Interoffice

National Radio Astronomy Observatory

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To: Addressee

From: J. Coe, F. Crews

ADDITIONAL BASELINE TO INTERFEROMETER
MILO No. 114

Subject: Additional Baseline to Interferometer Tasks

We have divided this project into 4 parts. You will find listed under each part the associated tasks provided by various members of the committee.

The areas are:

Part I - Site
Part II - Link
Part III - Telescope
Part IV - Computer

I. SITE

A. General

This site was selected because of the requirement to add another interferometer baseline oriented at right angles to the existing 85-1, 45-ft baseline; and with a length comparable to the existing 85-1, 45-ft baseline.

The new site is near Monterville, WV in Randolph County, and is found at latitude 38° 33' 28", longitude 80° 09' 30", just west of Monterville on state route 15. The direct distance between 85-1 and the new site is 31.7-km compared to 35.2-km for the existing 85-1, 45-ft distance. The baseline thus established has an azimuth of 295.4° from 85-1 compared with an azimuth of 206.9° for the 85-1, 45-ft baseline, resulting in an angle of 88.5° between the baselines. From this new site it is possible to establish a satisfactory microwave link transmission path to the Green Bank Interferometer Control Building.

The site is at the top of a ridge, offering no sky blockage. It also offers no wind protection. However, because of the lay of the site it may be possible to locate the telescope where some wind protection is provided, depending

on the final outcome of the microwave link path studies. Here again there will be full sky coverage.

B. Conceptual Description of Site

The site will consist of the telescope with its foundation, a microwave link tower and foundation, a telescope service elevator and pad, a standby generator capable of stowing the telescope, fuel storage for the generator, electronic equipment housing, a shelter for service personnel, an enclosure for the environmental monitors, a tank for the water storage, and a small amount of weather protected storage. If the 85-3 telescope is relocated to the new site, the equipment housing is already provided, and a trailer or other suitable housing is needed for storage and for the use of personnel who will periodically go to the site. If a new 45-ft or other telescope is provided, a trailer large enough to house electronic equipment and for the use of personnel is required. In this case an additional trailer or prefabricated building will be used for storage.

Apart from normal heating and lighting requirements, the electronic equipment housing must be temperature controlled (the main prerequisite is air conditioning) to provide an

environment of 70°F ± 10°F in a high equipment-density-heat area. Therefore, air conditioning must be included in the site plan.

Suitable security provisions such as fences, dusk to dawn lighting, and appropriate signs are required.

C. Utilities

If the decision is to move 85-3, 3 phase power (about 50-kw) will be required. From first observation this does not appear to be readily available, even though a high tension line passes near the site. Power for a single phase requirement (45-ft telescope, for example) of 20-kw appears to be available from the line passing near the site. In any event commercial power will be used. A standby generator for emergency stowing of the telescope is required. Telephone lines are near the site. A small amount of potable and non-potable water is required for occasional human use.

D. Miscellaneous

A 43 MHz transmitter/receiver will be used for voice communication. Environmental monitors are required for recording environmental conditions and for operating consid-

erations. These monitors are: wind speed, barometric pressure, temperatures (inside equipment house ambient), dew point, and a visual monitor for surveillance of antenna conditions.

E. Site Tasks

An outline of the work required to complete the site is as follows:

1. Site Investigation
   a. Establish exact location and approximate area needed.
   b. Determine ownership, establish availability, acquire copies of deed(s).
   c. Negotiate temporary use of property.
   d. Make soil tests.
   e. Investigate security measures necessary.

2. Develop Site Plan
   a. Design access road.
   b. Design parking.
   c. Investigate telescope clearances.
   d. Design foundations for telescope and microwave tower.
   e. Select equipment housing and storage.
   f. Investigate standby power requirements.

g. Specify and or design air conditioning, lighting and heating.

h. Design utility services (electricity, telephone, sewage, water, drainage, security fence, outside and security lighting.

i. Investigate service elevator requirements.

j. Complete overall site plan design including landscaping and seeding.

k. Prepare environmental impact statements.

3. Finalization of Property Acquisition

a. Determine size from site plan.

b. Obtain approval of method of use (lease, buy).

c. Prepare appropriate documents to acquire use of land.

d. Negotiate final arrangements.

4. Contracts

a. Specify number of distinct contracts.

b. Prepare RFQ packages.

c. Obtain necessary approvals.

d. Put out RFQs.

e. Award contracts.

f. Supervise contract fulfillment.

5. Purchased Items

a. Specify

equipment housing

communications transmitter/receiver

visual surveillance monitor

heating

standby generator

telescope service elevator

environmental equipment enclosure

temperature monitors

storage

microwave tower

air conditioner

lights

dew point monitor

wind speed monitor

barometer

b. Solicit Prices and Place Orders

c. Install

equipment housing

communications transmitter/receiver

visual surveillance monitor

heating

standby generator

telescope service elevator

environmental equipment enclosure

temperature monitors

storage

microwave tower

air conditioner

lights

dew point monitor

wind speed monitor

barometer

II. LINK

A. General

The link includes all of the equipment needed to provide a phase stable local oscillator signal at the remote site, to transmit two 30 MHz wide radiometer outputs to the control building, and to transmit antenna control and position information to and from the remote site. Equipment will be provided to transmit the output from environmental monitors at the remote site; i.e. wind speed, barometric pressure, outside temperature and dew point. A visual monitor will also be provided for surveillance of antenna conditions.

B. Description of Microwave Link

The microwave link will operate in the 16 to 18 GHz frequency range. It will be implemented with a small parabolic antenna and feed on a 30 to 40 foot tower at each end. Passive reflectors will be used to reflect the microwave beam through a route that provides adequate path clearance. The transmitted and received signals will be offset in frequency. A transmitter and receiver will be located in the equipment buildings and connect to the parabolic antennas through waveguide. Because of the attenuation at these frequencies the waveguide length will be restricted to thrity to forty feet. A new high frequency link will be installed to the existing site at Huntersville. This would eliminate the interference problems caused by the low frequency link.

C. Microwave Link Tasks

An outline of the work required to construct the microwave link follows:

1. Determine link requirements:
   a. Reliability
   b. Phase stability of local oscillator
   c. S/N ratio for IF, video, local oscillator
   d. Bandwidth of link
   e. Select frequencies
   f. Obtain license

2. Select optimum microwave link path:
   a. Plot path profiles for possible routes
   b. Compute required path clearances
   c. Compute and compare path losses
   d. Compute passive reflector gains vs. size
   e. Select passive reflector sites
   f. Check paths by visual means
   g. Compute link reliability
   h. Check availability of passive reflector sites
   i. Negotiate for passive reflector sites

3. Design link:
   a. Determine minimum size for reflectors and antennas
   b. Prepare plan for passive repeater sites
   c. Design foundations for passive reflectors and antenna towers
   d. Design local oscillator phase control
   e. Design transmitters and modulators
   g. Design receivers and demodulators

4. Master oscillator modifications:
   a. Design lobe rotator frequency conversion

5. Procure microwave link components
   a. Prepare RFQ's (10 to 20)
   b. Issue purchase orders

6 Assemble link components
   a. Master oscillator lobe rotator
   b. Western site transmitter
   c. Western site receiver
   d. (2) control building transmitters
   e. Huntersville site receiver

7. Test assemblies

8. Install link assemblies:
   a. Transmitters
   b. Receivers
   c. Waveguide
   d. Feeds and link antennas
   e. Passive reflectors

9. Test microwave link:
   a. Alignment of link antennas & reflectors
   b. Measurement of S/N ratios
   c. Measurement of fade margins

D. Modifications and Additions to Digital Equipment

1. Control computer modifications. We will continue to use the DDP 116 for the control computer. The addition of two new hardware ports is required. One would dump data currently going to disk into the new data analysis computer. Even if the data analysis computer is not part of original plan, we would add link at this time. The second link would be a two way data/command link to the remote site. Data would be supplied to microwave link as a serial data stream for modulation at each end. We would get back a serial data stream from the microwave receiver at each end. Cost would be minimal since most of the equipment would be constructed locally.

2. Data Communication and Monitering. The first approach here would be to provide a duplicate of the 45-foot link boxes.

Since we are proposing to have a telephone link to the new site, I think an additional data link would be appropriate. If power is down at the remote site, it would provide a basic set of measurements under battery backup. These might include, wind speed, temperature and other items that telescope operations consider important. If power is up but there is some question about link data, we could steal a few frames of link data and send them back over the telephone line. It is not clear whether the telephone connection should be able to command the telescope but this should be considered. If this type approach looks feasible, I would also propose to do something like it at the current 45-foot site only using 43 MHz radio instead of telephone lines.

3. Delay. The present delay system is being studied to reduce the interference to the 300-foot. Depending upon the outcome of this study, we may need to build it into an RFI tight rack. The changeover period would be a good time to do this if it becomes necessary.

4. Lobe Rotator. The maximum offset rate needs to be determined to assure ourselves that the present system is adequate. Again if the increase is small, we might implement it with a slight clock change in lobe rotator.

III. TELESCOPE

A. General

The telescope will consist of the telescope itself, the telescope drive and control circuitry, telescope position encoders and displays, a focus mount with associated control and display of position, a receiver front end, the necessary power supplies and front end control equipment, and all control, power, and instrumentation cables between the so-called "equipment house" and various parts of the telescope.

B. The Telescope

There are 3 choices of telescopes at the Monterville site. These are: relocate 85-3, purchase a new 45-ft. telescope, or purchase a new telescope whose general performance is equal to the 45-ft., and whose diameter is equal to or greater than 40 feet. A study of the costs and effort involved is required in order to make a decision as to which telescope will be used. An outline of this study effort is listed below.

1. Estimate total time and costs to relocate 85-3. Included are:

    a. Telescope disassembly, transport and reassembly.

    b. Modifications to 85-3 for reliability and reduction of continuing maintenance effort.

    c. Requirement for 3 phase power.

    d. Telescope foundations at Monterville site.

    e. Paint 85-3 at Monterville site.

    f. Removal of old wiring and cabling at Green Bank site.

    g. Acquisition and installation of new wiring and cabling at Monterville site.

h. Final adjustment of surface panels and alignment of telescope.

i. Cost of removal of telescope from site (if project is cancelled.

2. Estimate total time and costs for a new telescope. Included are:

a. Purchase and erect a new telescope (45-ft. or other) at Monterville site.

b. Requirement for single phase power.

c. Telescope foundations at Monterville site.

d. Adjustable focus mount with drive and readout.

e. Acquisition and installation of wiring and cabling.

f. Electronic equipment house.

g. Final adjustment of surface panels and alignment of telescope.

h. Cost of removal of telescope from Monterville site (if project is cancelled).

3. Compare the direct costs and time of the above.

4. In addition to the direct costs, the following less tangible items must be considered in selecting the telescope.

a. Overall reliability - continuing maintenance costs and maintenance manpower required.

b. Environmental, operational and survival conditions.

c. Obsolescence of major telescope parts.

d. Relative costs of the standby generator.

e. Relative demands on NRAO personnel during disassembly, moving and reassembly of 85-3 versus assembly of a new telescope.

With all the above comparisons, the telescope for the Monterville site can be selected. In order to support the above comparisons, a detailed listing of tasks peculiar to the relocation of 85-3 and those tasks peculiar to a new telescope are listed below. The cost and time involved in these tasks should be fitted into the appropriate section of the study outline.

C. Tasks peculiar to the relocation of 85-3.

1. Relocation.

a. Write specification to disassemble, move, and reassemble.

b. Prepare bid package.

c. Solicit bids.

d. Determine time and costs and aware contract(s).

e. Supervise disassembly, moving and reassembly of telescope.

2. Modifications to polar and declination drives.

a. Write specifications.

b. Prepare bid package.

c. Solicit quotes.

d. Determine time and costs and award contract(s).

e. Supervise installation of modifications.

3. Telescope drive and control circuitry.
   a. Design.
   b. Determine costs and time and purchase components.
   c. Fabricate.

4. At Green Bank site remove from 85-3.
   a. Instrumentation cables.
   b. Cable trays.
   c. Encoders.
   d. Power and control wiring to telescope.
   e. Lighting.
   f. Conduit.
   g. Limit switches.
   h. Motor generator set.
   i. Air conditioning/heating.
   j. Power transformer.
   k. Equipment racks.
   l. Equipment house.

5. Instrumentation cables (multiconductor and coax).
   a. Determine requirements.
   b. Procure parts.
   c. Assemble and test.

6. Power and control wiring to telescope.
   a. Determine requirements.
   b. Procure parts.

7. Air conditioning/heating (in site plan).
   a. Determine requirements.
   b. Pass to site plan group.

8. Install.
   a. Conduit.
   b. Power and control wiring to telescope.
   c. Cable trays.
   d. Instrumentation cables.
   e. Encoders.
   f. Lighting.
   g. Limit switches.
   h. Air conditioning/heating (in site plan).
   i. Equipment house.
   j. Telescope control panels and racks.

9. Electrical power - in site plan.
   a. Determine amount of 3 phase power required.
   b. Costs and time required to install power.
   c. Pass to site plan group.

10. Telescope foundations.
    a. Design.
    b. Estimate cost and time required.
    c. Pass information to site design group.

11. Telescope painting.
    a. Prepare specification.
    b. Prepare bid package.
    c. Solicit quotes.
    d. Determine costs and time and award contracts.
    e. Supervise painting.

12. Final adjustment of surface panels.

13. Final adjustment of encoders and setting of limit switches.

D. Tasks peculiar to a new Telescope.

1. Acquisition and erection of telescope.
    a. Determine requirements.
    b. Write specifications.
    c. Prepare bid package.
    d. Solicit quotes.
    e. Determine costs and time and award contract.
    f. Supervise fabrication and erection.

2. Electrical power - in site plan..
   a. Determine amount of single phase power required.
   b. Costs and time required to install power.
   c. Pass to site plan group.

3. Foundations.
   a. Design.
   b. Estimate costs and time.
   c. Pass information to site design group.

4. Focus mount.
   a. Determine requirements.
   b. Prepare specifications.
   c. Prepare bid package.
   d. Solicit quotes.
   e. Determine costs and time and award contract.
   f. Install

5. Focus mount drive and readout.
   a. Determine requirements.
   b. Determine cost and time required.
   c. Design.
   d. Procure parts.
   e. Assemble.
   f. Install.
   g. Test.

6. Telescope drive control panels and rack.
   a. Determine requirements.
   b. Determine cost and time required.
   c. Design.
   d. Procure parts.
   e. Assemble.
   f. Install.
   g. Test.

7. Equipment housing.
   a. Specify size, general construction.
   b. Turn requirements over to site plan group.
   c. Receive costs and time from site plan group.
   d. Modify as required for power distribution and lighting.

8. Instrumentation cables (multiconductor and coax).
   a. Determine requirements.
   b. Procure parts.
   c. Assemble and test.
   d. Install.

9. Install encoders.

10. Power and control wiring to telescope.
    a. Determine requirements.
    b. Procure.
    c. Install.
    d. Test.

11. Lighting and outlets.

    a. Determine requirements.

    b. Procure.

    c. Install.

12. Air conditioning/heating - in site plan.

    a. Determine requirements.

    b. Pass to site plan group.

13. Final adjustment of surface panels.

14. Final adjustment of encoders and setting of limit switches.

E. Additional Tasks not Peculiar to the Choice of Telescope.

1. Encoders.

    a. Purchase material.

    b. Fabricate.

2. Front end modifications - the front end box local oscillator phase control must be redesigned to operate with the 16-18 GHz link. (This work will also be required on the existing 45-ft.). The tasks are:

    a. Determine requirements.

    b. Design phase control loop.

    c. Procure components.

    d. Assemble.

    e. Make front end boxes available for modification.

    f. Install phase control system.

g. Install front end boxes on telescopes.

h. Test.

3. Encoder electronics.

   a. Procure components.

   b. Fabricate.

   c. Test.

   d. Install.

4. Install racks in equipment house.

5. Test of complete telescope control and monitor.

6. Complete front end tests.

7. Telescope pointing and performance tests.

IV. Computer

A. It is suggested that the DDP-116 digital computer be retained as the control and data acquisition computer. Many man-years of programming effort have gone into the existing software which, in general, has proven to be very reliable. If 85-3 is selected as the new, remote telescope there obviously will be no more than four elements of the proposed interferometer. If a new 40 or 45 ft. telescope is erected at a remote site, there will be five telescopes available. Everything regarding the computer is based on the premise that the interferometer will remain a four element instrument.

The DDP-16 is already programmed for a four element interferometer. The main difference will be coordinate conversion and a radio link. The orthogonality will have little effect. The greater distance should have no more effect than the present remote antenna.

B. If the DDP-116 is replaced, a massive programming effort will be necessary. The basic equations will, of course, be unchanged, but the difference in language structure as well as peripheral interface differences will preclude using practically all of the present software.

C. The addition of an analysis computer will have some, but not much, effect on the DDP-116. In essence, the data will be passed from the DDP-116 to the new computer, rather than written to a disk.

D. The hardware task of adapting the DDP-116 to the project is covered under the Data Communication and Monitoring portion of the link.