Developing the Telescope Control System for the TP2m

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The Trans-Pacific Two-Meter Telescope (**TP2m**) is a collaborative project among six partners: National Central University (**NCU**), Academia Sinica Institute of Astronomy and Astrophysics (**ASIAA**), Universidad Nacional Autónoma de México (**UNAM**), Shanghai Astronomical Observatory (**SHAO**), Henan Academy of Science (**HNAS**), and Aix-Marseille Université (**AMU**). The telescope is scheduled for deployment at San Pedro Mártir (**SPM**) in Mexico by late 2026. The primary objective is to study **Time-Domain Astronomy** as well as establishing the observation network connecting **LSST (Alert)→TP2m→Lulin**. The TP2m will also collaborate with the nearby **COLIBRI 1.3m** (UNAM & AMU; also at SPM) for simultaneous observations, enabling data acquisition through complementary instruments. Our software team is currently developing the Telescope Control System (**TCS**) to facilitate remote, automated, and robotic operations through a phased development approach.

Project Status and Timeline

Telescope: Upgrades finalized in Japan in Late 2025. Shipping to Mexico in Early 2026.

Construction: Enclosure & Dome installation at SPM from Spring – Late 2026.

Telescope Server: Currently located at NCU for software development. Deployment to SPM in Early 2027.

Science Instruments:

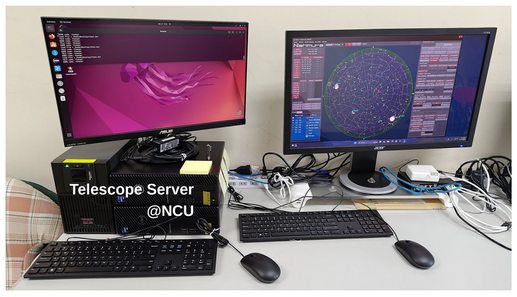
(1) Multi-color CCD Imager (NCU)
(2) IR Camera (NCU)
(3) IFU Spectrograph (SHAO)
(4) ESOPO Spectrograph (UNAM)

Software Development (TCS):

(1) Taiwan Team (NCU & ASIAA): Observer mode, hardware interface, and foundational operation (by the end of 2026)

(2) UNAM Team: Robotic mode.

Web UI: Real-Time Status



Real-Time Status

Date and Time

LST Time:	2026-01-12 23:49:31
UTC Time:	2026-01-12 08:18:39
SPM Time:	2026-01-12 01:18:39
Taiwan Time:	2026-01-12 16:18:39
Julian Date:	2461052.84628

Target Status

	<Telescope>	<Command>	<Difference>	
RA:	0	None		[hms]
Dec:	0	None		[dms]
Az:	0		0	[arcsec]
El:	0		0	[arcsec]
CsPA:	0		0	[arcsec]
Epoch:	2000			
az_sp:				
el_sp:				
CsPA_sp:				

Focus

Focus A	<hostPC> 0.0000	[mm]
Focus B	<hostPC> 0.0000	[mm]
Focus A-B	<hostPC> 0.0000	[mm]
Focus +:	<hostPC> 10.0000	[mm]
Focus -:	<hostPC> -20.0000	[mm]

Mirror

Mirror Cover Status:	<waiting for decoding>
Secondary Mirror:	<waiting for decoding>
Third Mirror Rotation:	<waiting for decoding>
Third Mirror:	<waiting for decoding>
7th Mirror:	<waiting for decoding>

Rotator

Rotator 1 Linkage: <hostPC> Unlinked
Rotator 2 Linkage: <hostPC> Unlinked
Rotator 3 Linkage: <hostPC> Unlinked

Telescope Status

Current Error:	<hostPC>	001
Current Status:	<waiting for decoding>	0000
Tracking Status:	<hostPC>	Stop
GPS Status:	<waiting for decoding>	

Dome

Dome Linkage:	<hostPC>	Unlinked	
Dome Status:	<waiting for decoding>	0	
Dome Angle:	<hostPC>	0.0	[degree]
Dome Azimuth:	<hostPC>	0	[degree]
Dome Light:	<waiting for decoding>		
Dome Slit:	<waiting for decoding>		

Satellite Tracking Status

Tracking File Running: <hostPC> Stopped
Tracking Waiting Time: <hostPC> 0.0 [sec]

Environment

Temperature:	<hostPC> 5.2	[°C]
Humidity:	<hostPC> 75	[%]
Pressure:	<hostPC> 1030.7	[hPa]
Wavelength:	<hostPC> 0.5	[micron]

Observatory Information

Observatory:	<hostPC> Lulin
Longitude:	<hostPC> +120:52:21.70 [dms]
Latitude:	<hostPC> +23:28:09.50 [dms]
Altitude:	<hostPC> 2862 [m]

HostPC Connection

TCP/IP Connection:	<socket> Connected
HostPC IP:	<socket> 140.115.34.90
HostPC Port:	<socket> 8766
Last Reboot Date:	<hostPC> 2026/01/08
Last Reboot Time:	<hostPC> 17:27:01
Telescope Controller Connection:	<hostPC> Disconnected
Command Enable:	<hostPC> Disabled

Goal: Develop a Linux-based python framework allows communication with Telescope Server (Linux) for integrated control of the telescope and dome.

Technical Highlight:

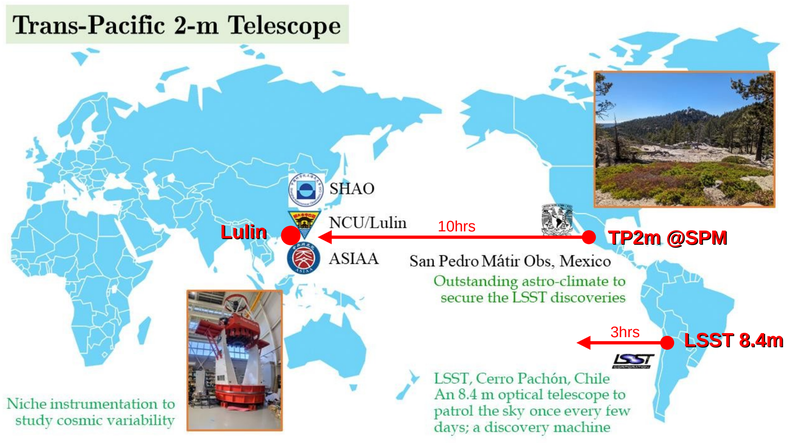
1-Hz Refresh Rate: Successfully polling data and status from server over TCP/IP.

Web UI Ready: Layout finalized; awaiting hardware connection.

Next Phase:

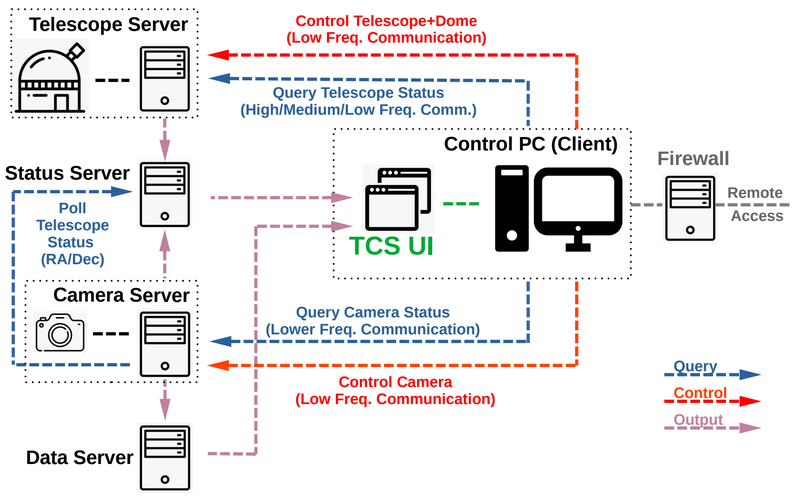
HEX Code Decoding: Parse HEX-encoded status messages returned by server.

Integration: Integrate telescope status to Sky Map, fits header, and related modules.



Site: San Pedro Mártir (SPM) in Mexico (115.4637W, 31.0439N; 2800m).
Sky Quality: 0.6'' seeing; 70% photometric nights; 80% spectroscopic nights.
Infrastructure: SPM hosts several facilities, incl. COLIBRI and TAOSII.

TCS Software Architecture Diagram



Communication between TCS and Hardware:

(1) Status Updates: Retrieve real-time updates for the telescope, dome, and instrument at various communication frequencies.

(2) Hardware Control: Send commands to operate the telescope, dome, and instrument with low communication frequencies.

(3) Metadata Integration: Coordinate, telescope position, and target name will be written into image header.

Active TCS UI Dashboard

Goal: Develop a Linux-based python framework allows displaying the status and controlling the telescope, dome, and instruments.

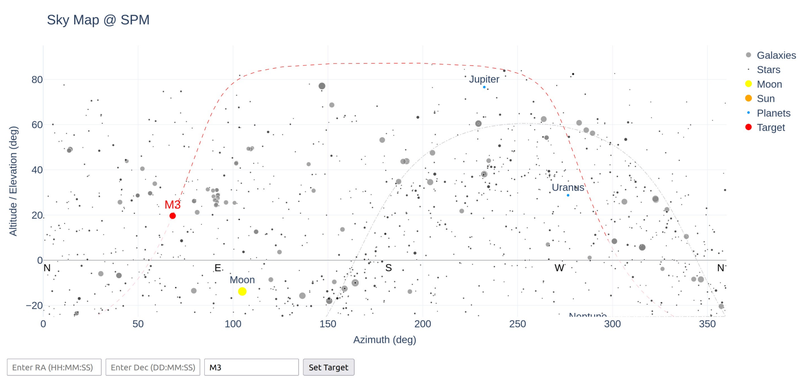
Workspaces: The integrated TCS UI features multiple specialized workspaces for specific operational tasks.

(1) Control Terminal: Control telescope, dome, and instruments.
(2) Telescope Real-Time Status: Telescope and dome status.
(3) Interactive Sky Map: The target coordinate and it's sky path.
(4) Instrument Control: Multi-color CCD Imager control available.

Web UI: Interactive Sky Map

Sky Map

SPM



Enter RA (HH:MM:SS) | Enter Dec (DD:MM:SS) | M3 | Set Target

Technical Highlight:

(1) Alt-Az Coordinate: Inspired by the SMA observation interface.

(2) Multi-Site Support: Quick switch between SPM/Lulin/LSST for visibility comparison.

(3) Real-Time Updates: The Sky Map update every 10 sec.

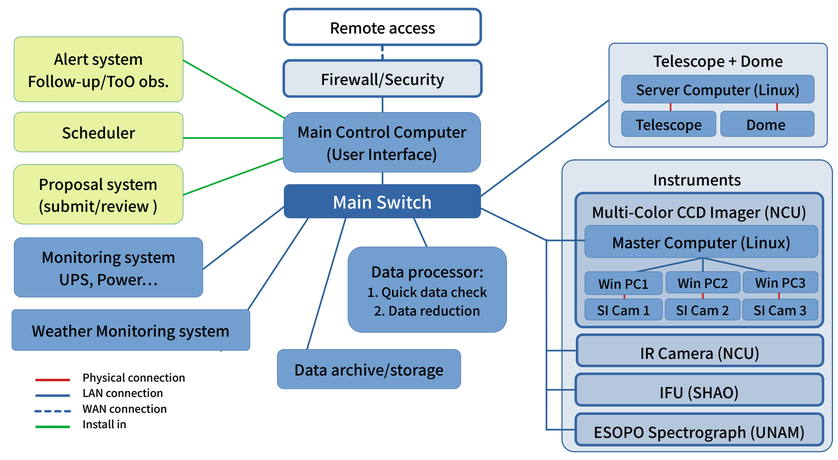
(4) Manual Coordinate Entry: Input a target coordinates (RA, Dec) will display the target's position and its sky path.

(5) SIMBAD Integration: Auto-fetch SIMBAD database by target name and display the target's position and its sky path.

Next Phase:

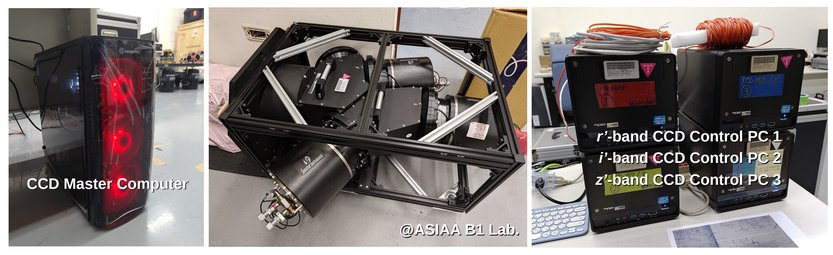
Hardware Synchronization: Telescope pointing indicator.

TCS Software Module Design



Our TCS software includes several modules: (1) Telescope and Dome control, (2) Instruments control, (3) Data archive, (4) Data processor, (5) Monitoring systems, (6) Alert system, (7) Scheduler, and (8) Proposal system

Instrument Control: Multi-color CCD Imager



Development Site: Currently stationed at ASIAA for CCD control module development.

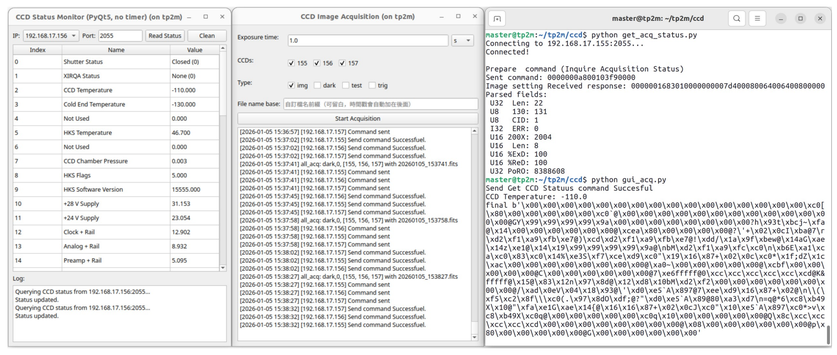
Hardware: 3 SI-1100 cameras (*r'*-band, *i'*-band, and *z'*-band) mounted on a beam splitter box with 2K × 4K CCD sensors.

Interface: Each connected to a control Windows PC via optic fiber.

Master Control: Linux-based computer for centralized simultaneous control and remote access over TCP/IP.

Clock Synchronization: Simultaneous timestamps across all 4 computers.

GUI & CLI Modes: Image Data Acquisition

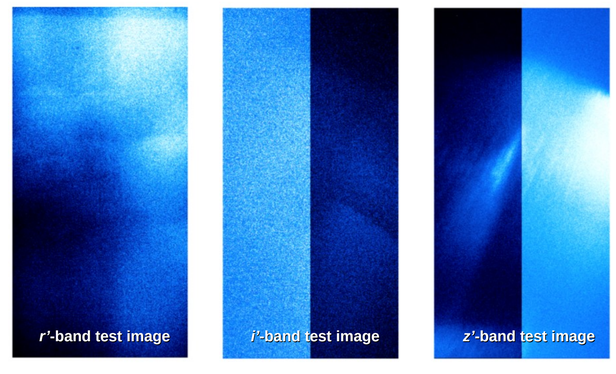


Goal: Develop a Linux-based python framework to communicate with CCD windows software over TCP/IP through **binary message decoding**.

Dual Interface: We have developed both **GUI** to allow local control and **CLI** (Command Line Interface) to allow remote control. Both UIs can display the CCD status and acquisition image fits data.

(Credit: Yen, Sheng-Feng & Liao, Wei-Hung)

Synchronous Exposure Test Images



Technical Highlight:

Synchronized Exposure: Achieved simultaneous 3 CCD triggering with a timestamp offset of **~40ms**.

Next Phase:

Flexible Exposure Modes: Enabling independent exposure time for each CCD.

Readout Optimization: Parameter tuning for maximize data quality & readout efficiency.

Fits Header Integration: Automatically recording metadata (Target, RA, Dec, WCS...) into image files.