

Road Conditions for Antenna Transportation from San Pedro de Atacama to Pampa la Bola

N. Ukita^a, R. Kawabe^a, S. Sakamoto^a, H. Ezawa^a, N. Yamaguchi^a, T. Takahashi^a,
S. Yamamoto^b, T. Hasegawa^c, Y. Moriguchi^d, T. Takano^e, H. Andoh^f,
K. Miyawaki^g, and H. Honda^g

^a Nobeyama Radio Observatory, NAOJ

^b Department of Physics, University of Tokyo

^c Institute of Astronomy, University of Tokyo

^d Department of Physics, Nagoya University

^e Department of Electronics and Mechanical Engineering, Chiba University

^f Department of Information and Computer Engineering, Toyota National College of Technology

^g Communication Systems Center, Mitsubishi Electric Corporation

(September 9, 2000)

ABSTRACT

Information of the road from San Pedro de Atacama to the Pampa la Bola site was collected for transportation operation of a 10-m antenna. Inclinations and widths of the road were measured. Turnouts, opencuts, and obstacles were located. It appears to be possible to transport a 10-m dish with a double tractor and trailer from San Pedro de Atacama to the Pampa la Bola site.

1. INTRODUCTION

Early in July 2000, we visited the LMSA and ALMA sites in northern Chile to figure out processes of antenna transportation. Nobeyama Radio Observatory (NRO)¹ constructed a 10-m submillimeter antenna¹ in March 2000, which was designed as an experimental antenna for the LMSA project². The telescope is under initial tests at Nobeyama. NRO and universities in Japan and Chile jointly plan to install and operate it on a high altitude plateau in northern Chile (Pampa la Bola of the Atacama Desert, 4800m in elevation; Figure 1) to continue antenna evaluations on-site for submillimeter performance. This project is called as Atacama Submillimeter Telescope Experiment (ASTE).

The people involved in the LMSA/ALMA project(s) have visited the sites many times, and know that one can transport the antenna to the site. To be properly accomplished, all processes of transportation must be inspected thoroughly to ensure safety and no difficulties/obstacles throughout the way to the site. In 1999, a Caltech group constructed an antenna of a 6.5-m diameter at the Llano de Chajnantor (<http://www.astro.caltech.edu/~tjp/CBI/>). The antenna as a whole was packed in a large container, and was transported from Pasadena to the Chajnantor site.

The 10-m telescope will be de-assembled, and packed into several containers, and is supposed to be assembled at a nearby village of San Pedro de Atacama at an elevation of 2,400 m. One option is to assemble them completely into a single unit (65 ton); and another is to make

¹Nobeyama Radio Observatory is a branch of the National Astronomical Observatory, Japan, an inter-university research operated by the Ministry of Education, Science, Sports, and Culture, Japan.

a unit of the 10-m main dish (13 ton) and three units of the telescope mount (30, 11, and 11 ton). In the latter case, we transport the main-dish unit with a trailer (see Figure 2), which needs to examine the road over 62 km from San Pedro de Atacama to Pampa la Bola. As the first step, we have collected information relevant to transportation of a 65-ton, 10-m antenna, such as widths and inclinations of the road, locations and sizes of turnouts, locations of obstacles for a large-size vehicle, etc.

This note is just to briefly describe findings obtained during our visit, which may in the future be useful to our community. The body of the report consists of brief memos and tables (Table 1 and 2) of data in the second section and photographs in Appendices.

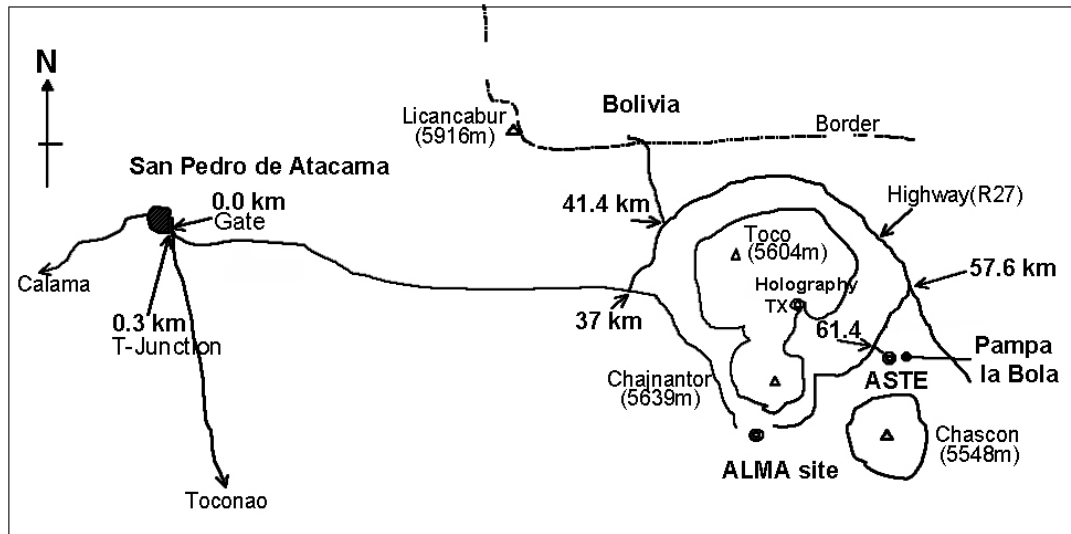


Figure 1. A sketch of the area from San Pedro de Atacama to the ASTE site(not scaled)

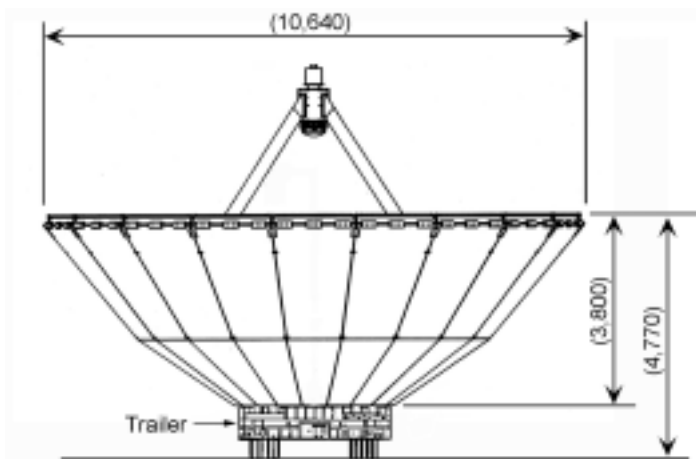


Figure 2. A 10-m main dish on a trailer

2. INVESTIGATION

A sketch of the area is shown in Figure 1. Maps and topographies can be obtained from the ALMA web site (<http://www.tuc.nrao.edu/mma/sites/sites.html>). The area seems to be a result

from pyroclastic flow; a stream of heated rocks and volcanic ash produced by large-scale volcanic eruptions. The highway, which goes from San Pedro de Atacama to Argentina, was recently paved, and was in good conditions over the entire course except for one location (Location #21 in Table 2, Photograph B-16). There are neither rapid curves nor steep up-and-down slopes. There are five opencuts in the highway. No houses are built along the highway. At 58 km, the route branches off the highway, and leads to the LMSA/ALMA site. It is an unpaved road. The final access pass to the telescope site was in an off-road condition (Photograph A-10).

2.1. Road Slope and Width

Table 1 summarizes slopes of the road. Road slopes were measured with an inclinometer mounted in our vehicle. An offset of the inclinometer was measured when the vehicle was on a flat place. The first 10 km is flat and straight (also see Photograph A-1). Later, the road has a gentle slope of 3-5 degrees. At some locations, slopes were an inclination of 6-7 degrees (Opencut #1 and #2; Photograph A-3, 4). The access road crosses moraine (Location #33 in Table 2) at about 600 m from the turning point to Pampa la Bola (Photograph A-8, 9). The slope has a pitch angle of 8 degree and roll angle of 2 degree.

The road width was measured with a steel tape. The length between two white lines was measured to be 7.8 m all over the highway; the width between the road shoulders were equal to or more than 10 m approximately.

2.2. Turnout

Turnouts are key locations at the side of the road where our slow trailer(s) can wait to let other fast vehicles pass. In Table 2, we listed 15 turnouts useful for our operation.

2.3. Opencut

Opencuts are danger zones in the route. The 10-m main dish on a trailer may hit a sidewall of the opencuts. In particular, the second and third opencuts in the list have steep walls (see Photographs B-12, 13, 14, and 20). It would be better to have a pedestal between the carrier bed and the base of the main dish to have more clearance (Figure 2).

2.4. Obstacle

Road-sign boards that stand at opposite sides of a road get in the way of over-sized transporters. There are two such places at which the trailer has to pass slowly with pre-cautions (Location #14 and #22, Table 2). There were no traffic lights, cables, and bridges over the road, except for a T-junction near San Pedro (Location #2 in Table 2).

One of the most difficult spots in the route seems to be the location #33 in Table 2 at which a transporter rides over a moraine. The road is a S-shape curve, and is currently unpaved (Photographs B-22). The maximum inclination was 8 degree, and the maximum roll angle was about 3 degree. It seems to be impossible for a standard 4 drive-wheel tractor to restart climbing with a 30-ton load trailer on such a steep unpaved slope ($\mu=0.4$). Possible measures would be (1) to pull the trailer with a twin tractor, (2) to pave the slope ($\mu=0.7$), (3) to reduce the slope to an inclination of about 5 degree.

2.5. Miscellaneous

The roads in the village were narrow, and it is impossible for a large-size trailer to pass through the village. A bypass road around the village San Pedro de Atacama is constructed, but it is not yet open for use. It will be open in September 2000(A. Otárola, private communication).

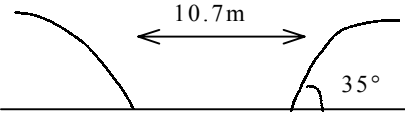
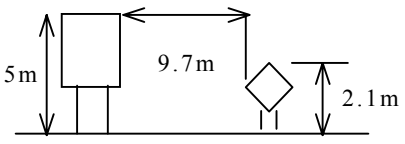
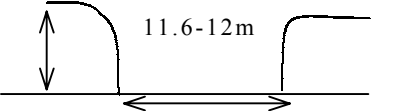
REFERENCES

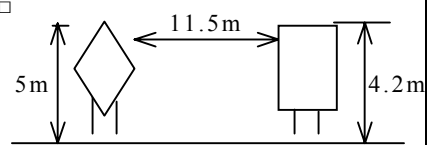
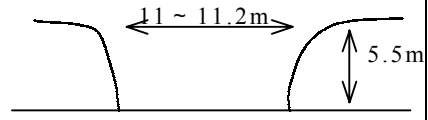
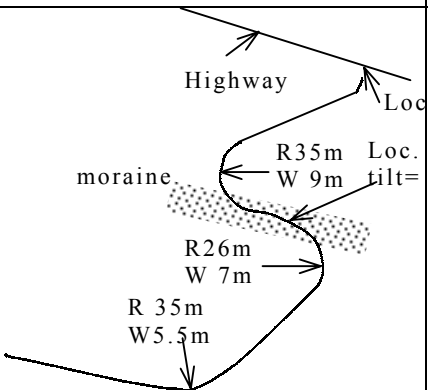
1. N. Ukita, et. al., "NRO 10-m submillimeter telescope," in *Radio Telescopes*, H.R. Butcher, ed., *Proc. SPIE* **4015**, pp.177-184, 2000.
2. M. Ishiguro, "Japanese Large Millimeter and Submillimeter Array," in *Advance Technology MMW, Radio, and Trivets Telescopes*, T.G. Philips, ed., *Proc. SPIE* **3357**, pp. 244-253, 1998.

Table 1. Road conditions from San Pedro de Atacama to the LMSA site

No	Distance [km]	Road Condition	Inclination [deg]	Comments	Photo No.
1	0.0 ~ 9.4	flat	< 1		A-1
2	9.4 ~ 11.2	gentle slope	about 2		
3	11.2 ~ 11.8	gentle down slope	about -2		A-2
4	11.8 ~ 28.5	gentle slope	3 ~ 5		
5	28.5 ~ 29.5	steep slope	6 ~ 7	opencut #1	A-3
6	29.5 ~ 30.1	steep slope	about 5		
7	30.1 ~ 30.8	steep slope	about 6	opencut #2	A-4
8	30.8 ~ 35.8	gentle slope	3 ~ 5		A-5
9	35.8 ~ 40.9	S-curved gentle slope	3 ~ 5		A-6
10	40.9 ~ 41.3	S-curved gentle down slope	2 ~ 3		
11	41.3 ~ 57.6	gentle up/down slope	< 2 ~ 3		A-7
12	57.6 ~ 61.2	unpaved	< 5	The moraine section has an inclination of 8 degree.	A-8,9
13	61.2 ~ 61.6	gentle down off-road slope			A-10

Table 2. Information about turnouts, opencuts, and signboards on the way from San Pedro de Atacama to the LMSA site (July, 2000)

No	Location	Distance [km]	Comments (from SPdA to LMSA site)	GPS data			Sketch	Photo No.
				No	Latitude	Longitude		
1	Checkpoint gate	0.0	At the traffic control gate, pass through at a low speed	-				B-1
2	T-junction	0.3	Turn left to the site (go straight on to Toconao)	-				
3	Turnout #1	4.7	On the left side; a width of 12 m, a length of >60 m;	-				B-2
4	Turnout #2	7.5	On the right side; a width of 12 m; unpaved	13	-68.123807	-22.918352		B-3
5	Turnout #3	12.6	On the left side, a width of 10 m	14	-68.074905	-22.924854		B-4,5
6	Turnout #4	13.5		15	-68.065796	-22.922896		
7	Turnout #5	14.9	On the right side; a small area	-				B-6
8	Turnout #6	19.3	On the right side; a width of 7.5 m	17	-68.010848	-22.911341		B-7
9	Turnout #7	21.0	On the right side	18	-67.996166	-22.910660		
10	Turnout #8	24.0	On the left side	19	-67.967874	-22.908804		
11	Turnout #9	24.9	On the left side; a width of 7.3 m	20	-67.956786	-22.908943		B-8
12	Turnout #10	26.4		21	-67.943428	-22.910949		
13	Opencut #1	28.5	Rock walls with a wide open angle	22	-67.923269	-22.914334		B-9
14	Sign boards at both sides	29.7	The height of signboard on the right side was 2.1m; the left 5m. The span of the inner edges of the boards was 9.7 m.	24	-67.912288	-22.915515		B-10, B-11
15	Opencut #2, begin	30.1	The span between the rock walls was 12 m. Road inclination of 5°	25	-67.908340	-22.916046		
16	Opencut #2	30.4	Span of 11.6m; road inclination of 6°	26	-67.905443	-22.916394		B-12
17	Opencut #2	30.6	Span of 12.1m; road inclination of 6°	27	-67.903125	-22.916641		B-13
18	Opencut #2, end	30.8		28	-67.900609	-22.916952		B-14
19	Turnout #11	31.7	On the left side	29	-67.893094	-22.917778		
20	Turnout #12	32.4	On the right side	30	-67.887182	-22.920128		B-15
21	Caution: Soft-shoulder	35.0	The right shoulder outside a guardrail was collapsed.	31	-67.863332	-22.929097		B-16

22	Sign boards at both sides	35.3	The height of signboard on the right side was 4.2m; the left about 5m. The span of the inner edges of the boards was 11.5 m. (The boards are bolted to poles.)	32	-67.861272	-22.929789		B-17 B-18
23	Turnout #13	39.5	On the right side, some rocks	33	-67.824757	-22.922258		
24	Turnout #14	40.5	On the right side	34	-67.817096	-22.923835		
25	Turning point to Bolivia	41.4	T-junction to the border of Bolivia	-				B-19
26	Turnout #15	43.0	On the right side	-				
27	Opencut #3, begin	51.4	The span between the rock walls was 11 m. The height of tops of the rock walls was 5-5.5 m.	35	-67.727022	-22.905960		B-20
28	Opencut #3, end	51.6		-				
29	Turning point to the holography TX site	52.8	Turn right to the holography TX site.	43	-67.717538	-22.911550		
30	Opencut #4	53.7	The rock wall span of 11.6 m; height of 3 m.	37	-67.709770	-22.917864		
31	Opencut #5	56.6	The rock wall span of 11.5 m; height of 3 m.	38	-67.691660	-22.937321		
32	Turning point to Pampa la Bola	57.6	Turn right to the ALMA/LMSA site. (Notice board of Osengtel)	39	-67.687116	-22.945689		B-21
33	Moraine	58.2	The maximum inclination pitch of 8°; a roll angle of 2~3°; unpaved road	40	-67.688903	-22.948704		B-22
34	To the site	61.4	From unpaved road to off-road	41	-67.704637	-22.969271		
35	LMSA containers	61.8		42	-67.702662	-22.969008		B-23
36	ASTE telescope		300 m SSE of the LMSA container houses	46	-67.703242	-22.971728		B-24

Appendix A







Appendix B









B-13



B-14



B-15



B-16





B-21



B-22



B-23



B-24