Session 2 - status of astronomers mitigation actions

Ground-Based DarkSky Protection and Orbital Pollution Mitigation at the Moquegua Astronomical Observatory (OAM) - IAU W73, Peru

AGENCIA ESPACIAL DEL PERU CONIDA

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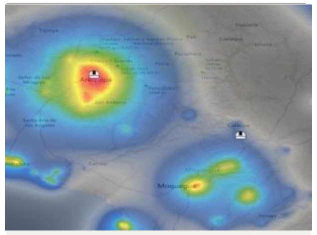
PERUVIAN SPACE AGENCY - CONIDA

Summary

1.

Observatory Overview

2.



Dark Sky Protection

3.

Telescope Capabilities

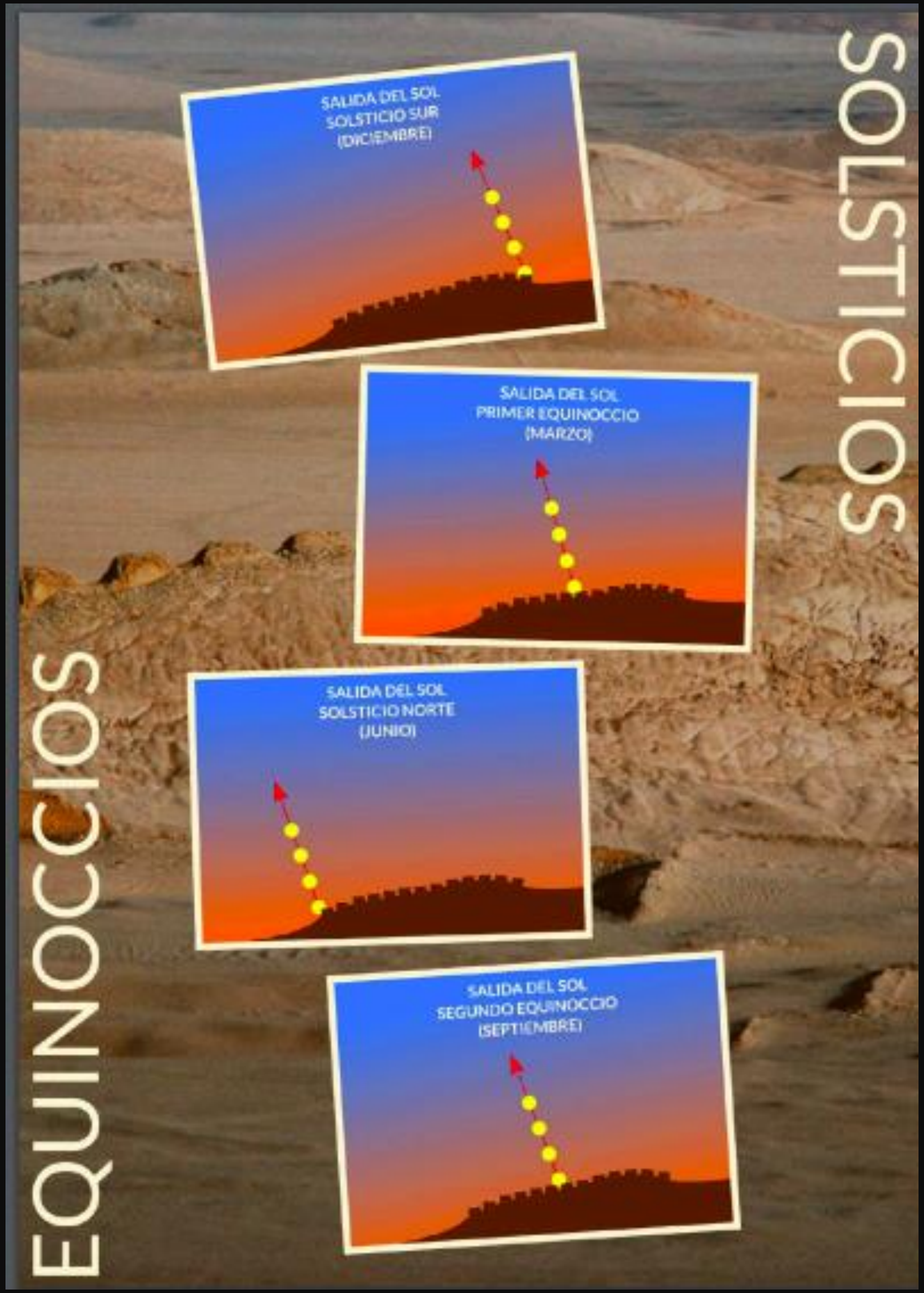
4.

Mitigation Through Observations

5.

Combined Strategy & Outlook

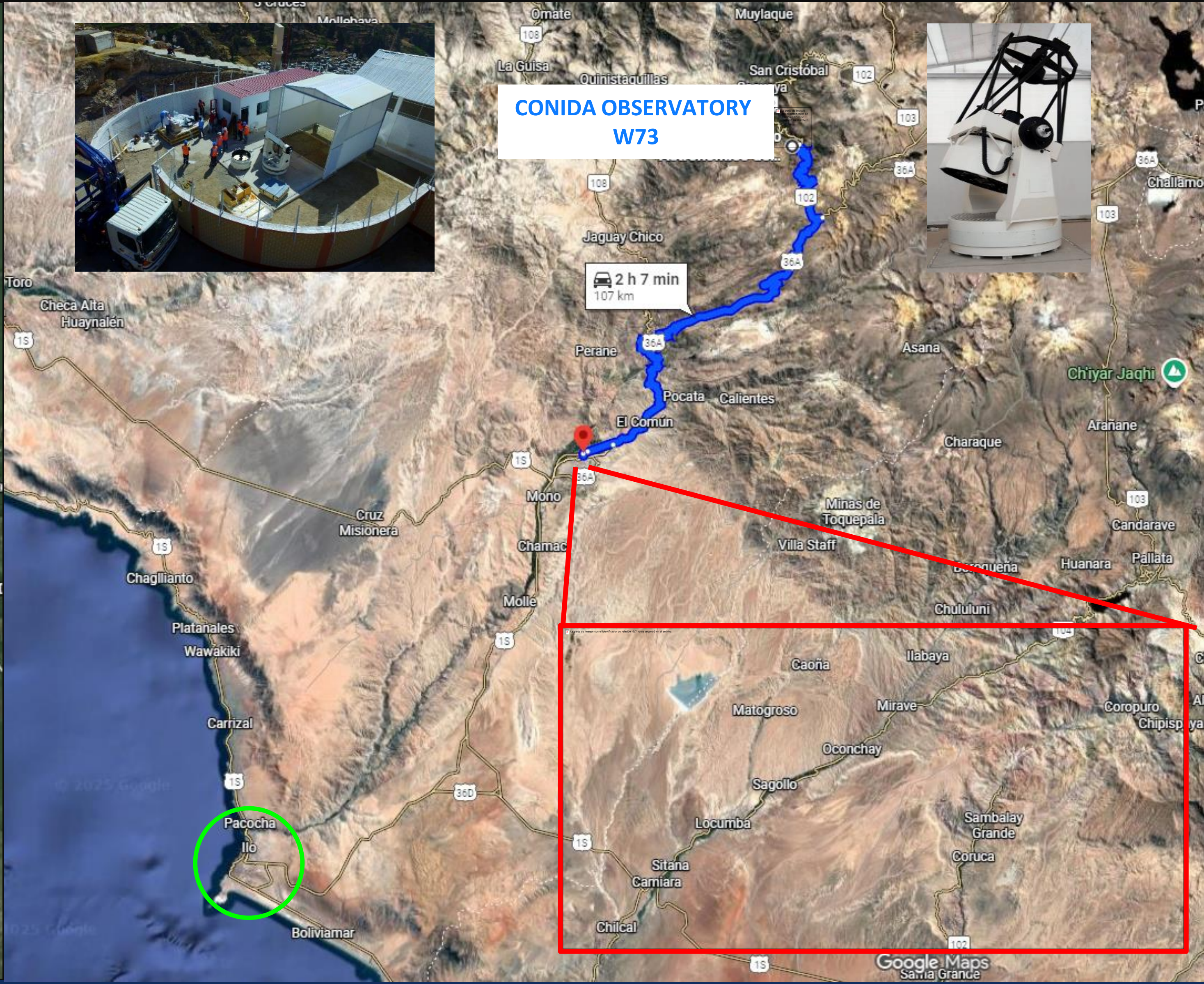
1.-Observatory Overview


SOLSTICIOS
SALIDA DEL SOL
SOLSTICIO SUR
(DICIEMBRE)
SALIDA DEL SOL
PRIMER EQUINOCCIO
(MARZO)
SALIDA DEL SOL
SOLSTICIO NORTE
(JUNIO)
SALIDA DEL SOL
SEGUNDO EQUINOCCIO
(SEPTIEMBRE)
EQUINOCCIOS


C/2025 R2 (SWAN)
Ayaviri(Puno) - Peru
AGENCIA ESPACIAL DEL PERU
CONIDA

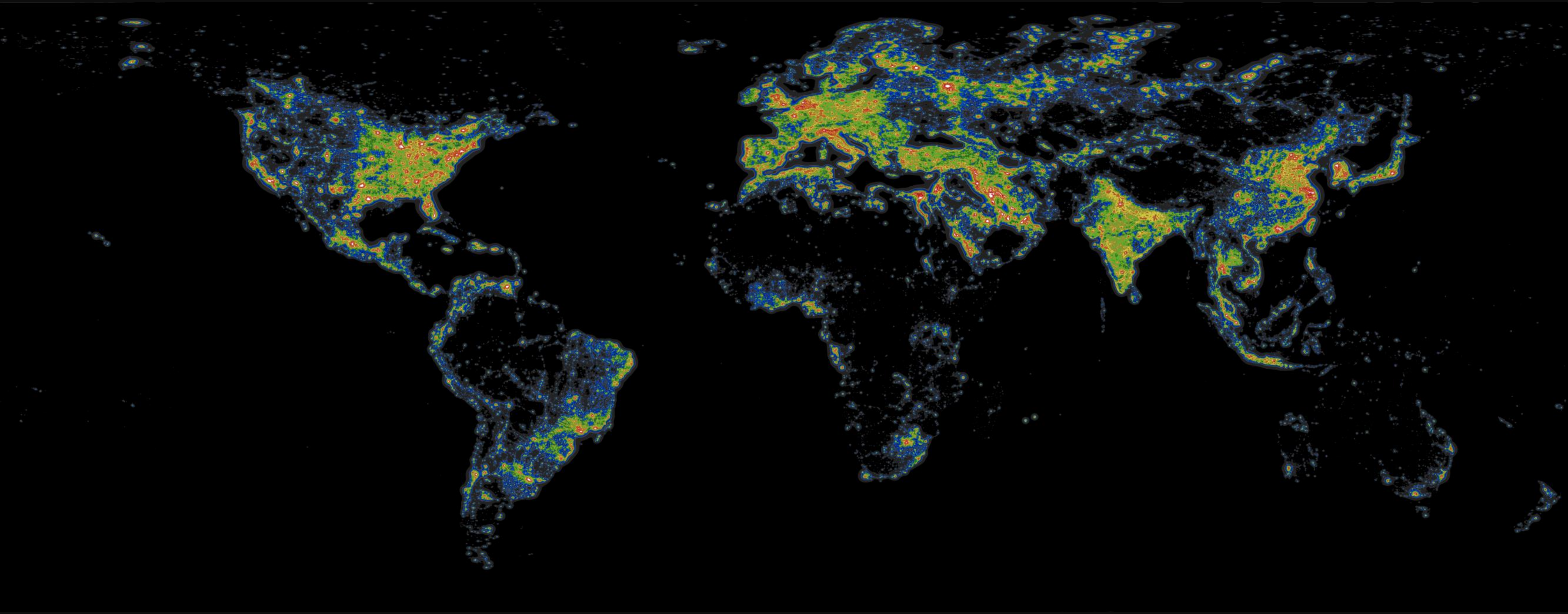
LOCATION


Quito
Ecuador
Guayaquil
Cuenca
AMAZONAS
Trujillo
ACRE
Perú
Lima
RONI
Cusco
2hrs
2hrs
Bolivia
Cochabamba
Sucre

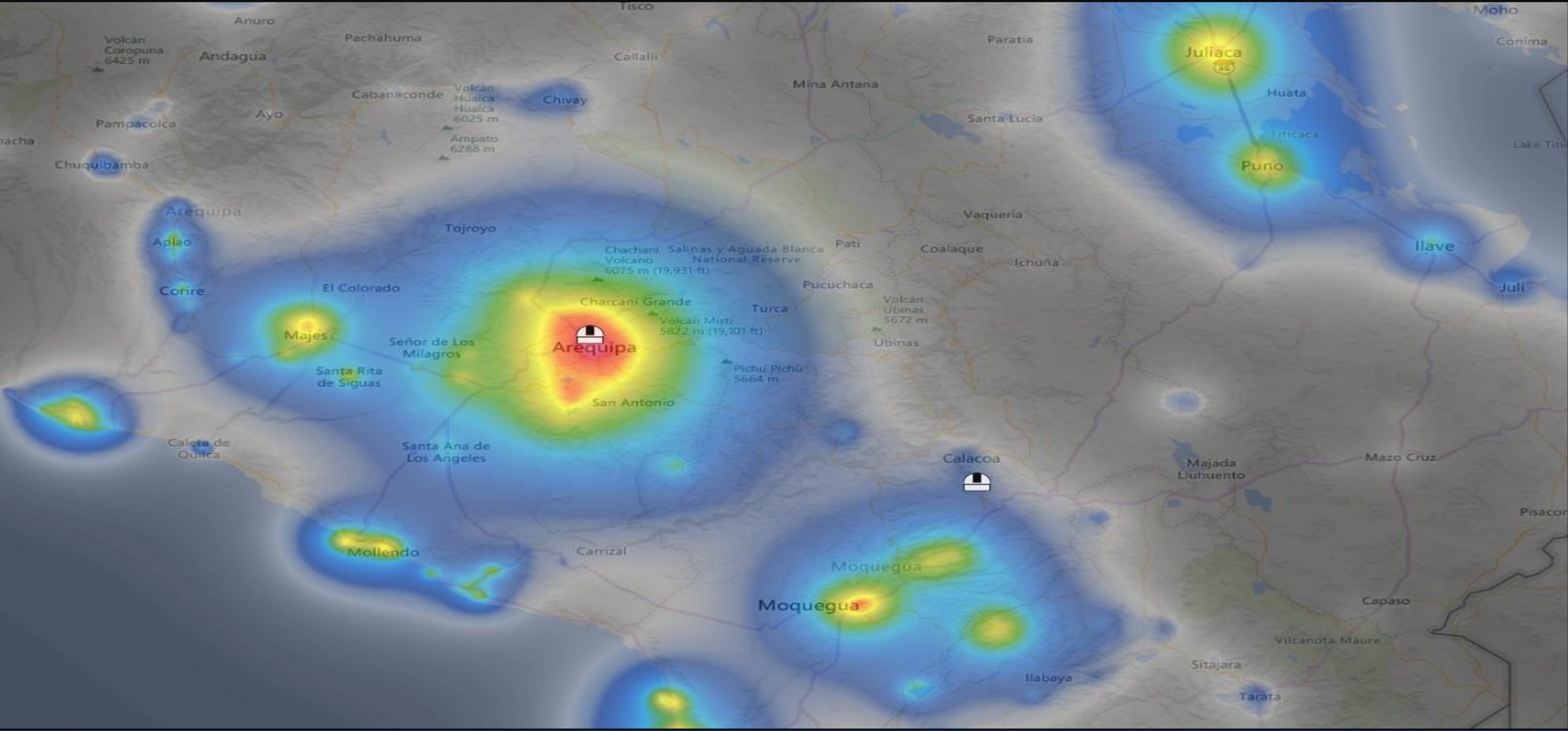

CONIDA OBSERVATORY
W73
2 h 7 min
107 km
Omate
Muylaque
La Guisa
Quinistaquillas
San Cristóbal
Jaguay Chico
Toro
Checa Alta
Huaynalen
Perane
Asana
Ch'iyar Jaqhi
Pocata
Calientes
El Común
Arañane
Charaque
Mono
Cruz
Misionera
Minas de
Toquepala
Villa Staff
Candarave
Chamac
Huanara
Pallata
Chagllianto
Molle
Chululuni
Platanales
Wawakiki
Caoña
Ilabaya
Matogroso
Mirave
Coropuro
Carrizal
Oconchay
Sagollo
Pacocha
Ilo
Locumba
Sambalay
Grande
Coruca
Sitana
Camiara
Boliviamar
Chilcal
Google Maps

2.-DarkSky Protection

Light Pollution Map



Light Pollution Map

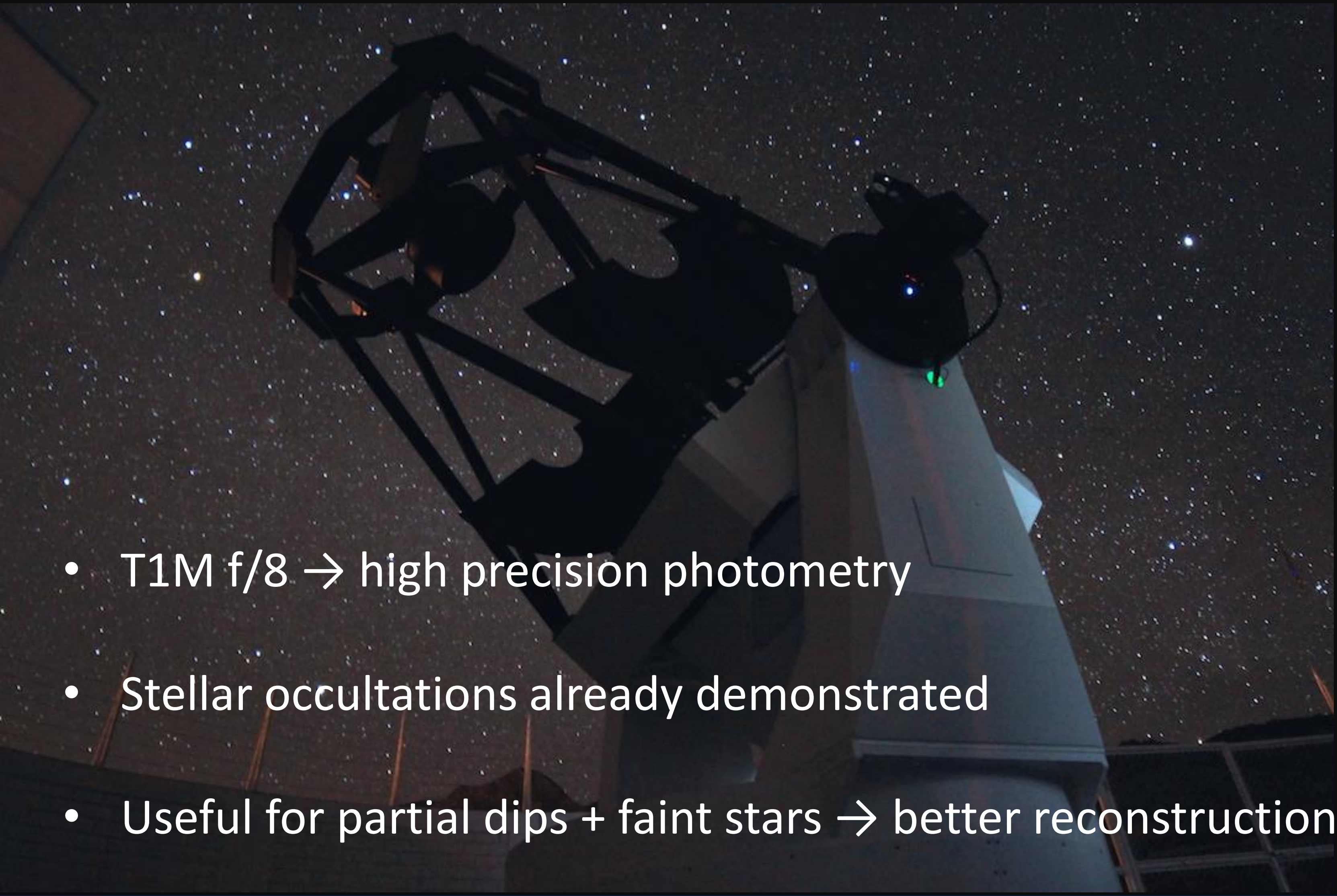


LOCATION

- Light pollution increase detected
- SQM monitoring system
- Infrastructure upgrades
- Ongoing work with local authorities (CONIDA signed an agreement focused on astrotourism and improving light-pollution policies, providing technical support).

3.-Telescope Capabilities

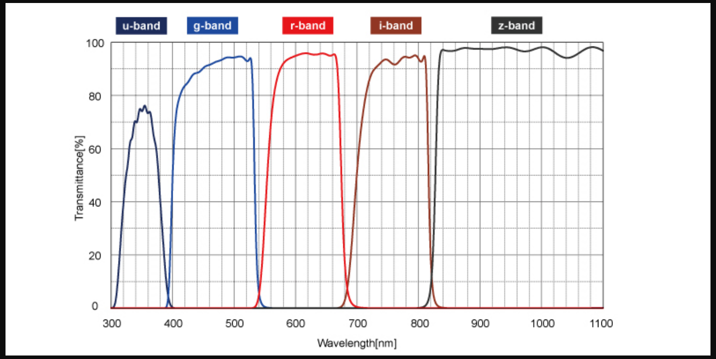
T1M SCIENTIFIC CAPABILITIES



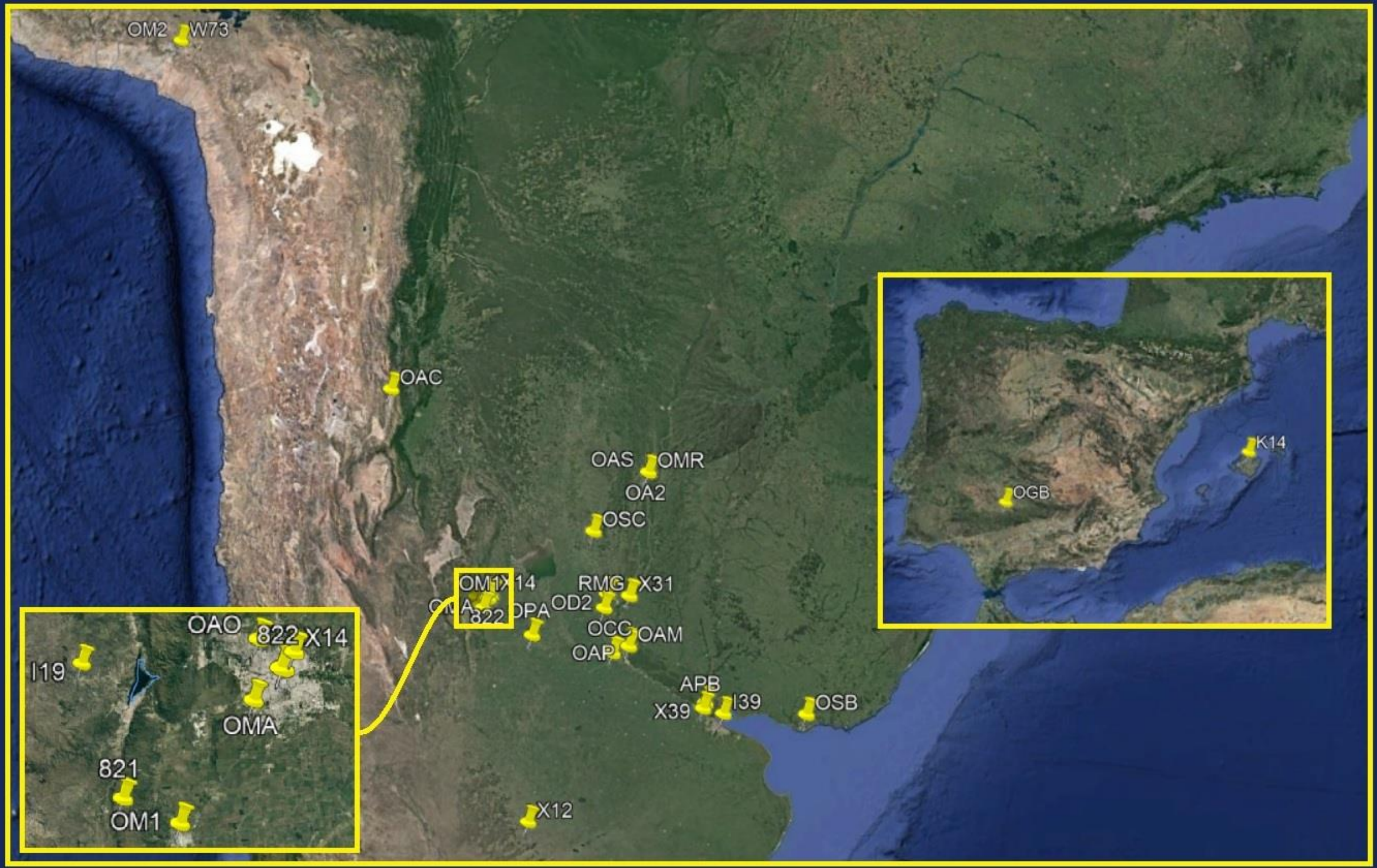
- T1M f/8 → high precision photometry
- Stellar occultations already demonstrated
- Useful for partial dips + faint stars → better reconstructions

MAIN FEATURES

Diameter	1000mm
Focal length	8000mm
Detector CCD	KAF-16803
Type of CCD	Front Illuminated
FOV CCD	15.7” x 15.7”
Pixels	4096 x 4096
Pixel Size	9 um
Pixel Scale	0.23”/pix



T1M SCIENTIFIC CAPABILITIES



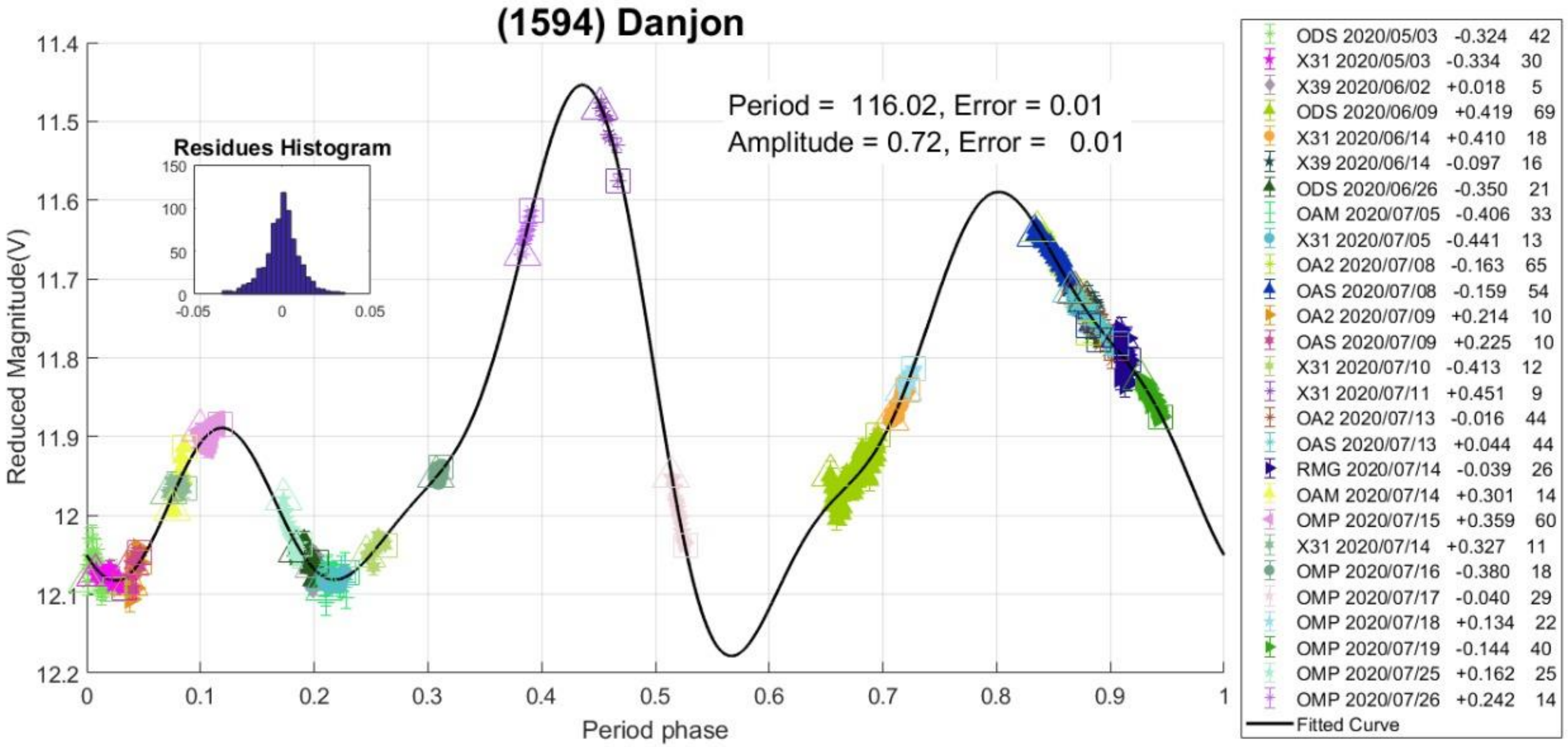
OBSERVATORIOS GORA AL 09/03/2021

- Estación Astrofísica Bosque Alegre (MPC 821)
- Observatorio Astronómico Córdoba (MPC 822)
- Observatorio Astronómico El Gato Gris (MPC I19)
- Observatorio Cruz del Sur (MPC I39)
- Observatorio de Sencelles (MPC K14)
- Observatorio Los Cabezones (MPC X12)
- Observatorio Orbis Tertius (MPC X14)
- Observatorio Galileo Galilei (MPC X31)
- Observatorio Antares (MPC X39)
- Observatorio Astronómico de Moquegua 1 (MPC W73)
- Observatorio AstroPilar (GORA APB)
- Observatorio Astronómico Calchaquí (GORA OAC)
- Observatorio de Aldo Mottino (GORA OAM)
- Observatorio Astronómico Aficionado Omega (GORA OAO)
- Observatorio Astro Pulver (GORA OAP)
- Observatorio de Ariel Stechina 1 (GORA OAS)
- Observatorio de Ariel Stechina 2 (GORA OA2)
- Observatorio Candela Celeste (GORA OCC)
- Observatorio de Damián Scotta 1 (GORA ODS)
- Observatorio de Damián Scotta 2 (GORA OD2)
- Observatorio Astronómico Giordano Bruno (GORA OGB)
- Observatorio Astronómico Vuelta por el Universo (GORA OMA)
- Observatorio Chopis (GORA OM1)
- Observatorio Astronómico de Moquegua 2 (GORA OM2)
- Observatorio Astronomico Municipal Reconquista (GORA OMR)
- Observatorio Punto Azul (GORA OPA)
- Observatorio de Sergio Babino (GORA OSB)
- Observatorio Astronómico Municipal de San Cristóbal (GORA OSC)
- Observatorio de Raúl Melia (GORA RMG)

PRO-AM

GORA
Grupo de Observadores de Rotaciones de Asteroides

T1M SCIENTIFIC CAPABILITIES



(Colazob et al. 2020)

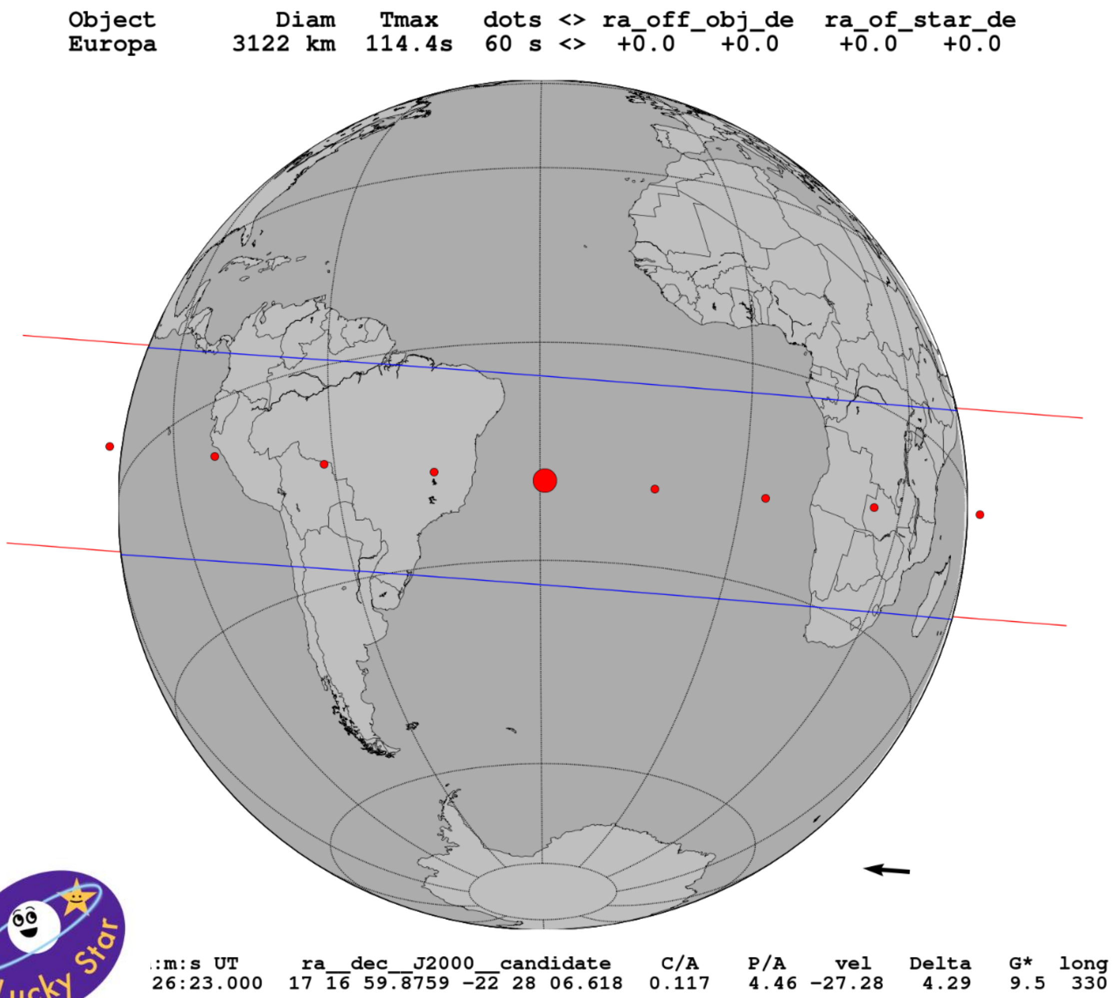
Observatory	Telescope	Camera	
Estación Astrofísica Bosque Alegre	Newtonian (1540 mm; f/4.9)	CCD	APOGEE Alta U9
Observatorio El Gato Gris	SCT (355 mm; f/10.6)	CCD	SBIG STF-8300M
Observatorio Cruz del Sur	Newtonian (200 mm; f/4.0)	CMOS	QHY-174
Observatorio Orbis Tertius	Newtonian (200 mm; f/5.0)	CCD	QHY6 Mono
Observatorio de Sencelles	SCT (254 mm; f/4.3)	CCD	SBIG ST-7XME
Observatorio Galileo Galilei	RCT ap (405 mm; f/8.0)	CCD	SBIG STF-8300M
Observatorio Antares	Newtonian (250 mm; f/5.0)	CCD	QHY9 Mono
Observatorio AstroPilar	ODK (250 mm; f/6.8)	CCD	FLI-8300M
Observatorio de Aldo Mottino	Newtonian (250 mm; f/4.7)	CCD	SBIG STF-8300M
Observatorio Astro Pulver	SCT (203 mm; f/10.3)	CMOS	QHY5 LII M
Observatorio de Ariel Stechina 1	Newtonian (254 mm; f/4.7)	CCD	SBIG STF-402
Observatorio de Ariel Stechina 2	Newtonian (305 mm; f/5.0)	CMOS	QHY 174M
Observatorio de Damián Scotta	Newtonian (300 mm; f/4.0)	CCD	SBIG ST-402 XME
Observatorio Astronómico de Moquegua	RCT APM (1000 mm; f/8)	CCD	FLI ProLine 16803
Observatorio Municipal Reconquista	Newtonian (254 mm; f/4)	CMOS	QHY 174M
Observatorio de Raúl Melia	SCT (200 mm; f/10.0)	CCD	Meade DSI Pro II
Observatorio Uraniborg	SCT (280 mm; f/6.3)	CCD	ATIK 414ex
Observatorio Mazariegos	SCT (200 mm; f/7.6)	CCD	ATIK 314L
Observatorio Nuevos Horizontes	SCT (235 mm; f/6.3)	CCD	Atik 3.14 L Plus
Observatorio Montcabrer	SCT (300 mm; f/9.2)	CCD	Moravian G4-9000
Blue Mountains Observatory	SCT Edge (355 m; f/7.0)	CCD	SBIG STF-8300M

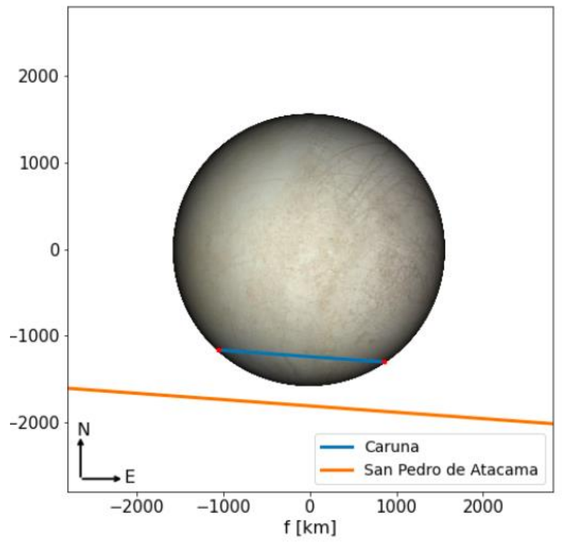
Table I. List of observatories and equipment.

Number	Name	20yy/mm/dd	Phase	L_{PAB}	B_{PAB}	Period(h)	P.E.	Amp.	A.E.	Grp
57	Mnemosyne	07/13-09/02	11.7,17.2	258	16	26.12	0.01	0.24	0.01	MB-O
188	Menippe	02/28-06/06	*17.0,17.9	209	-8	11.98	0.07	0.15	0.01	MB-O
191	Kolga	07/25-09/08	13.7,19.9	270	11	17.59	0.01	0.50	0.01	MB-O
236	Honoria	03/21-04/21	*9.8,1.6	209	3	12.34	0.01	0.10	0.01	MB-O
261	Prymno	06/19-07/30	18.9,25.6	235	2	8.00	0.01	0.37	0.02	FLOR
270	Anahita	04/29-05/26	*9.4,6.0	236	-1	15.07	0.01	0.32	0.01	FLOR
469	Argentina	04/21-07/26	*8.7,20.4	227	-14	8.79	0.01	0.11	0.01	MB-O
530	Turandot	08/11-09/15	6.5,18.5	307	-1	19.94	0.01	0.17	0.01	MB-O
584	Semiramis	04/11-06/03	11.3,20.1	177	-12	5.07	0.03	0.24	0.05	MB-I
921	Jovita	05/19-07/03	6.2,19.7	229	11	15.57	0.01	0.13	0.01	MB-O
936	Kunigunde	09/09-09/24	*4.1,2.7	389	-3	8.83	0.01	0.29	0.01	THM
994	Otthild	03/19-05/02	*15.8,5.8	219	-11	5.95	0.01	0.11	0.01	MB-I
1157	Arabia	08/15-08/23	1.9,4.8	320	-3	11.55	0.02	0.41	0.03	MB-O
1180	Rita	07/29-09/20	2.1,14.7	304	-6	29.78	0.01	0.09	0.01	HIL
1269	Rollandia	04/03-06/14	*2.1,15.1	199	3	39.81	0.01	0.08	0.01	HIL
1594	Danjon	05/03-07/26	*10.9,30.3	242	0	116.02	0.01	0.72	0.01	MB-I
3519	Ambiorix	07/11-09/21	*9.0,27.9	305	-1	5.78	0.03	0.29	0.05	MB-I
52768	1998 OR2	05/08-05/17	36.9,33.3	236	-20	4.01	0.02	0.19	0.03	NEA

Table II. Observing circumstances and results. The phase angle is given for the first and last date. If preceded by an asterisk, the phase angle reached an extremum during the period. L_{PAB} and B_{PAB} are the approximate phase angle bisector longitude/latitude at mid-date range (see Harris et al., 1984). Grp is the asteroid family/group (Warner et al., 2009). FLOR: Flora; HIL: Hilda; MB-I/O: main-belt inner/outer; NEA: Near-Earth Asteroid; THM: Themis

T1M SCIENTIFIC CAPABILITIES





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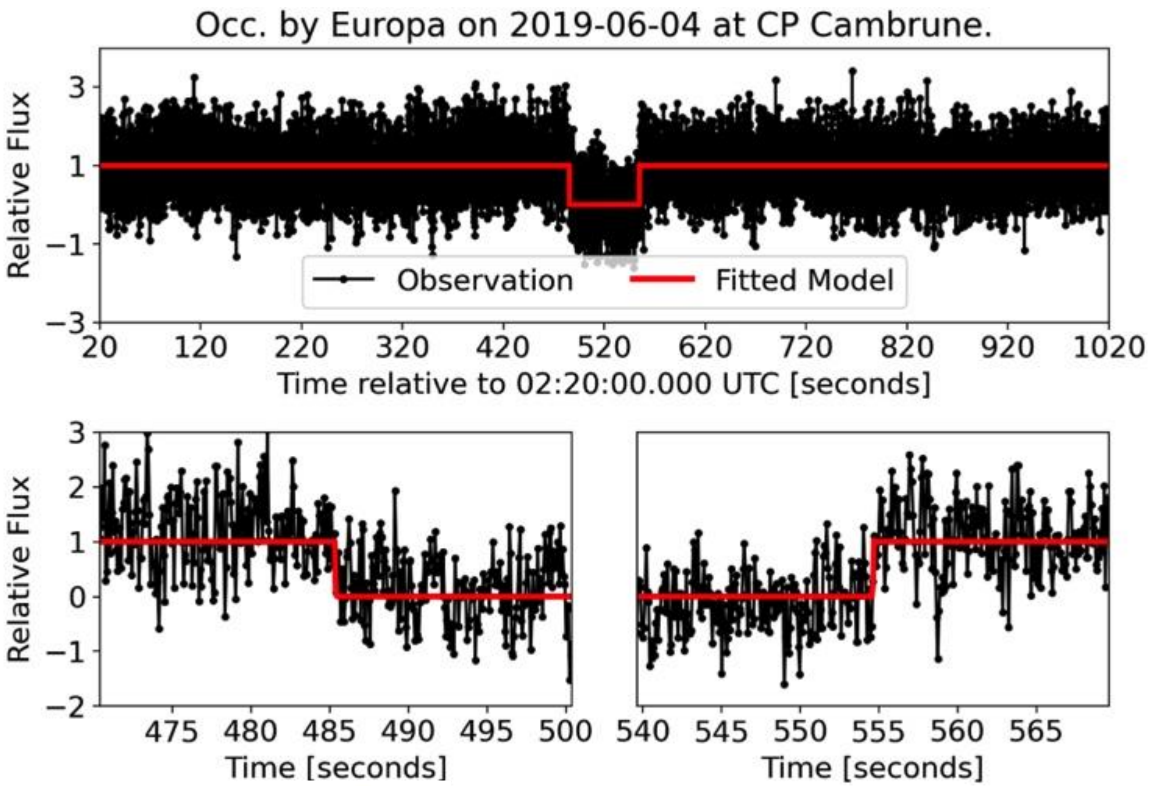
T1M SCIENTIFIC CAPABILITIES



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OPEN ACCESS

Milliarcsecond Astrometry for the Galilean Moons Using Stellar Occultations

B. E. Morgado[1,2,3,6], A. R. Gomes-Júnior[2,4], F. Braga-Ribas[1,2,3,5], R. Vieira-Martins[1,2,6], J. Desmars[7,8], V. Lainey[8], E. D'aversa[9], D. Dunham[10], J. Moore[10], K. Baillié[8], D. Herald[11,12], M. Assafin[2,6], B. Sicardy[3], S. Aoki[13], J. Bardecker[10], J. Barton[10], T. Blank[10], D. Bruns[10], N. Carlson[10], R. W. Carlson[14], K. Cobble[10], J. Dunham[10], D. Eisfeldt[10], M. Emilio[15], C. Jacques[16], T. C. Hinse[17,18], Y. Kim[19,20], M. Malacarne[21], P. D. Maley[10,22], A. Maury[23], E. Meza[24,25], F. Oliva[9], G. S. Orton[14], C. L. Pereira[1,2,5], M. Person[26], C. Plainaki[27], R. Sfair[4,28], G. Sindoni[27], M. Smith[10], E. Sussenbach[29], P. Stuart[10], J. Vrolijk[30], and O. C. Winter[4] ▲ Hide full author list

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4.-Mitigation Through Observations

STELLAR OCCULTATION AS MITIGATION

Table 1. Overview of orbital altitudes (h), sizes (R_s), angular diameters (θ_s), speeds (ω_s), and crossing times (τ_s) of satellite categories.

Orbit/class	h (km)	R_s (m)	θ_s ($''$)	v_s (km s^{-1})	τ_s (ms)
LEO 'CubeSat'	400	0.5	0.5	7.67	0.13
LEO 'Starlink'	400	5	5.2	7.67	1.30
LEO 'KeyHole'	400	15	15.5	7.67	3.91
GPS 'Galileo'	20 000	2	0.04	3.89	1.02
GEO 'Orion'	36 000	100	1.14	3.06	65.2

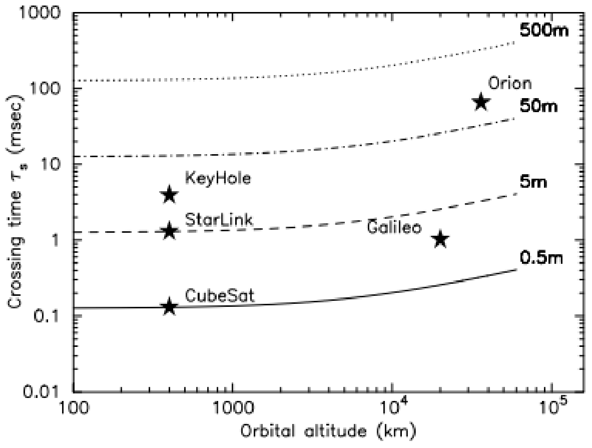


Fig. 1. Shadow crossing time as a function of orbital altitude of a satellite around Earth, for various satellite sizes. Indicated are representative classes of satellites in LEO, MEO, and GEO orbits.

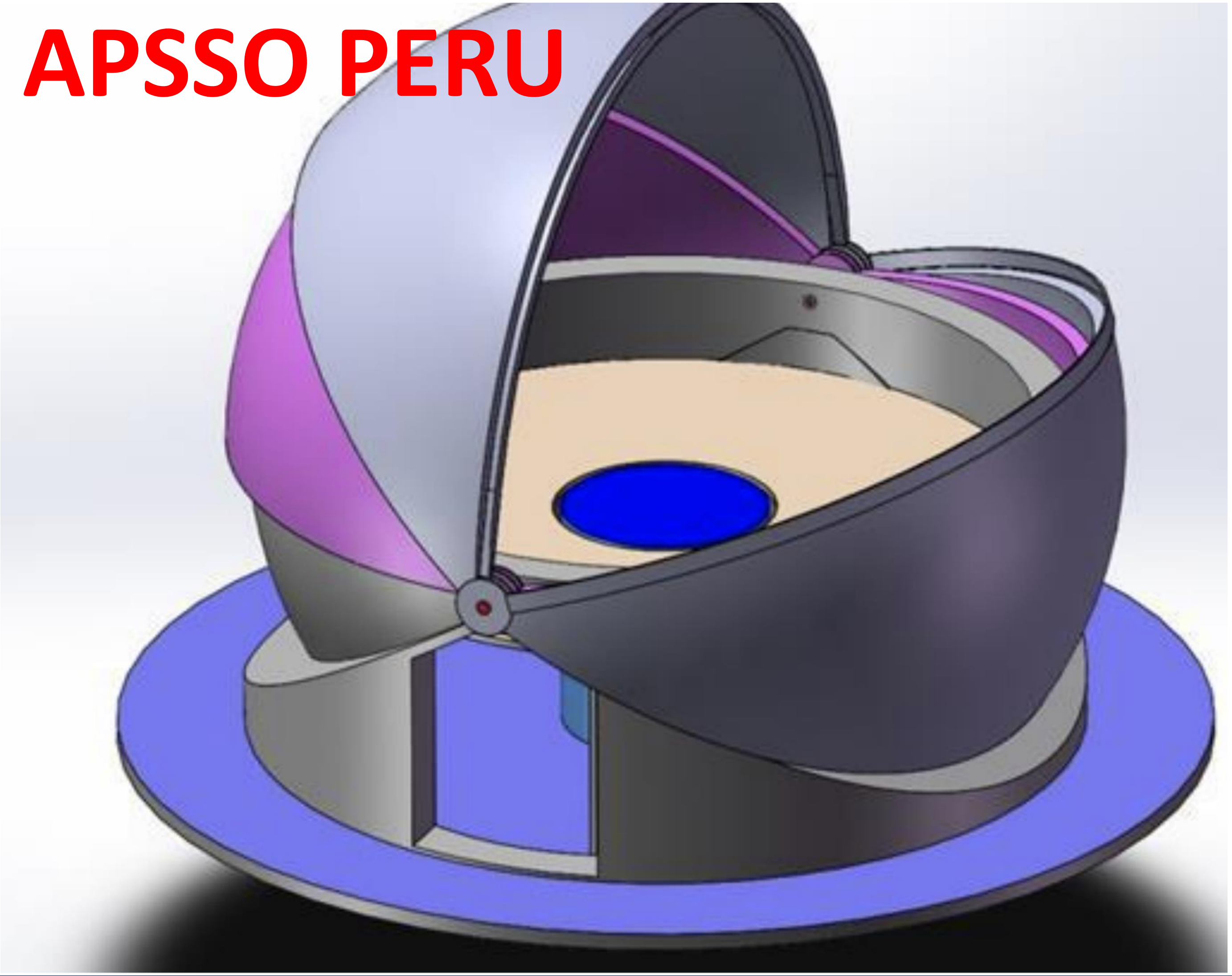
Groot, P. J. (2022)

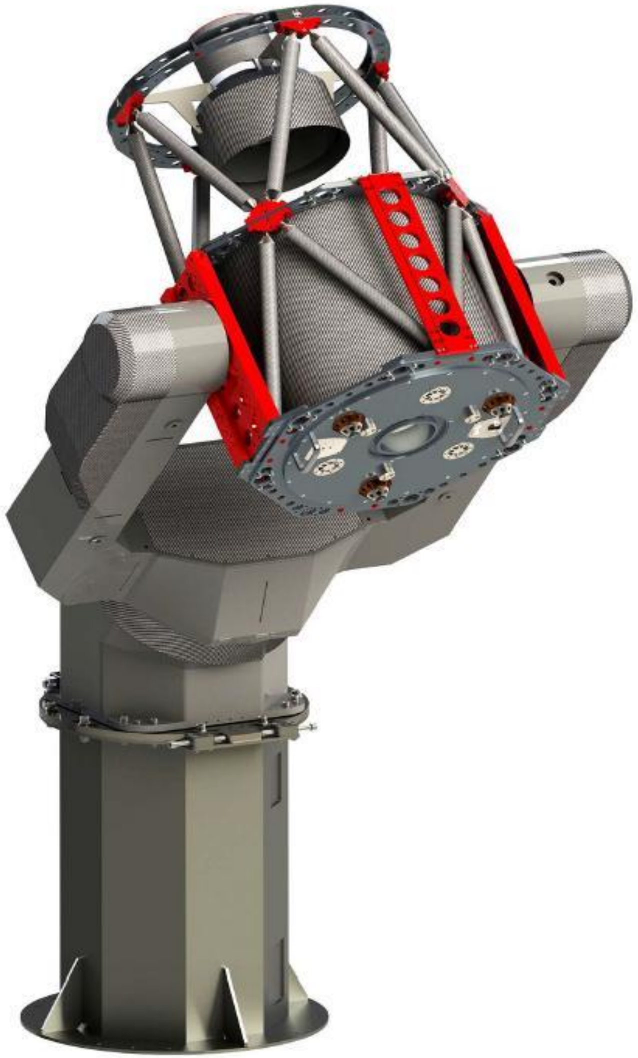
Why occultations matter:

- Size/shape estimation
- Attitude changes
- LEO/GEO potential
- Wide-field telescope increases event probability

4.- Combined Strategy & Outlook

COMBINED ESTRATEGY





TWO-TELESCOPE STRATEGY

- APSSO (60 cm): rapid detection, high cadence
- T1M (1 m): detailed follow-up
- Complementarity = stronger scientific + mitigation output
- Occultations + light curves (RSOs) = actionable SSA data

CONCLUSIONS AND NEXT STEPS

- Reopening = new capability for Peru and global community
- DarkSky (ongoing).
- Technical request for occultation-mode with APSSO
- Main mitigation (try observe satellite occultation + RSO photometry)
- OAM positioned to support international SSA networks

[redacted]

AGENCIA ESPACIAL DEL PERU

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THANKS FOR YOUR ATTENTION!