GLOBESAR

RADAR Systems

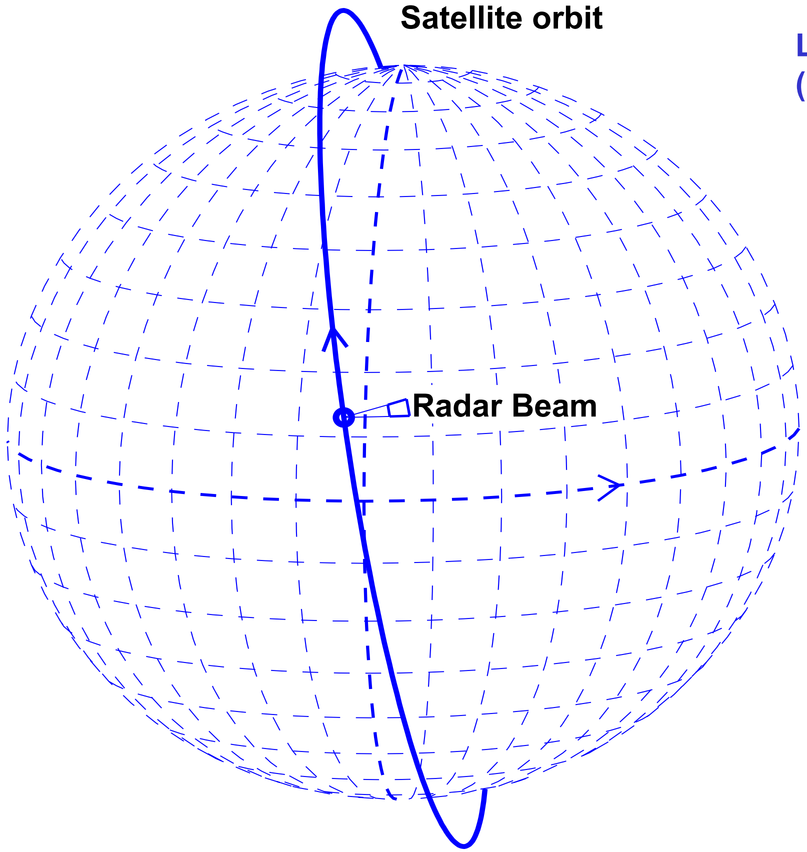
Natural Resources Canada
Ressources naturelles Canada

Canada

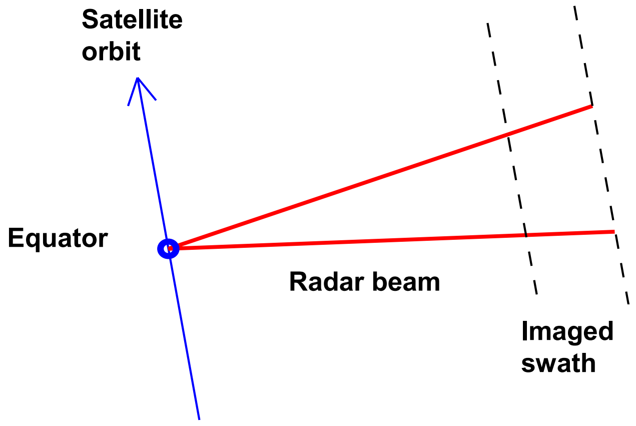
Applications of SAR

- Measuring motion of the Earth's surface, to help us better understand earthquakes and volcanoes and support emergency management efforts.
- Studying the movements and changing size of glaciers and ice floes to help better understand long-term climate variability.
- Developing highly detailed and accurate elevation maps.
- Monitoring floods and where they are likely to occur.
- Assessing terrain for the likelihood of finding oil or other natural resources.
- Early recognition and monitoring of oil spills.
- Assessing the health of crops and forests.
- Planning urban development and likely effects.
- Studying land cover and land use change.

Geometry of satellite orbit and Earth rotation



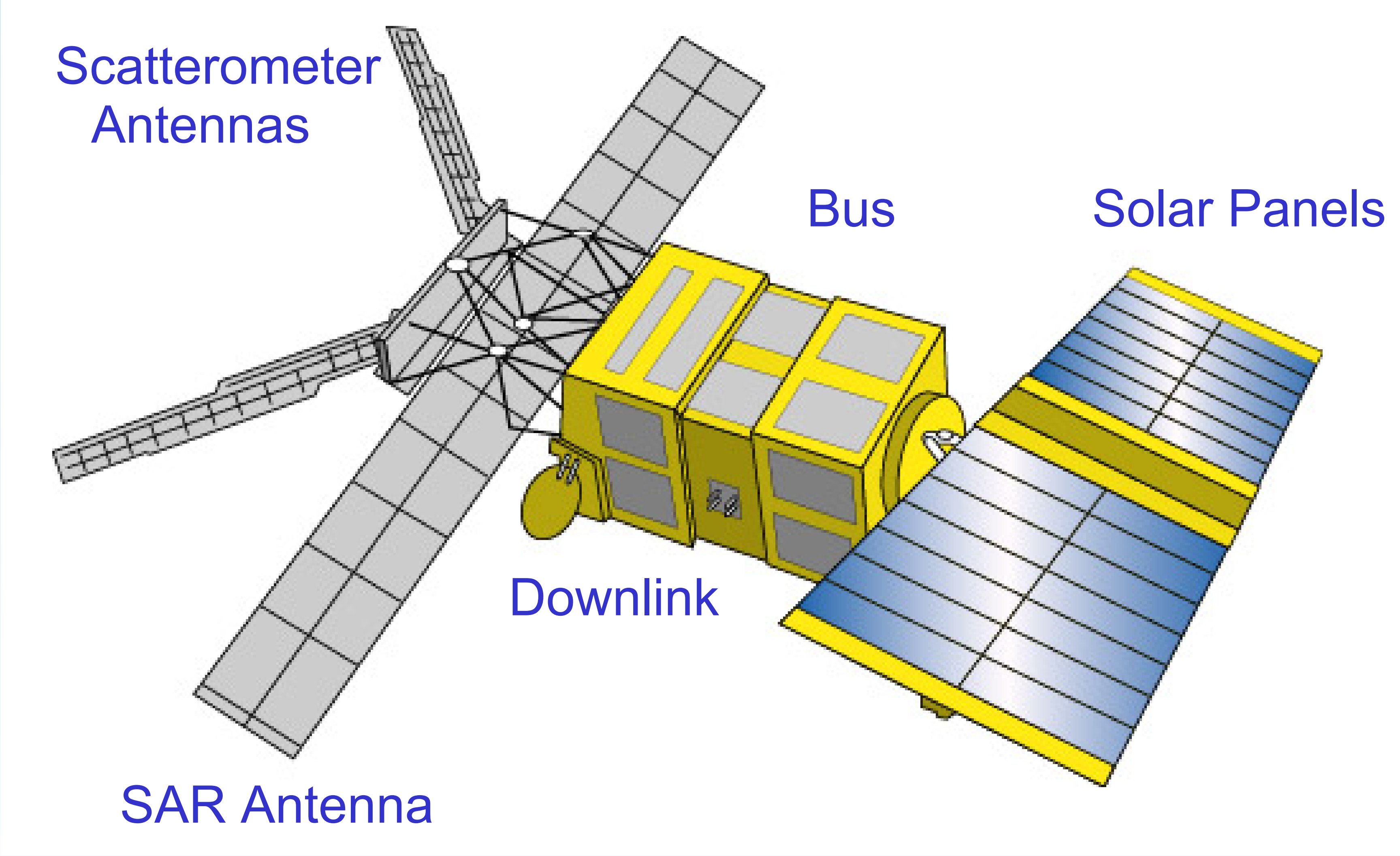
Lat and long lines are 10 deg apart
(1100 km at the equator)



RADARSAT altitude is 800 km
Inclination is 98 deg, Period is 98 min

The satellite ‘ moves ’ 26 deg west
every orbit (2830 km at the equator)

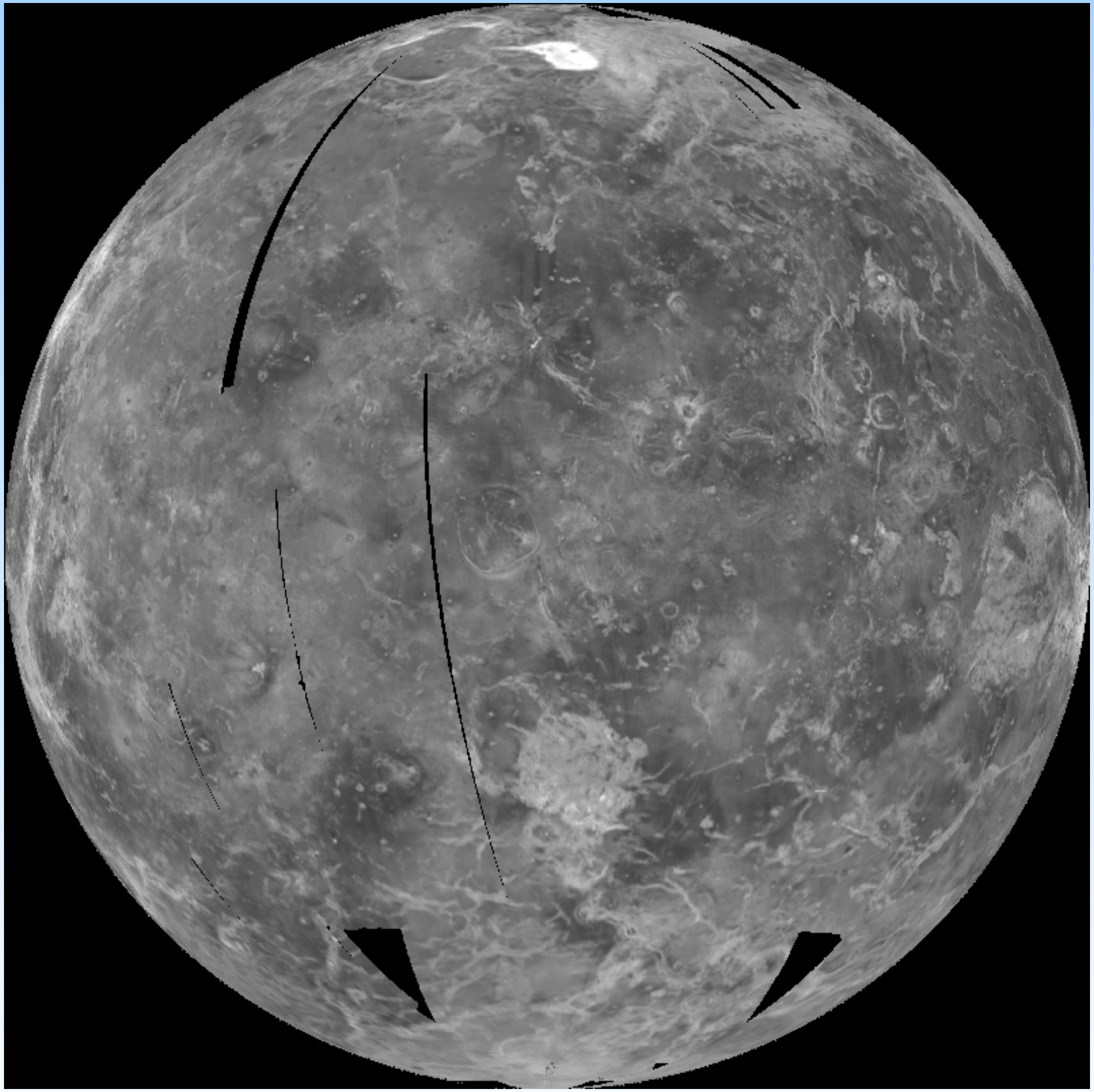
ERS Configuration



Previous Satellite SAR Missions

• SEASAT	1978
• SIR-A	1981
• SIR-B	1984
• Magellan	1990
• ERS-1	1991
• J-ERS-1	1992
• SIR-C / X-SAR	1994
• RADARSAT-1	1995
• ERS-2	1995
• Shuttle SRTM	2000

Magellan Mission to Venus 1



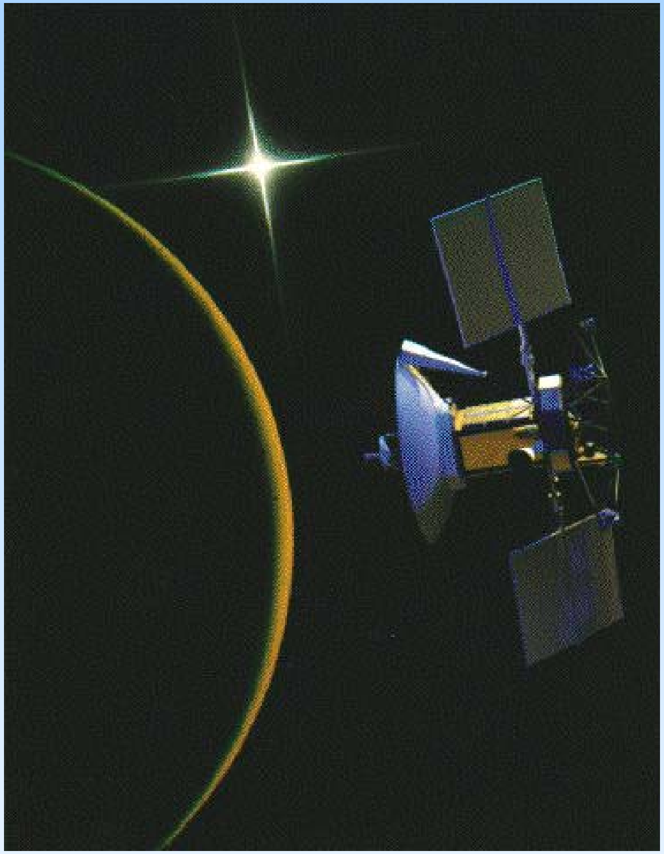
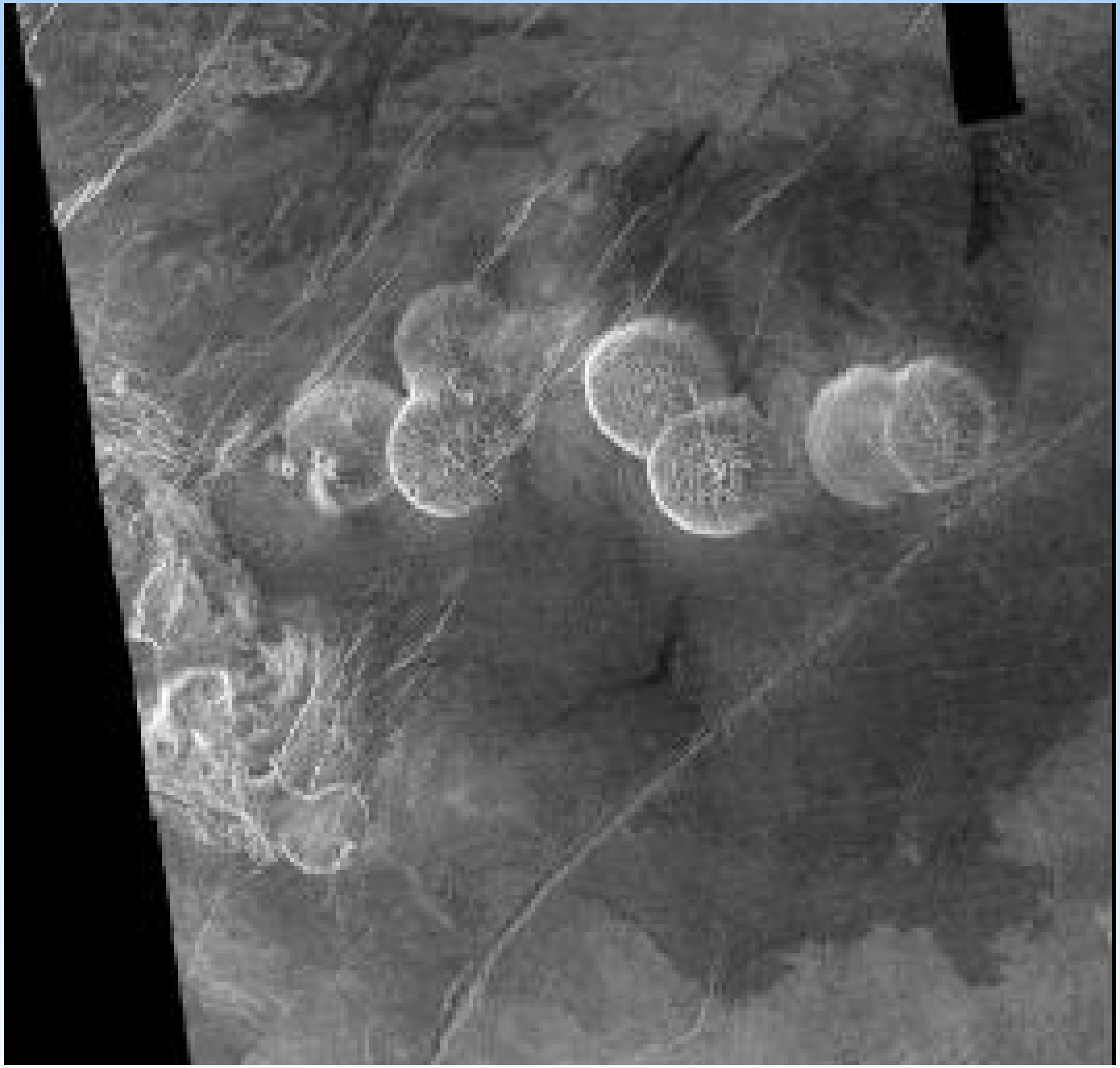


Image courtesy of JPL

Magellan Mission to Venus 2



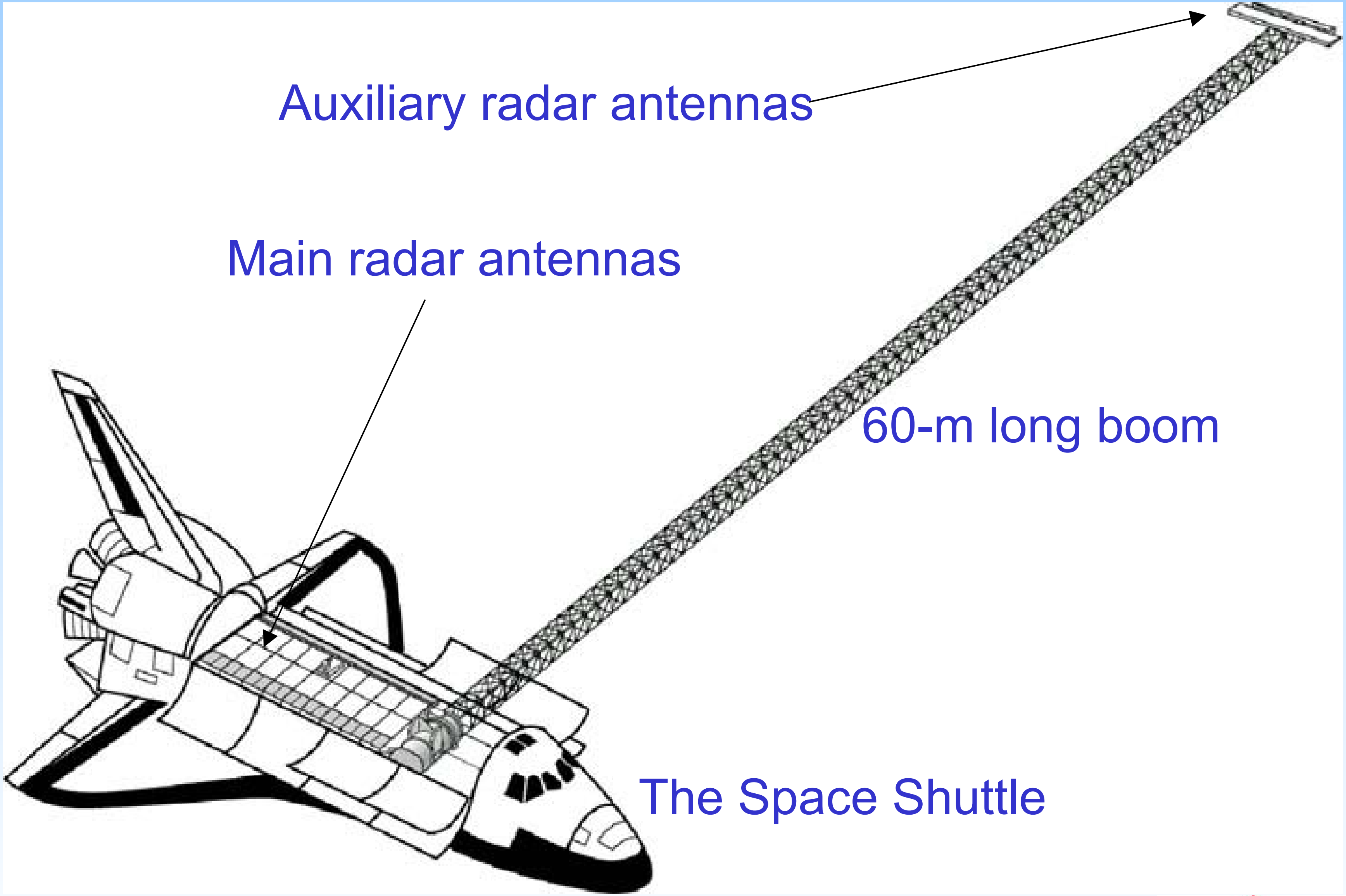
Lava domes on surface of Venus imaged by the Magellan radar

Image courtesy of JPL

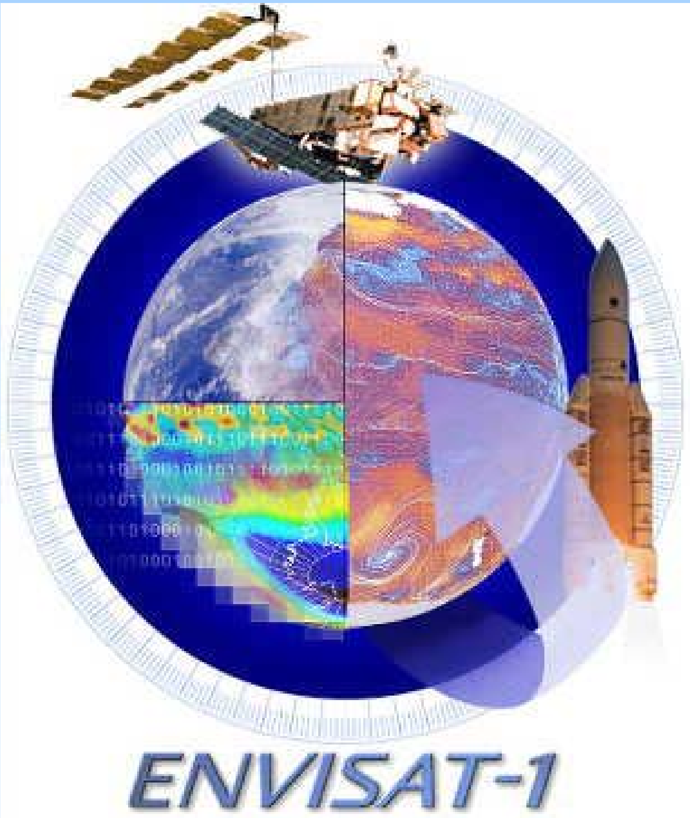
Future Satellite SAR Missions

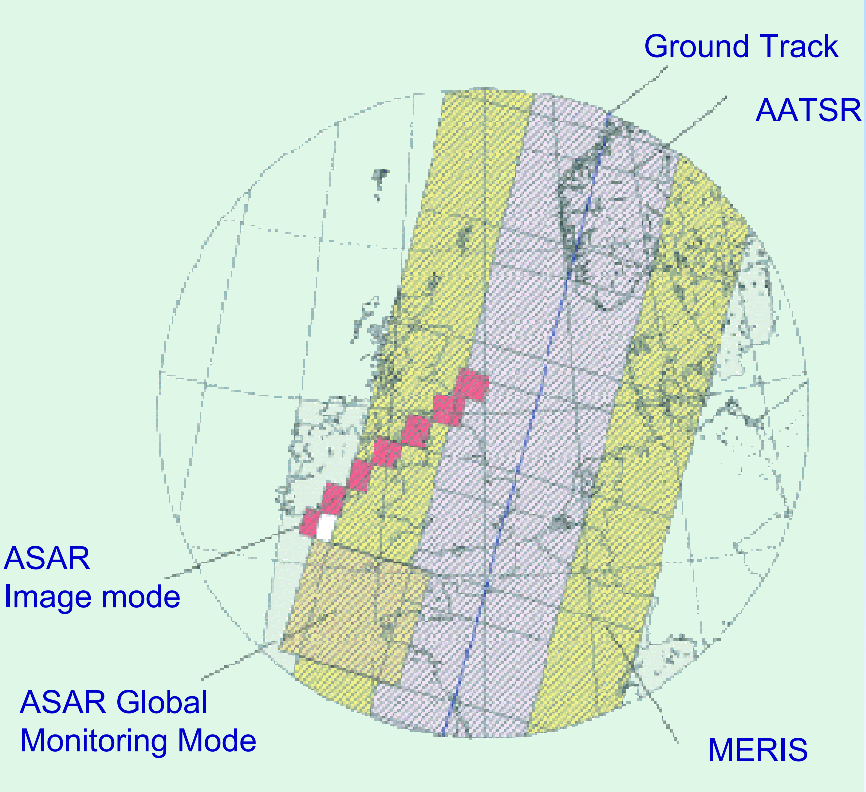
• ENVISAT	2001
• SAOCOM	2002
• ALOS	2002
• RADARSAT-2	2003
• LightSAR	

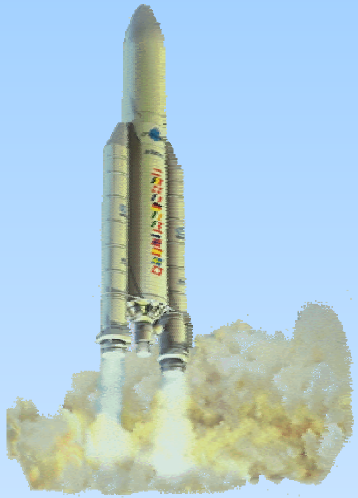
The NASA/DLR SRTM Mission



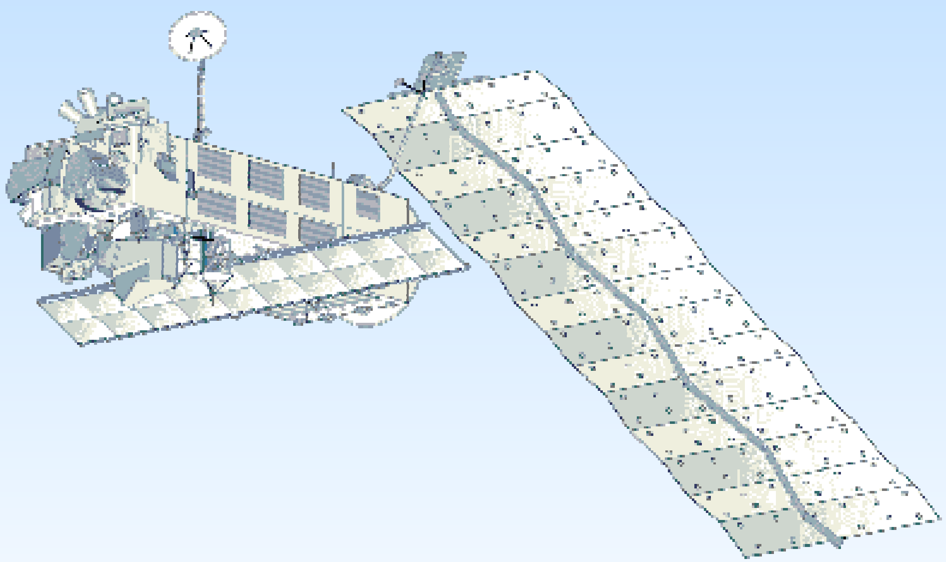
The ENVISAT Mission 1

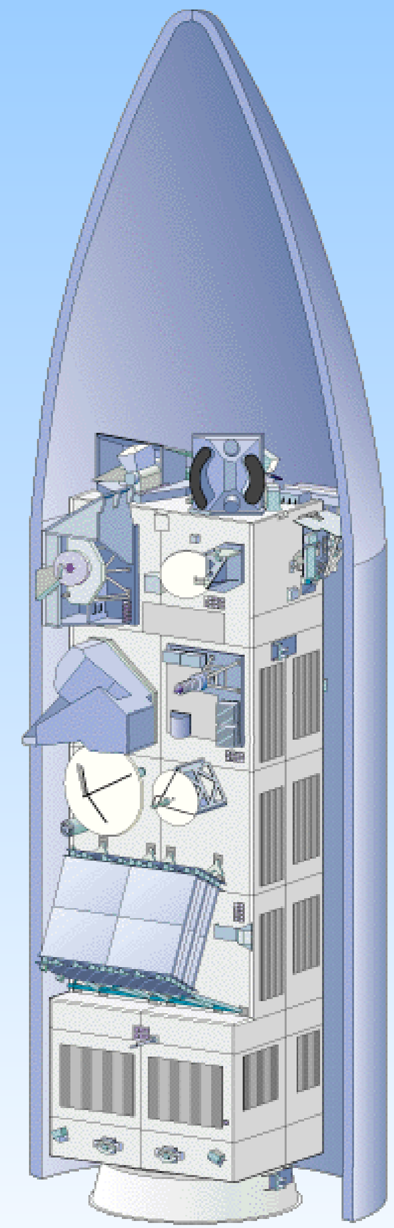




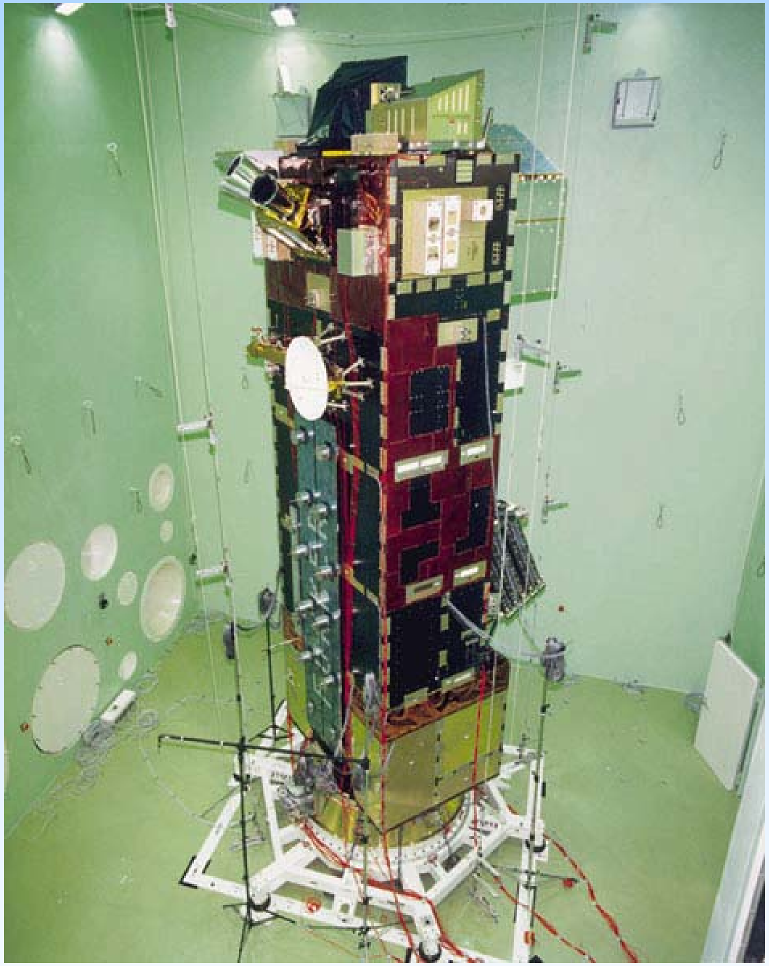


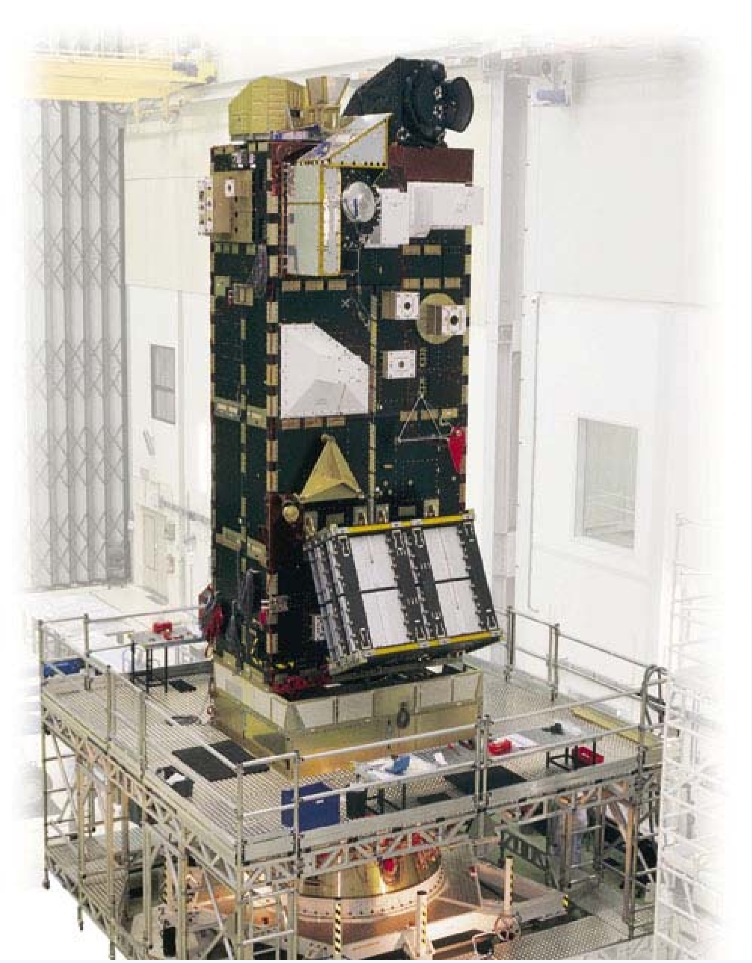
The ENVISAT Mission 2



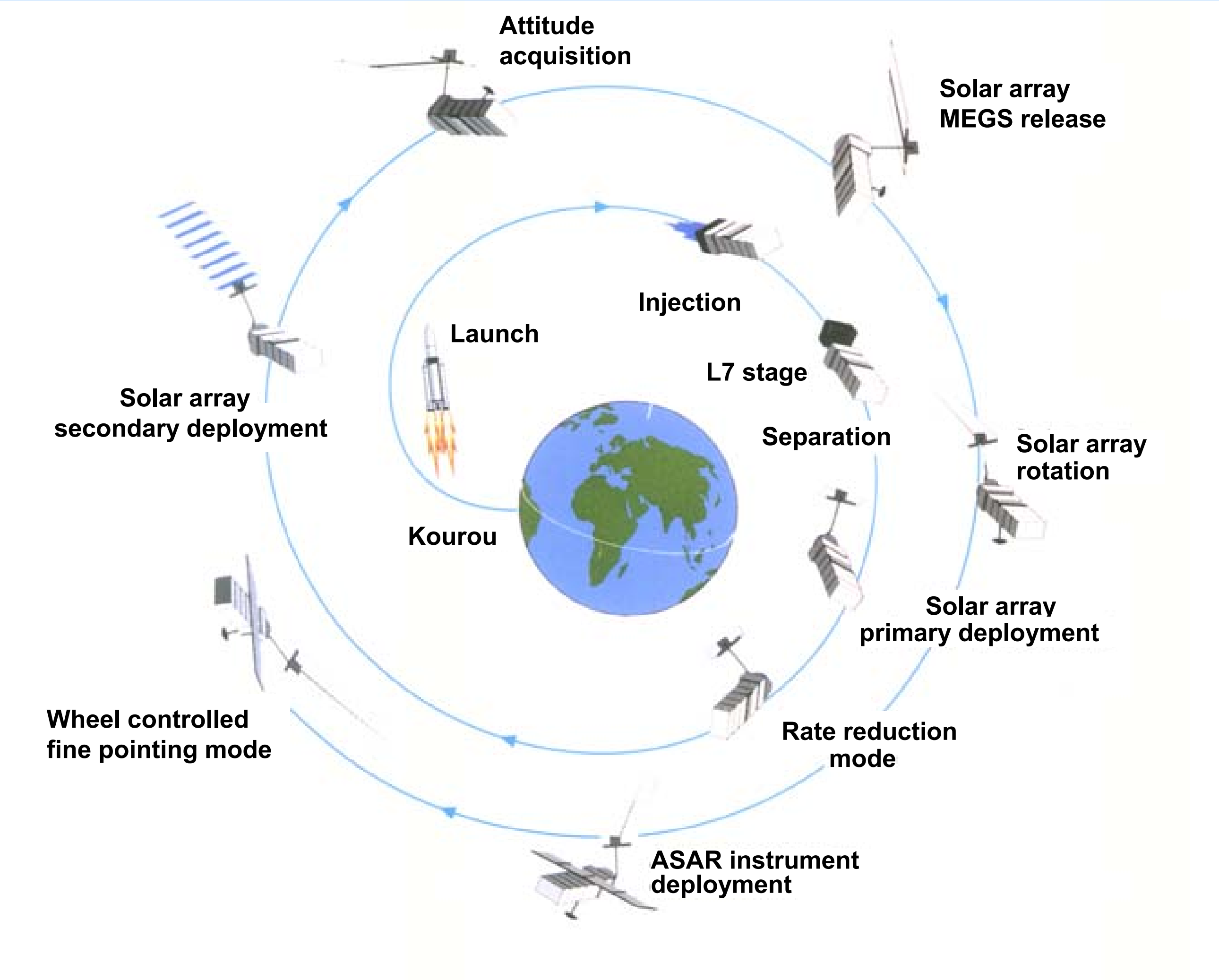


The ENVISAT Satellite under Construction





The ENVISAT Mission — LEOP Phase



Radar Systems

Notes

Slide 2

These applications have been demonstrated using SEASAT, SIR-B/C, ERS and RADARSAT data. Some applications are still in the research stage, while others, such as **ice monitoring**, are fully operational today (1999).

The list here came from the LightSAR web pages. They are a list of applications which are expected to be used by the future LightSAR system.

Slide 3

We will often be dealing with satellite SAR data, whose geometry is shown in this slide. The main difference from aircraft SARs is that their coverage pattern is governed by orbit mechanics and by the Earth's rotation, as illustrated here.

Slide 4

This slide shows the configuration of the ERS-1 (1991) and the nearly identical ERS-2 (1995) satellites. Rather than only a SAR system, they also have a scatterometer and a radar altimeter.

The SAR antenna is 10 m long and 1.2 m wide. The satellite attitude is controlled so that long dimension of the SAR antenna is aligned with the velocity vector of the satellite's orbit. It can also be steered with a time-varying skew to compensate for the Earth's rotation. This is called the *yaw-steering mode*, and it makes the radar beam perpendicular to the satellite ground track, effectively steering the beam to "zero-Doppler".

The "bus" contains all the electronics and support equipment of the satellite system. This includes items like:

- control computer
- power supply control system
- attitude control system
- radar transmitters and receivers
- radar data handling system
- satellite/earth communications system

Slide 5

The NASA SEASAT mission was the first civilian SAR satellite, and opened up the SAR sensor to the remote sensing community. It only lasted 4 months before an electrical failure shut it down, but in that time an enormous amount of data was collected in North America.

Of particular note to Canada is that a receiving station was built in Newfoundland which operated well throughout the mission, and that engineers at MacDonald Dettwiler were the first in the world to produce a digital image from a satellite SAR system.

Slide 6

SAR is useful not only on Earth, but has been used by NASA for some of its planetary missions. The most dramatic example is the 1990-92 Magellan Mission to Venus.

Because Venus is perpetually cloud covered, conventional optical instruments could not acquire an image of the surface of Venus.

In the Magellan Mission, an S-band (2 GHz) SAR was used to obtain 100 *m* resolution images of almost the entire surface of Venus. Scientists used images to understand the geophysical and geological processes on Venus, enhancing our understanding of the solar system.

Slide 7

Many new things were learned from the Magellan data, such as the existence of these lava domes in Alpha Regio region of Venus.

Slide 9

The Shuttle Radar Topography Mission (SRTM) was a joint 11-day shuttle mission (STS-99, Atlantis) of NASA, the U.S. Department of Defense' National Imagery and Mapping Agency (NIMA), DLR, and ASI, the Italian Space Agency. It flew from February 11 to 22, 2000.. Two independent SAR systems, one in C-band (NASA JPL instrument) the other in X-band (DLR/ASI), operated with the main antenna of each instrument located in the open cargo bay of the shuttle, with a second receive antenna mounted on a deployable outboard mast. SRTM represents the first use of fixed baseline single-pass spaceborne InSAR technology with wide-swath scanning SAR and dual frequencies.

The heart of the SRTM is a SAR interferometer using the existing SIR-C/X-SAR hardware in the shuttle cargo bay augmented by secondary C- and X-band receive antennas mounted at the tip of a 60 *m* boom.

The spatial resolution of the images is 30x30 *m*, with a circular location error of less than 20 *m*. The vertical accuracy is < 16 *m* (90% Linear Error).

Slide 10

Envisat-1 is a multi-sensor satellite mission managed by the European Space Agency. It is scheduled for launch in January 2002.

Envisat-1 will carry an advanced SAR system, called ASAR. It will have various resolutions and swath widths, and will have a ScanSAR mode like RADARSAT. It will have both horizontal and vertical polarization, but not full quad polarization (the HH and VV channels are not mutually coherent).

In addition to the SAR sensor, it will have an advanced along-track scanning radiometer (AATSR), and MERIS, a multi-frequency optical imager.

Slide 11

Have you ever wondered how a satellite with big solar panels and a SAR antenna fits into the launch vehicle ? It’s a tight squeeze !

Envisat-1 will be launched by the French Ariane-5 rocket, which has a cylindrical cargo bay, about 17 *m* long and 5 *m* in diameter. Ariane-5 can place two 3000 kg satellites simultaneously or one satellite with a mass of up to 6800 kg in geostationary transfer orbit, compared with a maximum Ariane-4 payload of 4400 kg.

After the rocket has reached its operational altitude, the nose cone is eased off, and the satellite let go in space. A small rocket on the bottom of the satellite pushes the satellite into its final orbit, usually about 800 Km above the Earth's surface.

Slide 12

Envisat-1 is now being tested in the Space Laboratory at ESTEC (1999).

ESTEC is the European Space Agency's main technology centre, and is located in Noordwijk in the Netherlands.

Slide 13

Did you ever wonder how a satellite gets launched ?

This slide shows how the Envisat-1 satellite will be launched from Kourou, French Guyana in January of 2002. LEOP stands for the "Launch and Early Orbit Phase", and is the most critical period in a satellite's lifetime.

Note some of the following steps:

• orbit injection (using rockets to get to the final orbit)

• deployment of solar arrays

• locking on to the correct attitude

• deployment of SAR antenna