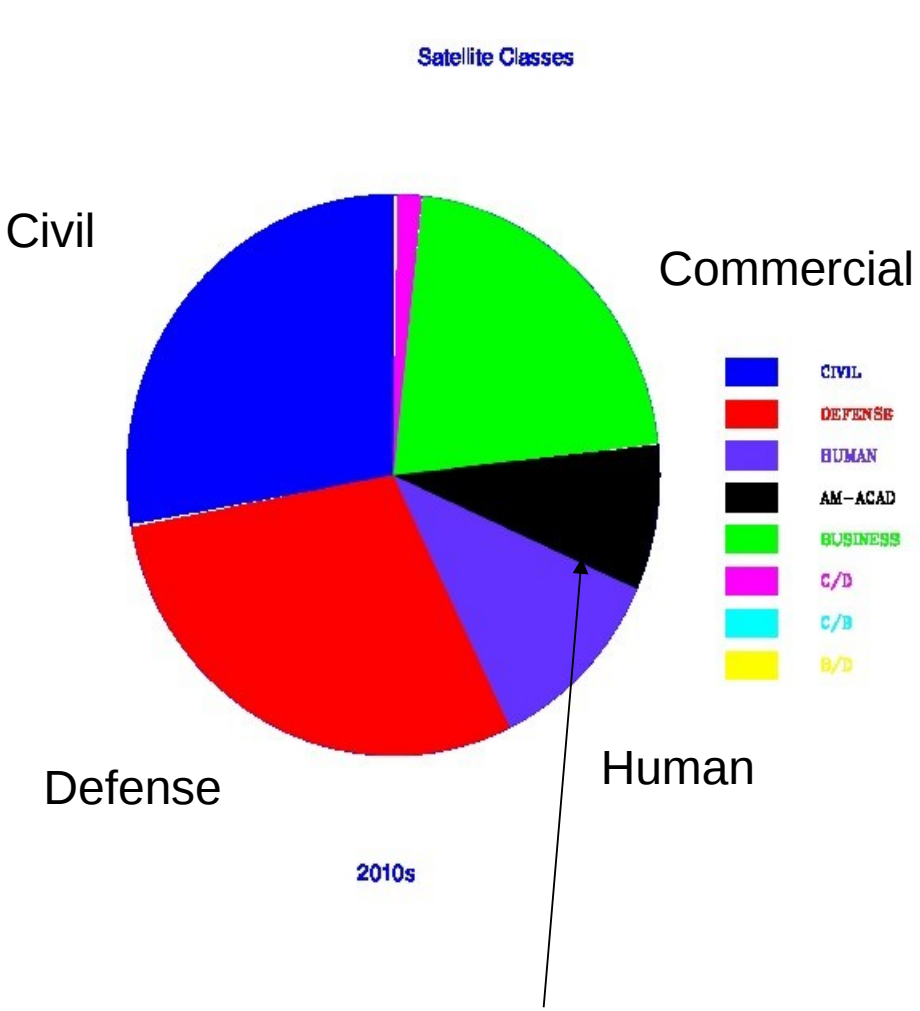
SES ASTRA
An SES GLOBAL Company

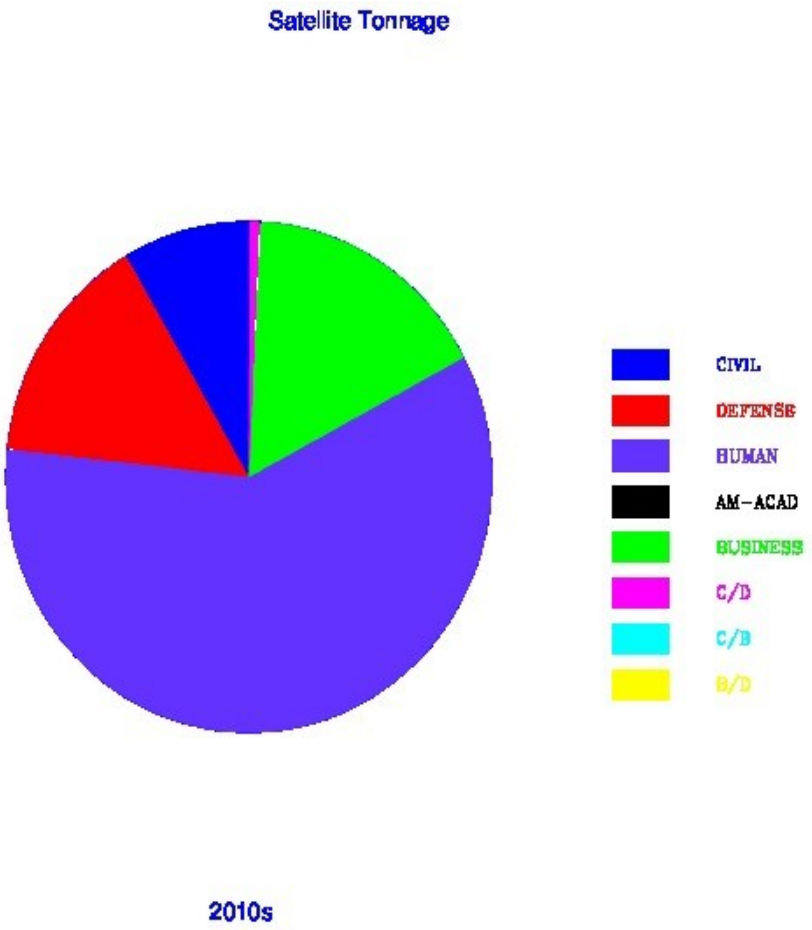
The INTERNATIONAL TELECOMMUNICATIONS SATELLITE ORGANIZATION
- in the 1960s, an IGO
Now 149 member countries

Intelsat

Operations privatized in 2001
Headquarters in Bermuda until 2009, then Luxembourg




Satellite Classes
Civil
Commercial
Defense
Human
Non-profit
CIVIL
DEFENSE
HUMAN
AM-ACAD
BUSINESS
C/D
C/B
B/D
2010s


Satellite Tonnage
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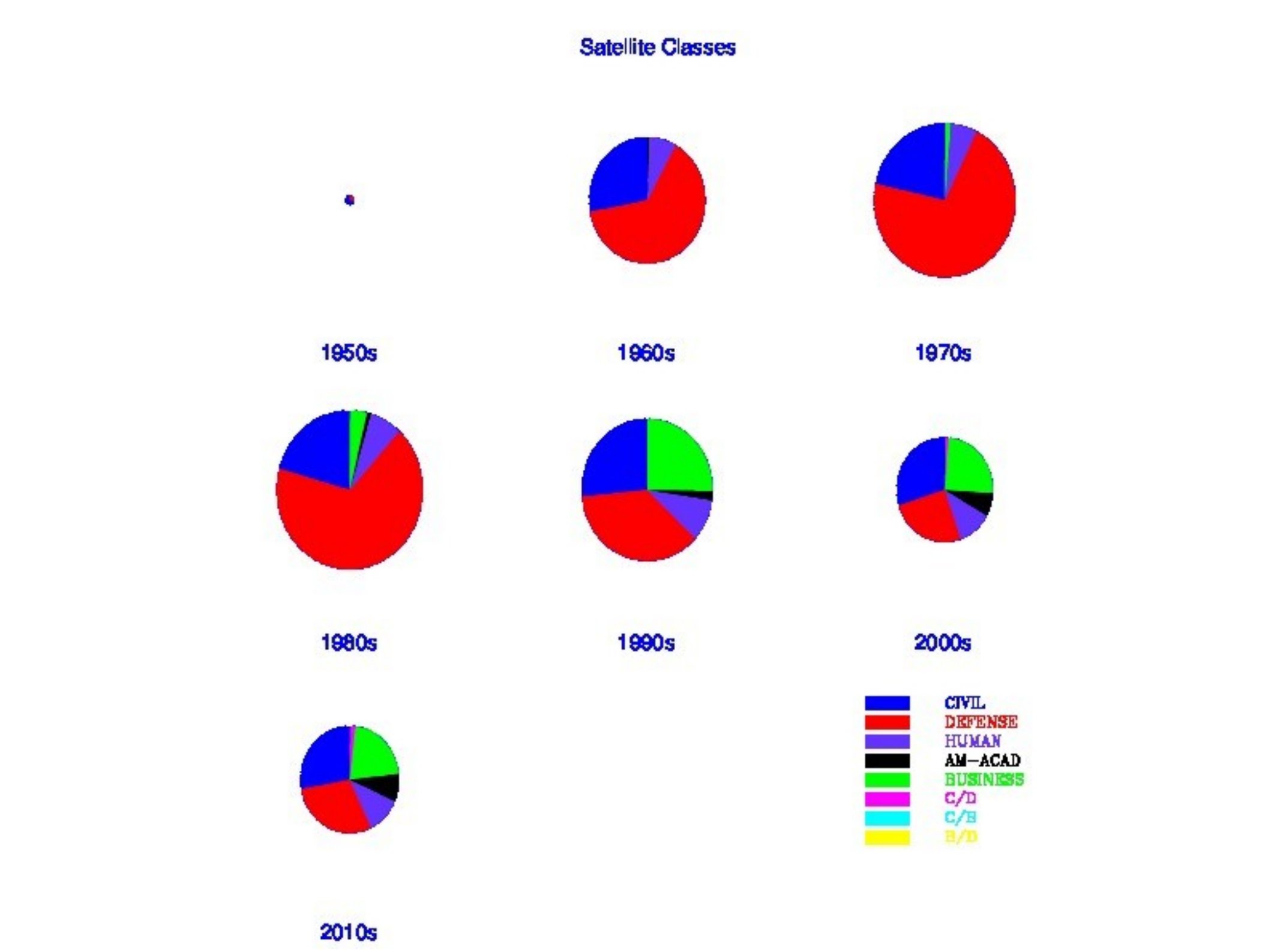
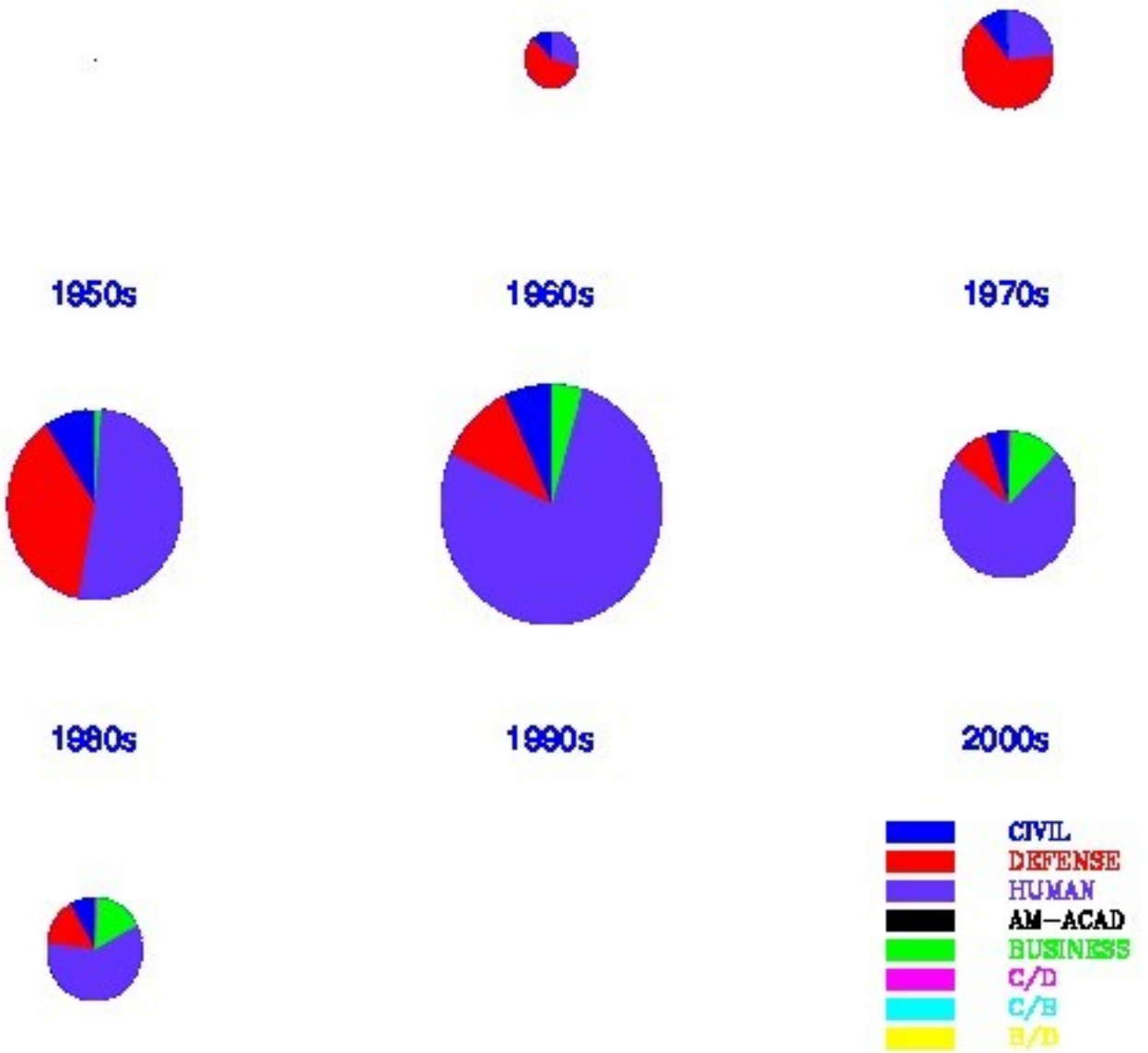
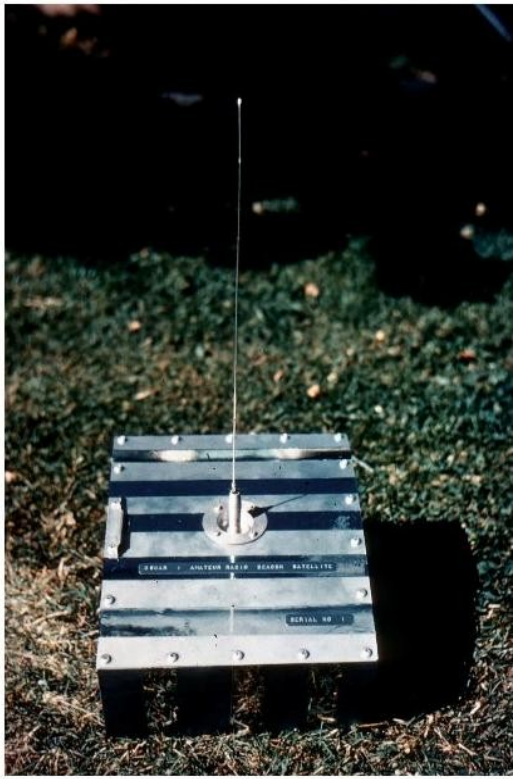
HUMAN
AM-ACAD
BUSINESS
C/D
C/B
B/D
2010s


Satellite Classes
1950s
1960s
1970s
1980s
1990s
2000s
2010s
CIVIL
DEFENSE
HUMAN
AM-ACAD
BUSINESS
C/D
C/E
B/D

Satelite Tonnage by Class



The Democratization of Space



Dec 1961 – the first amateur satellite
Built by radio amateurs in California
Hitched a ride strapped to the side of a spy satellite rocket

OSCAR – Orbiting Satellite Carrying Amateur Radio

Guildford, 1981: the University of Surrey builds amateur radio satellite UoSat-1
It becomes the basis of a series of cheap commercial satellites affordable
by developing countries

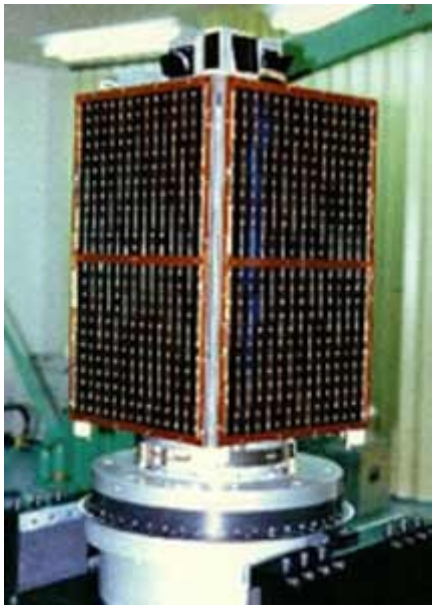
Alsat (Algeria) 2002

Tiungsat (Malaysia) 2000

Fasat (Chile) 1998

Posat
(Portugal)
1993

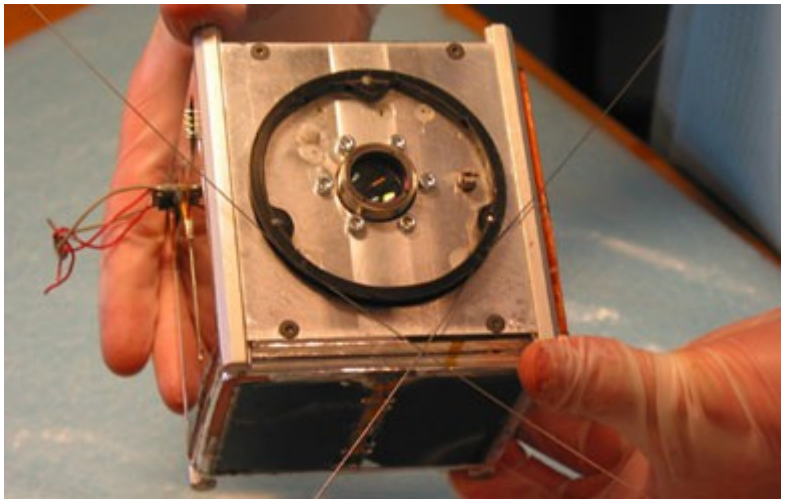
Bilsat (Turkey) 2003



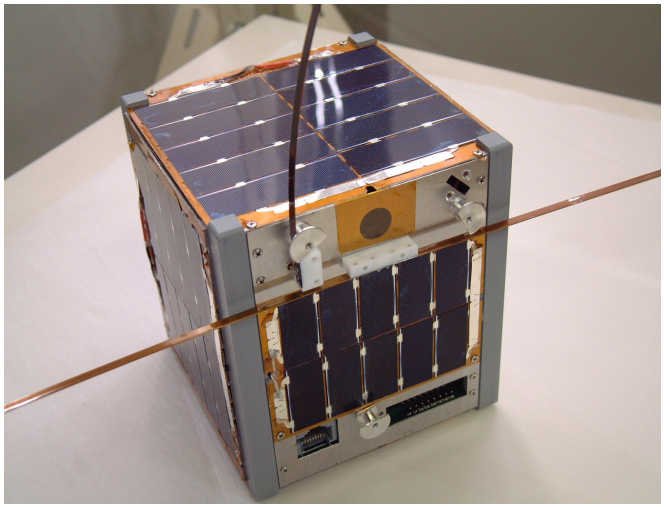
Uribyol
S Korea 1992

Nigeriasat-2 2011

Cubesats: 1 kg, 10 cm (2 lb, 4 in for the metric impaired)
Standard kit for universities to make students build sats in engineering courses
Can also make '3U' cuboids 30 x 10 cm
102 Cubesats launched since 2003 by 66 organizations in 20 countries



Aalborg U. 2003



Univ. of Tokyo, 2003

Cubesat deploy from ISS, 2012

Triple-cube Quakesat, Stanford 2003

USA CalPoly, Stanford, Cornell, Kentucky, UIUC, Arizona, U Louisiana-Lafayette, Berkeley, Montana State, Hawaii, Colorado, Texas-Austin, Michigan, Kansas, USC Los Angeles, Auburn, Utah State, San Jose State, Texas A&M, Aerospace Corp, NRO, Boeing, NASA, Los Alamos

Canada Toronto
Switzerland Lausanne, SUPSI
Colombia U Sergio Arboleda (Bogota)
Germany Aachen
Denmark Aalborg, DTU
Spain Vigo
France U Montpelier 2
Hungary Budapest U. Tech.
Italy Roma-Sapienza, Torino Poly
India IIT Kanpur
Japan Tokyo, Tok.Tech,Hokkaido,Fukoka,
Korea Hankuk AvU,
Norway NTNU Trondheim
Netherlands Delft
Poland Warsaw Poly
Romania Bucharest
Turkey Istanbul ITU, Tubitak
UK Surrey
Vietnam FPT Univ

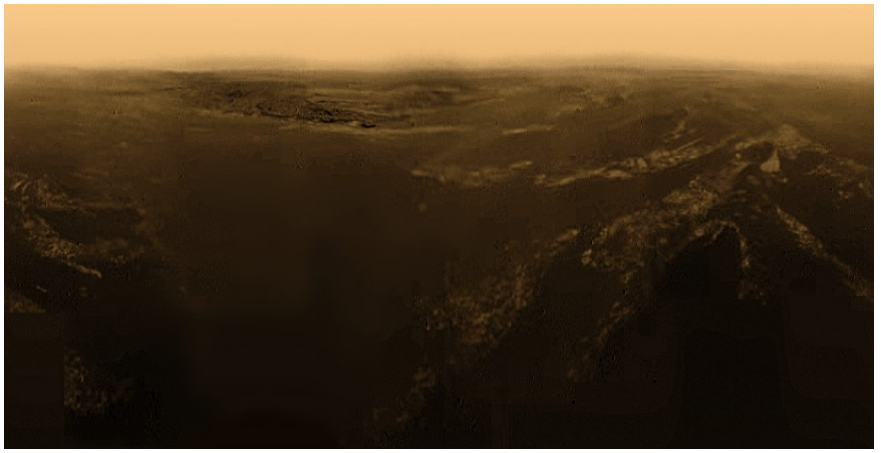
Earth orbit is now globalized
Until recently the rest of the solar system was a superpower preserve

MOON:

USSR 1959 USA 1962 Japan 1990 Europe 2003 China 2007 India 2008

VENUS:
US 1962 USSR 1966 Europe 2006

MARS:
US 1964 USSR 1971 Japan 2003 Europe 2003



JUPITER:
US 1973   Europe 1992 (ULS)

SATURN:
US 1979 Europe 2005 (hitching a ride with US)

COMETS:
US 1985 USSR 1986 Europe 1986 Japan 1986

ASTEROIDS:
US 1991 Japan 2005 Europe 2008 China 2012

MERCURY, URANUS, NEPTUNE: Only USA

The future of space globalization

- Human spaceflight

  USSR 1961 USA 1961-62

  As passengers:
  Czech SSR, Poland 1978 W Germany 1983 …. now 37 nations

  With own habitable modules:
  Europe 1983 Japan 2008

  Launching own astronauts:
  China 2003

  Coming soon?
  - India?

Even Cambridge has astronauts:
Mike Foale (BA, PhD Cantab, Queens) - ISS Commander, Expedition 8
Nick Patrick (BA Eng. Cantab, Trinity) - Shuttle astronaut, made 2 flights
David Saint Jacques (PhD Cantab, Corpus) – in training

If you know of any Oxford astronauts, please let me know.