

**How many people are in space  
right now?**

**What was the average human  
population of outer space in 1992?**

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**How many satellites were launched in  
1992?**

**What fraction were for scientific  
research?**

**Which country launched the most  
satellites?**

**How many people are in space  
right now?**

*2*

**What was the average human  
population of outer space in 1992?**

$3\frac{1}{2}$  (*Max 12; Min 2*)  
(*3.25 men, 0.25 women*)

**How many satellites were launched in  
1992?**

*117*

**What fraction were for scientific  
research?**

*1 in 7*

**Which country launched the most  
satellites?**

*Russia*

# SPACEFLIGHT in the NINETIES

Jonathan McDowell

What's Up In Space?

How have things changed in a decade?

## 1. Human Spaceflight

- (a) A Space Census
- (b) Space Shuttle
- (c) Space Station Freedom
- (d) Space Station Mir

## 2. Artificial Satellites

- (a) Who launches satellites?
- (b) What do they do?
- (c) What's being planned?

## A Space Census

- 61 astronauts in 1992

46	U.S.
6	Russian
6	European
2	Canadian
1	Japanese

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37 men 9 women

- However, weighted by time in space:

2	Russian
$1\frac{1}{6}$	U.S.
$0\frac{1}{6}$	European
$0\frac{1}{20}$	Canadian
$0\frac{1}{50}$	Japanese

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$3\frac{1}{4}$  men  $0\frac{1}{4}$  women

- 1993 schedule looks similar

# The Space Shuttle

- 1973: End of Apollo  
Lean times for US astronauts
- 1983: “Trouble-Plagued” Shuttle Program  
in test phase
- 1993:
  - 52 orbital flights (+1 failure)
  - No serious ( $> 1$  day) delays in count-downs in almost 2 years
  - Orbiters, boosters, engines heavily re-used

## Shuttle Trends

- More Spacelab missions
- Fewer satellite launches
- Space Station assembly

## Shuttle Successes

- From orbit to Mach 10 glider to runway landing
- Reusable spaceship  
(15 flights by Discovery)
- Reusable rocket engines  
(17 flights by engine 2012 over 10 years)
- Regular turnround in 4 months
- In-orbit satellite repair
- Much more science than in early missions
- Crucial experience in running space missions
- 50 seats to orbit a year - the same each year as the total number of US astronauts flown in all previous programs (Mercury, Gemini, Apollo).

## Shuttle Failures

- Cost savings not achieved
- Flight rate less than hoped
- Did not replace older rockets

## **A Shuttle flight - Launch**

- Launch from Kennedy Space Center
- Orbiter engines on first, then solids
- Engines fed by ET drop tank
- Solids dumped at 2 minutes - halfway to space
- In space at about 4 minutes
- Solids hit Atlantic, recovered
- Engines off at 8 minutes
- Tank dumped at 9 minutes
- Now in orbit but perigee in atmosphere
- Tank hits Indian Ocean
- OMS-2 at 45 minutes
- Open bay doors
- “On Orbit”



## **A Shuttle flight - Landing**

- Close bay doors
- OMS Deorbit
- Entry  
(Deorbit + 30 minutes)
- Hypersonic slalom  
(Deorbit + 45 minutes)
- Speed brake
- Final approach
- Gear down
- Landing
- Drag chute
- Wheels stop
- Ferry back to KSC

## **1992 Shuttle Highlights**

- 4 Spacelab missions
- Intelsat Rescue
- Tethered Satellite

## **1993 Shuttle Highlights**

- Hubble repair
- Krikalyov flight
- More Spacelab, EDO missions
- Spacehab

# Human Spaceflight Capabilities

- Getting to Space (1957,1961)
- Changing Orbit (1961,1965)
- Rendezvous (1965)
- Docking (1966)
- Spacewalks (1965)
- Repair work (1973)
- Refuelling (1978; not US)
- Construction work (1985)

# Space Station Freedom

- The big project for the second half of the 1990s
- Much criticized - too expensive, not useful
- International project - Japanese and European laboratory modules, Canadian robot arms
- In orbit assembly - lots of dockings and spacewalks
- First launch 1996
- First module 1997
- 20 construction launches to 2000
- Zero-g manufacturing, medicine, biology, Earth environment observation
- In 7 years the US will have a space station with several modules and a permanent crew.

# The Mir Orbital Piloted Station

- Mir has been in orbit for 7 years
- Permanent occupation of space since Tuesday, 5 Sep 1989
- Permanent crew of 2, may increase to 4
- Record year long mission in 1987/8
- 4 missions longer than 8 months (previous record was 7 months; US record is 3 months).
- 11 resident crews
- 16 Soyuz crew transport spaceships
- 33 Progress robot supply ships
- 4 main modules, 3 docking ports
- 31 spacewalks

## Mir Operations

- Sep 7, 1992 spacewalk removed the last official Soviet flag still flying
- Operated by NPO Energiya, Russia
- Crew training by Russian air force
- Launches from Kazakhstan
- Limited involvement by Ukraine
- 50 per cent funding from foreign passengers

## Mir Components

- Soyuz ferry - made 1960s for lunar program
- 160 of all Soyuz types launched, 69 with crews
- Mir core module - Salyut heritage
- Kvant module - astrophysics, attitude control
- Kvant-2 airlock module - Almaz heritage
- Kristall module - manufacturing, docking ports
- Sofora structure - attitude control

## Mir Plans

- Anatoliy Solov'yov and Sergei Avdeev on orbit for 6 months
- Gennadiy Manakov and Aleksandr Polishchuk launch on Sunday to replace them
- Test docking at APAS port
- Possible spacewalks to move solar panels
- New modules - Priroda
- US visitor
- Shuttle docking
- Mir 2 in late 90s - more of the same.
- Buran?



## Planetary Exploration in the 90s

Feb 1990	GALILEO	at Venus
Mar 1990	HAGOROMO	in lunar orbit
Aug 1990	MAGELLAN	in Venus orbit
Oct 1991	GALILEO	at (951) Gaspra
Feb 1992	HITEN	in lunar orbit
Feb 1992	ULYSSES	at Jupiter
Jul 1992	GIOTTO	at P/Grigg-Skjellerup
Aug 1993	MARS OBSERVER	at Mars
Jul 1994	ULYSSES	over South Solar Pole
? 1995	MARS-94	at Mars
Jul 1995	ULYSSES	over North Solar Pole
Dec 1995	GALILEO	at Jupiter
1998?	CASSINI	at Venus
1999?	CASSINI	at Venus again
2005	CASSINI	at Saturn
2005	HUYGENS	at Titan

## Satellites in Space - another census

- 117 satellites in 1992 - roughly steady for 25 years
- 61% Russian, 19% US, 20% other
- Fewer US launches in 80s, now back to level of 70s. Still below level of 60s.
- More Soviet launches in 80s, now back to level of 70s.
- Other countries now increasing share (was 10%)

# What do Satellites Do?

- Research
    - Astronomy
    - Atmospheric studies
    - Geodesy
    - Magnetospheric studies
    - Satellite technology development
    - Calibration
    - Biological research
    - Semiconductor manufacturing
    - Drug purification
- (16 out of 117 in 1992)

# What do Satellites Do?

- Looking at Earth (civilian)
  - Weather
  - Environment and Resources
  - Mapping

(6 out of 117 in 1992)

- Looking at Earth (military)
  - Imaging
  - Radar
  - Missile alert
  - Electronic intelligence

(27 out of 117 in 1992)

# What do Satellites Do?

- Communications
  - Military communications
  - Military command links
  - Telephone relay
  - Data relay
  - Cable TV relay
  - TV broadcasting (DBS)

(50 out of 117 in 1992, half military)
- Navigation
  - Ships
  - Planes
  - Missiles
  - Trucks

(17 out of 117 in 1992)
- Advertising! (1 out of 117 in 1992)

# What do Satellites Do?

- Weapons
  - Orbiting bombs
  - Killer satellites
  - Beam weapons

(0 out of 117 in 1992)

## **Satellites in the 90s:**

### **- More Commercial**

- Spacehab - Commercial use of Shuttle
- Foton - Russian commercialization
- Pegasus, Conestoga - Launchers
- Comet - Commercial recoverable satellite
- On-orbit sale of comsats

### **- Less Military**

- 15% fewer in 1992 than in 1972, 1982

### **- More International**

- Fewer Russian satellites
- More European satellites
- More Pacific Rim satellites

### **- Smaller**

- 'Lightsat' craze began late 1980s
- Revolt against outrageous costs

## **Mission To Planet Earth:**

- Weather and environmental satellites for 30 years already
- Original grandiose plans rescoped, still major effort
- Small probes start this year or next
- Main launches start 1998
- Vice President may play a major role



# Space Astronomy in the 90s

## Great Observatories

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1990	Hubble	Optical/UV
1991	Compton	Gamma
1994	Fixed Hubble	Optical/UV
1998	AXAF-I	X-ray

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## Smaller missions

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Radio	Radioastron	(Russia)
Submillimeter	SWAS	(60 Garden St)
Infrared	ISO	(Europe)
Optical	Hipparcos	(Europe)
Ultraviolet	EUVE, FUSE	(NASA)
X-ray	ROSAT	(Germany)
	Astro-D	(Japan)
	XTE	(NASA)
	XMM	(Europe)
Gamma	Granat	(Russia, France)

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## Space Technology in the 90s

- 1993 Hubble Repair
- 1994 Mir assembly complete?
- 1994 Aerobraking experiments
- 1994-5 Automatic docking tests
- 1995 Shuttle docks with Mir
- 1995 Galileo at Jupiter
- 1996 Freedom construction begins