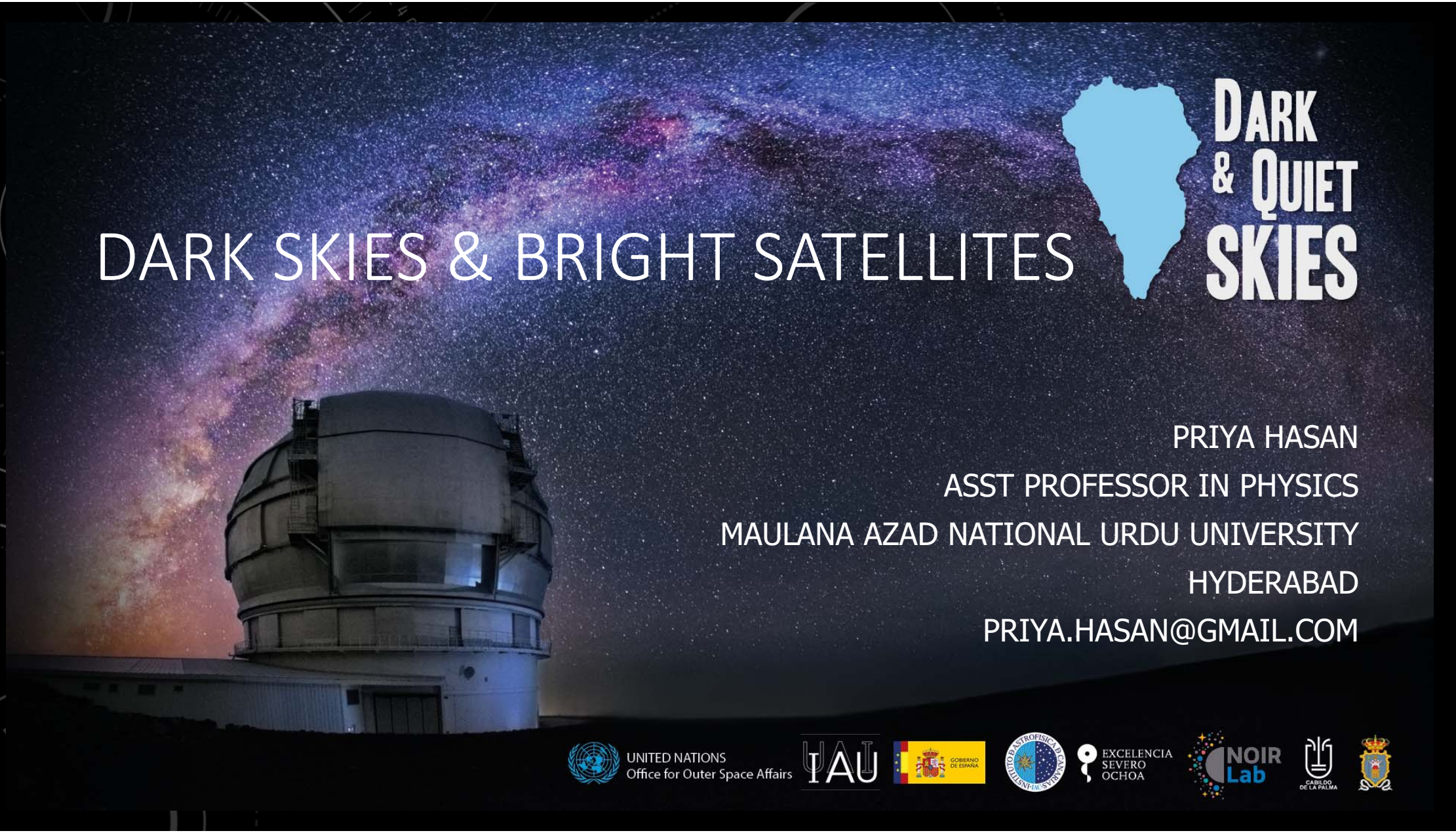

DARK SKIES & BRIGHT SATELLITES
DARK & QUIET SKIES
PRIYA HASAN
ASST PROFESSOR IN PHYSICS
MAULANA AZAD NATIONAL URDU UNIVERSITY
HYDERABAD
PRIYA.HASAN@GMAIL.COM
UNITED NATIONS
Office for Outer Space Affairs
IAU
GOBIERNO DE ESPAÑA
EXCELENCIA SEVERO OCHOA
NOIR Lab
CABILDO DE LA PALMA

2019-Nov-18 0800 UT

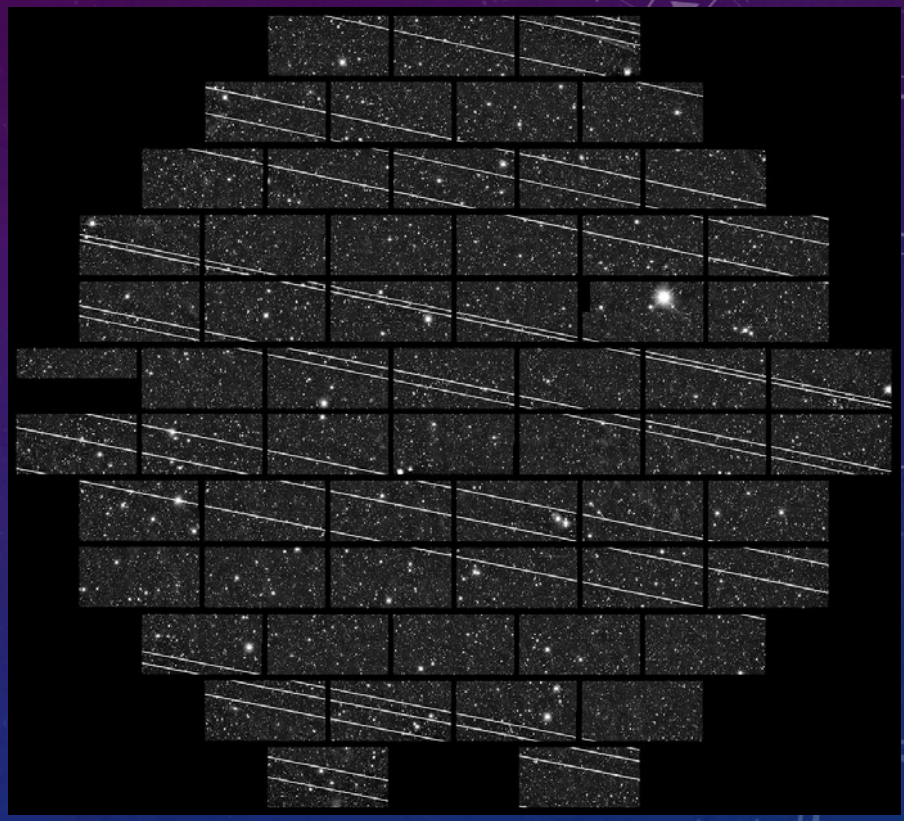
NSF Blanco 4.0-m telescope

DECAM

Cerro Tololo, Chile

2019-Nov 18
~2 sq. degrees
4.0-m mirror
single 333 sec exposure

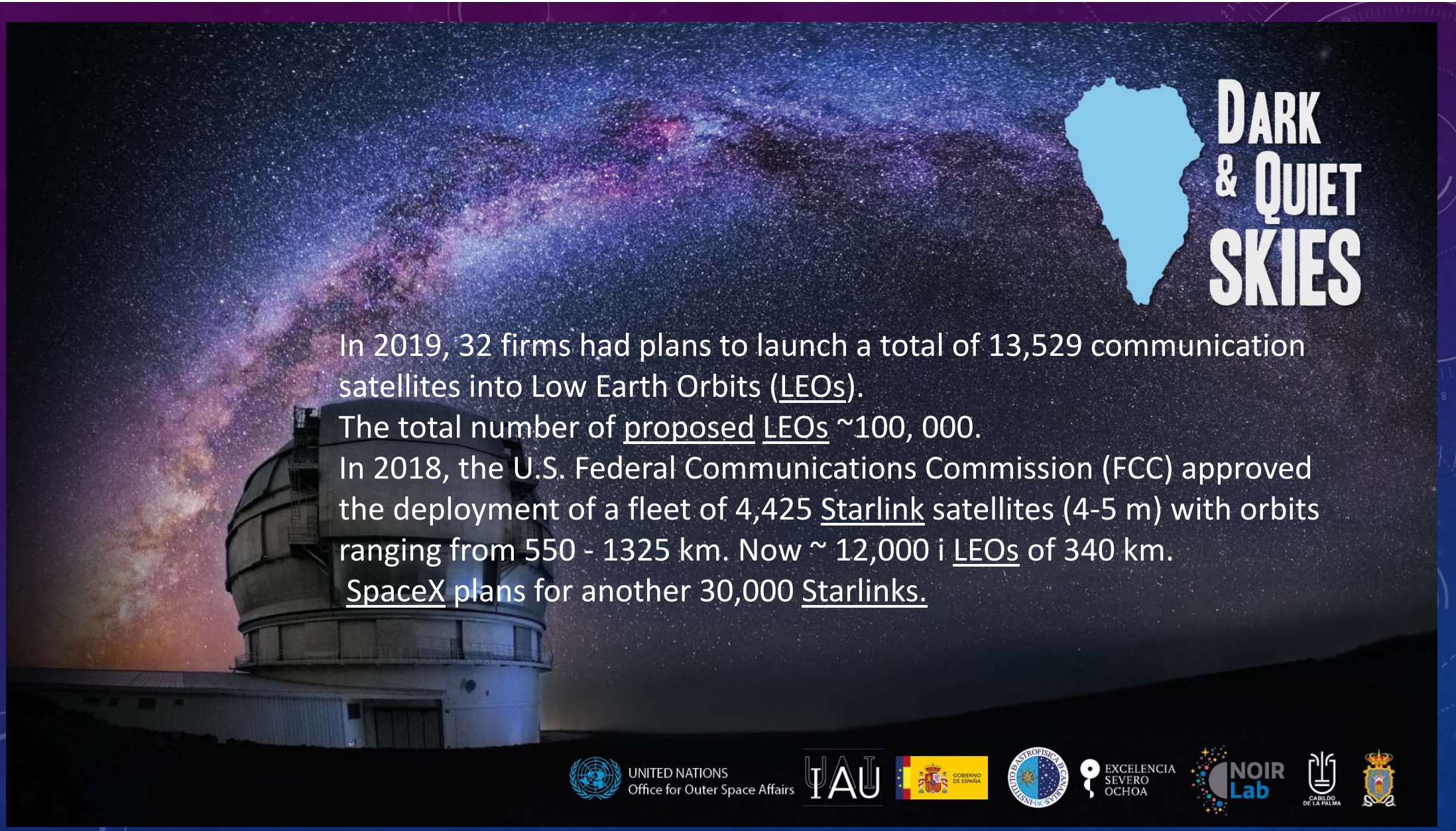
19 satellites cross the field
at different times
4 seconds



These satellites will be brighter then 99\% of the present objects in orbit.

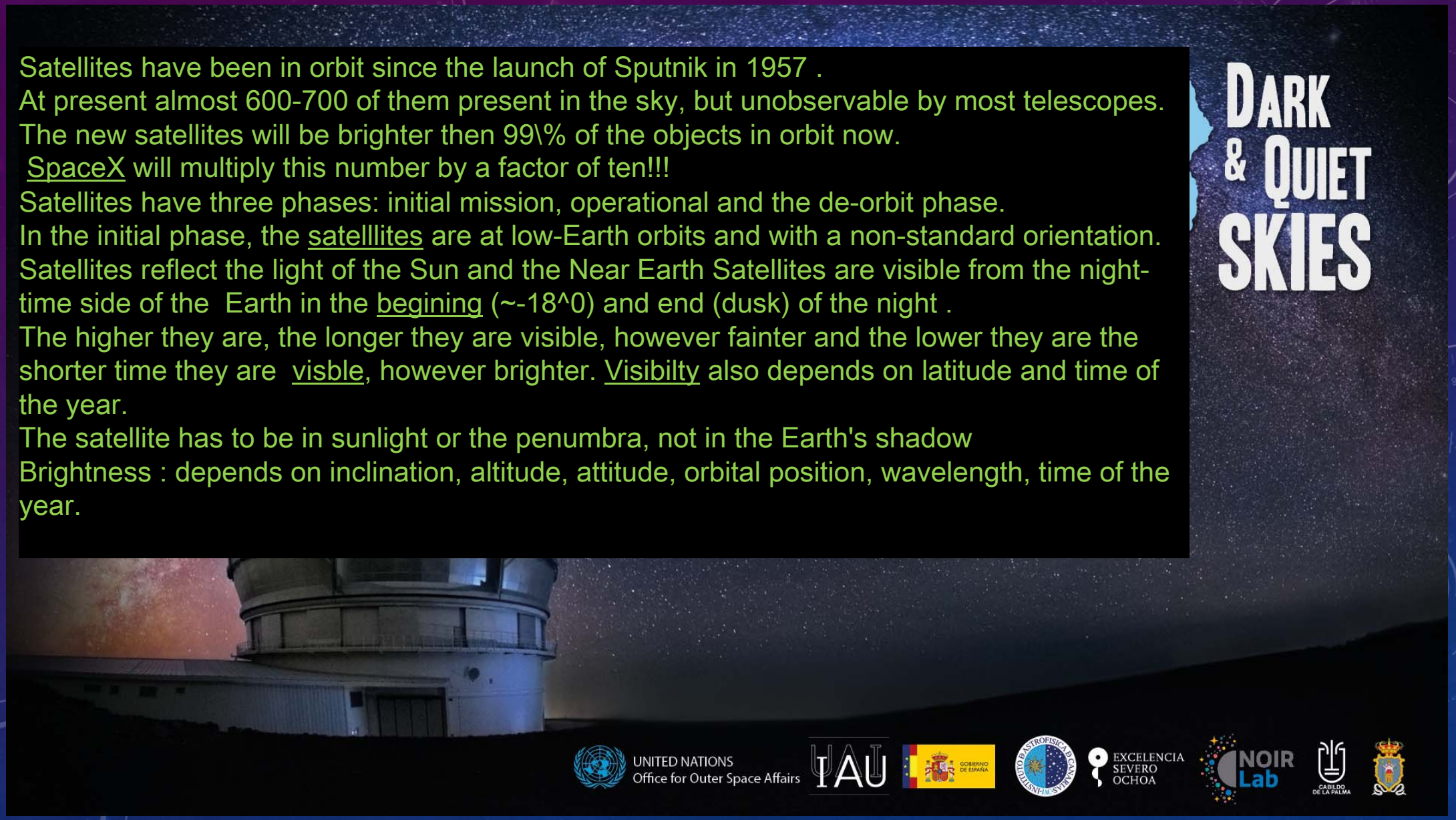
AN IMAGE FROM THE CERRO TOLOLO INTER-AMERICAN OBSERVATORY SHOWS STREAKS LEFT BY STARLINK SATELLITES.

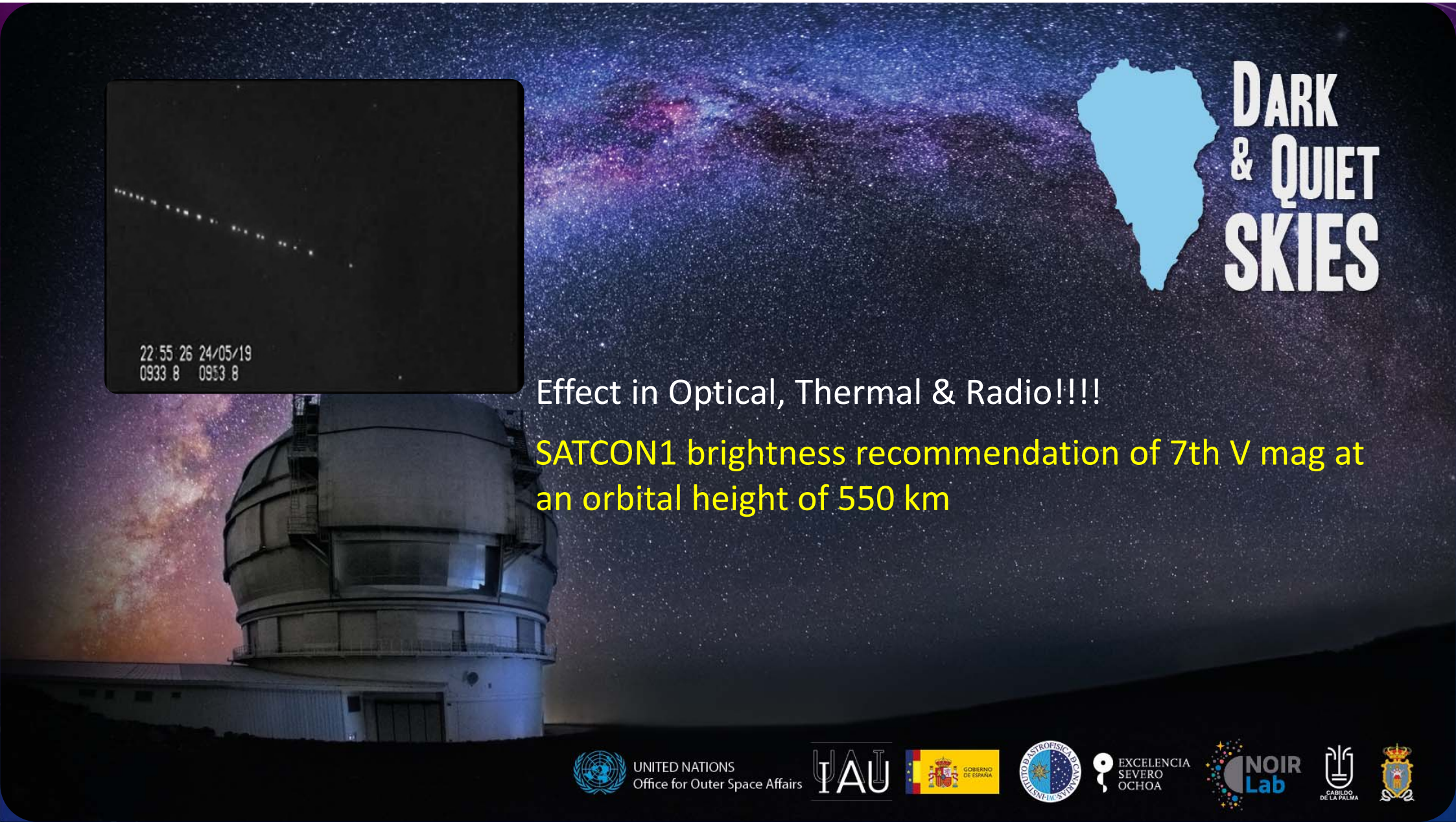
(IMAGE CREDIT: NSF'S NATIONAL OPTICAL-INFRARED ASTRONOMY RESEARCHLABORATORY/CTIO/AURA/DELVE)

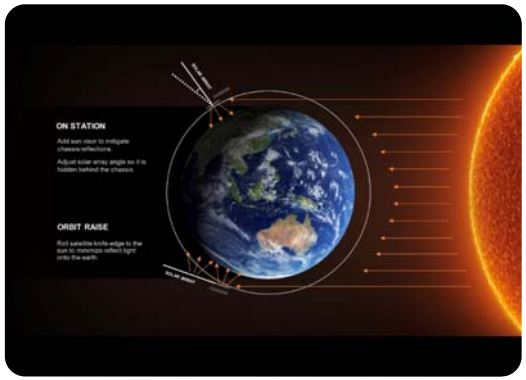

DARK & QUIET SKIES
In 2019, 32 firms had plans to launch a total of 13,529 communication satellites into Low Earth Orbits (LEOs).
The total number of proposed LEOs ~100, 000.
In 2018, the U.S. Federal Communications Commission (FCC) approved the deployment of a fleet of 4,425 Starlink satellites (4-5 m) with orbits ranging from 550 - 1325 km. Now ~ 12,000 i LEOs of 340 km.
SpaceX plans for another 30,000 Starlinks.
UNITED NATIONS
Office for Outer Space Affairs
IAU
GOBIERNO DE ESPAÑA
EXCELENCIA SEVERO OCHOA
NOIR Lab
CABILDO DE LA PALMA


DARK
& QUIET
OneWeb (6-7 m)planned a fleet of 47,844 satellites went backrupt after launching 74 satellites. In January 2021, they obtained funding to launch 648 satellites and hope to expand the number to 6372.
Amazon planned Project Kuiper to launch 3236 satellites into LEO, but no launches have happened.
Startups like AST SpaceMobile and Swarm plan smaller constellations of > 100 satellites aimed at specific markets such as mobile communications and the Internet of Things.
Companies in China also have plans for 12,992 satellites and probably even more.
UNITED NATIONS
Office for Outer Space Affairs
IAU
GOBIERNO DE ESPAÑA
EXCELENCIA SEVERO OCHOA
NOIR Lab
CABILDO DE LA PALMA

Satellites have been in orbit since the launch of Sputnik in 1957 .
At present almost 600-700 of them present in the sky, but unobservable by most telescopes.
The new satellites will be brighter then 99\% of the objects in orbit now.
SpaceX will multiply this number by a factor of ten!!!
Satellites have three phases: initial mission, operational and the de-orbit phase.
In the initial phase, the satelllites are at low-Earth orbits and with a non-standard orientation.
Satellites reflect the light of the Sun and the Near Earth Satellites are visible from the night-time side of the Earth in the begining (~-18^0) and end (dusk) of the night .
The higher they are, the longer they are visible, however fainter and the lower they are the shorter time they are visble, however brighter. Visibilty also depends on latitude and time of the year.
The satellite has to be in sunlight or the penumbra, not in the Earth's shadow
Brightness : depends on inclination, altitude, attitude, orbital position, wavelength, time of the year.

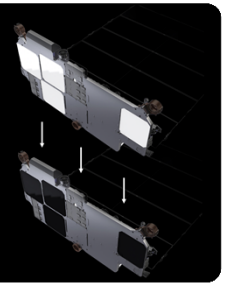



22:55:26 24/05/19
0933.8 0953.8
DARK & QUIET SKIES
Effect in Optical, Thermal & Radio!!!!
SATCON1 brightness recommendation of 7th V mag at an orbital height of 550 km
UNITED NATIONS
Office for Outer Space Affairs
IAU
GOBIERNO DE ESPAÑA
EXCELENCIA SEVERO OCHOA
NOIR Lab
CABILDO DE LA PALMA



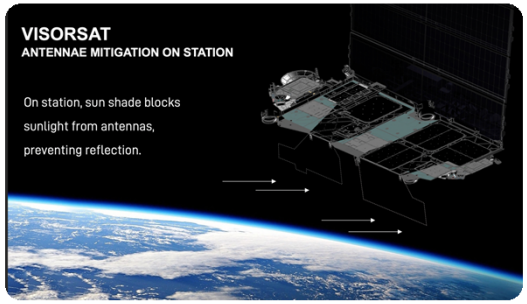
DARKSAT
ANTENNAE MITIGATION ON STATION

Ground-based observations of our initial test experiment proved we can significantly reduce brightness. Subsequently, we developed a higher-performance option.



VISORSAT
ANTENNAE MITIGATION ON STATION

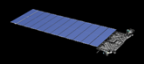
On station, sun shade blocks sunlight from antennas, preventing reflection.



On station, brightness is driven by antennas since the satellite is in the "shark-fin" configuration during sunset and sunrise.

SHARK-FIN

During orbit raise, brightness is driven by the "open book" configuration for thrusting and drag and sunlight reflects off both the antenna and array.



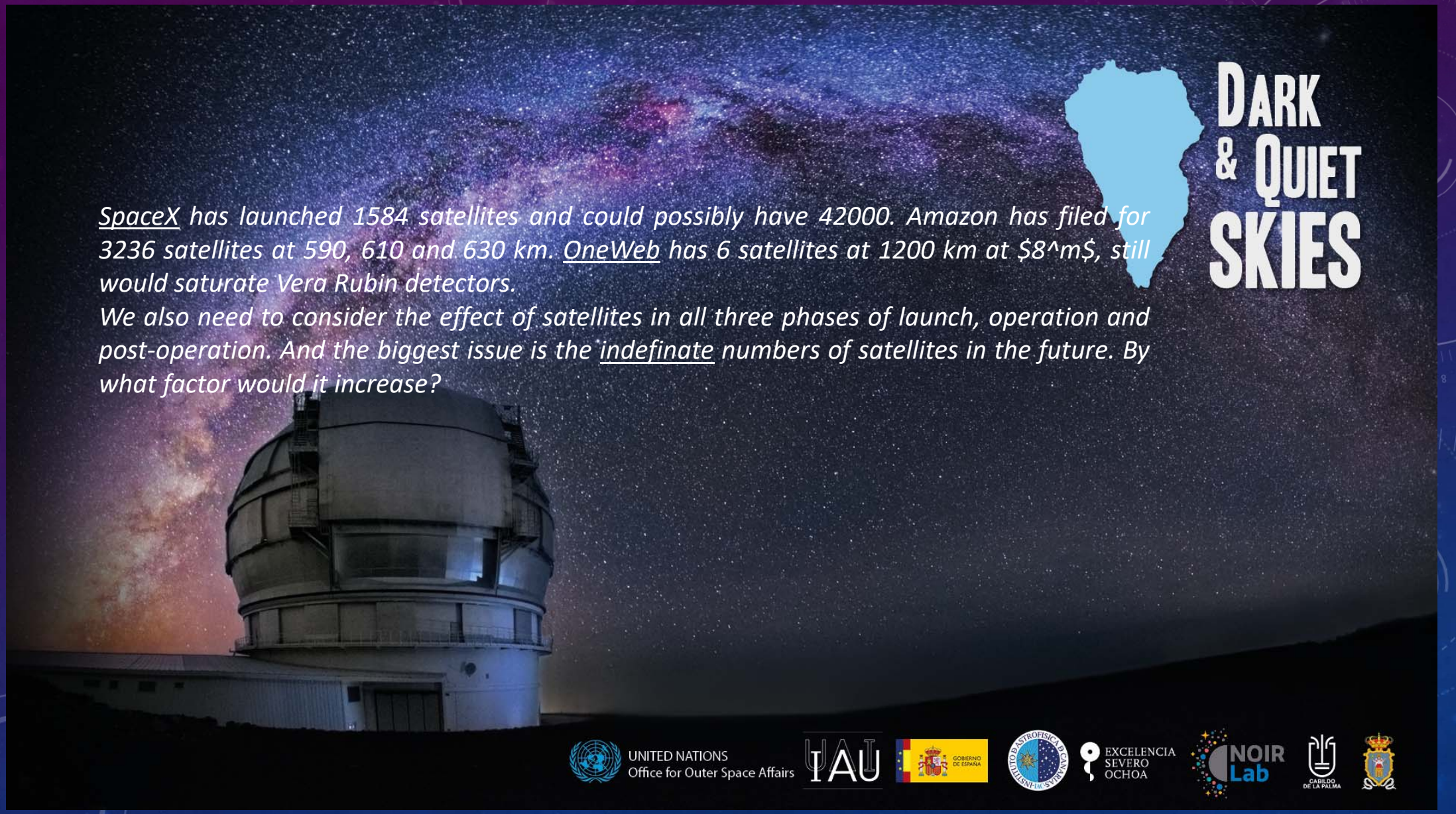
OPEN BOOK

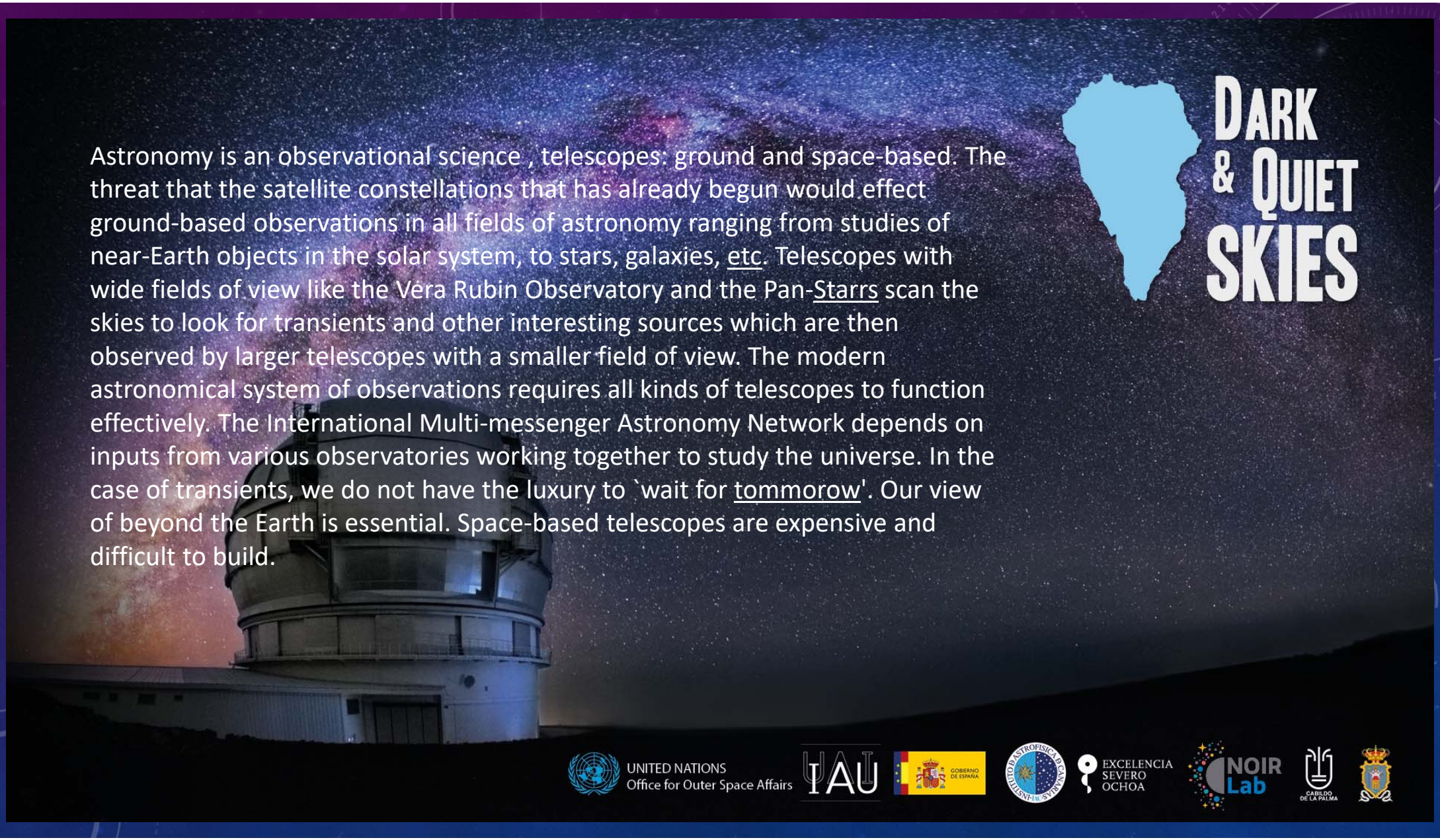
Reduce reflectivity (paint then `black')
Reflect the light elsewhere Fewer, that would reduce the problem
Smaller, to reduce the effect of a single satellite
 Predictable: So that observations can be scheduled

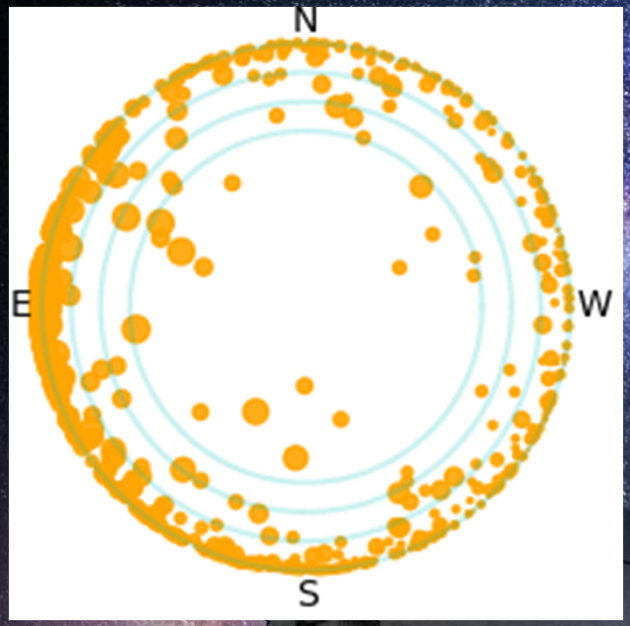
Recommendation: Support an immediate coordinated effort for optical observations of LEOsat constellation members, to characterize both slowly and rapidly varying reflectivity. A comprehensive satellite constellation observing network with uniform observing and data reduction protocols for feedback to operators and astronomical programs. Mature constellations will have the added complexity of deorbiting of the units and on-orbit aging, requiring ongoing monitoring.

Recommendation :. Determine the cadence and quality of updated positional information or processed telemetry, distribution, and predictive modeling required to achieve substantial improvement (by a factor of about 10) in publicly available cross-track positional determination.

Recommendation : Adopt a new standard format for publicly available ephemerides beyond two-line-elements (TLEs) in order to include covariances and other useful information. The application noted in Recommendation 2 should be compatible with this format and include the appropriate errors.


DARK & QUIET SKIES
SpaceX has launched 1584 satellites and could possibly have 42000. Amazon has filed for 3236 satellites at 590, 610 and 630 km. OneWeb has 6 satellites at 1200 km at 8^m, still would saturate Vera Rubin detectors.
We also need to consider the effect of satellites in all three phases of launch, operation and post-operation. And the biggest issue is the indefinate numbers of satellites in the future. By what factor would it increase?
UNITED NATIONS
Office for Outer Space Affairs
IAU
GOBIERNO DE ESPAÑA
EXCELENCIA SEVERO OCHOA
NOIR Lab
CABILDO DE LA PALMA


DARK & QUIET SKIES
Astronomy is an observational science , telescopes: ground and space-based. The threat that the satellite constellations that has already begun would effect ground-based observations in all fields of astronomy ranging from studies of near-Earth objects in the solar system, to stars, galaxies, etc. Telescopes with wide fields of view like the Vera Rubin Observatory and the Pan-Starrs scan the skies to look for transients and other interesting sources which are then observed by larger telescopes with a smaller field of view. The modern astronomical system of observations requires all kinds of telescopes to function effectively. The International Multi-messenger Astronomy Network depends on inputs from various observatories working together to study the universe. In the case of transients, we do not have the luxury to `wait for tommorow'. Our view of beyond the Earth is essential. Space-based telescopes are expensive and difficult to build.
UNITED NATIONS
Office for Outer Space Affairs
IAU
GOBIERNO DE ESPAÑA
EXCELENCIA SEVERO OCHOA
NOIR Lab
CABILDO DE LA PALMA



DARK & QUIET SKIES

Satellites above the VLT. Orange ones are illuminated, grey are in the shadow.

UNITED NATIONS
Office for Outer Space Affairs

IAU

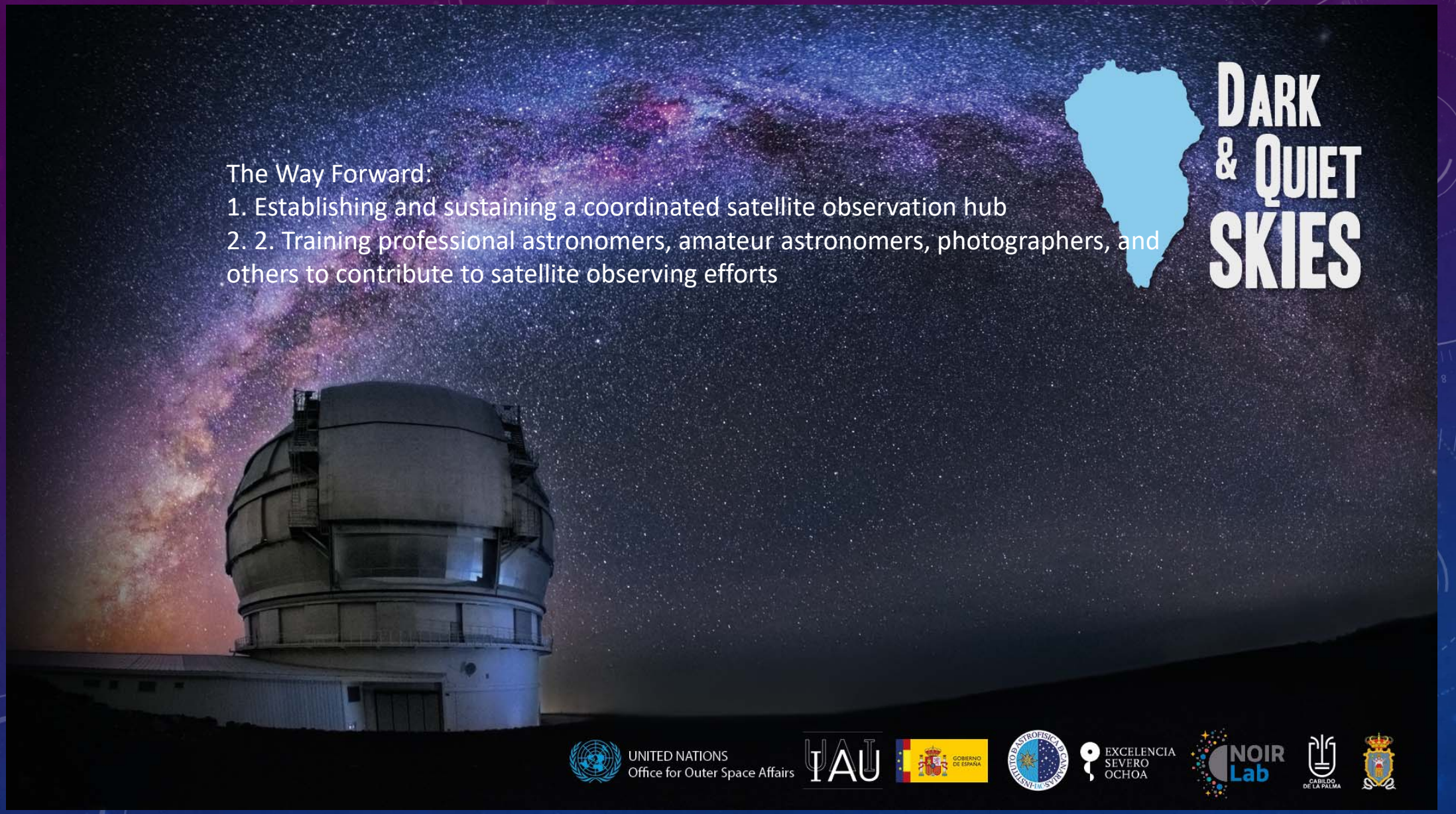
GOBIERNO DE ESPAÑA

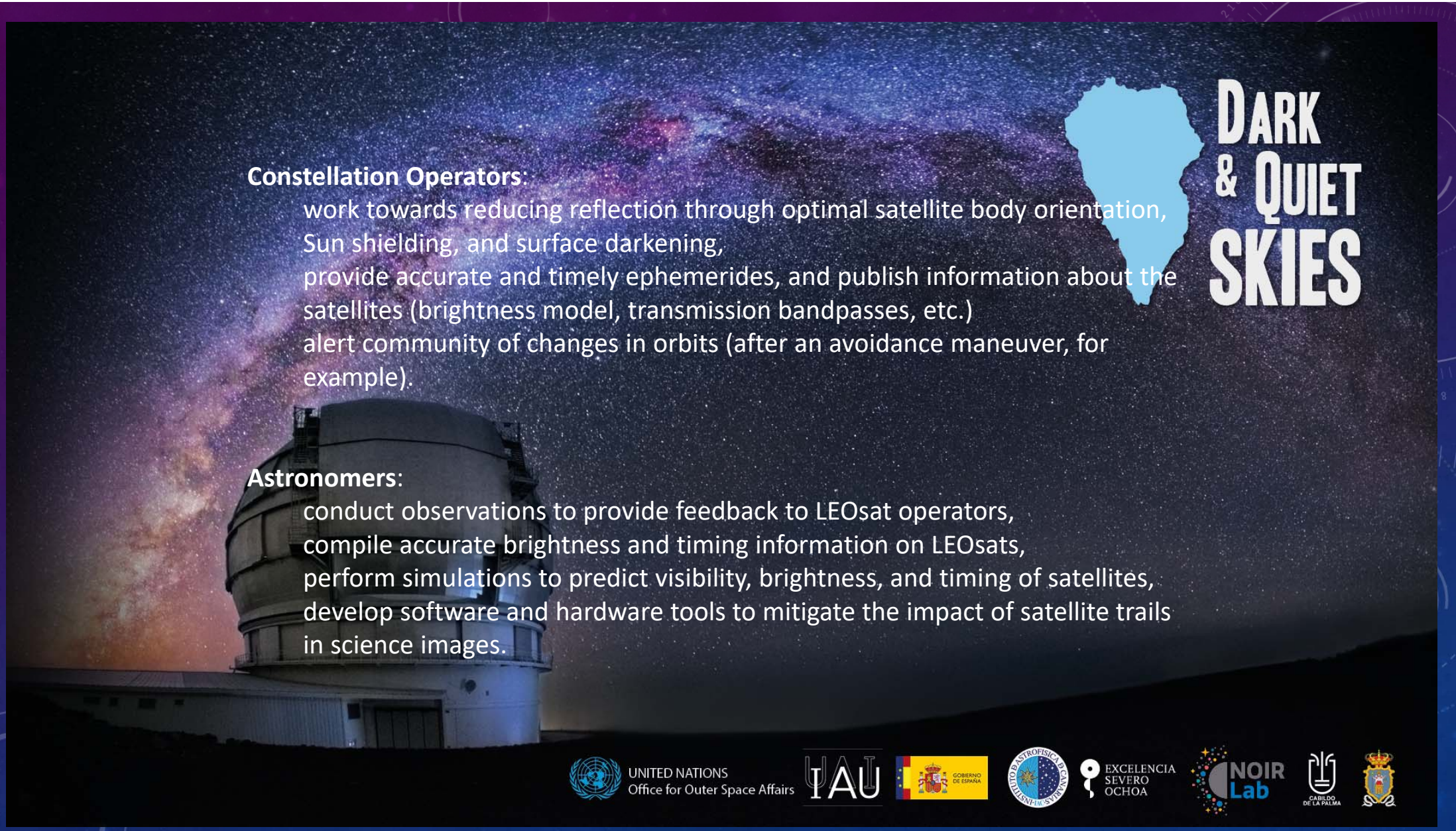
INSTITUTO DE ASTROFÍSICA DE CANARIAS

EXCELENCIA SEVERO OCHOA

NOIR Lab

CABILDO DE LA PALMA


DARK & QUIET SKIES
The Way Forward:
1. Establishing and sustaining a coordinated satellite observation hub
2. 2. Training professional astronomers, amateur astronomers, photographers, and others to contribute to satellite observing efforts
UNITED NATIONS
Office for Outer Space Affairs
IAU
GOBIERNO DE ESPAÑA
EXCELENCIA SEVERO OCHOA
NOIR Lab
CABILDO DE LA PALMA


DARK & QUIET SKIES
Constellation Operators:
work towards reducing reflection through optimal satellite body orientation, Sun shielding, and surface darkening,
provide accurate and timely ephemerides, and publish information about the satellites (brightness model, transmission bandpasses, etc.)
alert community of changes in orbits (after an avoidance maneuver, for example).
Astronomers:
conduct observations to provide feedback to LEOsat operators,
compile accurate brightness and timing information on LEOsats,
perform simulations to predict visibility, brightness, and timing of satellites,
develop software and hardware tools to mitigate the impact of satellite trails in science images.
UNITED NATIONS
Office for Outer Space Affairs
IAU
GOBIERNO DE ESPAÑA
EXCELENCIA SEVERO OCHOA
NOIR Lab
CABILDO DE LA PALMA


Training for Astronomers!!
International Space Laws!!
DARK & QUIET SKIES
ONLY IN THE DARKNESS CAN YOU SEE THE STARS.
- Martin Luther King Jr -
UNITED NATIONS
Office for Outer Space Affairs
IAU
GOBIERNO DE ESPAÑA
EXCELENCIA SEVERO OCHOA
NOIR Lab
CABILDO DE LA PALMA