AIAA Houston Section

Since 1962

Horizons, Newsletter of AIAA Houston Section

AUGUST 2017

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Calendar of Events

LAUNCHES

9/5	Ariane 5	ELA-3, Kourou, French Guinea
9/7	Falcon 9	LC-39A, Kennedy Space Center, FL
9/9	Proton	Baikonur Cosmo-drome, Kazakhstan
9/11	Atlas 5	SLC-3E Vandenberg Airforce Base, CA
9/12	Soyuz	Baikonur Cosmo-drome, Kazakhstan
9/21	Rockot	Plesetsk Cosmo-drome, Russia
9/25	Atlas 5	SLC-41, Cape Canav-
9/27	Falcon 9	Cape Canaveral, FL
9/28	Proton	Baikonur Cosmo-
9/30	Falcon 9	SLC-3E Vandenberg Airforce Base, CA

NOTE:
Annual leadership retreat has been postponed.

AIAA Space & Astronautics Forum

9/12— 9/14 Orlando, FL

21st CEAS Aeroacoustics Specialist Committee

9/13— 9/16 Dublin, Ireland 2017

AIAA Regional Leadership Conference

9/14—9/15 Orlando, FL

36th Digital Avionics Systems Conference

9/17— 9/21 St. Petersburg, FL

68th International Astronautics Congress

9/25— 9/29 Adelaide, Australia

International Symposium for Personal & Commercial Spaceflight

10/11—10/12 Las Cruces, NM

AIAA Beyond B2B: Connecting for Growth

10/12 New Orleans, LA

Letter from the Editor

Shen Ge, Horizons Editor

Dear readers,

As we head towards a new year here at AIAA Houston, I'm reminded once again of the remarkable achievement we have accomplished so far and the exciting year ahead. Harvey has hit us quite hard but Houston is resilient and we are already getting back on our feet.*

In this issue, we have a cover feature on the final mission stages of Cassini around Saturn by astrodynamicist Dan Adamo. We are also covering climate change and the local response and an article from our French sister section on how light pollution has affected birds. So read on and offer your views. Also, please note that in later issues, there will be a column from our current Chair, Svetlana Hanson.

Sincerely,

Shen Ge

Horizons Editor

Figure:

Tropical Storm Harvey NASA astronaut Randy Bresnik snapped the above photo of Harvey from the ISS at 2:27PM ET August 28, 2017.

(Image Credit: NASA)

Special: Cassini's Endgame at Saturn

Dan Adamo, Astrodynamics Consultant

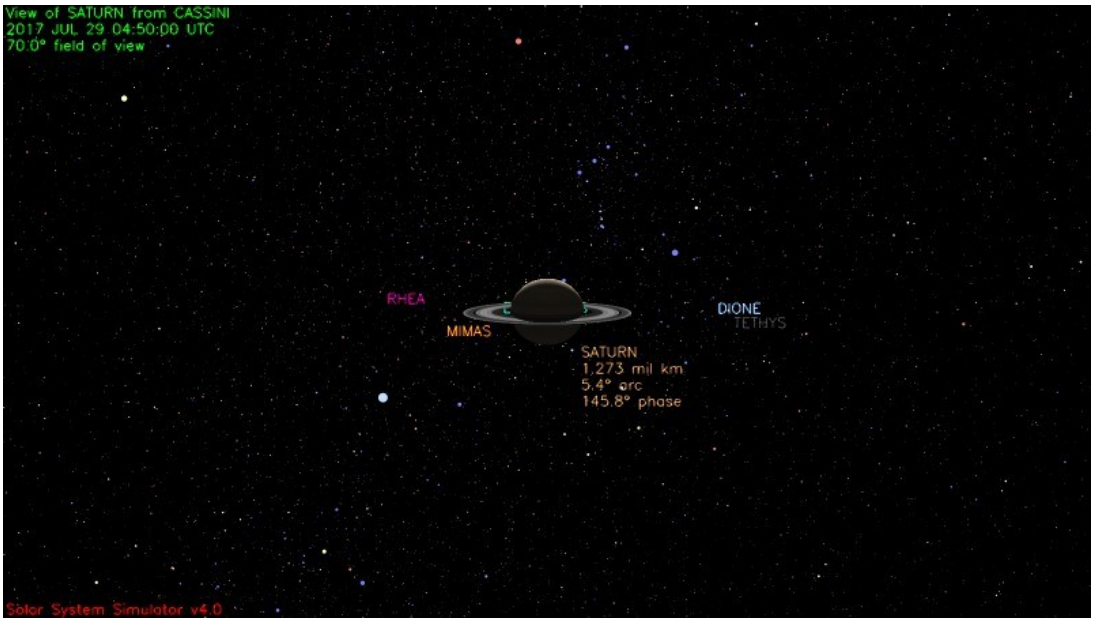
Figure 1:

Saturday, July 29 (DOY 210)

Early today Cassini coasted through apoapsis [or apochrone], the highest and slowest part of its orbit of Saturn. This marked the start of its Saturn orbit #286 [or Orb 286].

As soon as the long ISS [Cassini's Imaging Science Subsystem] observation of Kiviuq [Saturn's small irregular moon] was done, it was time for Kappa Orionis to re-emerge from behind Saturn's atmosphere, this time in the sunlit north. UVIS [Cassini's Ultraviolet Imaging Spectrograph] watched it for another 70 minutes as it re-appeared. This blue star is well known as the lower-left star in the constellation Orion's main quadrangle. It can be seen beginning to egress from Saturn occultation, in this simulated view from Cassini:

https://go.nasa.gov/2uS8j6b



Introduction

Launched on 15 October 1997, the Cassini spacecraft required gravity assists from Venus, Earth, and Jupiter before achieving Saturn orbit on 1 July 2004[1]. Since then, it has served as launch platform for the Huygens probe's historic landing on Saturn's major moon Titan[2], discovered briny water ice in geysers erupting from the moon Enceladus[3], imaged exotic moonlets within Saturn's rings[4], witnessed complex ring particle dynamics[5], monitored global storms in Saturn's atmosphere[6], confirmed hydrocarbon lakes dotting Titan's surface[7], and provided unique perspectives of Saturn[8] along with many more views and insights evoking our awe.

On 15 September 2017, Cassini's 13-year tour of the Saturn system ends with incineration high in the planet's atmosphere. This disposal measure is in accord with NASA's forward planetary protection policy because Cassini is running out of propellant with which to control its trajectory. Disposing of the spacecraft in Saturn's atmosphere ensures it does not inadvertently crash onto Titan or Enceladus. Thanks to Cassini, both of these moons are now known to harbor subsurface liquid water oceans where extant life is possible.

References

[1] https://saturn.jpl.nasa.gov/resources/1776/ (accessed 7 August 2017).

[2] https://saturn.jpl.nasa.gov/resources/2958/ (accessed 7 August 2017).

[3] https://saturn.jpl.nasa.gov/resources/4852/ (accessed 7 August 2017).

[4] https://saturn.jpl.nasa.gov/resources/7695/ (accessed 7 August 2017).

[5] https://saturn.jpl.nasa.gov/resources/2570/ (accessed 7 August 2017).

[6] https://saturn.jpl.nasa.gov/resources/5329/ (accessed 7 August 2017).

[7] https://saturn.jpl.nasa.gov/resources/5959/ (accessed 7 August 2017).

[8] https://photojournal.jpl.nasa.gov/catalog/PIA08329 (accessed 7 August 2017).

[9] https://ssd.jpl.nasa.gov/?horizons (accessed 7 August 2017).

[10] https://saturn.jpl.nasa.gov/news/3096/one-final-burn/ (accessed 11 August 2017).

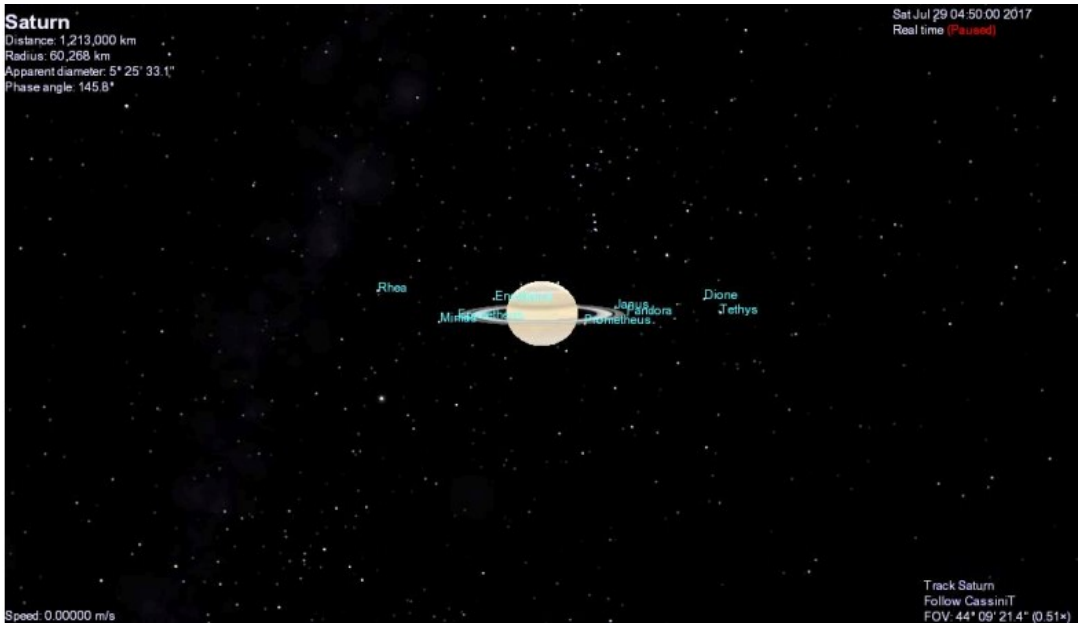


Figure 2:

The same stellar egress is rendered with Celestia[11] software in Figure 2 using Cassini trajectory data imported from Horizons. Celestia rendering of Saturn in Figure 2 is considerably brighter than in Figure 1 in order to reproduce easily visible stars. Positioning of those stars with respect to Saturn in Figures 1 and 2 is identical at the scale for these renderings. Consequently, the two figures serve to illustrate a high degree of correlation between the Cassini trajectory being flown in the real world and that posted to Horizons.

[11] https://celestiaproject.net/ (accessed 7 August 2017).

Mission Planning Pedigree

Cassini trajectory data presented in this article are obtained from JPL's Horizons ephemeris server[9] in a posting dated 9 September 2015. Trajectory data generated 2 years beforehand are still valid for Cassini disposal because, as of 15 July 2017, the spacecraft had performed 360 of 492 planned trajectory correction impulses to preserve mission design[10]. In Saturn orbit, such control is made possible with remaining onboard propellant, together with some heavy lifting from gravity assists during Titan flybys. To demonstrate the precision of posted Horizons data, consider the following report from the 3 August 2017 "Cassini Spacecraft Update".

Enabling Cassini Mission Objectives with Titan Gravity Assists

Throughout Cassini's sojourn in Saturn orbit, Titan gravity assists enable a broad spectrum of scientific observations. Thanks to Titan's gravity, dramatic changes in Cassini orbit inclination with respect to Saturn's equator, minimal orbit distance from Saturn (perichrone), orbit period, and apochrone/perichrone orientation with respect to the Sun/Saturn line are possible with relatively miniscule propellant consumption.

Since Titan orbits Saturn at an inclination of 0.28° and a distance near 1.2 million km, persistent Titan flybys require Cassini to maintain one of its orbit plane nodes on Saturn's equatorial plane near 1.2 million km. As illustrated in Figures 1 and 2, other moons of Saturn and ring particles orbit the planet at low inclinations too. When Cassini's orbit inclination is also low, close observations of moons other than Titan can then be planned. The scientific downside to low orbit inclinations is Cassini can only view Saturn's rings edge-on, as illustrated by Figure 3 (on next page).

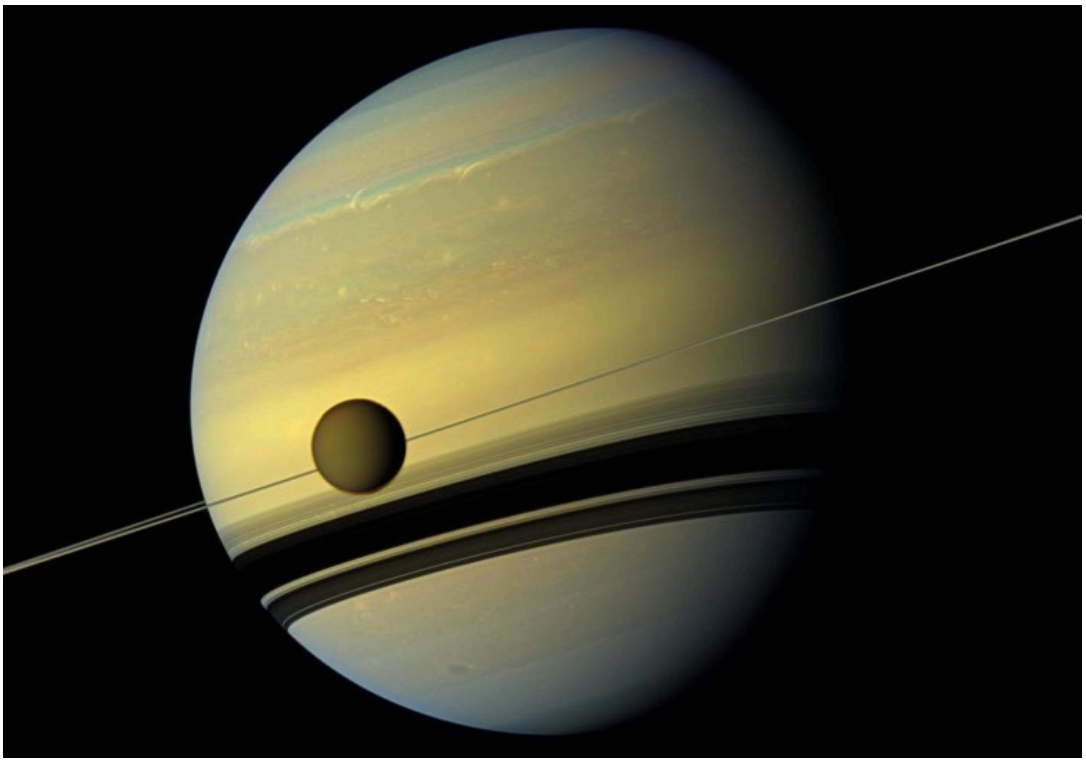


Figure 3:

Cassini observes Titan on 6 May 2012 from a distance of 778,000 km as the moon (5151 km in diameter) transits Saturn. Note the barely visible edge-on rings behind Titan and their shadows cast onto the planet. These shadows are nearly impossible to observe from Earth because our planet's Saturn perspective differs little from the Sun's.

Reference: https://saturn.jpl.nasa.gov/resources/5631/ (accessed 9 August 2017).

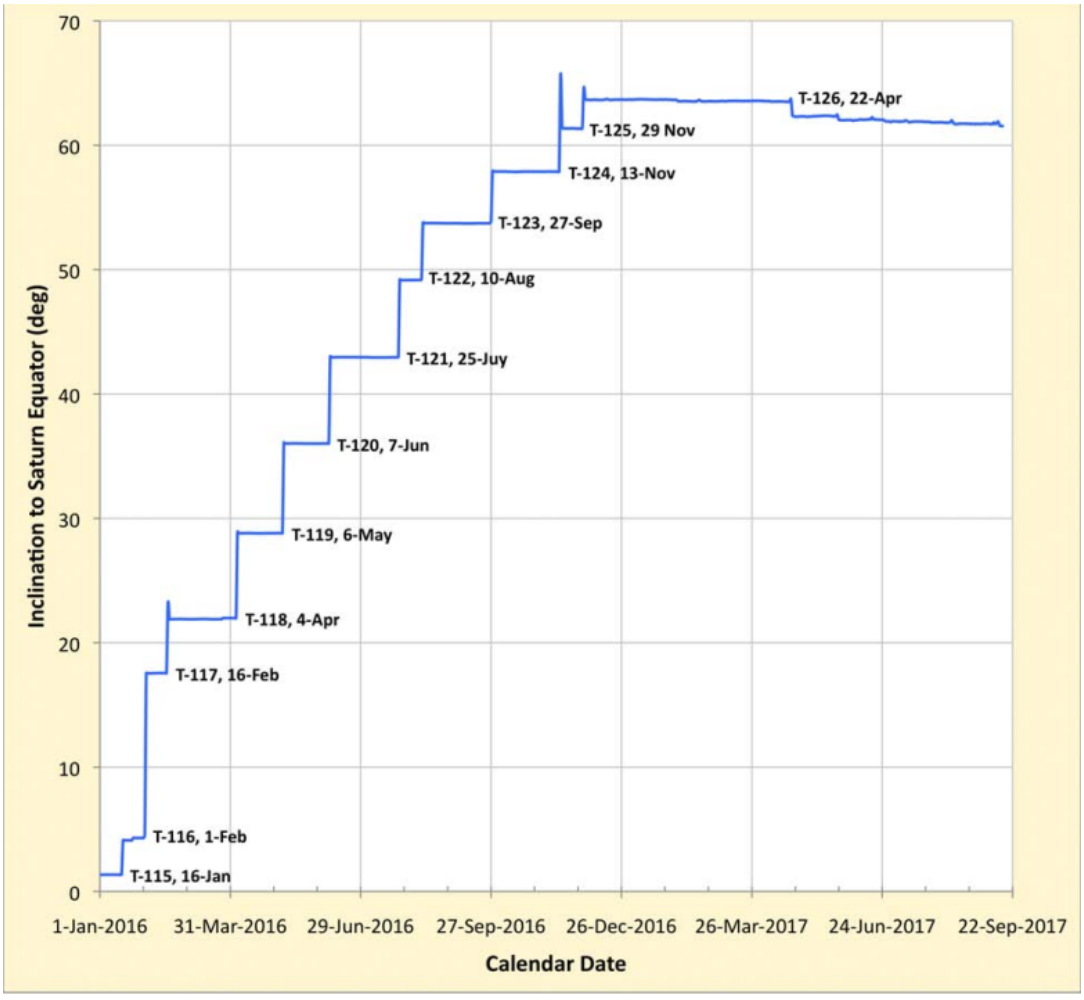


Figure 4:

Many Titan flybys (each designated with a "T-nnn" code, where "nnn" is a chronologic integer) are primarily dedicated to altering Cassini orbit inclination. Over time, these gravity assists provide a balance between observations only possible at low inclinations and those only possible at high inclinations. This figure illustrates how such inclination changes are accomplished from 2016 until Cassini disposal.

Inclination is typically incremented or decremented during each Titan flyby (annotated with a "T-nnn" chronologic counter) to a degree far beyond the capability of Cassini propulsion alone. Plot data are at 1-day intervals, and "spikes" can arise when an inclination value is obtained during a Titan gravity assist.

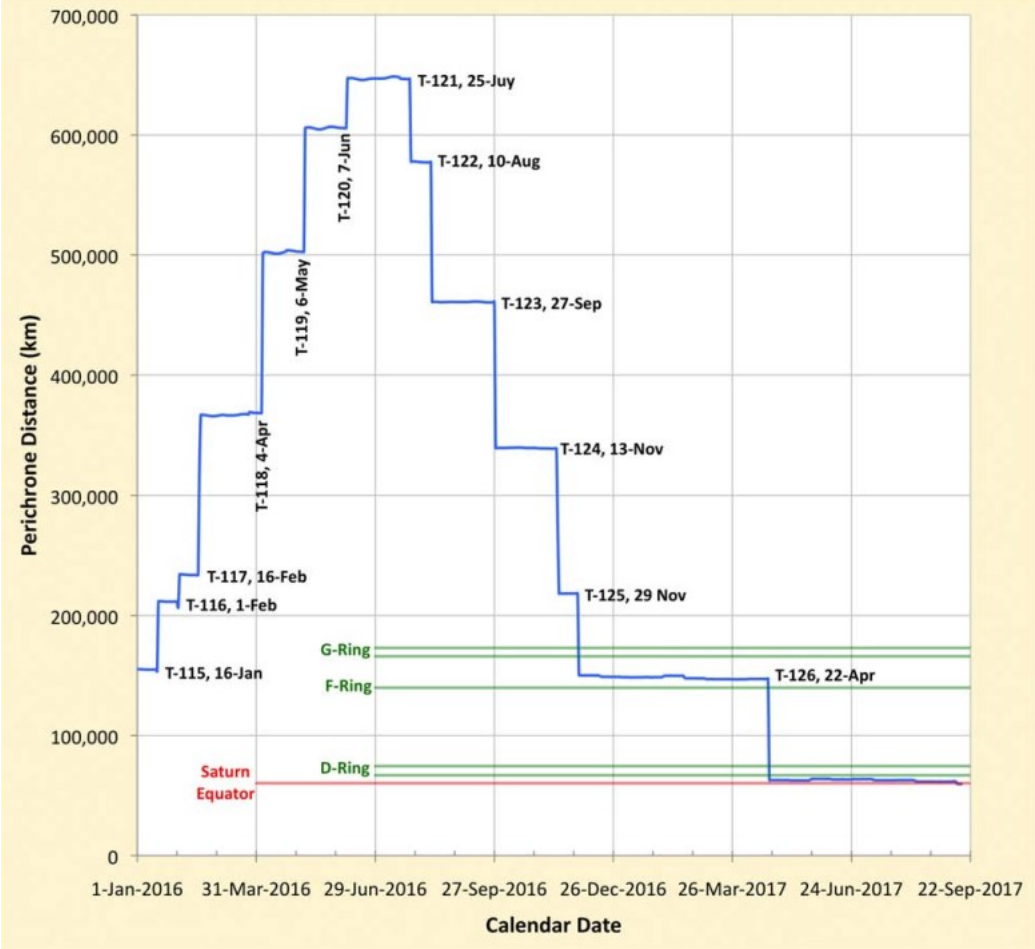


Figure 5:

Cassini perichrone distance from Saturn's center is plotted as a function of UT (blue) from 1 January 2016 until spacecraft incineration on 15 September 2017. Note how perichrone avoids regions about Saturn in which ring particles orbit, as annotated in green, thereby evading high-probability collisions. The red Saturn Equator annotation is at a distance of 60,268 km, where the planet's equatorial atmospheric pressure is 1 bar.

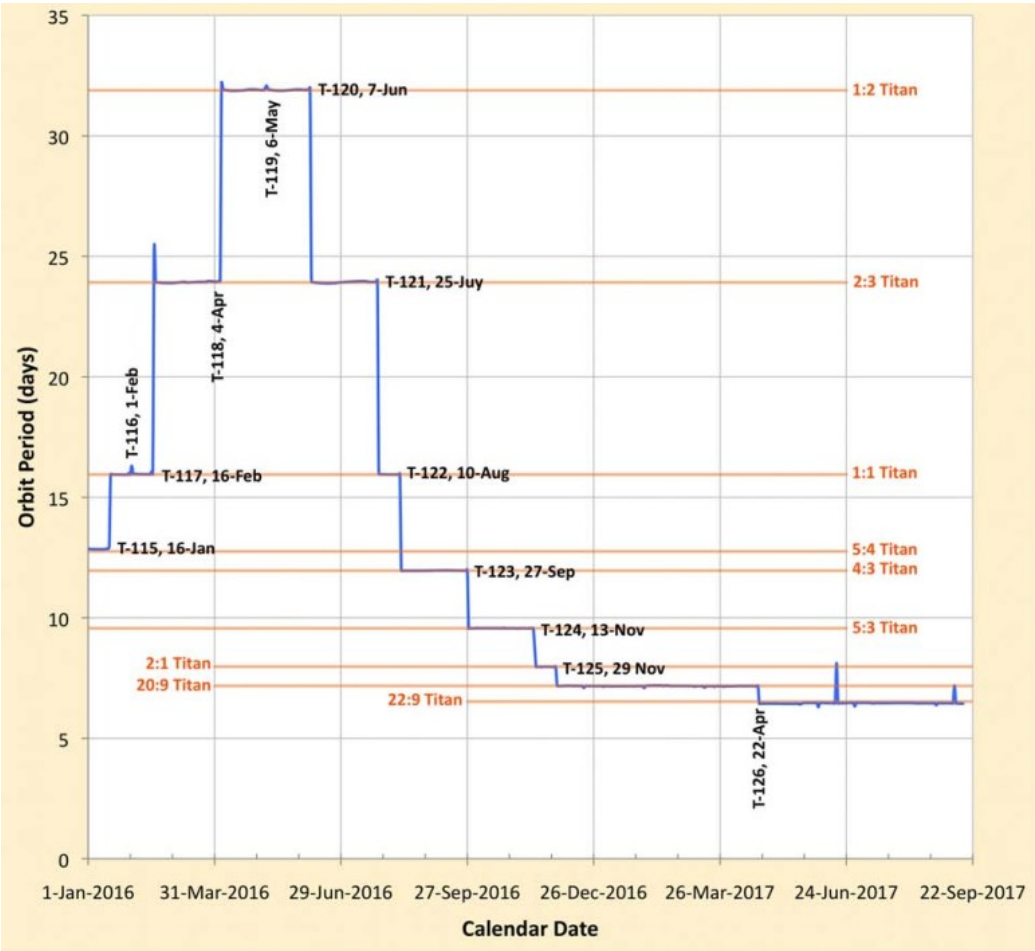


Figure 6:

Achieving a practical cadence of gravity assist flybys with reasonable propellant consumption requires Cassini maintain an orbit period resonance with Titan. Each resonance is expressed with j:k notation in which Cassini makes j complete orbits of Saturn in the same time Titan makes k complete orbits of Saturn with a fixed period of 15.945 days.

Cassini orbit period is plotted as a function of UT (blue) from 1 January 2016 until spacecraft incineration on 15 September 2017. To maintain a practical cadence of Titan gravity assists in support of mission objectives, a variety of orbit period resonances must be achieved between Cassini and Titan as annotated in orange.

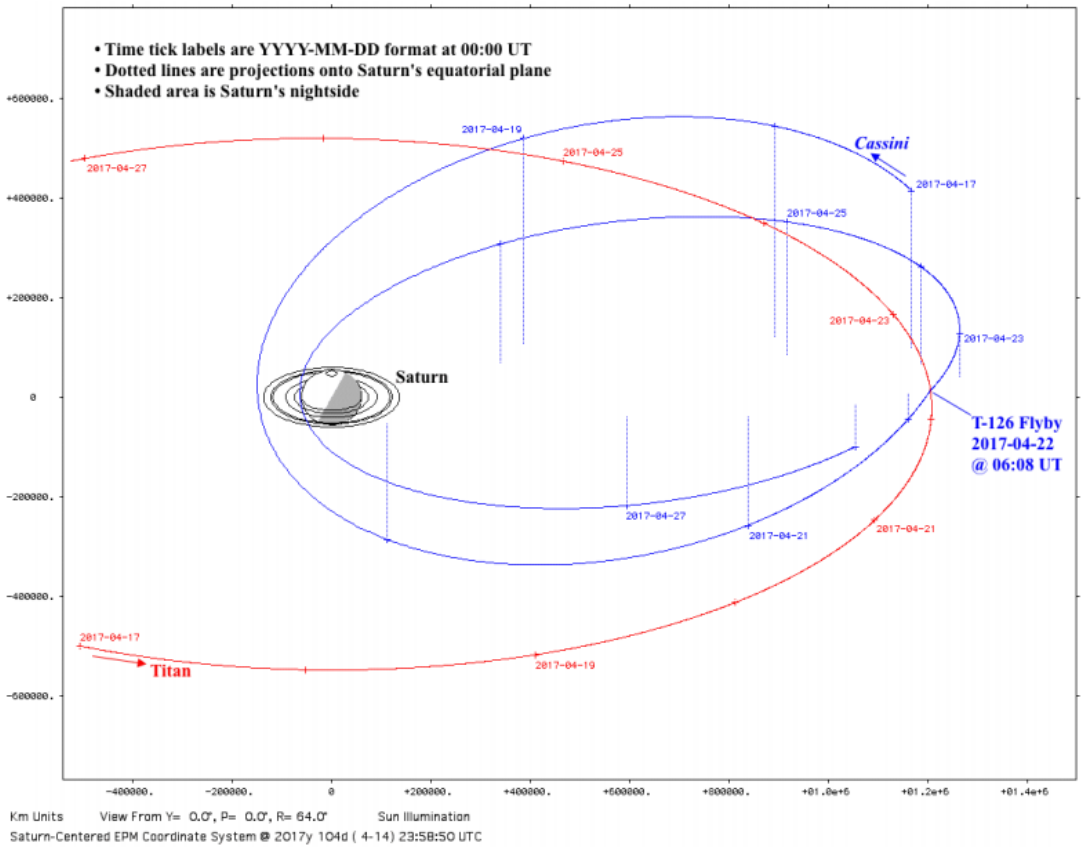


Figure 7:

T-126 flyby on 22 April 2017 causes perichrone to jump from immediately outside Saturn's major rings to a distance just inside them. This gravity assist initiates the mission's Grand Finalé phase with Cassini plunging 22 times between Saturn's atmosphere and its innermost D-Ring at 61.8° inclination[12]. Saturn-centered motion of Titan (red) and Cassini (blue) are plotted before and after T-126 flyby. Titan gravity assist shifts perichrone from outside Saturn's major rings to inside them. When Cassini reaches apochrone shortly after T-126, Orb 271 and Grand Finalé phase begin.

[12]https://saturn.jpl.nasa.gov/mission/grand-finale/grand-finaleorbit-guide/ (accessed 13 August 2017).

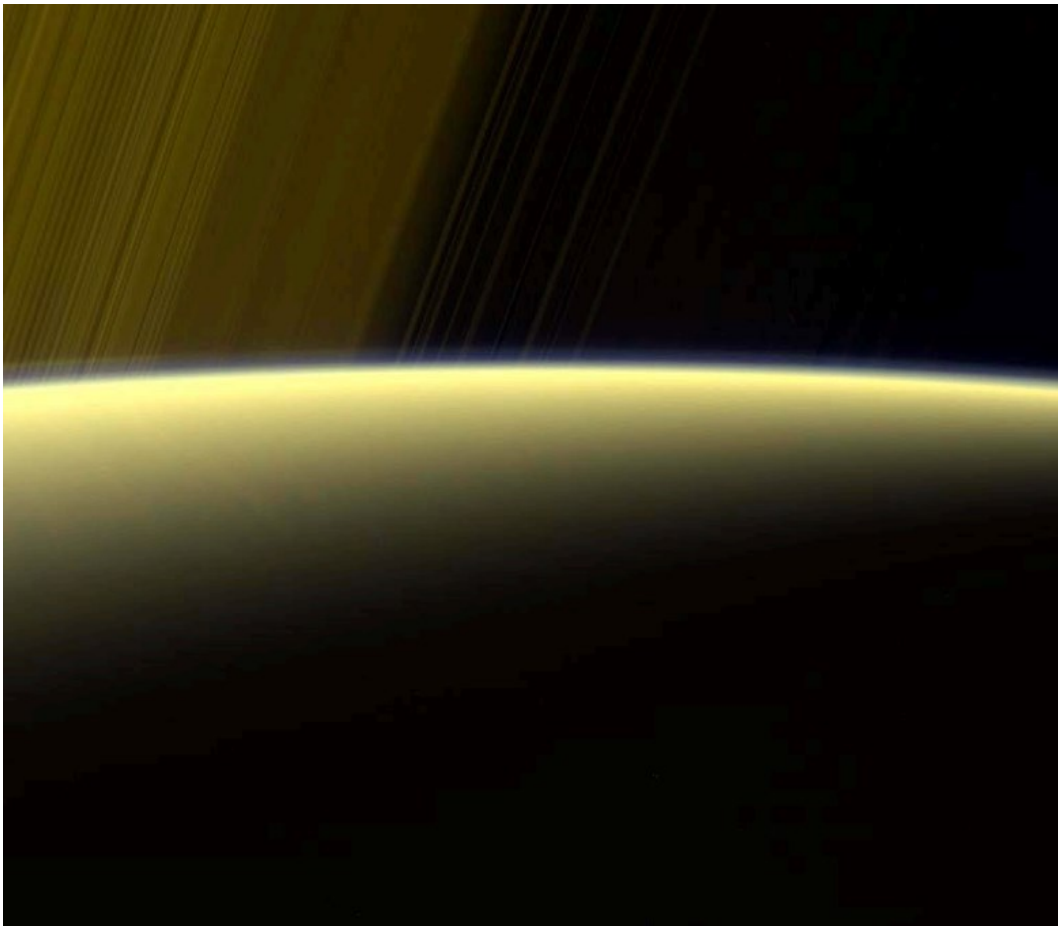


Figure 8:

After commencing Orb 284 at 1.25 million km from Saturn on 16 July 2017, Cassini captures planet's upper atmosphere partially backlit by its rings as Cassini begins its plunge to 14th Grand Finalé perichrone. Note detached haze layer in Saturn's stratosphere. On 15 September 2017, during its 23rd Grand Finalé perichrone passage, it loses attitude control and breaks contact with Earth above this layer shortly before atmospheric friction incinerates the spacecraft. Reference: https://saturn.jpl.nasa.gov/resources/7716/ (accessed 9

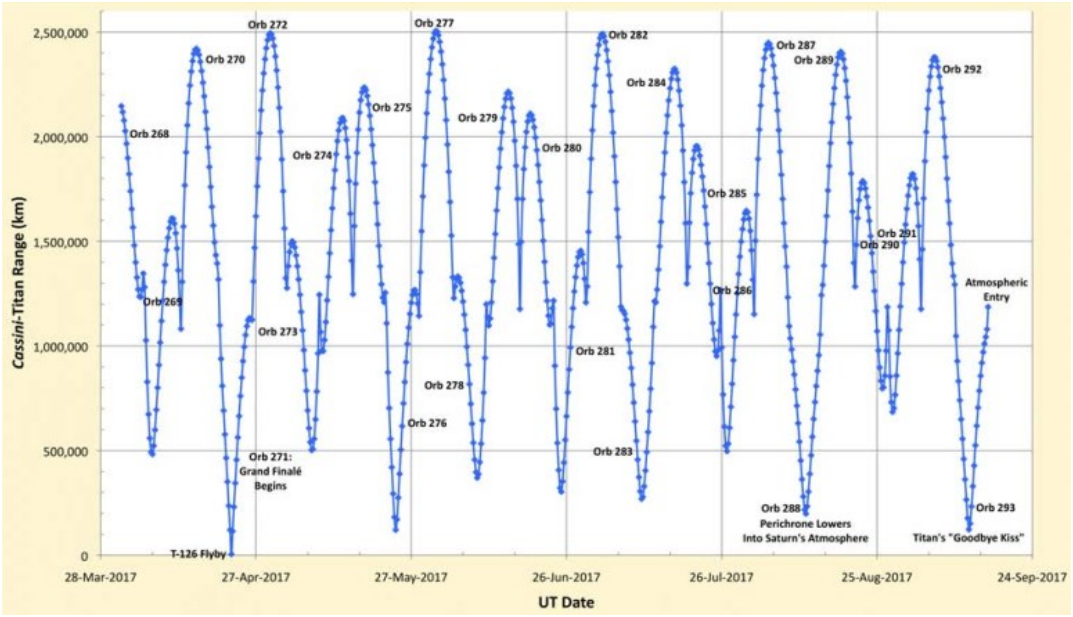


Figure 9:

Cassini range from Titan is plotted as a function of UT at 6-hour intervals from 1 April 2017 until final entry into Saturn's atmosphere on 15 September 2017. "Orb" annotations mark the start of each Cassini orbit as incremented at apochrone.

The Finale

As plotted in Figure 6, the T-126 gravity assist places Cassini in a 22:9 orbit period resonance with Titan. Although T-126 is Cassini's last close approach to Titan, Figure 9 indicates multiple encounters of the moon arise during Grand Finalé. When these encounters attain Cassini Titan range near 100,000 km, appreciable gravity perturbations are exerted on spacecraft's Saturn orbit. The last 5 perichrone passages prior to Cassini's incineration (Orb 288—Orb 292) are briefly inside Saturn's atmosphere, less than 1800 km above the 1 bar pressure level. As the post-T-126 resonance plays out after 22 Grand Finalé orbits by Cassini, a Titan encounter to within 123,000 km occurs on 11 September 2017 at the end of Orb 292. Informally known as "the goodbye kiss", gravity perturbations from this Titan encounter lower perichrone to a point Cassini incinerates in Saturn's atmosphere on Orb 293.

During Grand Finalé, Cassini makes observations of a quality impossible earlier in the mission. Higher resolution imagery of Saturn's north polar vortex and hexagonal jet stream[13] are obtained, while the planet's southern aurora is accessible for detailed photography[14]. Doppler shifts measured in Cassini's radio link with Earth significantly refine mass estimates for Saturn's rings and variations in the planet's gravity field. Magnetometer readings directly determine Saturn's rotation rate, a parameter previously inferred from cloud observations subject to ambiguous atmospheric wind and convection influences.

Near perichrone, direct sampling of inner ring particles and Saturn's uppermost atmosphere are made to determine their composition.

Because the rings and planet subtend relatively large angles throughout Cassini's Grand Finalé orbits, a greater number of stars can be observed to pass behind them. Measuring variations in starlight intensity at multiple wavelengths during an occultation provides valuable insights such as atmospheric pressure versus height (per the κ Ori occultation reproduced in Figure 1) and particle size distributions/densities in the rings. Related insights are made when Cassini's radio transmissions are received on Earth after passing through Saturn's atmosphere or rings.

Figure 10 (see next page) illustrates Cassini Saturn-centered motion during most of its last complete orbit, Titan's goodbye kiss, and final entry into the planet's atmosphere. Atmospheric forces are expected to result in loss of attitude control and communications with Cassini at 10:45 UT on 15 September 2017, about a minute after entry. These final signals will be received on Earth 83 minutes later at 12:08 UT. Requiem, Cassini!

References

[13] https://saturn.jpl.nasa.gov/resources/5805/ (accessed 13 August 2017).

[14] https://saturn.jpl.nasa.gov/resources/7720/ (accessed 13 August 2017).

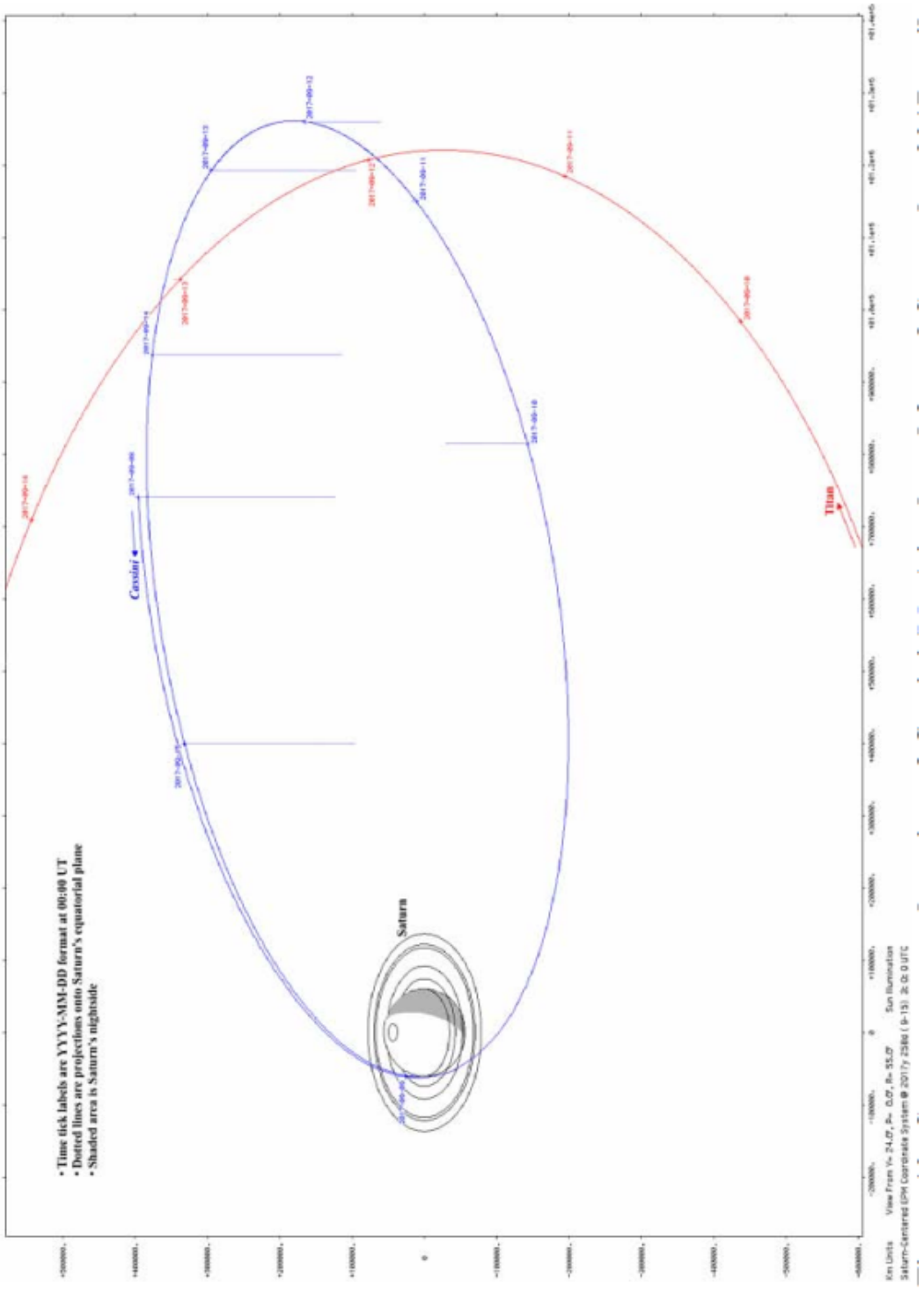


Figure 10:

Saturn-centered motion of Cassini (blue) is plotted from 8 September 2017 until 10:44 UT on 15 September 2017, only minutes before incineration, when the spacecraft enters Saturn's atmosphere for the final time on Orb 293. Motion of Titan (red) is also plotted during part of this interval as it encounters Cassini to trigger the spacecraft's disposal.

Climate Change & Local Responses

Douglas Yazell, Contributor

An electric car on display at AMC 30 on Dunvale during the free screening of An Inconvenient Sequel, Truth to Power, August 9, 2017. The owner of this Nissan Leaf is William Swann. The electric cars (including a Tesla Model S) were displayed by the Houston Chapter of the since-1967 Electric Auto Association (EAA, electricauto.org)

Image Credit: Douglas Yazell

Chasing Coral is a new Netflix climate movie that premiered on July 14, 2017. The movie makers encourage screening events, and the movie is available at no charge, and with their support for their campaign for corals and climate. See the movie website for more information. One such movie screening took place Saturday, August 5, 2017, in the Freeman Library of Harris County, the Houston-area library so close to our NASA Johnson Space Center, where most of my fellow AIAA Houston Section members live and work. The Meeting Space of the library was a beautiful space, capable of holding 70 people. The library provided everything except food and drink (provided by event organizers), and the host merely logged into his Netflix account. In this case, he used a free 30-day trial membership. A librarian verified our right to show this movie by looking at the movie website. Meanwhile, the movie makers emailed permission and support to us. Plenty of work is required to prepare such an event, but it went well, and we are grateful for such excellent service, facilities and equipment provided by our local library. Event organizers were Climate Reality Project and Citizens' Climate Lobby. Many avenues for publicity included the NASA/JSC newsletter whose main subject is sustainability.

Another great new climate documentary movie arrived at 7:00 PM in Houston Thursday, August 10, 2017, after a last-minute one-week delay, An Inconvenient Sequel, Truth to Power. It is a clever title, since the 2006 movie title was An Inconvenient Truth. Free screenings took place or are planned for Wednesday, August 9 (AMC 30 on Dunvale), and Tuesday August 15 (AMC Dine-In Houston 8). A Climate Reality Project volunteer (Leader) attracted 64 people to the showing of 7:00 PM Thursday, August 10, 2017, at Edwards Greenway, though it was neither a private showing nor a free screening. On August 9 and August 10, the Houston Chapter of the since-1967 Electric Auto Association (EAA, electricauto.org) displayed electric cars and engaged the public in discussions of ownership. On August 9 they displayed a Nissan Leaf and a Tesla Model S.

On August 10 they displayed 5 electric cars, a Tesla Model S, a Chevy Volt, the newer Chevy Bolt, a Ford C-Max, and a Nissan Leaf. As for my review of the movie, I recommend it without reservation. It is impressive that the first movie won two 2006 Oscars and its star, Al Gore, the 1993-2001 Vice President of the USA, shared 50% of the 2007 Nobel Peace Prize with 2,500 scientists (my best recollection of the number) of the United Nations Intergovernmental Panel on Climate Change (IPCC).

Deniers cannot be ignored, whether they are lying or not about their climate conclusions. The Paris Agreement was signed in 2015, ratified in 2016, and in 2017 the new President of the USA announced that the USA would start its exit from the Paris Agreement, followed by no one. The USA and the world responded to President Trump by saying they will continue to participate in the Paris Agreement with its guardrails of 2 C and 1.5 C. As required by the Paris Agreement, every nation will return with stronger and stronger commitments until the 2 C guardrail is respected, if not the 1.5 C guardrail. The press is learning to stop giving equal time to extremism.

The Climate Needs Space is a conference taking place in Toulouse France, October 10-11, 2017, with its organizer, the Air and Space Academy (AAE). The program committee webpage includes the logos of 11 organizations. Since 2012 I read on two occasions that of the 50 things we study for climate (as opposed to 6 things we study for weather; temperature, atmospheric pressure, wind, humidity, precipitation, and cloudiness, according to this web page of the National Geographic Society), most can be measured only from space. For example, from the Climate Change Initiative (An Ocean of Change web page) of the European Space Agency, "Change in sea level is considered to be a primary indicator of global climate change. Building on the most accurate and best calibrated long-term observations, possible *only from space*, the Climate Change Initiative supports continued improvement to the stability, accuracy, precision and consistency of sea-surface height records."

Eclairage Artifiel et Zones Boisées

Philippe Mariet and Madeleine Bourdeaux

3AF MP, French Sister Contributor

Nous avons souvent la certitude que l'éclairage artificiel a des effets positifs la nuit car il fait vivre les vitrines des magasins, illumine les monuments civils ou sacrés, met en valeur les ponts, permet de mieux voir les routes, que ce soit en ville ou à la campagne, etc. Mais c type d'éclairage a aussi des effets négatifs: certains animaux en souffrent, et la biodiversité (y compris la flore) en pâtit, que ce soit dans les zones boisées protégées urbaines, périurbaines, etc. Au début des années 2010, un endroit donné en France est éclairé 3300 heures par an en moyenne, contre 2100 heures il y a 20 ans (Source: Revue française « Science et Vie »). Si, lors d'une nuit de pleine lune, on mesure à peine 0.2 lux de lumière, il ne faut pas oublier qu'un réverbère commun de trottoir éclaire au minimum 25 fois plus.

Désorm ais présent partout où l'homme a des activités, l'éclairage artificiel a cependant une influence sur les cycles jour-nuit, que ce soit chez l'espèce humaine ou animale. Des mammifères aux oiseaux, aucune catégorie d'animaux n'est épargnée. Les différentes composantes du spectre lumineux n'ont pas le même effet sur toutes les espèces. Certaines longueurs d'onde de lumière (violets et bleus surtout) sont très nocives par rapport à d'autres ; elles sont présentes en grande quantité dans la lumière de certaines lampes, comme les LEDs. Certains animaux subissent des dégâts quelle que soit la composition spectrale de la lumière choisie: pour de telles espèces, du rouge au violet, toutes les radiations lumineuses sont nocives si elles les perçoivent la nuit (c'est le cas, notamment, des amphibiens et des reptiles). Seule la lumière jaune est sans conséquence pour les oiseaux. Les oiseaux urbains subissent, eux, déjà les dégâts de la pollution atmosphérique, du bruit, des bâtiments en verre… Et la pollution lumineuse s'y ajoute... au grand plaisir des chats domestiques, pour qui chasser la nuit devient tout de suite plus aisé grâce à l'éclairage artificiel! Un lampadaire autour duquel s'affolent les papillons de nuit agrège un ensemble d'animaux qui, autrement se déplaceraient ailleurs. Les insectes enivrés de lumière sont ainsi décimés nuit après nuit.

D'autres exemples existent malheureusement. Nous pouvons dès lors concevoir qu'au-delà de son aspect écologique et végétal, chaque zone boisée classée constitue, la nuit, une zone écologique noire, à rapprocher des trames écologiques noires. En parallèle des zones/trames vertes et bleues (espaces naturels protégés sur terre et dans les cours d'eau), de telles zones/trames « ponctuelles » constituent, de fait, des zones en ville où l'éclairage est fortement diminué, voire absent, permettant à la faune de trouver un refuge où les perturbations sont absentes. Alors, quelle pourrait-être la relation entre éclairage artificiel et zones boisées (qu'elles soient classées ou non classées) ?

Il existe aux USA des membres passionnés d'astronomie, qu'ils soient professionnels, amateurs, ou simplement curieux du fait astronomique. Ces membres rencontrent de plus en plus de difficultés pour vivre leur passion. Les observations, qu'elles soient faites par l'intermédiaire de simples jumelles, de lunettes astronomiques, ou, pour les professionnels, de véritables observatoires astronomiques, doivent s'affranchir le plus possible de cette pollution lumineuse gênante. Les LEDs à dominante violette et celles à dominante bleue, on l'a déjà dit, sont nocives, n'oubliez pas, Messieurs et Mesdames des villes des USA, que selon vos choix, vous ferez des heureux ou des malheureux parmi vos collègues astronomes.

Note:

An English translation of this article appears on the next page.

Astronomy, Artificial Lighting & Woodlands

Philippe Mariet & Madeleine Bourdeaux, 3AF MP, French Sister Contributor

Translator: Douglas Yazell, Houston Section

We are often confident that artificial lighting has positive effects at night as it brings alive store windows, illuminates civil or sacred monuments, highlights bridges, helps to better see the roads, whether in town or in the country, etc. But this type of lighting also has negative effects. Some animals suffer, and biodiversity (Including flora) is adversely affected, whether in wooded urban protected areas, near-urban areas, etc.

At the beginning of 2010, a given place in France is illuminated 3300 hours per year on average, compared with 2100 hours 20 years ago. (Source: French magazine Science and Life.) If, during the night of a full moon, we measure barely 0.2 lux of light, we must not forget that the typical reflection from a sidewalk illuminates at least 25 times more than that. Nevertheless, now everywhere people are active, artificial lighting has an influence on day-night cycles, both for people and animals. From mammals to birds, no category of animals is spared.

The different components of the light spectrum do not have the same effect on all species. Certain wavelengths of light (violet and blue especially) are very harmful compared to others. They are present in large quantities in the light from certain lamps, such as Light-Emitting Diodes (LEDs).

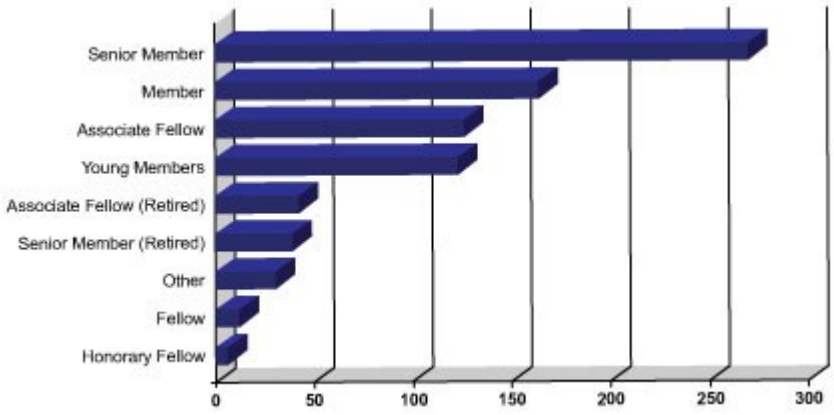
Certain animals suffer from damage whatever the spectral composition of the chosen light. For such species, from red to violet, all light radiation is harmful if it is perceived at night. (This is the case, for example, for amphibians and reptiles.)

Only yellow light is of no consequence to birds. Urban birds are already suffering from damage caused by air pollution, noise, and glass buildings. With light pollution is added, to the delight of domestic cats, for whom to hunt at night becomes immediately easier thanks to the artificial lighting!A lamppost, around which butterflies of the night (moths) are panicking, aggregates a group of animals which otherwise would move elsewhere. The insects inundated with light are thus decimated night after night. Unfortunately, there are other examples.

We can therefore conceive that, in addition to its ecological and vegetal aspects, each wooded zone constitutes, at night, a black ecological zone, to be compared to black ecological frames. In parallel with green and blue zones/frames (protected natural areas on land and in watercourses), such “point” zones/frames constitute, in fact, zones/frames in the city where lighting is greatly reduced, even absent, allowing wildlife to find a refuge where disturbances are absent.

What is the relationship between artificial lighting and woodlands (whether protected or not by classification)? In the US there are professional and amateur astronomers. Observations made through simple binoculars, astronomical telescopes or observatories must be freed from this unpleasant light pollution. The LEDs in which violet dominates and LEDs in which blue dominates are harmful. Do not forget, inhabitants of the cities of the US, that as a consequence of your choices you will create happy or unhappy people among your astronomical colleagues.

Section Information

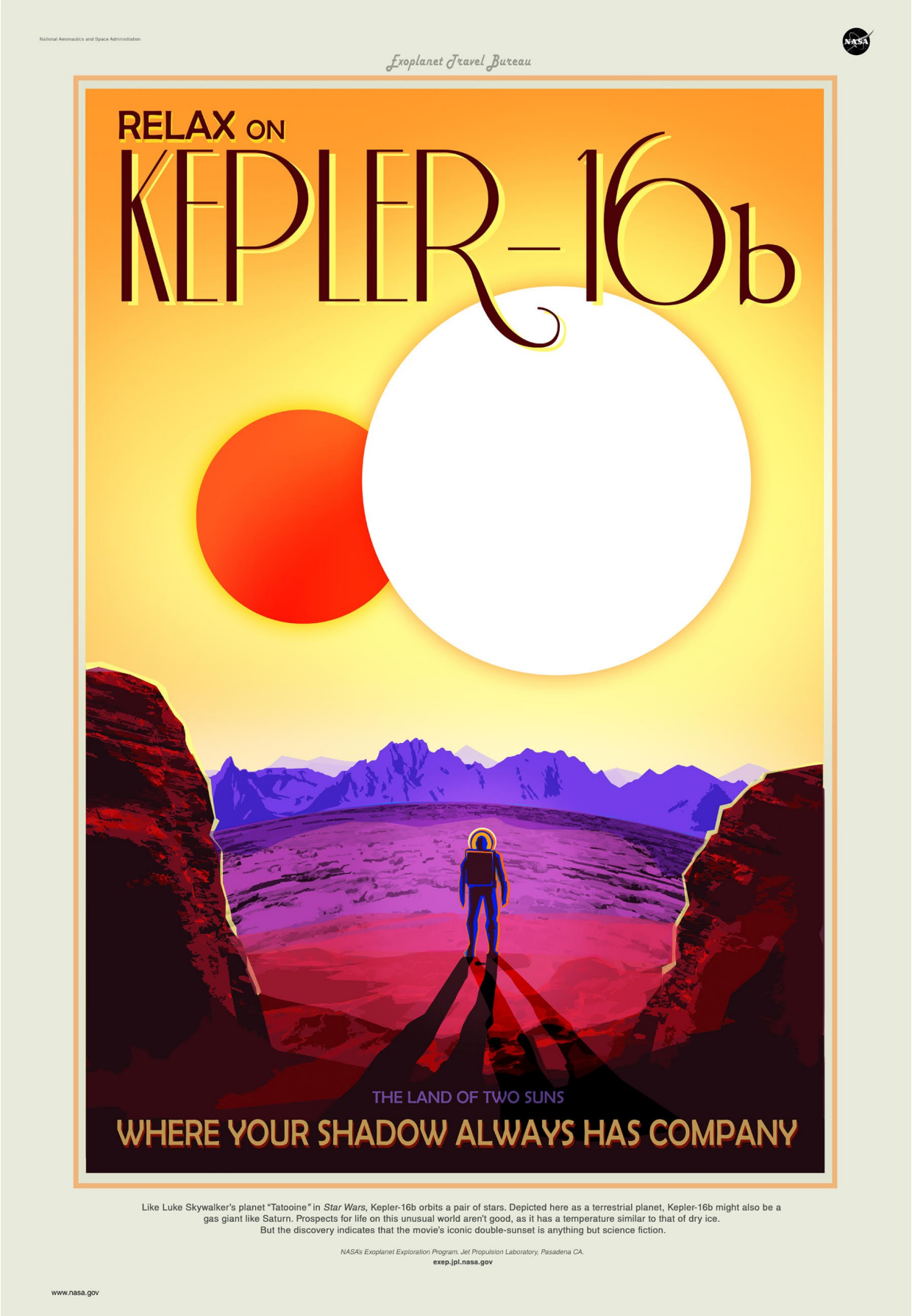


- Approximately 800 members
- 15 Technical Committees
- Executive Council Responsible for Section Activities
  - 6 Elected Officers
  - 10 Elected Councilors
  - Technical Committee Chairs (appointed)
  - 13 Operations Officers (appointed)

AIAA Objectives

- Strengthen membership and aerospace community participation
- Better serve nontraditional but rapidly growing technologies
- Additional emphasis on public policy programs that support and promote aerospace contributions to the nation
- Improve the quality and availability of resident aerospace educational programs

www.aiaahouston.org



Hypothetical travel brochure to the exoplanet Kepler-16b made by NASA. Kepler-16b orbits a pair of stars. Depicted here as a terrestrial planet, Kepler-16b might also be a gas giant like Saturn. *Image Credit: NASA*