Huygens at Titan

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Titan – The big questions
Huygens mission and instruments
First results

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Why Titan?

• Atmospheric chemistry and evolution
• Analogue for Archean atmosphere
• Prebiotic, organic chemistry involving atmosphere, surface, and interior
• Veiled surface
• Active geology?
• Liquids and Earth-like geology?
Saturn's Satellites and Ring Structure

- Pan
- Atlas
- Prometheus
- Janus
- Prometheus
- Enceladus
- Tethys
- Dione
- Rhea
- Hyperion
- Titan
- Iapetus
- Phoebe

All bodies are to scale except for Pan, Atlas, Telestos, Calypso, and Helene, whose sizes have been exaggerated by a factor of 5 to show rough topography.

Not shown:
- Pan (2.22 Rs)
- Atlas (2.28 Rs)
- Prometheus (2.31 Rs)
- Janus (2.35 Rs)
- Encke Division
- Cassini Division
- Epimetheus
- Mimas
- Enceladus
- Tethys
- Dione
- Helene
- Titan (20.3 Rs)
- Hyperion (24.6 Rs)
- Iapetus (59.1 Rs)
- Phoebe (214.9 Rs)

This graphic is available in color if required.
Lebreton and Matson 2002
Titan’s Atmosphere

- How has it changed over time? Primordial, recent, cyclic?
- What is the source of methane?
- Aerosols, hazes, and clouds
- What is the chemistry like, especially organics?
- Are dynamics like cyclostrophic Venus?
Titan’s Surface and Interior

- Are or were liquids present?
- Are there organic sediments from ethane/methane rain?
- How active is surface geology – volcanoes, tectonics, fluvial processes, cratering?
- What is mix of $\text{H}_2\text{O}$, $\text{NH}_3$, rock in interior?
- Subsurface ocean connected to surface?
1655, Christiaan Huygens discovers that Saturn has a satellite, Titan.

1659, Huygens proposes that Saturn is surrounded by a thin, flat ring.
• Play animateddescent90s.mov
Huygens Atmospheric Structure Instrument (HASI)

• Entry accelerometers - p,T(z) from 1270 km
• Direct p,T instruments
• Thermal balance, dynamics, waves
• Permittivity, wave, and altimetry – AC and DC fields, ion and electron conductivities, sound, electrical properties of surface, surface roughness
• PWA looking at charged particles, lightning
Doppler Wind Experiment (DWE)

- Line-of-sight wind below 200 km from (a) Cassini and (b) Earth-based radio scopes
- Determine zonal wind speed, study dynamics of swinging probe, atmospheric turbulence
- Requires ultrastable oscillator on one of Huygens’ two transmission channels
Gas Chromatograph Mass Spectrometer (GCMS)

- Elemental and isotopic composition of gaseous atmosphere below 200 km
- Range is 2 – 141 amu
- Essential for atmospheric chemistry
- C, N isotopes imply atmospheric evolution
- Possibly analyze surface sample as well
Aerosol Collector Pyrolyser (ACP)

- Pyrolyse aerosol particles from ~50 km and ~20 km altitude, feed to GCMS
- Expect long chain hydrocarbons (CHNO)
- Study cloud chemistry, compare condensed to gaseous abundances
- Context for surface composition
Descent Imager/Spectral Radiometer (DISR)

- 14 photometers, VIS/IR spectrometers, imagers
- Surface images for geomorphology
- Measure spectrum of upward and downward flux at two polarisations, monitor solar extinction
- Thermal balance from fluxes, aerosol shape/size/distribution
Surface Science Package (SSP)

- Design for impact in liquid or solid, many small experiments
- Surface temperature, thermal conductivity, permittivity, refractive index, liquid density
- Speed of sound in ocean
- Sonar, plus tilt sensors for attitude/motion
- Penetrometer to characterize impact
- Plus same measurements during descent
• Play descentcam.mov
First Results

- Successful entry, survived impact, lasted for hours on surface
- One of two Cassini receiver channels not switched on, DWE got no data
- Rely on ground-based tracking instead
- 350 images returned, 350 lost
- Several other instruments lost some data, but, overall, mission was highly successful
Not Pretty Pictures

- $p, T(z)$ as predicted, plus large (gravity?) waves in upper atmosphere
- 4 minutes entry, 2.5 hour descent
- $5 \text{ ms}^{-1}$ impact, 15 g deceleration
- Surface solid, stiff crust above weaker (wet sand-like) substrate – crème brulee
- Clouds extended lower than expected (30 km, not 50-70 km)
- Liquid methane within few cm of surface
Pretty Pictures

- Orbital images and radar hard to interpret, Huygens images are much easier
- Very active surface, but no obvious liquids
- Flow in channels, around base of pebbles
- Dark areas are low-lying
- Hydrocarbon rain inferred from channels
What Next?

• More press releases – Media, web
• Conferences – LPSC, EGU, AGU
• Papers – 3 month Sci/Nat special issue
• Data Access – Eventually, probably
• Funding – NASA Cassini PS Program, Saturn DAP, plus usual sources
• More data – Cassini tour continues, future Titan mission possible?