Investigation of Techniques for Simulating Communications and Tracking Subsystems on Space Station Freedom

Final Report

NASA/ASEE Summer Faculty Fellowship Program -- 1991

Johnson Space Center

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Date Submitted: August 16, 1991

Contract: NGT-44-001-800

Abstract

The need to reduce the costs of Space Station Freedom has resulted in a major redesign and downsizing of the Station in general, and its Communications and Tracking (C&T) components in particular. Earlier models and simulations of the C&T Space-to-Ground Subsystem (SGS) in particular are no longer valid. There thus exists a general need for updated, high fidelity simulations of C&T subsystems. This project explored simulation techniques and methods that might be used in developing new simulations of C&T subsystems, including the SGS. Three requirements were placed on the simulations to be developed:

a) They run on IBM PC/XT/AT compatible computers

b) They be written in Ada as much as possible

c) Since control and monitoring of the C&T subsystems will involve communication via a MIL-STD-1553B serial bus, that the possibility of commanding the simulator and monitoring its sensors via that bus be included in the design of the simulator.

The result of the project is a prototype of a simulation of the Assembly/Contingency Transponder of the SGS, written in Ada, which can be controlled from another PC via a MIL-STD-1553B bus.

Introduction

The design of Space Station Freedom (SSF) has recently undergone a major redesign and reconfiguration. This has significantly impacted upon the Communications and Tracking Subsystem (CTS) and its space-to-ground (SGS) components. An earlier design was simulated [1] and used to test various aspects of the inter-system communications design of earlier models of SSF (so-called Demonstration 3B, [2]). These simulations are currently outdated, and the purpose of this investigation was to determine appropriate programming techniques that could be used in developing an updated simulation of the CTS in general, and the space-to-ground system in particular.

The various subsystems on SSF will be connected by two networks, one a token ring fiber optic network employing the Fiber Distributed Data Interface (FDDI) protocol, and other local "networks" consisting of MIL-STD-1553B busses to be used to control and monitor the operation of the component elements (generally comprised of what are called orbital replacement units, or ORU's) of the various subsystems on SSF, including the SGS. A simulation of the SGS should therefore include both ORU equipment simulation and some method of including the MIL-STD-1553B bus and its characteristics [3]. Fortunately, PC/XT interface cards are available from several manufacturers, including the ILC Data Device Corporation (DDC) of Bohemia NY. Such cards permit the use of an actual 1553B bus, thereby obviating the need to simulate bus interactions. One would need only interface a simulation running on a PC with an interface card and its associated software to, in effect, simulate an ORU. Several ORU's, running on separate PC's with 1553B cards could then be used to simulate a subsystem like the SGS. An evaluation of the viability of the latter approach proved an aspect of this investigation.

Method

The entire SGS system includes both S-band and Ku-band communication equipment. Given the amount of time available, it was decided to concentrate on the S-band system in general (the so-called Assembly/Contingency Subsystem, ACS, Fig. 1), and the S-band Transponder ORU in particular. It was felt that if a skeleton of this ORU could be simulated along with an interface to the 1553B bus, then greater detail could be fleshed in later (the sensor measurements list is still undergoing changes). A software prototye would be sufficient to establish proof of concept, and this became the main objective of the software development.

Since Ada is the language designated for software development on SSF, it was decided to make its use a requirement of any software simulation. The Ada compilers used was the Alsys DOS Ada Compilation System, Version 4.3.3, and the Alsys FirstAda System. The software drivers [4] supplied with 1553B interface card, DDC model BUS-65517, are written in the C programming language (specifically Microsoft C). This fact required the development of interface packages between the C and Ada languages so that the simulator software could communicate with the 1553B bus. In addition, a user interface to the bus would be needed to communicate control commands to the simulated ORU and to poll it for sensor readings (Control and Monitoring, CM).

Using techniques similar (but not identical) to those described in Ref. 1, it was decided to concentrate first on establishing appropriate Ada data structures to represent the various sensor measurements that were in the latest available requirements for the ACS equipment [5,6,7,8]. Data structures for the sensor measurements of the three major components of the S-band ACS, including the baseband signal processor (BSP), RF Antenna Group (RFG) as well as the transponder were established, and a rough simulation of the transponder was programmed. These various pieces of equipment can be "turned on" and sensor values read. In addition, the transponder can be "controlled" in that internal switches can be set, and signals change dynamically in a rough approximation of what would be expected when this equipment is initialized, and communications established. The control commands are sent to the transponder via the 1553B bus in the form specified in Ref. 6, (including appropriate 1553B subaddressing), and are read from the interface card via the Ada/C software interface packages. For testing and demonstration purposes, a third PC with a different 1553B interface card (SCI Technology, Inc., Huntsville AL, Model BCU/PC-1553) was used as a bus monitor to observe bus traffic (Fig. 2).

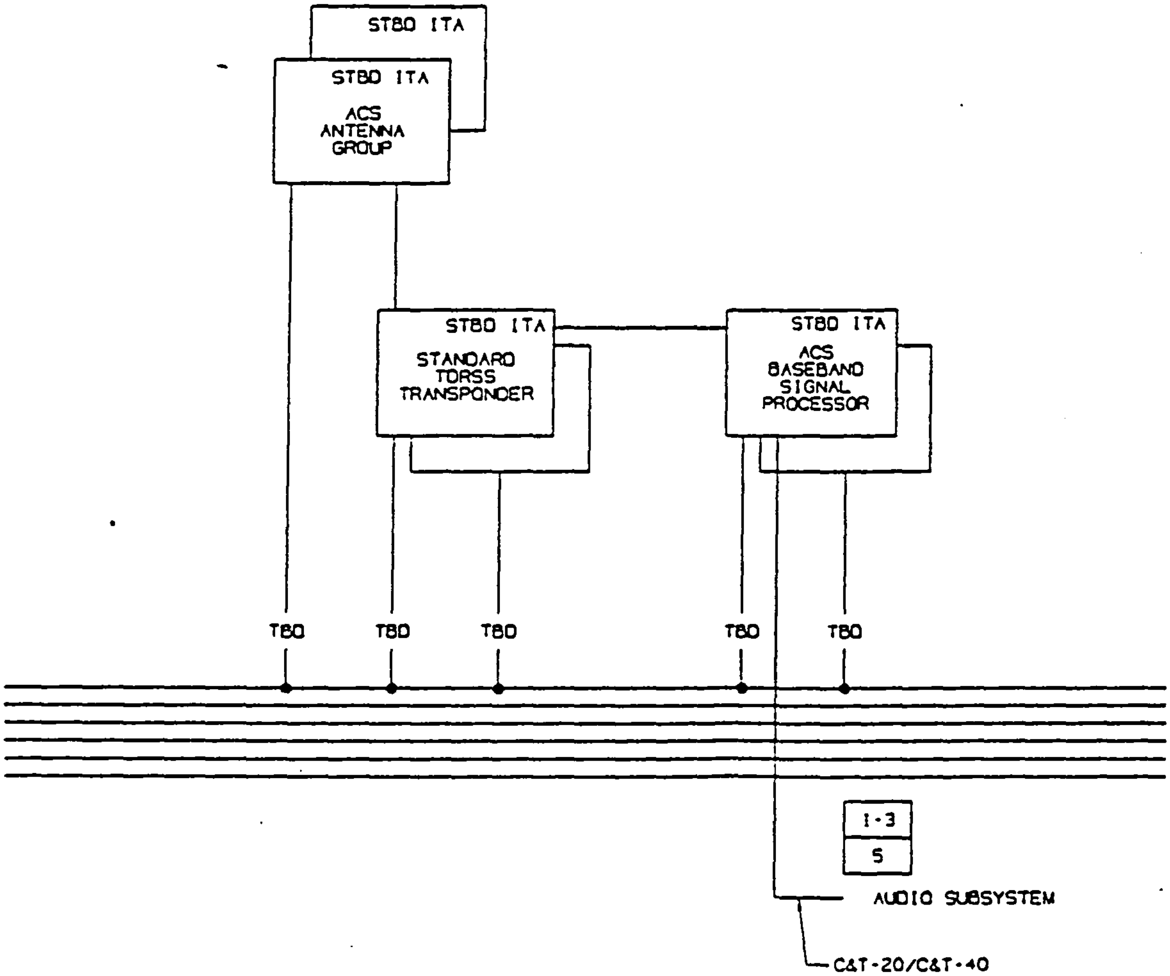

Fig. 1 -- S-Band Assembly/Contingency Space-to-Ground Communications and Tracking Components

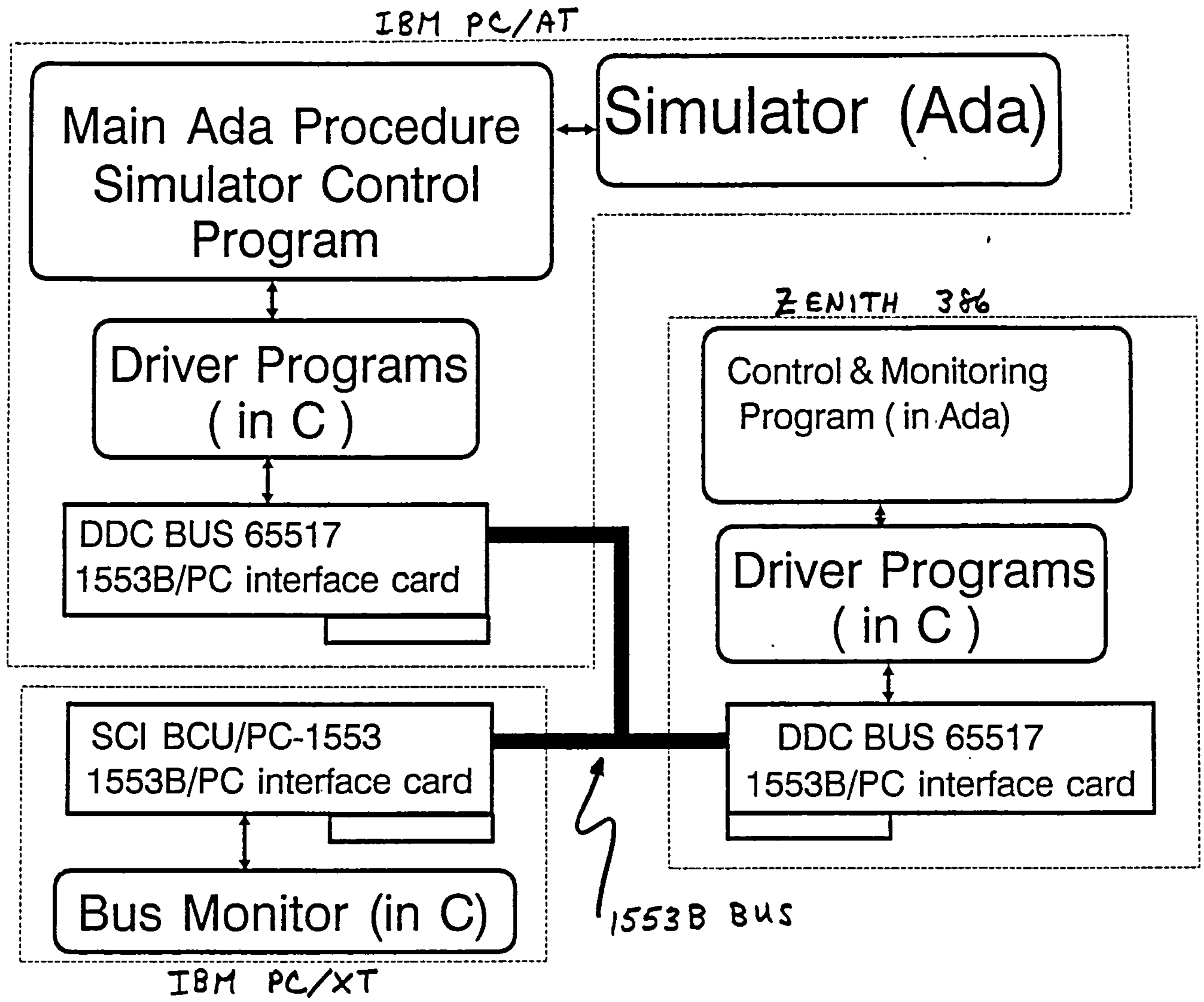

Fig. 2 -- Data flow between software elements and 1553B inter-PC serial connections for simulation testbed

Discussion

A prototype simulation of the S-band Assembly/Contingency Space-to-Ground Subsystem transponder was developed and demonstrated. In addition, a user interface running on a separate PC was developed which permitted Control and Monitoring commands to be sent to the simulator via a MIL-STD-1553B bus and appropriate PC/1553B interface cards. The prototype system indicates that it should be possible to set up a simulation of the space-to-ground components of the Communications and Tracking System of Space Station Freedom using separate PC's. Each PC (with MIL-STD-1553B interface card) could be used to simulate an ORU, and if an actual ORU were available, it should be possible, in principle, to substitute it for the simulation by plugging it into the 1553B bus, and disconnecting the PC simulating it. (Additional "real" signals might have to be applied to the actual ORU to demonstrate signal propagation that was otherwise emulated by the PC's).

The Ada programming language has some features that make it especially suited for this simulation. Chief among them was the "representation clause" construct which made it relatively easy to represent the complex data constructs that are used as Control and Monitoring data. Input/output, however, remains a continuing problem with Ada unless non-standard features are used (packages supplied by various compilers that are peculiar to the compiler). The latter was avoided in this exercise in order to make the code as portable as possible. Much time was therefore spent on the user interface to the system that sends Control commands to the 1553B bus for transmission. (Fortunately, the ANSI standard of "escape sequences" made what would have been an impossible problem at least tractable.)

Acknowledgements

Many thanks to all those who aided in this project. To name some is to omit others-- you know who you are, and I hope that I have sufficiently thanked you all personally.

One person who will be named is my "NASA Colleague", Oron Schmidt. Without his continued support and encouragement, I wouldn't have anyone to thank.

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