European Landers (Huygens/Philae)

John Zarnecki The Open University, UK

Beating records

- Largest mirrors ever launched for IR and X-ray astronomy;
- Most distant landing ever accomplished on an extraterrestrial object;
- True revolution in solar observations;
- First multi-points studies of the Earth magnetosphere;
- Orbiting a comet.







HORIZON 2000 PLUS



Cassini/Huygens

SPACE SCIENCE HORIZON 2000: A

· eesa





John Zarnecki

Public Lecture - The Royal Society

Titan Summary

- Only planetary satellite with an atmosphere (N₂, CH₄ and photolysis products)
- Mean density 1.88 g/cm³ (silicate rocks 2.5-3.5 g/cm³ ice ~1 g/cm³)
- Diameter of 5150km (40% of Earth)
- Surface Pressure: 1.5x Earth's; Temperature: 94 K (-179 C).
- Must be some source of methane on/in surface



Artwork by Mark Robertson-Tessi and Ralph Lorenz, LPL, University of Arizona (http://www.lpl.arizona.edu/~rlorenz)



Huygens





Entry, descent and Landing of Huygens







Credits: ESA/NASA/JPL/University of Arizona

Bright highlands: two styles of drainage networks



360° Panorama Normalised to 9 km Altitude



Mosaic of images taken between 17 & 8 km altitude





20 cm





ESA/NASA/University of Arizon

15 cm

2

8

Horizon at 88.5°

240 cm

85 cm

Public Lecture - The Royal Society



The Huygens probe experiment(er)s

ACP



DWE



GCMS









HASI

DISR



SSP

Mesurement of the Concentration of Chemical Constituents



Results to Date

- CH4 mole fraction altitude profile
- 14N/15N = 183<u>+</u>5
- $12C/13C = 82.3 \pm 1$
- $D/H = (2.3 \pm 0.5) \times 10-4$
- 36Ar = (2.8<u>+</u>0.3)x10-7
- $40Ar = (4.32 \pm 0.1) \times 10^{-5}$
- Kr and Xe below 10-8 mole fraction
- CO2, C2H6, and C2N2 altitude and surface profiles



CH₄ and N₂ Surface Profiles



Location of ACC-E penetrometer and SSP on the Huygens Probe



SSP Surface Impact



ACC-E penetration force record

Onset of penetration- low force seen for first few fractions of a second- a soft coating of ~8mm thickness?



ACC-E penetration force record

Hard impact into a crust or a pebble...followed by **main penetration** into irregular substrate





Entry Accelerometry



HASI ACC

- Sundstrand QA2000-030 servo accelerometer
- Sensitive to 0.3µg at the top of the atmosphere
- Density profile measurement





HASI ACC Data



HASI Density Profile



Credit: ESA / ASI / UPD / OU /









Astrobiology : Titan

Similarities of Titan with the Earth

- Atmosphere, structure, composition, greenhouse properties, climate similarities (haze ↔ ozone)

- Many geological similarities (liquid bodies, fluvial networks, dunes, (cryo)-volcanism, mountains, tectonics, erosion, impact craters ...)

- Ice on Titan ↔ rock on Earth
- Methane cycle ↔ water cycle

BUT : Still to be fully understood!!

In addition: an organic chemistry with many similarities with the early Earth's prebiotic chemistry

















A cornerstone of the ESA long-term space science programme

Proceedings of an ESA Workshop held at the University of Kent at Canterbury, UK, 15 - 17 July 1986 SPACE SCIENCE HORIZON 2000: A RETROSPECTIVE VIEW

Comet Nucleus Sample Return Cornerstone Workshop Canterbury Liete Möffler Cherhard Grin - Jans Baline Wan Harris Jane L. Hanne olga illelita San and loura Johnens rionie Omoerleerle Ewand an Willia W Crea Jan Wood hyoking Sen black Unich lipmaputiente bli Whehangt mal Niedner Poler A. Weling . Lukz Manoune RANJomos Rog Hike Hellenaun Paul Weisian Trictich Bounon Milex Simon yree Gillian Zanieck Douald a Clayfor Robert Hutchison Fabricio Reperioral Elink lepher Jehn Carvelli Laike Mitander Humberto Campins yves Canyerina Ednard Halley alica ilerti Eren mary Land Hullinger Pat Beran Vich Clube Lle a Einstein Filter y Boud 2 Lo Bad GSPACE

8-9 Feb 2018

8-9 Feb 2018

11

SPACE SCIENCE HORIZON 2000: A RETROSPECTIVE VIEW

→ ROSETTA'S JOURNEY





Philae





Philae



APXS ÇIVA CONSERT COSAC PTOLEMY **MUPUS** ROLIS ROMAP SD2 SESAME

Alpha X-ray spectrometer:composition Six micro-cameras: surface imaging Radio tomography of nucleus Evolved gas analyser: organics Evolved gas analyser: isotopic ratios Probe on anchor: structure, properties Imaging system: descent and landing Magnetometer/plasma monitor Drill to 20cm: deliver to analysis ovens Probes comet outer layers









1 Oct – 19 km orbit 15 Oct – 10 km orbit









120 m from target point!!!

touchdown point

taken at 15:43 taken at 15:18

before



15:19

5:23





Where was the lander? Had to wait until 2016 and the final close orbits of the mission to get an unambiguous image







→ PHILAE'S MAGNETIC FIELD MEASUREMENTS BEFORE AND AFTER SURFACE COLLISION

The measurements are compared with a hypothetical model assuming a slightly magnetised surface. The model also includes the strength of and variation in the interplanetary magnetic field near the comet nucleus.



Thanks to the bounce – more data Close to surface, expect comet magnetic field to dominate external field. This was not seen – data suggests that comet is not magnetized.

ESA/Rosetta/Philae/ROMAP

ESA/Rosetta/RPC/MAG

→ MUPUS INVESTIGATIONS AT ABYDOS

→ Temperature profile



Philae results

Agilkia

- Dusty region (10s cm deep), ~ lunar regolith, possibly covering hard subsurface
- Impact displaced ~180 kg material from surface, some entering sensors
- Organic molecules, including some never detected before.
- •Combined with Rosetta nucleus does not have magnetic field, constraining formation model

Abydos

- -145 to -180 C temperature cycle low thermal inertia indicates thin dust layer
- Surface fracturing (as observed by Rosetta)
- Hard sub-surface measured ~ sintered ice
- •Comet loosely compacted 75-85% porosity.



Global impact





Global coverage, social media and awareness





Physics World: 2014 breakthrough of the year
Science Magazine: Breakthrough of the year
NBC News: 2014 Year in Space top mention
Nature: Andrea Accomazzo - #1 in Nature's list of 10 people who mattered this year
A mention in the Facebook and Google year in review videos

			-C. 1085-125-868	
Prompted Awareness	Germany	France	Italy	UK
Rosetta	75%	72%	70%	69%







Science Advisory Committee, 1978