Remote Sensing Of Titan

- Lifting The Veil On The Origins Of Life?

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University of Brighton

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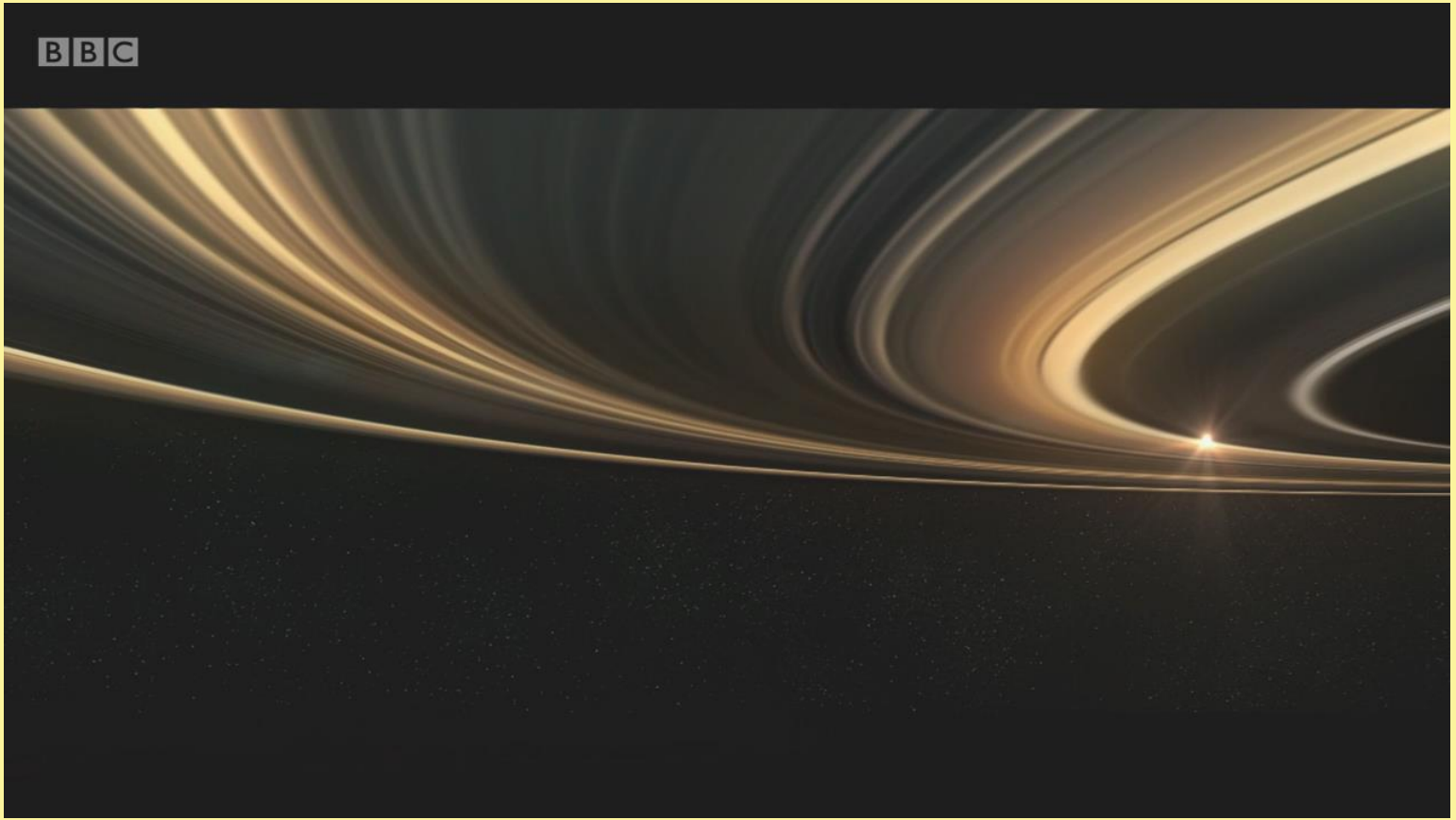
- *Exploration of Titan was made a critical science objective of Voyager probes*

Source: BBC4 Storyville strand; “The Farthest: Voyager’s Interstellar Journey”; https://www.bbc.co.uk/programmes/b09gvnty; Last shown 2019.
Also on Screenbound Pictures DVD as: “The Farthest (Extended Theatrical Version)”, released 2017.

Titan Was Designated A PRIME OBJECTIVE For Voyager Mission



Carl Sagan (voiceover); Astronomer, Planetary Scientist, Astrophysicist and Cosmologist

John Casani; Voyager Project Manager

Jim Bell; Author of “Interstellar Age”

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- *When Voyager reached Titan in 1980 its cameras were defeated by 'smog'…*

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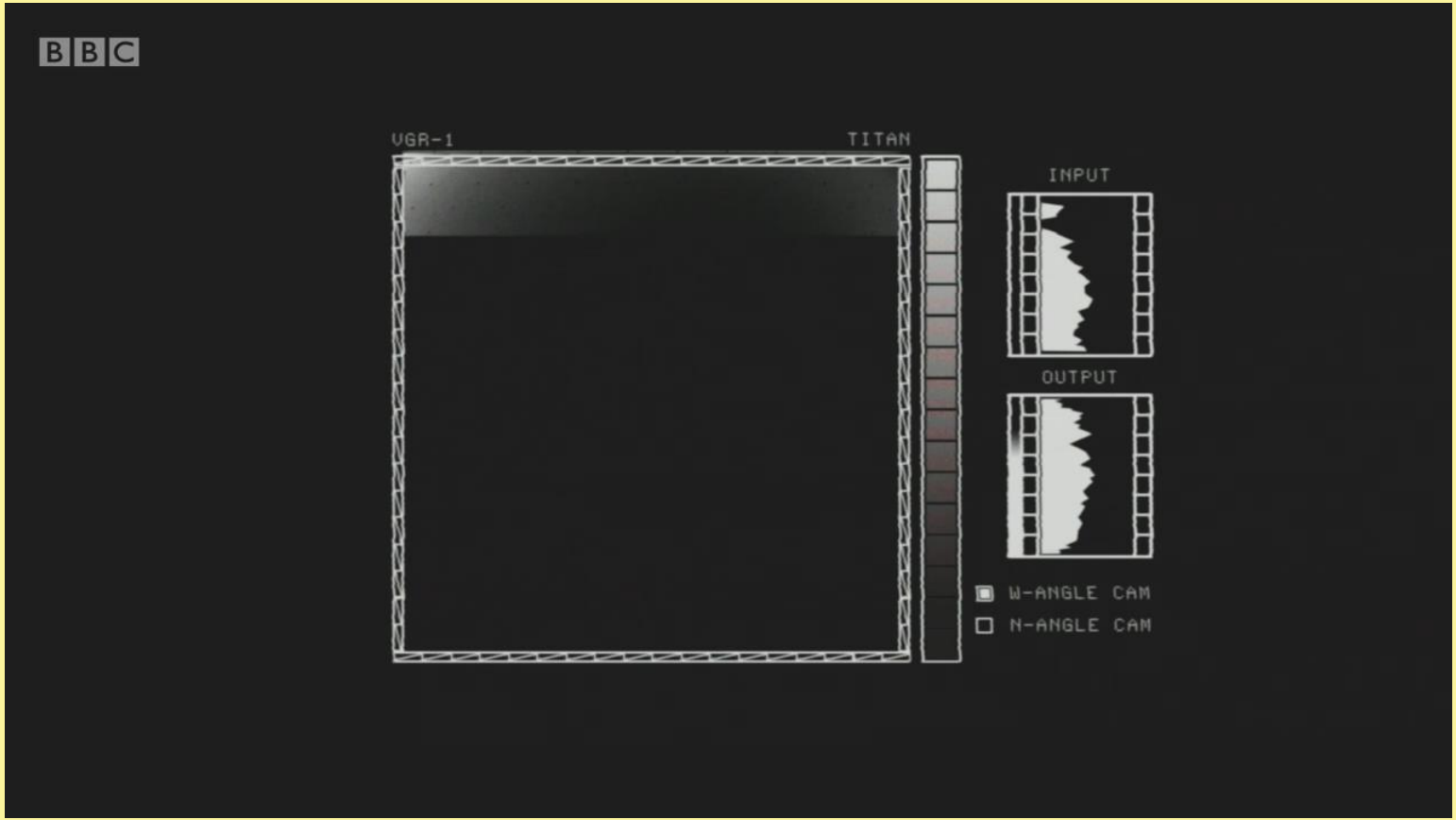
… BUT, Titan’s Atmosphere Was Impenetrable To Voyager 1’s Cameras…



Jim Bell;
Author of “Interstellar Age”
Larry Soderblom;
Voyager Imaging Science Team (Astrogeologist)

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- *Eventually, NASA/ESA/ISA plot collaborative return to Saturnian System*
  - *Cassini-Huygens orbiter and probe combination blasted off in 1997*

    → Aiming to penetrate 'the veil' of Titan's smog of 'THOLIN' organics…

Cassini-Huygens Mission Aims To Draw Back The Veil on Titan

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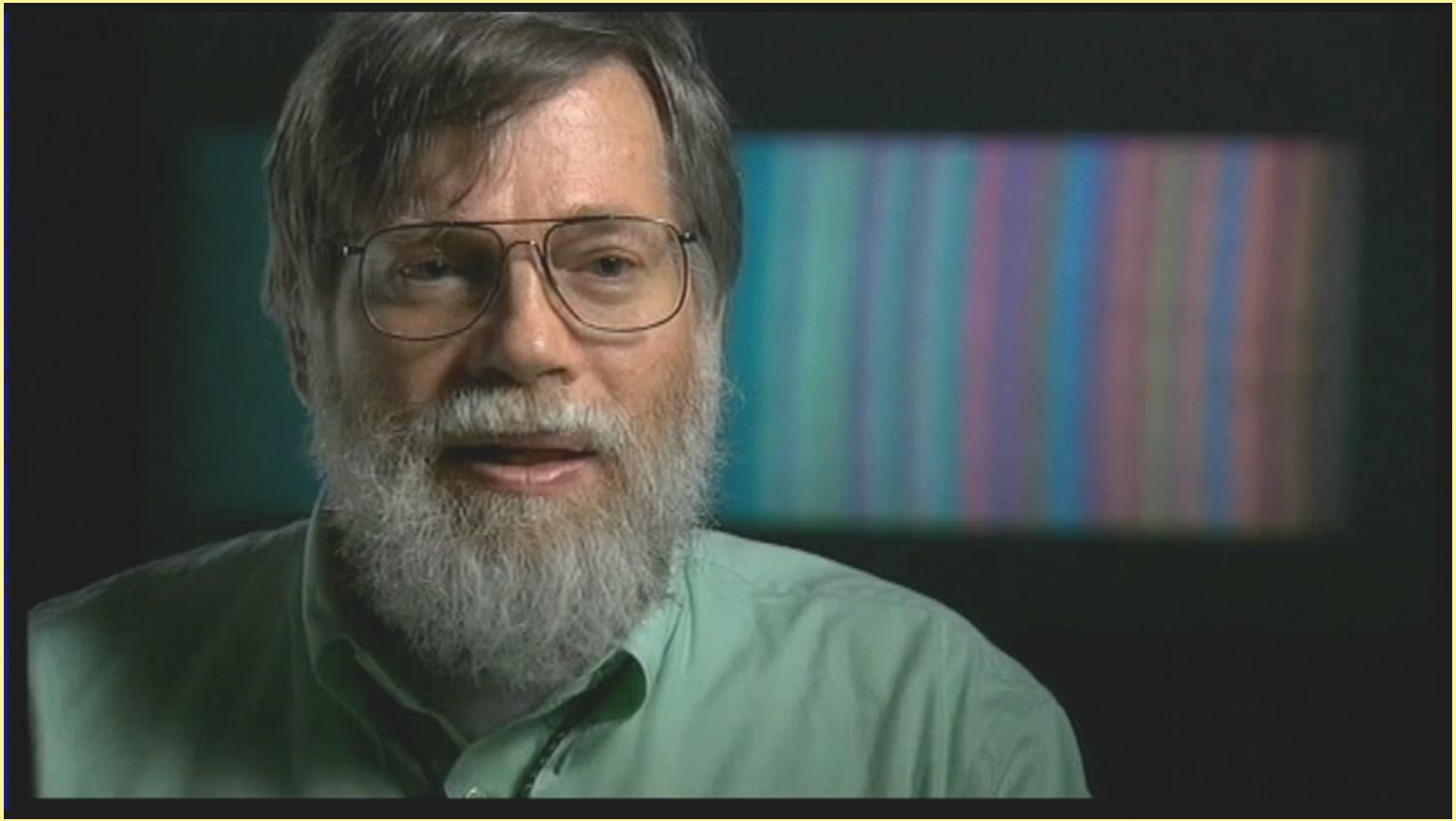
Source: BBC Horizon strand; “Saturn: Lord of the Rings”; https://www.bbc.co.uk/programmes/p00607tg; 2004-5 Season.

After The Voyager Imaging Disappointment, Cassini-Huygen's Instrument Package Was Carefully Considered For The Study of Titan…



Larry Esposito; Principal Investigator, Cassini Ultraviolet Imaging Spectrometer (UVIS) Jack Fortune; Narrator

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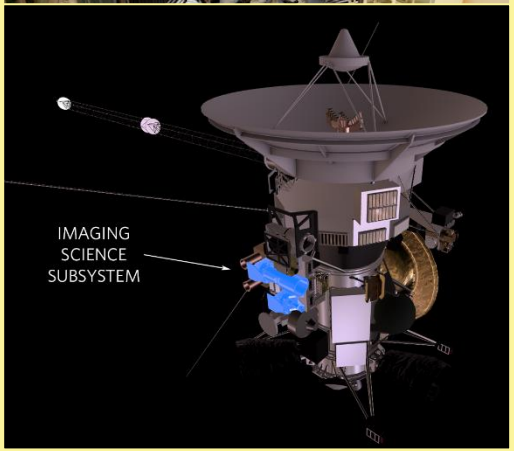

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Source: BBC Horizon strand; “Saturn: Lord of the Rings”; https://www.bbc.co.uk/programmes/p00607tg; 2004-5 Season.

ISS Has Twin 1kx1k CCD Cameras Sensitive From Near-UV To Near-IR, Including 938 nm, Which Confers Some Smog Penetration Ability…

Jack Fortune;
Narrator
Caroline Porco;
Team Leader, Cassini Imaging Science Subsystem (ISS)

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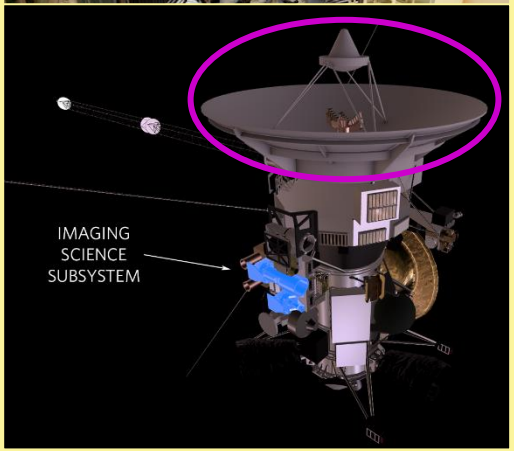

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Source: BBC Horizon strand; “Saturn: Lord of the Rings”; https://www.bbc.co.uk/programmes/p00607tg; 2004-5 Season.

The Active-Sensing, Synthetic Aperture Radar (Ku-Band; λ = 2.18 cm), Could Penetrate Thick Atmospheres With Ease…

Jack Fortune;
Narrator

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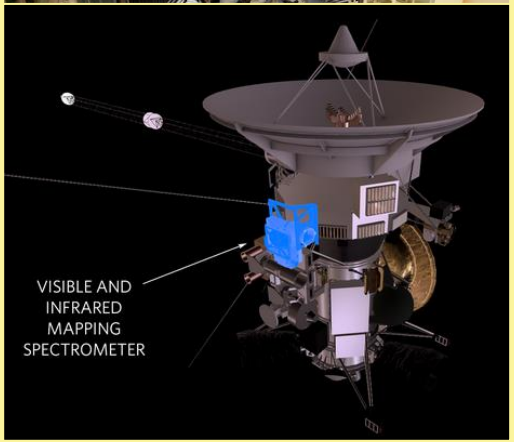

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VIMS Scans From 0.35 μm (Near-UV) To 5.1 μm (Mid-IR) In 352 Bands & Delivers A 2-D Map Of Spectral Responses…

Jack Fortune;
Narrator
Bob Brown;
Team Leader, Cassini Visual and Infrared Mapping Spectrometer (VIMS)

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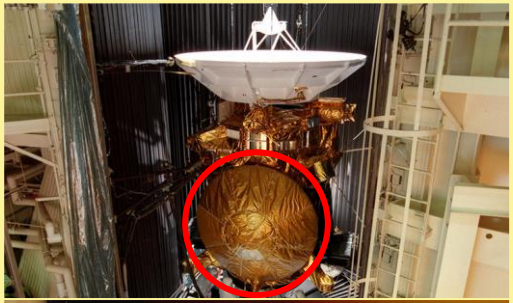

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ESA’s Huygens Probe Was Designed To Enter Titan’s Atmosphere And Make Measurements All The Way Down To The Surface…

Jack Fortune;
Narrator
John Zarnecki;
Principal Investigator, Huygens Surface Science Package (SSP)

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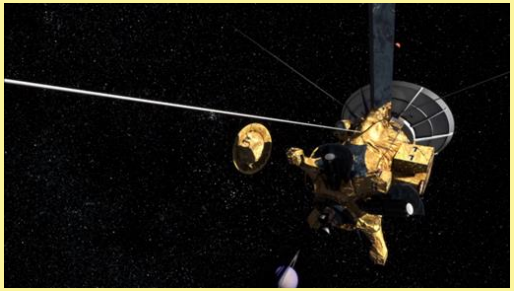

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Source: Yesterday Channel; “Secrets of the Solar System; Episode 7; - Saturn”; https://uktvplay.uktv.co.uk/shows/secrets-of-the-solar-system/watch-online/6166352070001; 2019.
Animation of Huygens's trajectory from 25 December 2004 to 14 January 2005, https://upload.wikimedia.org/wikipedia/commons/7/72/Animation_of_Huygens_trajectory.gif

On Christmas Day, 2004, The Huygens Probe Was Released; - On A Ballistic Trajectory To Enter Titan's Atmosphere…

Jim Al-Khalili;
Narrator
Earl Maize;
Cassini-Huygens Programme Manager
Julie Webster;
Cassini Spacecraft Operations Team Manager

Recommended Reading: The Saturn System Through The Eyes Of Cassini; eBook & https://en.wikipedia.org/wiki/Titan_(moon); & https://solarsystem.nasa.gov/missions/cassini/science/titan/ & Lorenz, R (2017). *NASA/ESA/ASI Cassini-Huygens*, Haynes ISBN 9781785211119 : Recommended Viewing: http://sci.esa.int/cassini-huygens/39218-huygens-descent-to-titan-surface/

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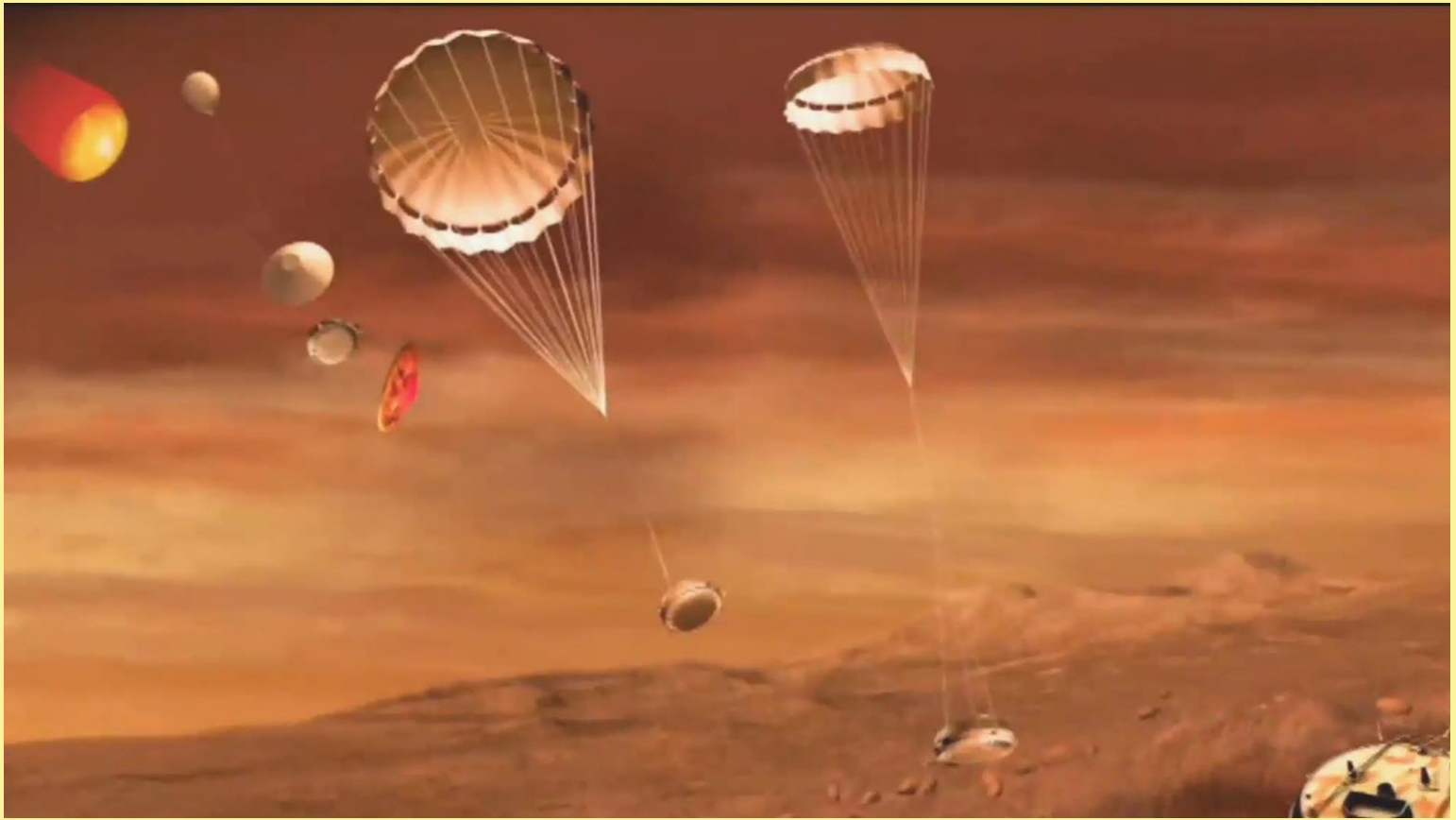
After Coasting For 20 Days Huygens Entered Titan's Atmosphere At 6000 ms^{-1}, But 5 ms^{-1} Was Required To Land Safely On The Surface…



Manish Patel; Planetary Scientist

Earl Maize; Cassini-Huygens Programme Manager

Olivier Witasse; ESA Planetary Scientist

Jim Al-Khalili; Narrator

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Erich Karkoschka, Lunar and Planetary Lab, DISR team, University of Arizona; https://sci.esa.int/web/cassini-huygens/-/39218-huygens-descent-to-titan-surface; 2015

The Probe’s Descent Took 150 Mins; - Longer Than Expected, But Huygen’s Batteries Lasted 72 Mins On The Surface, Despite -180°C Temperature!

Elizabeth ‘Zibi’ Turtle;
Principal Investigator of Dragonfly Mission
David Harrington;
Narrator of final descent ANIMATION, created by University of Arizona team responsible for the Descent Imager / Spectral Radiometer (DISR) instrument, which captured the images seen

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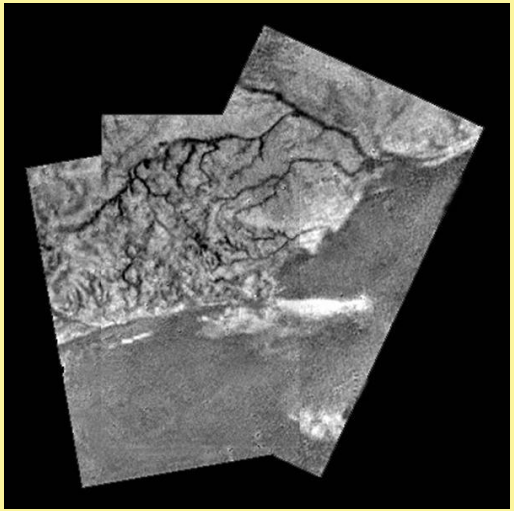

Source: BBC, The Sky At Night; “Unveiling Titan”; https://www.bbc.co.uk/iplayer/episode/p00f8xfz/the-sky-at-night-unveiling-titan; Broadcast 7 Feb 2005.

The Legacy Of Liquid Was Clearly Evident On The Surface Of Titan, Although The Probe Did Not Encounter ANY Liquid At The Landing Site…

Michelle Dougherty; Magnetometer Team Leader, Cassini Orbiter

John Zarnecki; Principal Investigator, Huygens Surface Science Package

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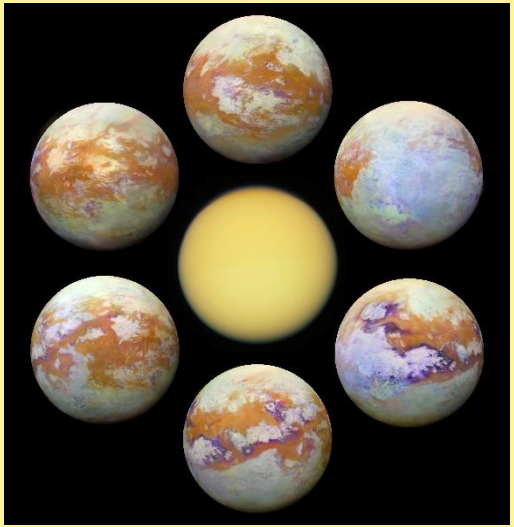

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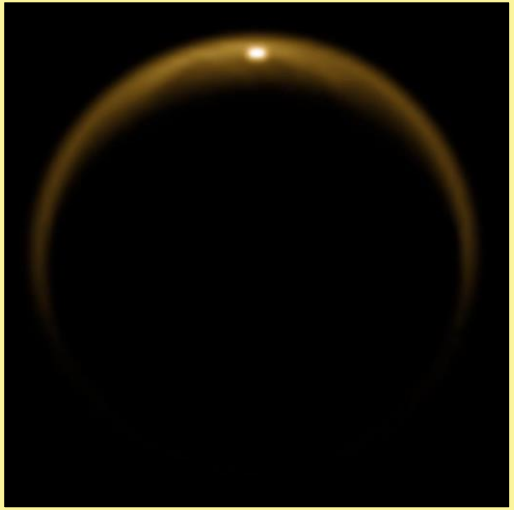

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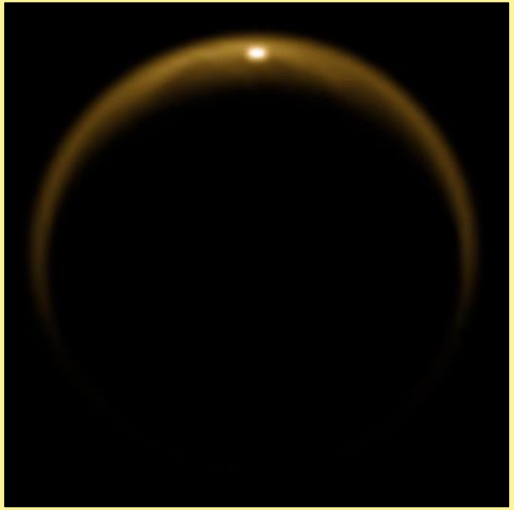

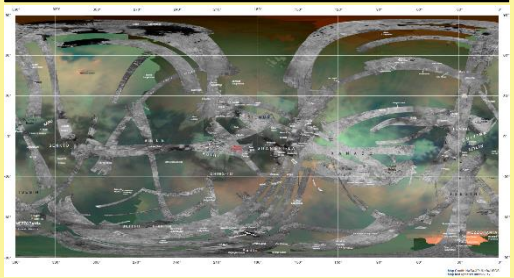

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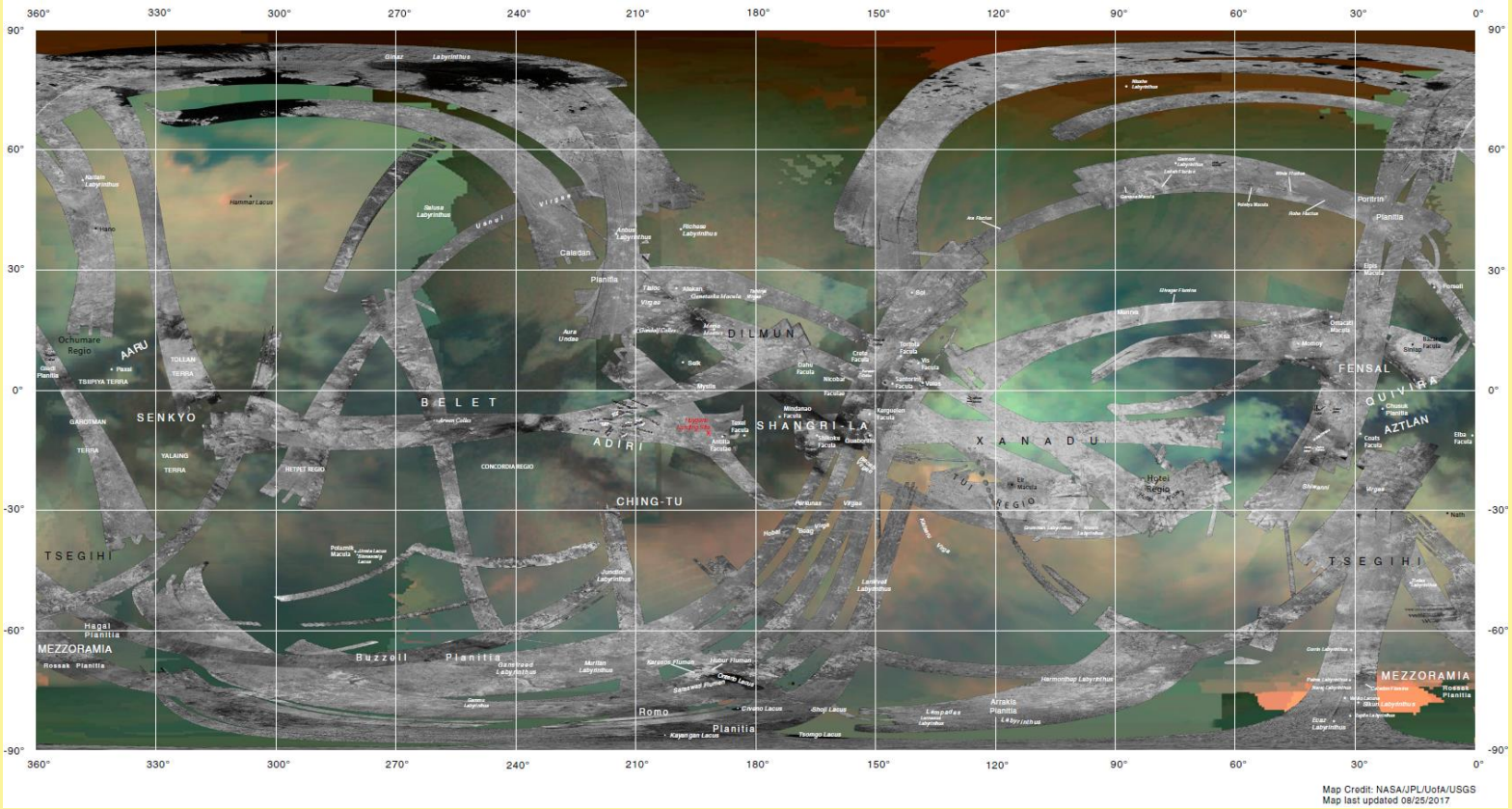
Source: The Planetary Society, Bruce Murray Space Image Library, Maps of Titan with place names;
https://planetary.s3.amazonaws.com/assets/images/6-saturn/2017/20171025_Titan_comp_VIMSimage.pdf; Last accessed 1 Dec 2022.

Cassini Radar Swaths (Monochrome) Overlaying VIMS Image Map (RGB); - Cylindrical Projection



Huygens Landing Site
Lat; 10.6°S
Long; 192.3°W
Cassini radar Monochrome; ʎ=2.18 cm
VIMS spectral mapping;
R; ʎ=5 μm
G; ʎ=2 μm
B; ʎ=1.3 μm
The very ‘radar dark’ patches in NW are the three major liquid ‘seas’ on Titan, viz; Punga Mare, Kraken Mare & Ligeia Mare

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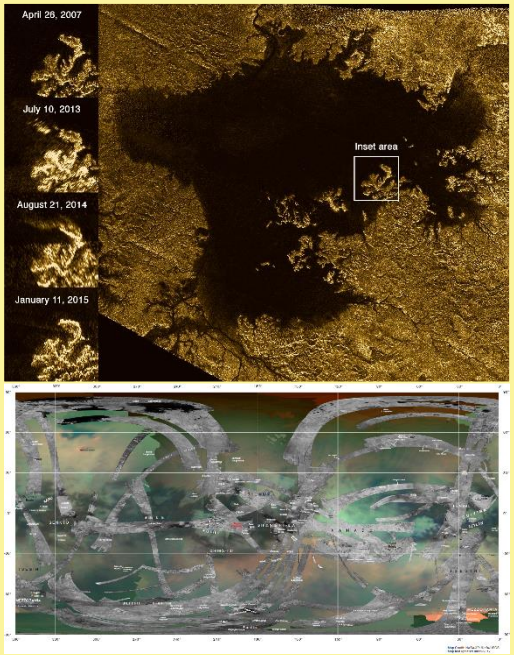
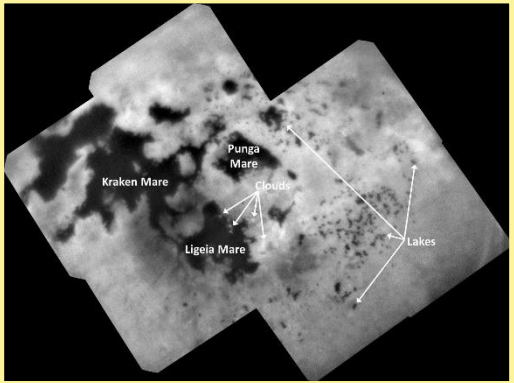
      …and RADAR has observed transient features in maria; e.g. Ligeia Mare…



Recommended Reading: The Saturn System Through The Eyes Of Cassini; eBook & https://en.wikipedia.org/wiki/Titan_(moon); & https://solarsystem.nasa.gov/missions/cassini/science/titan/ & Lorenz, R (2017). *NASA/ESA/ASI Cassini-Huygens*, Haynes ISBN 9781785211119 : Recommended Viewing: http://sci.esa.int/cassini-huygens/39218-huygens-descent-to-titan-surface/

Cassini-Huygens Mission Aims To Draw Back The Veil on Titan

- At Voyagers' flyby, Titan's haze had preserved that moon's mystery



- Cassini-Huygens was instrumented to penetrate atmosphere
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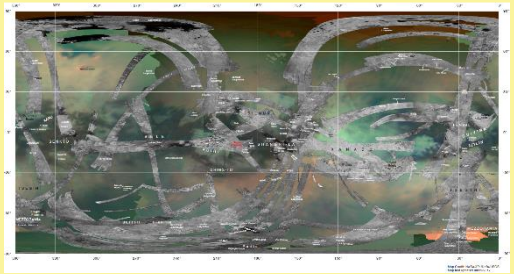

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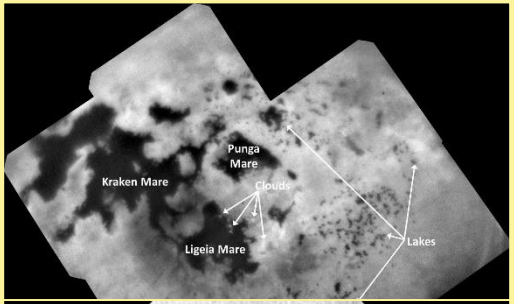

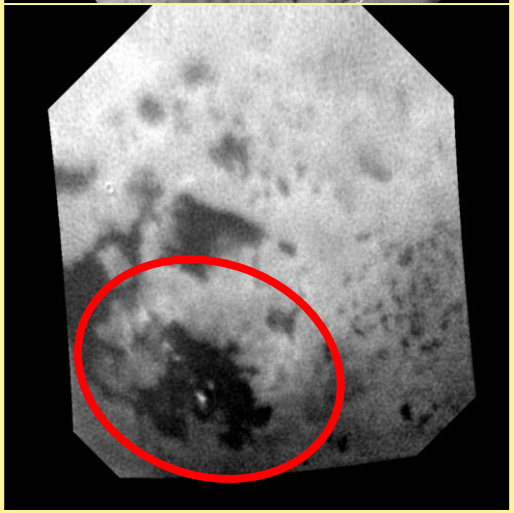

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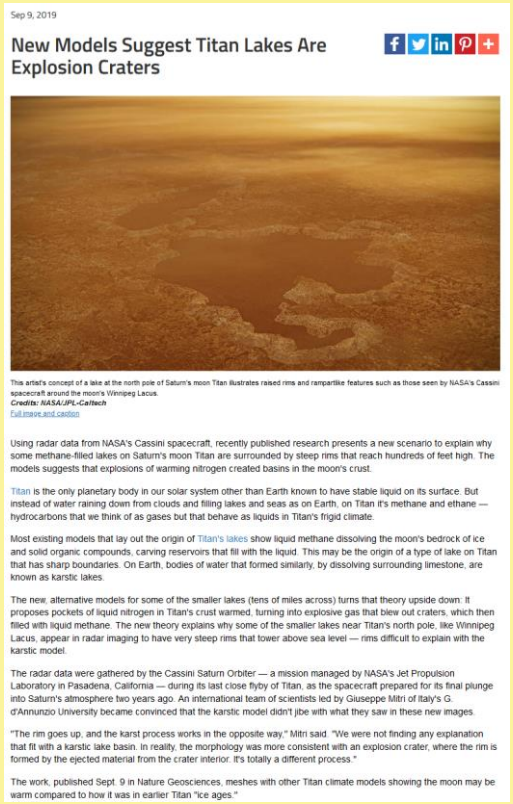

Sep 9, 2019

New Models Suggest Titan Lakes Are Explosion Craters

This artist's concept of a lake at the north pole of Saturn's moon Titan illustrates raised rims and rampartlike features such as those seen by NASA's Cassini spacecraft around the moon's Winnipeg Lacus.
Credits: NASA/JPL-Caltech
Full image and caption

Using radar data from NASA's Cassini spacecraft, recently published research presents a new scenario to explain why some methane-filled lakes on Saturn's moon Titan are surrounded by steep rims that reach hundreds of feet high. The models suggests that explosions of warming nitrogen created basins in the moon's crust.

Titan is the only planetary body in our solar system other than Earth known to have stable liquid on its surface. But instead of water raining down from clouds and filling lakes and seas as on Earth, on Titan it's methane and ethane — hydrocarbons that we think of as gases but that behave as liquids in Titan's frigid climate.

Most existing models that lay out the origin of Titan's lakes show liquid methane dissolving the moon's bedrock of ice and solid organic compounds, carving reservoirs that fill with the liquid. This may be the origin of a type of lake on Titan that has sharp boundaries. On Earth, bodies of water that formed similarly, by dissolving surrounding limestone, are known as karstic lakes.

The new, alternative models for some of the smaller lakes (tens of miles across) turns that theory upside down. It proposes pockets of liquid nitrogen in Titan's crust warmed, turning into explosive gas that blew out craters, which then filled with liquid methane. The new theory explains why some of the smaller lakes near Titan's north pole, like Winnipeg Lacus, appear in radar imaging to have very steep rims that tower above sea level — rims difficult to explain with the karstic model.

The radar data were gathered by the Cassini Saturn Orbiter — a mission managed by NASA's Jet Propulsion Laboratory in Pasadena, California — during its last close flyby of Titan, as the spacecraft prepared for its final plunge into Saturn's atmosphere two years ago. An international team of scientists led by Giuseppe Mitri of Italy's G. d'Annunzio University became convinced that the karstic model didn't jibe with what they saw in these new images.

"The rim goes up, and the karst process works in the opposite way," Mitri said. "We were not finding any explanation that fit with a karstic lake basin. In reality, the morphology was more consistent with an explosion crater, where the rim is formed by the ejected material from the crater interior. It's totally a different process."

The work, published Sept. 9 in Nature Geosciences, meshes with other Titan climate models showing the moon may be warm compared to how it was in earlier Titan "ice ages."

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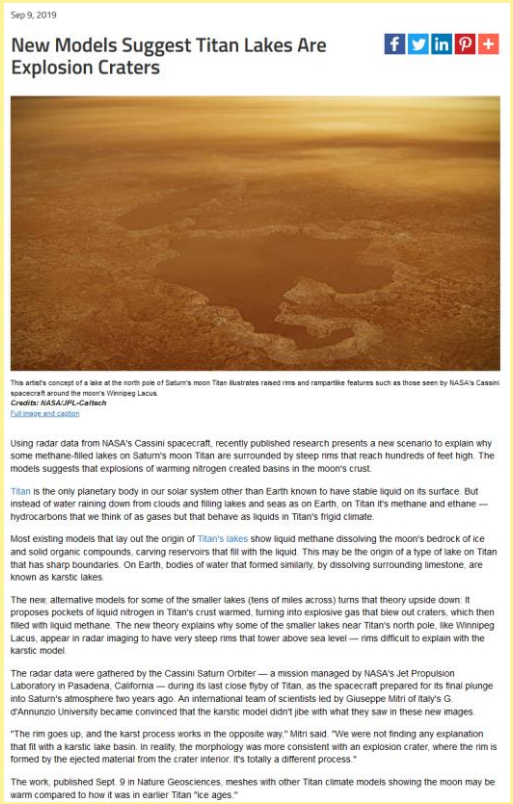

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- Many questions remain; - *more 'Ground Truth' is required…*

Credits 1; - Speakers to camera (in order of first appearance)

‘critical science objective of Voyager’; BBC4 Storyville strand; “The Farthest: Voyager’s Interstellar Journey”; https://www.bbc.co.uk/programmes/b09gvnty; Last shown 2019

Carl Saga (Voiceover)	Astrophysicist, Astronomer, Cosmologist, Scientist
John Casani	Voyager Project Manager
Jim Bell	Author of ‘Interstellar Age’

‘camera were defeated by ‘smog’; BBC4 Storyville strand; “The Farthest: Voyager’s Interstellar Journey”; https://www.bbc.co.uk/programmes/b09gvnty; Last shown 2019

Jim Bell	Author of ‘Interstellar Age’
Larry Soderblom	Voyager Imaging Science Team (Astrogeologist)

‘Cassini-Huygens was instrumented to penetrate atmosphere’; BBC Horizon strand; “Saturn: Lord of the Rings”; https://www.bbc.co.uk/programmes/p00607tg; 2004-5 Season

Larry Esposito	Principal Investigator, Cassini UVIS Instrument
Jack Fortune (Narrator)	Narrator; Horizon; ‘Lord Of The Rings’

‘ISS’; BBC Horizon strand; “Saturn: Lord of the Rings”; https://www.bbc.co.uk/programmes/p00607tg; 2004-5 Season

Jack Fortune	Narrator ; Horizon; ‘Lord Of The Rings’
Carolyn Porco	ISS Team Leader, Cassini

Credits 2; - Speakers to camera (in order of first appearance)

‘RADAR’; BBC Horizon strand; “Saturn: Lord of the Rings”; https://www.bbc.co.uk/programmes/p00607tg; 2004-5 Season

Jack Fortune	Narrator ; Horizon; ‘Lord Of The Rings’

‘VIMS’; BBC Horizon strand; “Saturn: Lord of the Rings”; https://www.bbc.co.uk/programmes/p00607tg; 2004-5 Season

Jack Fortune	Narrator ; Horizon; ‘Lord Of The Rings’
Bob Brown	VIMS Team Leader, Cassini

‘VIMS’; BBC Horizon strand; “Saturn: Lord of the Rings”; https://www.bbc.co.uk/programmes/p00607tg; 2004-5 Season

Jack Fortune	Narrator ; Horizon; ‘Lord Of The Rings’
John Zarnecki	Principal Investigator, Huygens Surface Science Package

‘Huygens departed Cassini’; Yesterday Channel; “Secrets of the Solar System; Episode 7; - Saturn”; https://uktvplay.uktv.co.uk/shows/secrets-of-the-solar-system/watch-online/6166352070001; 2019

Animation of Huygens's trajectory from 25 December 2004 to 14 January 2005, https://upload.wikimedia.org/wikipedia/commons/7/72/Animation_of_Huygens_trajectory.gif

Jim Al-Khalili (Narrator)	Narrator; Secrets Of The Solar System; ‘Saturn’
Earl Maize	Cassini-Huygens Program Manager
Julie Webster	Cassini Spacecraft Operations Team Manager

Credits 3; - Speakers to camera (in order of first appearance)

‘heatshields and ‘chutes’; Yesterday Channel; “Secrets of the Solar System; Episode 7; - Saturn”; https://uktvplay.uktv.co.uk/shows/secrets-of-the-solar-system/watch-online/6166352070001; 2019

Manish Patel	Planetary Scientist
Earl Maize	Cassini-Huygens Program Manager
Olivier Witasse	ESA Planetary Scientist
Jim Al-Khalili (Narrator)	Narrator; Secrets Of The Solar System; ‘Saturn’

‘descent’ ; Yesterday Channel; “Secrets of the Solar System; Episode 7; - Saturn”; https://uktvplay.uktv.co.uk/shows/secrets-of-the-solar-system/watch-online/6166352070001; 2019

Erich Karkoschka, Lunar and Planetary Lab, DISR team, University of Arizona; https://sci.esa.int/web/cassini-huygens/-/39218-huygens-descent-to-titan-surface; 2015

Elizabeth ‘Zibi’ Turtle	Planetary Scientist
David Harrington (Narrator)	University of Arizona Huygens Lander final descent animation

‘encountered no liquid’; BBC, The Sky At Night; “Unveiling Titan”; https://www.bbc.co.uk/iplayer/episode/p00f8xfz/the-sky-at-night-unveiling-titan; 7 Feb 2005

Michelle Dougherty	Magnetometer Team Leader, Cassini
John Zarnecki	Principal Investigator, Huygens Surface Science Package
Patrick Moore	(Silent observer)

Thank You For Your Attention!

Any questions?