A Dedicated 26-m SETI Sky Survey Instrument Facility: A Feasibility Study

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During February 1985, the Ground Spaceflight Tracking and Data Network (GSTDN) 26-m radio telescope facilities at Goldstone, California, and Canberra, Australia, are planned for deactivation. It is here proposed that these existing facilities, including large diameter (26-m) radio telescopes, control rooms, office buildings, and technical support facilities would provide an economical framework for a standalone SETI Instrument Facility. Additional benefits that would accrue from the proposed utilization of these facilities are the capability for remote monitor and control from the Deep Space Communications Complex (DSCC) Signal Processing Center, combined with a reduction in ground-induced radio frequency interference due to the physical distance to the other DSCC front end areas and the Signal Processing Center.

This article examines the feasibility of converting a deactivated GSTDN 26-m facility into a dedicated SETI Instrument Facility.

I. Introduction

The Search for Extraterrestrial Intelligence (SETI) Program is a NASA Supporting Research and Technology Program with primary intent to search the microwave region of the spectrum for signals of extraterrestrial intelligent origins. During the next several years, the foremost goal of the SETI Program is the development of a SETI breadboard instrument (Refs. 1 and 2). Ultimately, the goal of the SETI Program will be the exploration of a well-defined volume of multidimensional microwave search space using large existing radio telescopes and a new technologically sophisticated data acquisition and analysis system (Refs. 3 and 4). A major component of this search is the SETI "Sky Survey," which proposes to observe the entire celestial sphere over a wide range of frequencies. Primary requirements to conduct such a search at high sensitivity ($<10^{-22}$ W/m^2) are a low noise, large diameter radio telescope, available to SETI for long periods of time.

In 1985, the current Ground Spaceflight Tracking and Data Network (GSTDN) 26-m facilities are expected to be deactivated as part of the Networks Consolidation Program. This article explores the feasibility of converting one of these to-be-deactivated 26-m GSTDN facilities into a dedicated, SETI Sky Survey Instrument Facility.

II. SETI Sky Survey Requirements and Modes of Operation

The proposed SETI Sky Survey is intended to be a high resolution, high sensitivity search of the entire sky between the frequencies 1.0 and 10.0 GHz, with spot coverage to 25 GHz. The survey will be conducted by sweeping out swatches of the sky that are a half-power beamwidth wide, at a constant telescope drive rate. The minimum detectable flux for a constant telescope drive rate is:

$$\phi = (4\alpha kT_s/\pi\epsilon)\sqrt{\omega b\nu/70\, cD^3}$$

where

ϕ = flux, W/m^2

α = signal-to-noise ratio

k = Boltzman's constant

T_s = system noise temperature, K

ϵ = aperture efficiency

ω = angular tracking rate, deg/s

b = binwidth, Hz

ν = frequency, Hz

c = speed of light, m/s

D = diameter, m

Hence, for a given total survey time t (where $t \propto D\,\omega^{-1}$), sensitivity scales directly with system noise temperature and inversely with diameter:

$$\phi \propto T_s D^{-1}$$

Therefore, the fundamental requirements to perform the sky survey can be stated as:

(1) High radio telescope availability.

(2) Large radio telescope diameter.

(3) Low noise radio telescope front end.

The telescope drive rate will be set to achieve sensitivites in the range of 10^{-22} to 10^{-23} W/m^2 (a "range" of sensitivity results with a constant telescope drive rate because the sensitivity decreases with the square root of the frequency). This sensitivity range, coupled with the proposed (Ref. 2) 256-MHz bandwidth, 32-Hz binwidth Multichannel Spectrum Analyzer (MCSA), then determines the total amount of time necessary to complete the SETI Sky Survey.

The SETI Sky Survey System is intended to be automated to the fullest extent possible, with the largest deviation from the desire for automation resulting from the necessity to frequently "look-back," or check areas that appear promising. It is estimated that the look-back time will consume 25 to 50% of the total time of the survey. The time required to perform the SETI Sky Survey with look-back time, on a low noise front end, 26-m diameter telescope with MCSA is five years, assuming a dedicated telescope with an effective duty cycle of 16 hours per day.

III. The Standalone 26-m SETI Instrument Facility

The current NCP plan for combining the DSN and the GSTDN indicates that the still existing GSTDN 26-m facilities will be deactivated in approximately February 1985. It is here suggested that these 26-m GSTDN facilities at Goldstone, California, or Canberra, Australia, would provide an excellent and economical basis for a standalone SETI Instrument Facility. The economic utility of this concept stems directly from the existence of a complete, in-place radio telescope facility, including telescope structure, control room, office space, and technical facilities, such as power, water, air conditioning, and lighting. Additional benefits accrue in that the facilities are reasonably isolated from other radio telescope activities so as to lessen ground-induced radio frequency interference (RFI) problems, but are close to a Deep Space Communications Complex (DSCC) remote monitor and control facility (the DSCC Signal Processing Center). It is here considered that, following deactivation, the former GSTDN site would be stripped of all equipment and capabilities not directly related to or required by a SETI Instrument, and only those portions of the existing buildings required by SETI would be maintained.

Figure 1 is a functional block diagram that illustrates how the existing 26-m GSTDN facility would be reconfigured as a SETI Instrument. The existing system design of the SETI Sky Survey Instrument includes the following general subsystems and assemblies:

(1) Antenna Mechanical Subsystem: Antenna Control Assembly.

(2) Antenna Microwave Subsystem.

(a) Orthomode Feed Assembly.

(b) Parametric Upconverter Assembly.

(c) Maser Assembly.

(3) Receiver Subsystem.

(a) Noise Adding Radiometer Assembly.

(b) Receiver Assembly.

(c) A/D Converter Assembly.

(4) Spectrum Analyzer Subsystem

(a) Multichannel Spectrum Analyzer Assembly.

(b) Signal Detector Assembly.

(5) Signal Processor Subsystem

(a) Signal Processor Computer Assembly.

(b) Signal Processor Software Assembly.

(6) Monitor and Control Subsystem.

(a) Monitor Assembly.

(b) Controller Assembly.

(7) Frequency and Timing Subsystem.

(8) Communications Monitor and Formatter Subsystem.

(9) Technical Facilities Subsystem.

(a) Air Conditioning Group.

(b) Power Generation Group.

(c) Power Distribution Group.

(d) Site Protection Group.

(e) Facility Lighting Group.

(f) Civil Structures Group.

It is assumed that the Technical Facilities Subsystem will be transferred from the existing facilities essentially intact and will require little modification to meet SETI requirements. In the Antenna Mechanical Subsystem, the telescope surface may require modification to allow frequency coverage to 10 (or 25) GHz. The SETI Instrument equipment, from the Microwave Subsystem to the Signal Processor Subsystem, will be all new equipment – designed, fabricated, and implemented by the SETI Program.

IV. Operations Concept

The Operations of the SETI Instrument will be automated to the fullest degree possible. However, there will still be operator action required in terms of routine operations, such as changing of magnetic tapes, reconfigurations, and computer reinitializations. The concept proposed here is that routine monitor and operation of the SETI Instrument will be performed remotely from and by the personnel of the DSCC Signal Processing Center (SPC). In fact, this concept fits nicely into one of the roles of the Signal Processing Center, which is to monitor and operate the various DSCC front end areas (FEAs). In this regard, the SETI Instrument will appear just as the other remote, automated FEA facilities; the operators will monitor the SETI Instrument operation, and will perform some actions directly from the SPC (SETI monitor and control inputs), or will travel to the SETI Instrument Facility to perform other actions (such as mounting a magnetic tape).

V. Maintenance and Repairs

Maintenance and repairs of the SETI Instrument will be handled by the same DSCC personnel and in the same manner as would be the various DSCC FEAs. Routine maintenance will be on a scheduled basis. Equipment failures will be monitored at the SPC, with repair personnel dispatched from the SPC in response to indicated equipment malfunctions.

VI. A SETI Instrument Facility for Off-Line Operations

During the life of the SETI Sky Survey, it is assumed that one member of the SETI Science Team will be engaged on a full-time basis in both maintenance of the SETI Sky Survey configuration and in off-line data processing and analysis activities, such as:

(1) Analysis of false alarms.

(2) Adjustment of detection algorithm parameters concerned with threshold, baseline, system gain, and RFI recognition.

(3) Reconfiguration to look back at interesting or possible signal areas of the sky.

(4) Preliminary processing of magnetic tape recorded data prior to shipment to other Science Team investigators.

The availability of existing office space adjacent to the SETI Instrument itself combines to make an attractive concept as an all-inclusive SETI Instrument Facility, including both the Instrument and the off-line data processing analysis area, manned full time (i.e., 40 hours/week) by a member of the Science Team. Additional existing areas would be used for SETI data storage, working space for other SETI Science Team members who might choose to work directly at the SETI Instrument Facility at various times, and SETI conferences.

VII. Radio Frequency Interference (RFI) Considerations

The advantages of a deactivated 26-m GSTDN as a standalone SETI Instrument Facility are further enhanced by the site's (relatively) remote location from other transmitters and electronics within the DSCC. The site is (in the case of Goldstone) located approximately 12 kilometers from the other FEAs, with several ridges or hills interspersed between the two areas. The current GSTDN facility thus accrues the advantages of being sufficiently remote from the rest of the DSCC so as to reduce ground-induced RFI, but sufficiently close to the SPC to be monitored and operated remotely and conveniently.

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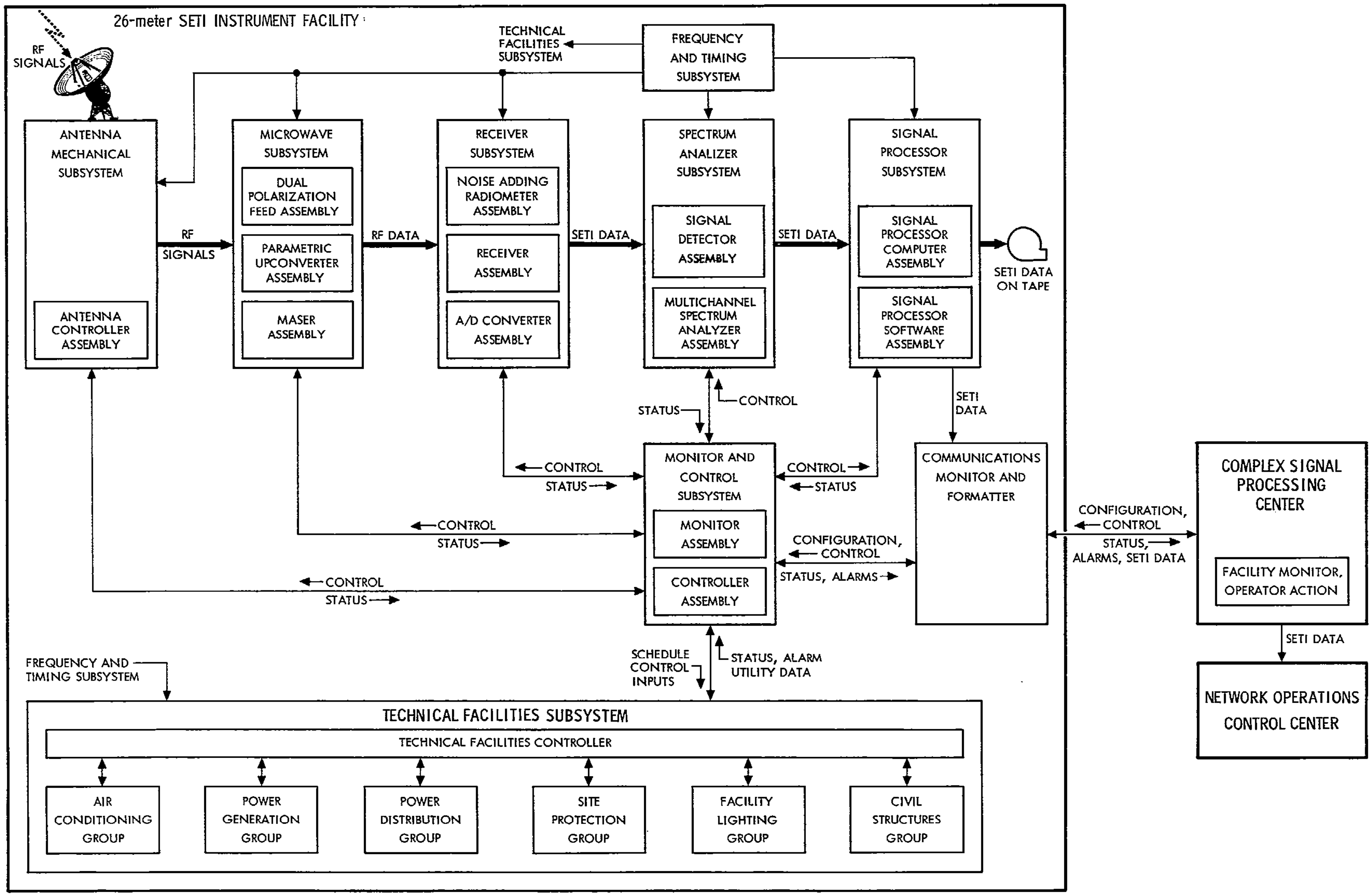

Fig. 1. 26-meter SETI Instrument Facility functional block diagram