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# The Remote Control System for the ASTE Telescope

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**Abstract.** The Atacama Submillimeter Telescope Experiment (ASTE) is a project to operate a 10-m submillimeter telescope at a high altitude site (4,800 m) in the Atacama desert in northern Chile. The key to successful telescope operation under the severe environment of the observing site is to realize a stable remote control system. The remote control system for ASTE consists of a newly developed operating software capable of remote observation and a satellite network facility (56-64 kbps), which connects the telescope site to the outside world including the operation base in San Pedro de Atacama (altitude 2,400 m) or institutes in Japan. The control software was developed based on the existing COSMOS3 system, which has been used for the 45-m telescope and the Millimeter Array (NMA) of the Nobeyama Radio Observatory (NRO) in Japan. The telescope operation with N-COSMOS3 in Chile started in April 2002. We have succeeded in the first remote observation from the base in San Pedro de Atacama in July 2002, followed by the first successful remote observation from Japan in October 2003.

## 1. Introduction - the ASTE project

The Atacama Submillimeter Telescope Experiment (ASTE; Figure 1) is a project to operate a 10-m submillimeter telescope at a high altitude site (4,800 m) in the Atacama desert in northern Chile. The aims of this project are to observe the southern sky through submillimeter waves, and to develop and establish a high

Figure 1. The ASTE telescope and its infrastructure at Pampa la Bola.

performance submillimeter telescope (see also Ezawa et al. 2004). The ASTE is a telescope of the National Astronomical Observatory of Japan (NAOJ), while the telescope is currently operated collaboratively by the ASTE team including NAOJ, University of Tokyo, Nagoya University, Osaka Prefecture University, and Universidad de Chile.

## 2. The ASTE control system

The telescope site is far from Japan and under a severe environment. Therefore, the key to successful telescope operation is to realize a stable remote control system. The control system for ASTE consists of a newly developed operating software capable of remote observation (N-COSMOS3) and a satellite network facility (56-64 kbps).

### 2.1. The ASTE network

The satellite network connects the telescope site to the outside world including the operation base in San Pedro de Atacama (altitude 2,400 m) or institutes in Japan through INTERNET2 collaborated with AccessNova. There are currently five operation sites as shown in Figure 2. Two sites (the telescope site and the base at San Pedro de Atacama) are in Chile, and the other three sites (NAOJ, NRO and University of Tokyo) are located in Japan.

### 2.2. N-COSMOS3

The new control software was developed based on the existing COSMOS3 system (Morita et al. 2003), which has been used for the NRO 45-m telescope and the NMA in Japan. This new system for ASTE employs the following features:

- **Remote operation through narrow-band network connection (56-64 kbps).**
  The original COSMOS3 was expanded with new functions as shown in Figure 3. Distinct features are information servers and traffic shaping.
- **Robust system to survive with sudden network connection failure.**

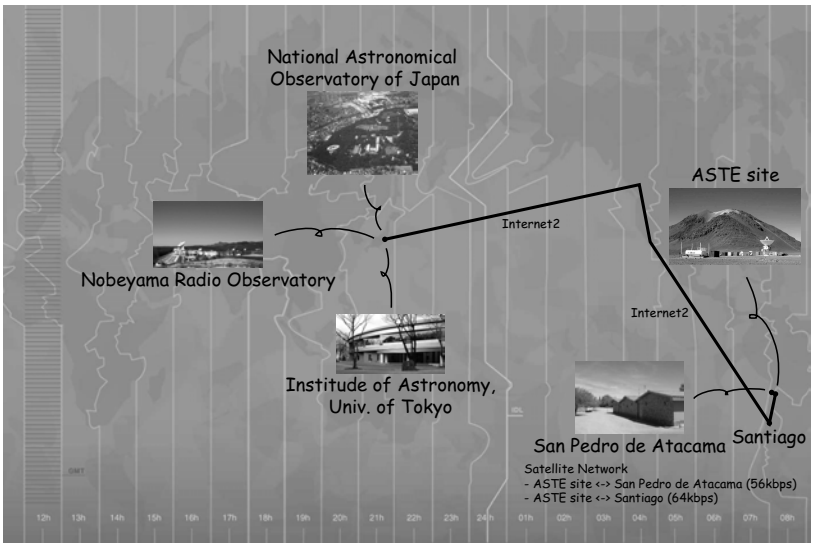


Figure 2. The current operation sites and the network routing. The satellite network connects the ASTE site to the base in San Pedro de Atacama and Universidad de Chile in Santiago. Internet2 lines collaborated with AccessNova are used between NAOJ in Japan and Universidad de Chile in Santiago.

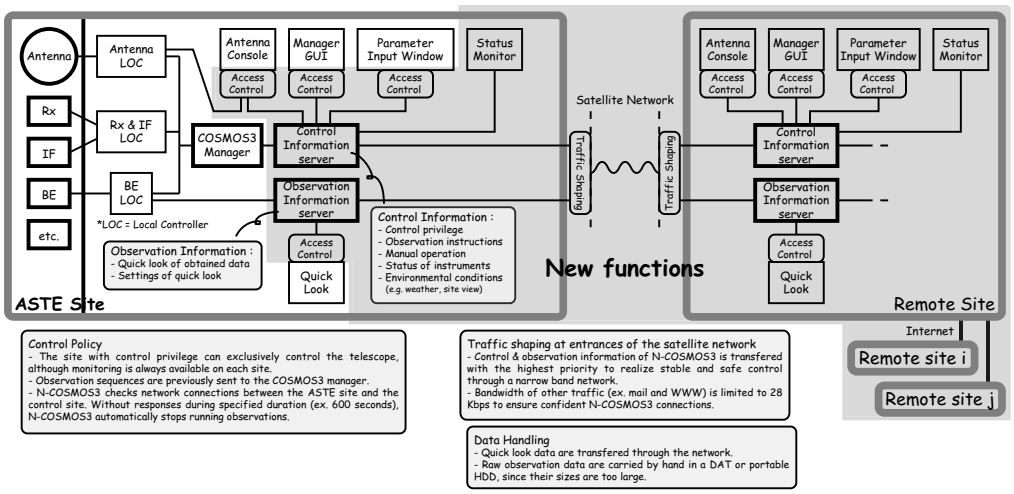


Figure 3. A diagram of N-COSMOS3. The gray zone indicates the expanded parts with new functions. All of the operational data are transfered via control and observation information servers, using a server-client method.

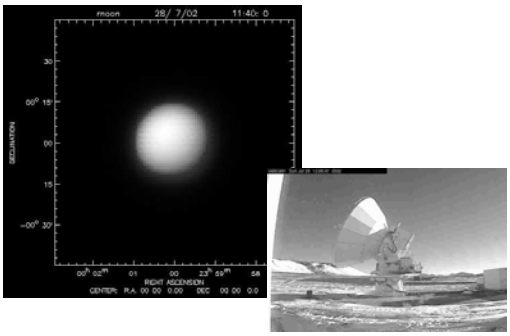


Figure 4. The first remote observations from the operation base in San Pedro de Atacama (Moon@345GHz & Web-camera image).

Observation tables are loaded into the COSMOS3 manager, and N-COSMOS3 at the ASTE site operates the telescope under the tables. N-COSMOS3 also checks network connections between the ASTE site and the control site. Without a response during a specified duration (e.g., 600 seconds), N-COSMOS3 automatically stops running observations.

- **Traffic shaping to guarantee necessary communication for telescope control.**
  Control and observation information of N-COSMOS3 is transfered with the highest priority to realize stable and safe control through a narrow bandwidth network. In addition, the bandwidth of other traffic (e.g., mail and WWW) is currently limited to 28 kbps to ensure confident N-COSMOS3 connections.
- **Multiple remote operating sites, including access control and easy change of remote sites.**
  The site with control privilege can exclusively control the telescope, although monitoring is always available at each site. Control and observation information such as control privilege and quick look is transferred through information servers via a server-client method. Raw observation data (maximum 15 GB/day) are too large to transfer through the satellite network; they are carried by hand on DATs or portable HDDs.

## 3. Status

We started operating the telescope with N-COSMOS3 in Chile in April 2002. We have succeeded in the first remote observation from the operation base in San Pedro de Atacama in July 2002 (Figure 4), followed by the first successful remote observation from Japan in October 2003. Now, most of observations and measurements are carried out from remote sites including the Japanese sites (Figure 5). Figure 6 shows astronomical results taken with such remote operations.

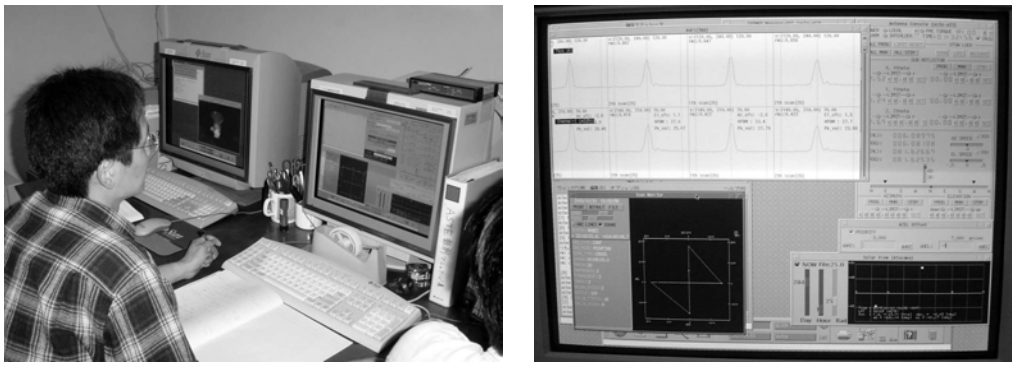

Figure 5. Remote observations in San Pedro de Atacama and a screen of N-COSMOS3.

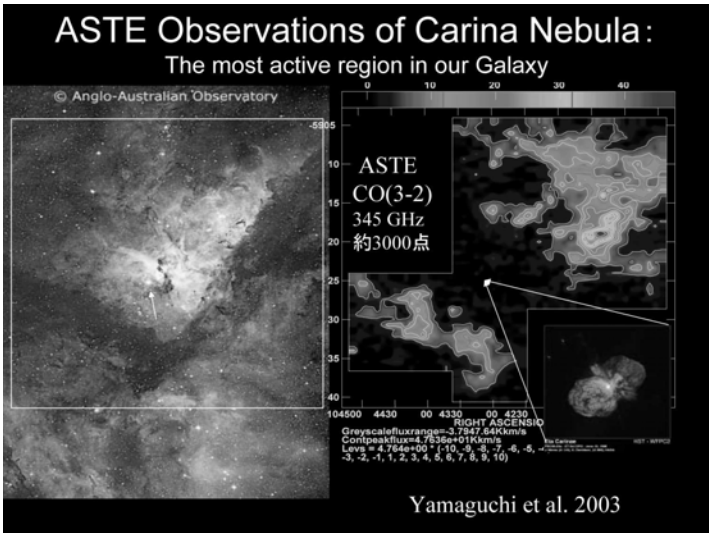


Figure 6. Astronomical observations of $^{12}$CO($J$=3-2) emission toward the Carina region taken with remote operations (Yamaguchi et al. 2003).

## References

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