TIMED CDR

Primary Ground Station

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Topics

- **Changes since PDR**
- **Ground Station Description**
- **Overview**
- **Antenna Subsystem**
- **Ground Station Electronics**
- **Reliability**

Changes Since PDR

- **Primary will be the APL 60 ft.**
- **Uplink will be added**
- **No free standing uplink**
- **Backup will be off campus**
- **Scheduling included in the Front End Processor**

Ground Station Description

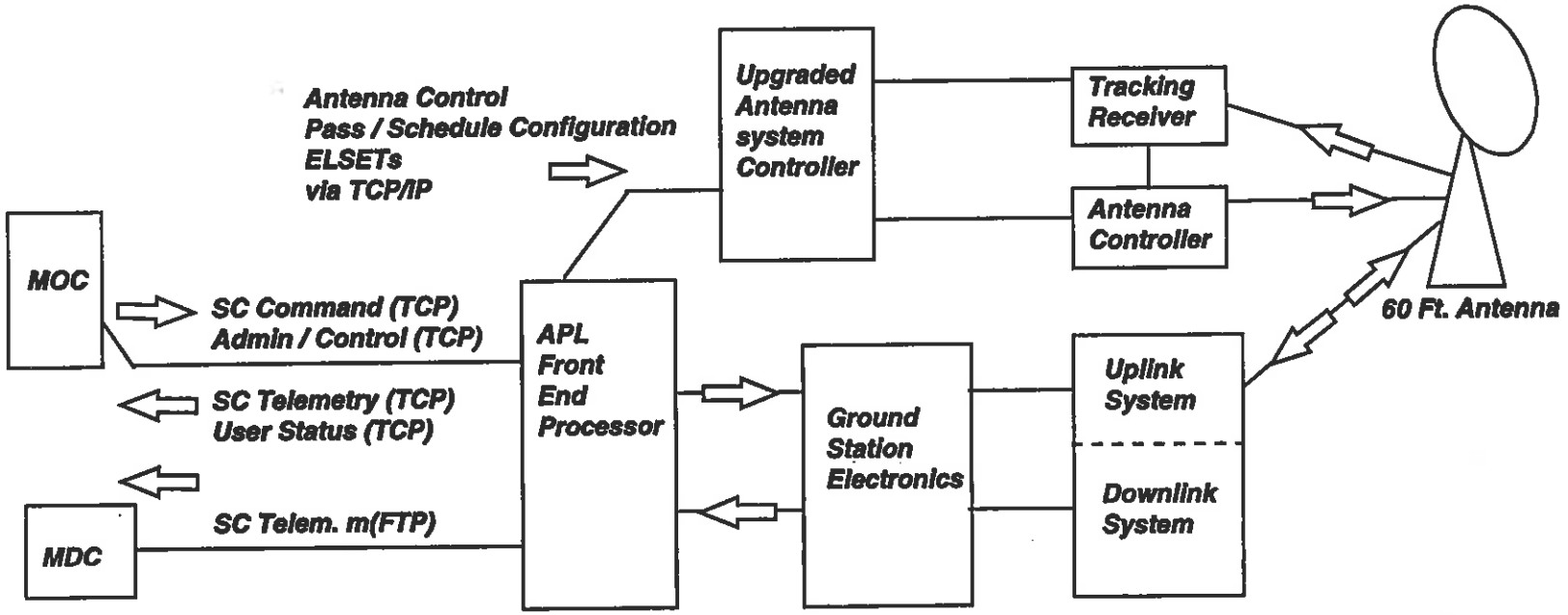
- **Prime Ground Station for TIMED is the existing APL 60 Foot Antenna system**
- **Modification of existing tracking feed to include Uplink capability**
- **Preservation of tracking ability without degrading performance**
- **Additional, TIMED Specific, station electronics added**

Overview

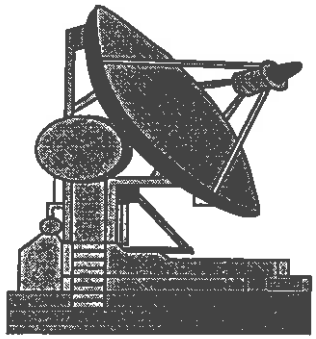
- **Selection was driven by RF interference issues and the need to co-exist with other assets on a non-interfering basis**
- **Required modifications were determined to be within the bounds of sound engineering practice and within the limits of the available resources**
- **The modified 60 foot antenna system was determined to be capable of supporting the mission requirements**

Station Diagram

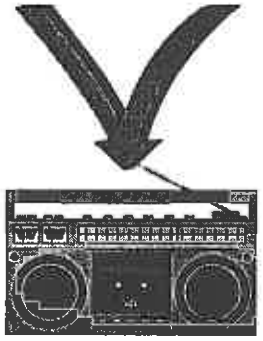
Overview



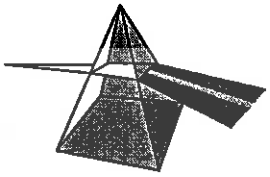
Telemetry Data Flow



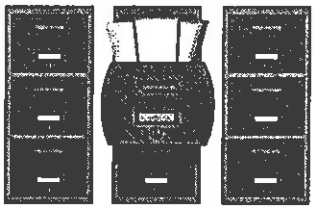
Telemetry Data



QPSK Receiver

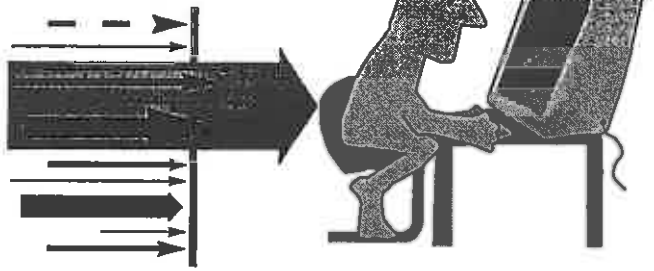


Bit & Frame Sync



Front End Processor

FTP & Sockets via TCP/IP



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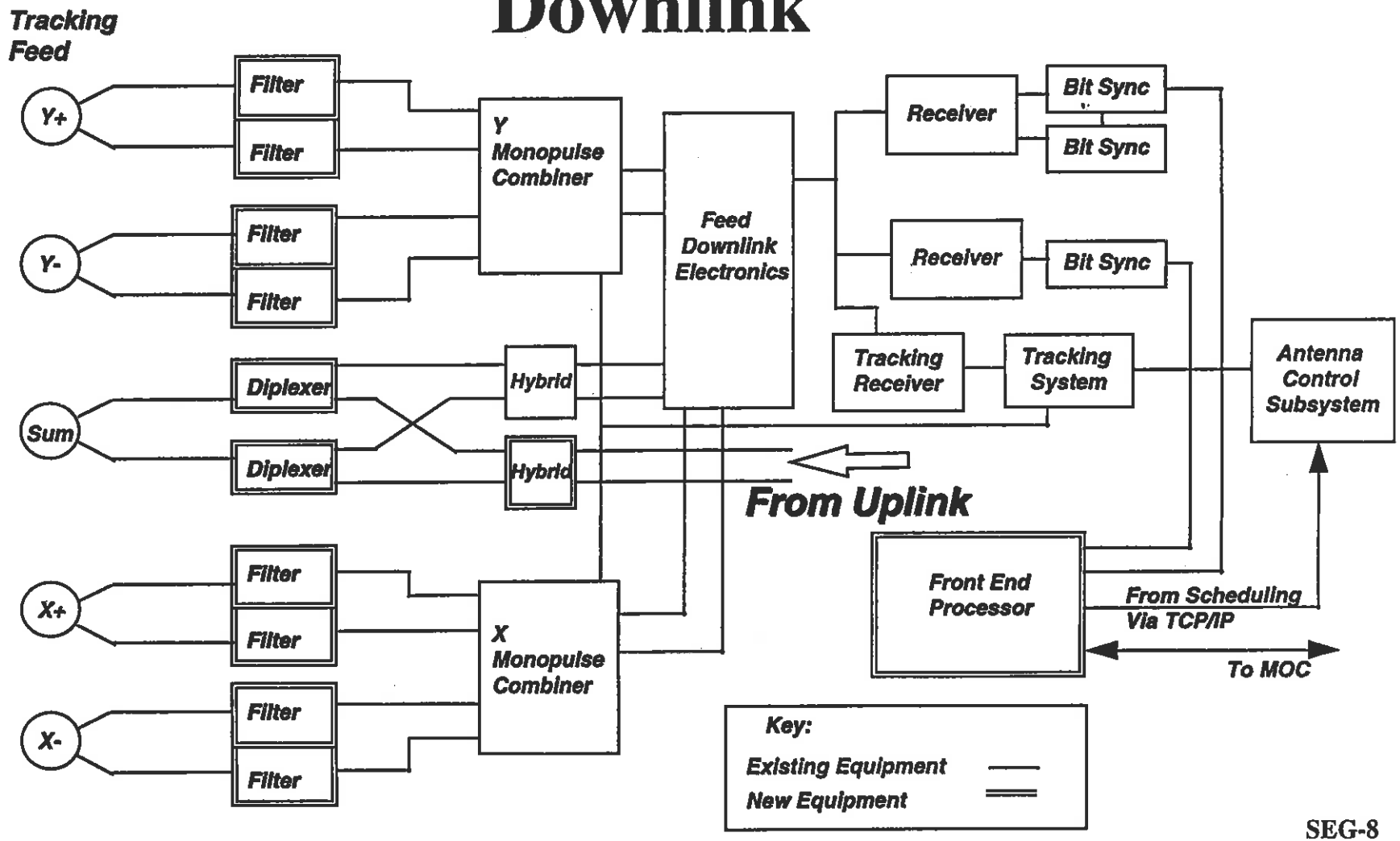
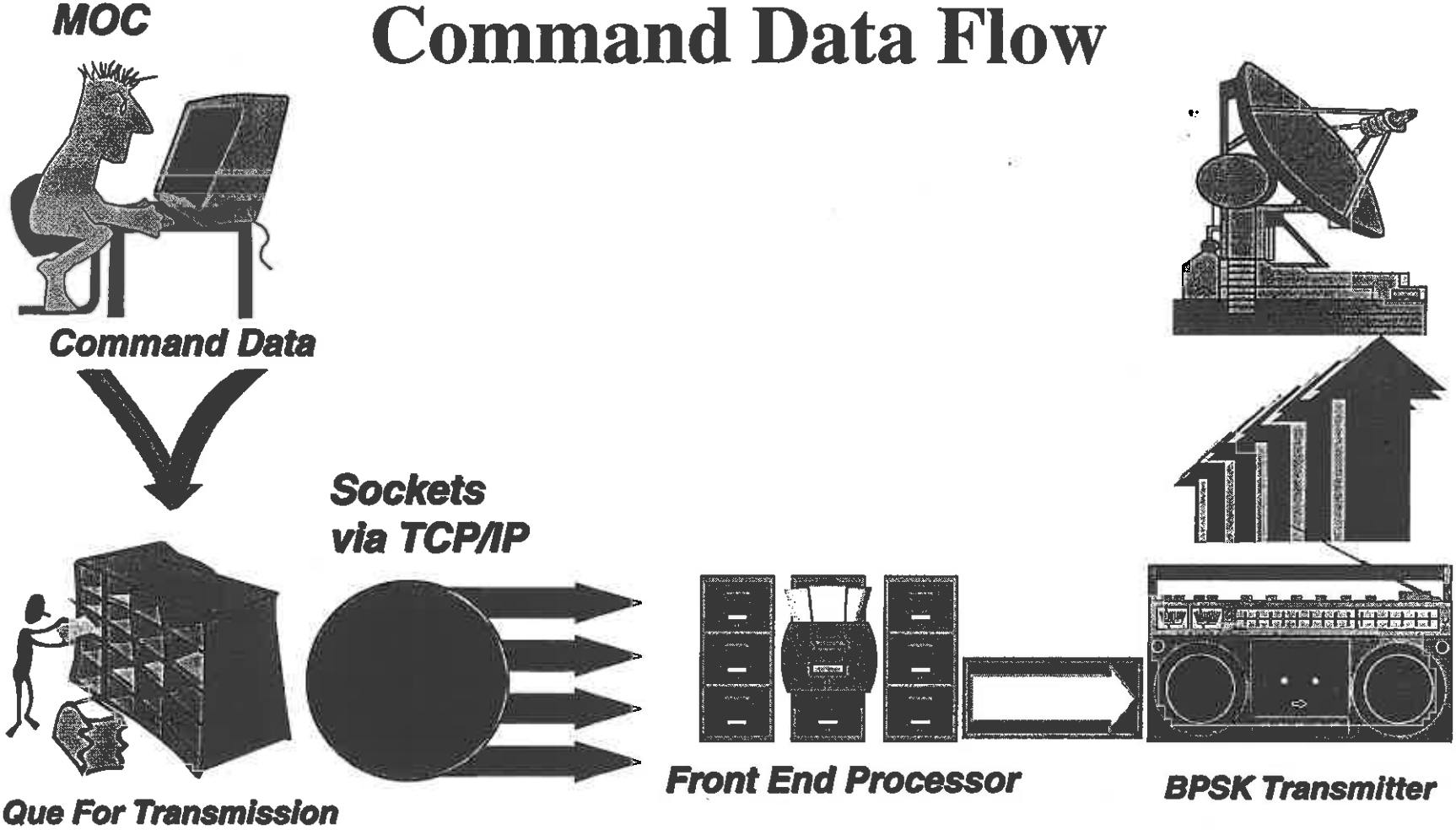
Downlink



Command Data Flow



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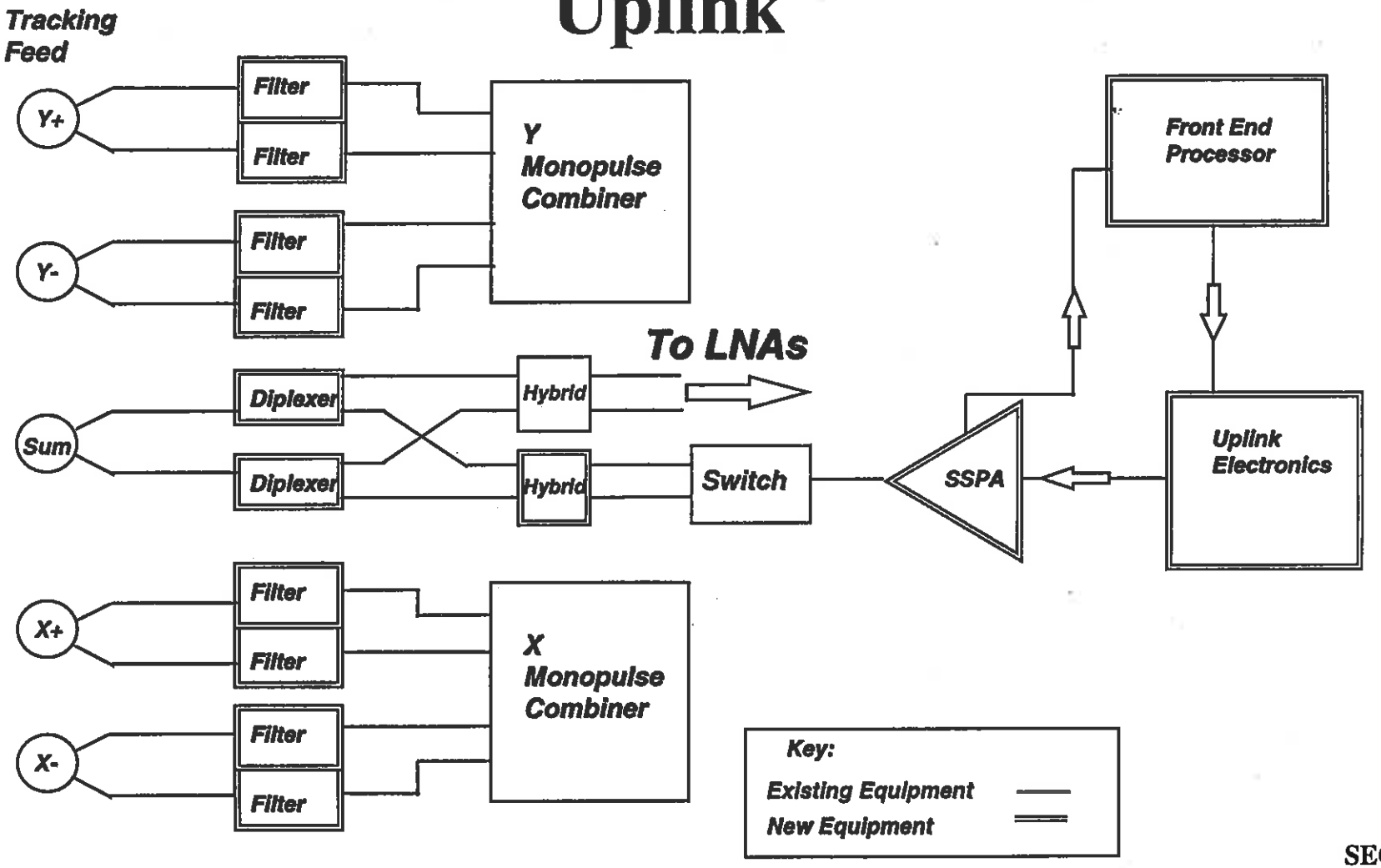
Uplink



Station Antenna Subsystem

- **Feed Modification**
  - **Electrical**
  - **Mechanical**
  - **Testing**
- **Tracking Electronics**
- **Antenna Control System**
- **Control Software**
- **Mechanical Analysis**
- **Obscura**
- **Reliability**

Station Antenna Subsystem
Feed Modification

- **Adds uplink capability to the 60 Ft. Antenna**
- **Prevents uplink interference to the downlink**
- **Preserves tracking capability**

  - **Feed Block Diagram**
  - **Component Specifications**
  - **Link Budget**
  - **Mechanical**
  - **Testing**
  - **Documentation**
  - **Areas needing special precautions**

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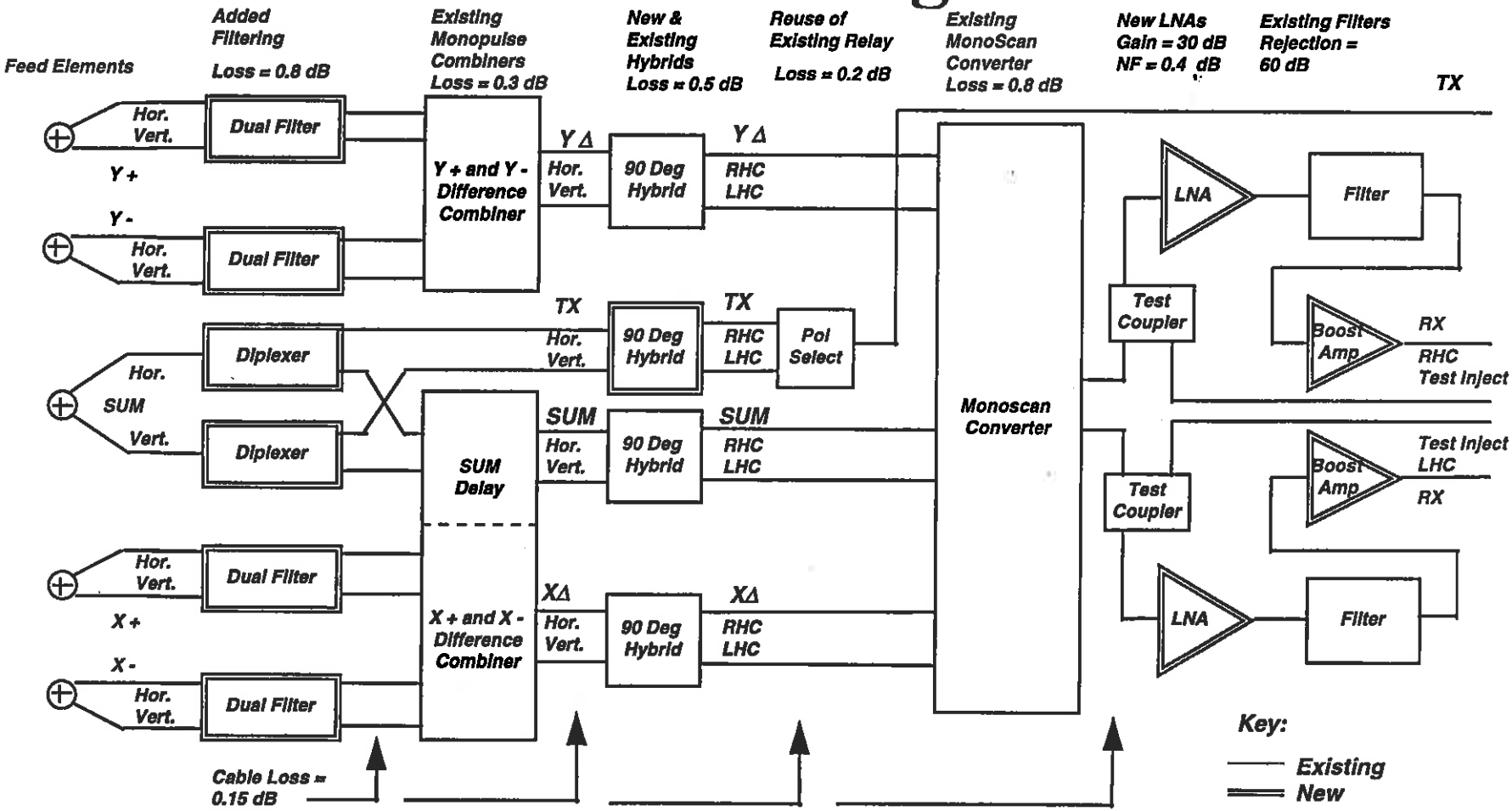
Feed Block Diagram



Feed Modification
Component Specifications

- **Diplexer**
  - Insertion Loss 0.8 dB max.
  - Rejection 70 dB min.
  - Power 43 dBm min.
  - Delay equalization ± 5 deg. max.
- **Dual Filter**
  - Insertion Loss 0.8 dB max.
  - Rejection 70 dB min.
  - Delay equalization ± 5 deg. max.

Feed Modification
Component Specifications (cont.)

- **90 Deg. Hybrid**
  - Loss — 0.3 dB max.
  - Power — 43 dBm min.
- **LNA**
  - Noise Figure — 0.4 dB max.
  - Gain — 30 dB typ.
- **Boost Amplifier**
  - Noise Figure — 2.0 dB max.
  - Gain — 30 dB typ.

Feed Modification

Link Budget

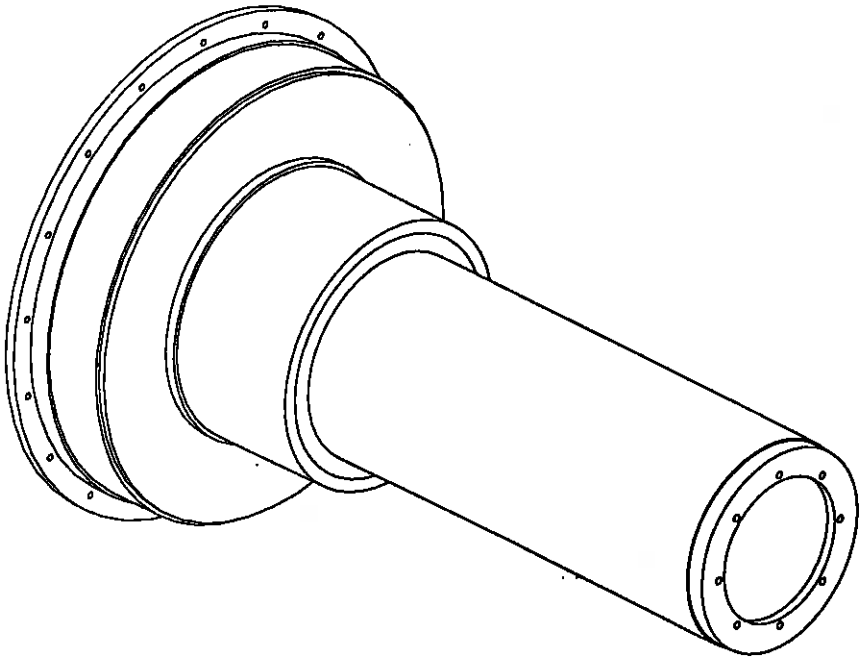
Item	Existing		Planned	
	Loss	T eff	Loss	T eff
Feed cable	0.15	10.19	0.15	10.19
Diplexer	0.00	0.00	0.80	58.66
Mono pulse comparitor	0.30	20.74	0.30	20.74
cable 2	0.15	10.19	0.15	10.19
90 deg combiner	0.50	35.39	0.50	35.39
cable 3	0.15	10.19	0.15	10.19
Monoscan converter	0.80	58.66	0.80	58.66
cable 4	0.15	10.19	0.00	0.00
Relay	0.20	13.67	0.00	0.00
cable 5	0.15	10.19	0.15	10.19
coupler	0.20	13.67	0.20	13.67
cable 6	0.15	10.19	0.15	10.19
Filter	0.50	35.39	0.50	35.39
LNA (NF)	0.75	54.67	0.40	27.98
Ta=(assumed)		42.00		42.00
SUMS (Loss... Temp)	3.40	335.32	3.85	343.43
Ga=(cal .5 eff)	49.48		49.48	
Geff=(Ga-L)	46.08		45.63	
T=(10*log(K))	25.25		25.36	
G/T=(Ga-T)	**24.23**		**24.12**	

Feed Modification
Mechanical

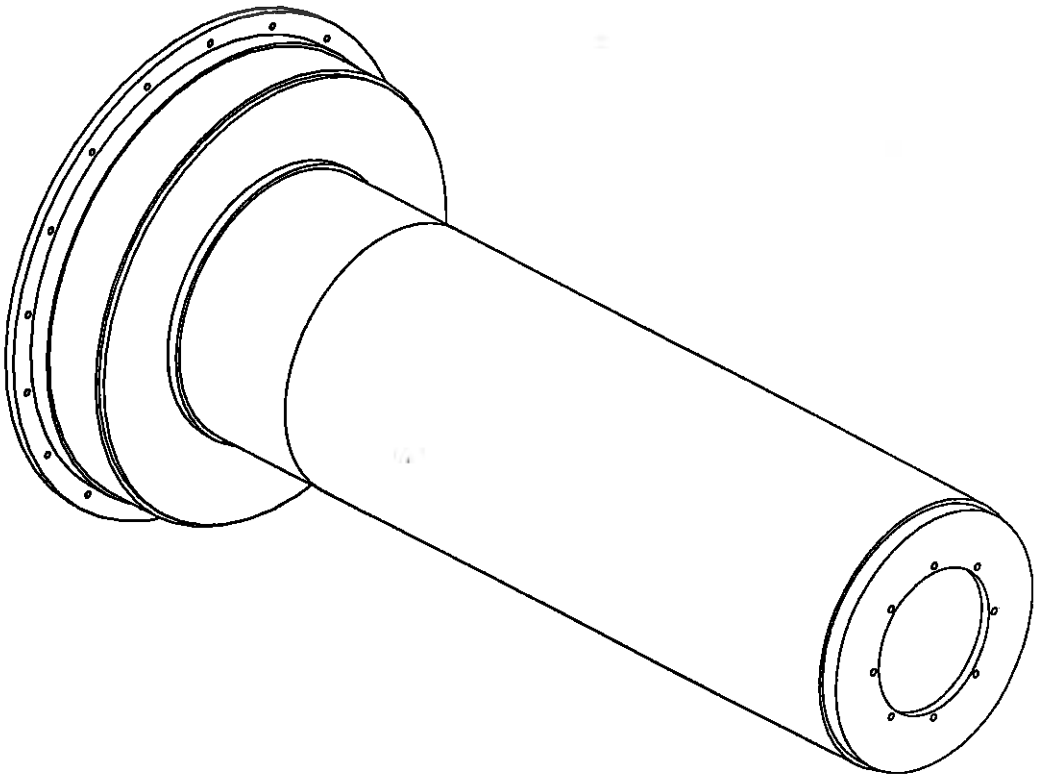
- **Feed housing**
  - **Pre-modification**
  - **Post-modification**
- **Feed electronics and structure**
  - **Pre-modification**
  - **Post-modification**
- **Filter bracket details**

Feed Housing

Pre-modification



Post-modification



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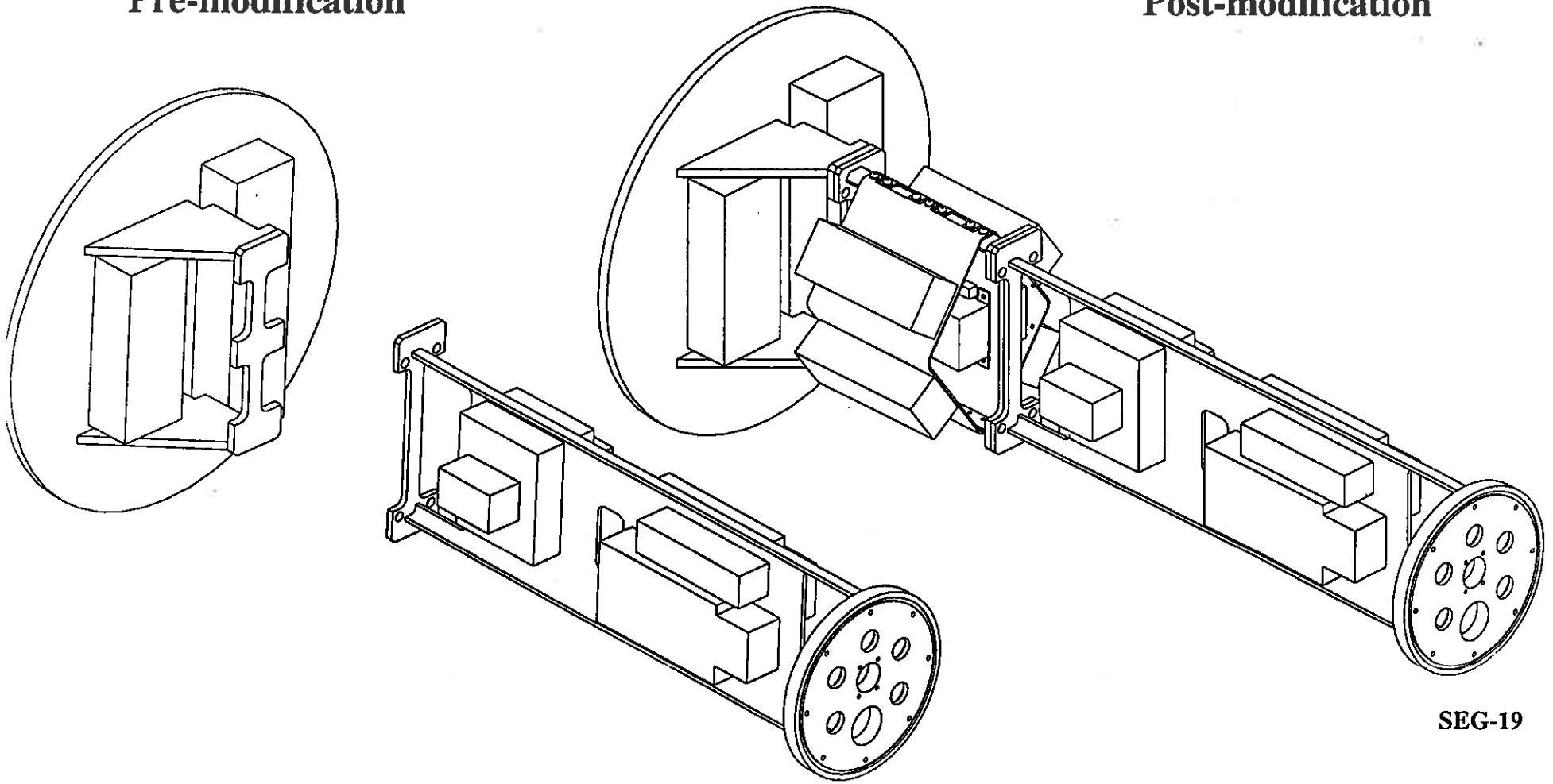
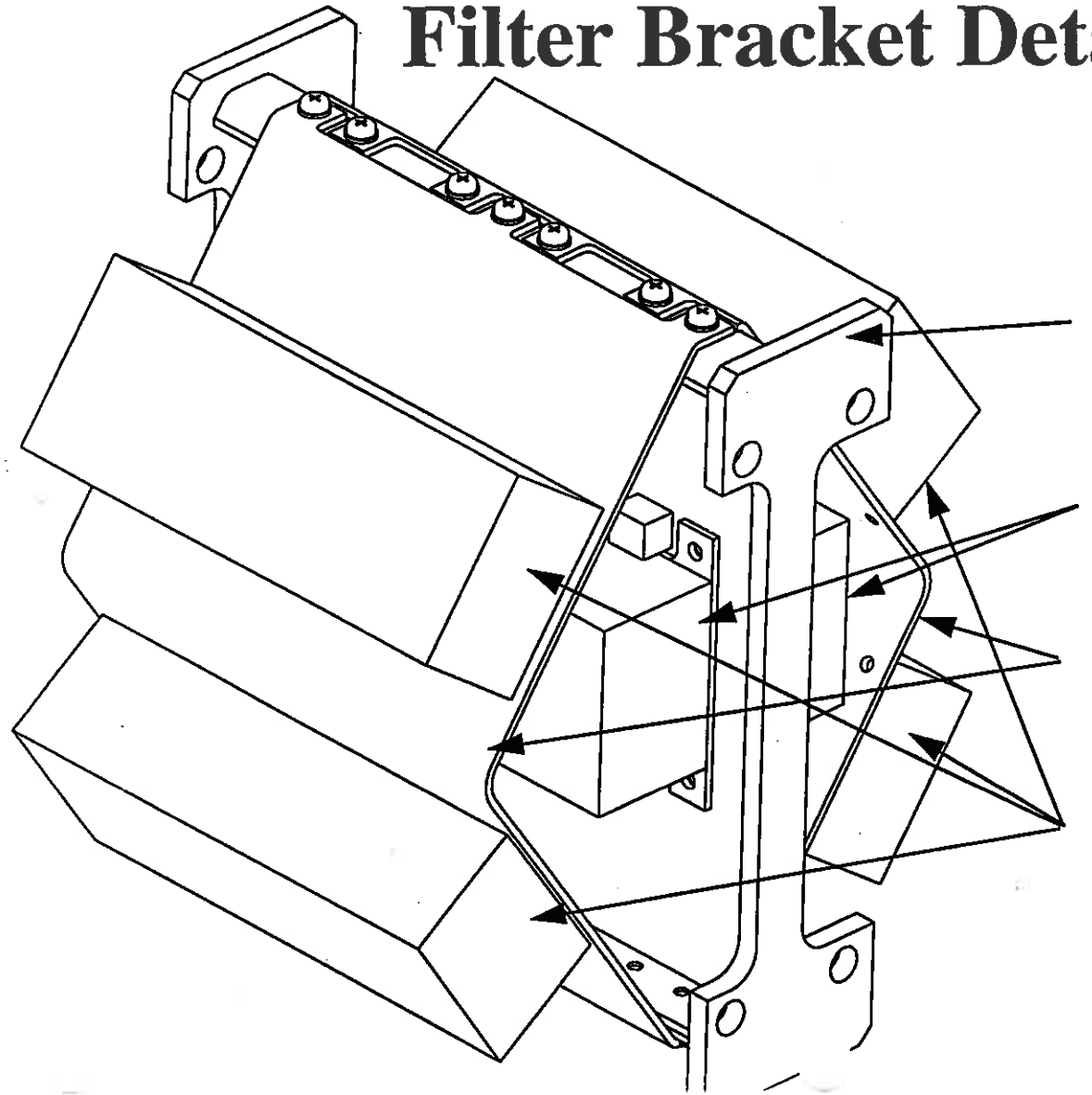
Feed Electronics and Structure

Pre-modification

Post-modification



Filter Bracket Details



New Central Web

Two Diplexers

Two Filter Brackets

Four Dual Filters

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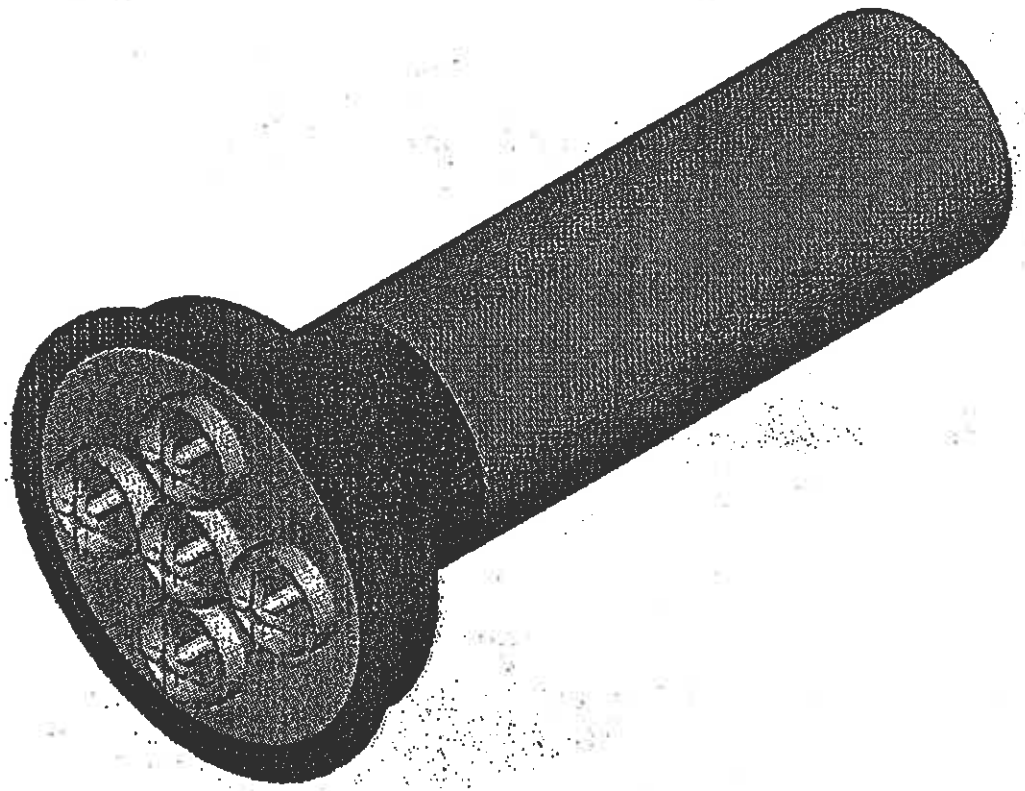
Finished Feed



Feed Modification
Testing

- **Pre modification Baseline testing**
  - **Tracking performance with simulated uplink**
  - **Feed characteristics**
- **Feed components verification**
  - **Sum feed to tracking element coupling**
  - **Calibration of internal losses**
  - **Adjustments to phase matching**
- **Post modification Verification Testing**
  - **Feed characteristics**
  - **Tracking performance**
  - **G/T**

Testing Status

Tracking system required to support TIMED

- **Tracking performance with simulated uplink testing currently underway**
  - **Test passes conducted while tracking MSX daily**
  - **Simulated uplink injected from dish vertex into tracking feed at up to 10 dB over anticipated post-modification level**
  - **Various frequencies and modulation formates are used**
- **No indication of any degradation in tracking performance has been detected**
- **Feed characteristics measurements planned for mid November**

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Documentation

- **As-built documentation**
  - Original SA documentation
  - APL archived performance data
  - Pre-modification performance measurements
  - Component characterizations
- **Mechanical / Fabrication documents**
- **Final performance results**
  - New component characterizations
  - Post-modification performance measurements
  - Antenna system
    - » G/T
    - » Patterns
    - » Tracking performance

Areas needing special precautions

- **Retaining the exact X, Y, Z & Rotational coordinates within the support structure when reinstalling the modified modified housing (keying).**
- **This will be accomplished by the use of precision measuring equipment in the shop and index marks**

Station Antenna Subsystem

Tracking Electronics

- **Existing MonoScan Feed (Scientific Atlanta)**
- **$\pm$ X and $\pm$ Y error signals summed onto downlink RF**
- **Separate Tracking Receiver**
- **MonoScan drive/demultiplexer & servo interface**
  - **APL Designed and built in 1987**
  - **Well maintained, documented, understood**
  - **Excellent "track" record**

Station Antenna Subsystem

Antenna Control System

SCF Provided

- **Hardware**
  - **Tracking Receiver**
  - **APL custom servo control electronics**
- **Planned Capital Software Improvements**
  - **(FY 98 non-TIMED)**
  - **2 Line ELSETS**
  - **True SGP-4**
  - **TCP/IP Control interface**

Station Antenna Subsystem

Control Software

- **Improved Software**
  (DeWitt & Associates Deliverables)
- **WIN 95 or WIN NT**
- **Written in C++**
- **Object Oriented**
- **Easily upgraded**

Control Software

Features

- SCF Provided upgrade
- Electronic entry of ephemeris by TIMED Front End Processor
  - 2 line ELSETS
  - FTP a file then notify via socket
- Passes generated on user request
- Remote scheduling
  - FTP a file then notify via socket
- Sockets require user ID and password

TIMED Modifications

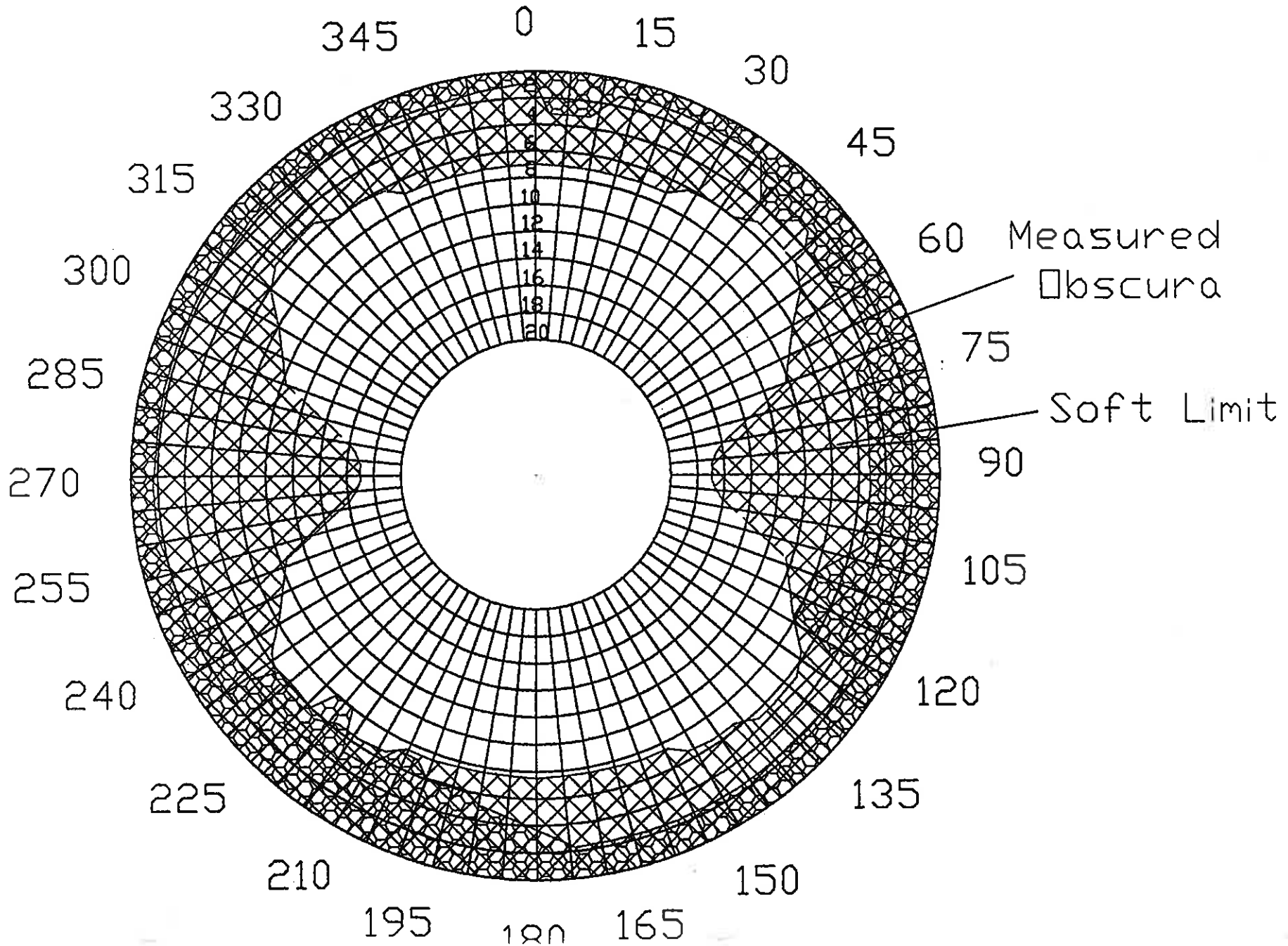
- **Station Software**
  - **Status output to socket connection (remote status)**
  - **Redefine software elevation limit from 7 deg to 5 deg**
    - » **System hard limits and overshoot allowances permit this**

Station Antenna Subsystem

Mechanical Analysis

- **Antenna pedestal is counter balanced by 25 Tons of counterweight**
- **Any additional weight added to the feed is insignificant even considering an 8:1 mechanical advantage due to length of moment arm**
- **No further mechanical analysis is required**

APL 60 Ft. Antenna Limits



Station Antenna Subsystem

Reliability & Maintenance studies

R. Denisson SEA-97-072

- **Electronic Systems**
  - Redesigned and remanufactured in 1985
  - Designers and all design data still at APL
  - Extensive documentation
  - Detailed design descriptions and transfer functions
  - No parts availability problems
  - Major parts ordered for spares... still in stock
- **Mechanical Systems**
  - Solid surface... no maintenance anticipated
  - Feed replaced in 1987
  - Pedestal refurbished in 1983... only minor PM anticipated
  - Spare hydraulic parts on hand... supported by various vendors
  - Maintenance and alignment staff in house

Maintenance Studies continued

- **Tracking System**
  - Installed / upgraded in 1987
  - Entire design done in house
  - Full documentation including software
  - Designer and programmer currently assigned to TIMED
- **Summary**
  - 60 Foot system newer than it appears
  - All major components replaced or refurbished in the mid 1980's
  - No significant down time since upgraded

Summary of Successes

GEOSAT operations summary as of February 28, 1990

- **1814 operational days**
  - **Data recovered from 9729 passes**
  - **3484 Recorder dumps**
  - **1790 passes below 10 deg.**
- **Down time**
  - **71 passes**
- **Availability 99.3 %**

Tracking Performance Data

- **Recent SCF data available**
  - **(Strip chart recordings of AGC, Error voltage, etc.)**
- **Analysis shows:**
  - **Autotrack is good**
  - **Program track subject to ELSET quality**
- **Detailed analysis is ongoing**

Coverage statistics

- **Software limit of the 60 ft. antenna moves to 5 deg.**
  - **Coverage statistics are now similar to those of the 10 meter**
  - **Change in software limits cause old analysis to be invalid**
- **New coverage analysis required**
  - **Design new analysis filter to compare 10 min. passes between 60 ft. and 10 meter**
  - **Determine the number of 10 min. passes missed by 60 ft. antenna due to pointing limits**

Station Electronics

- **Downlink Electronics**
- **Uplink Electronics**
- **Front End Processor**
- **Data Flow**
- **Scheduling a Pass**

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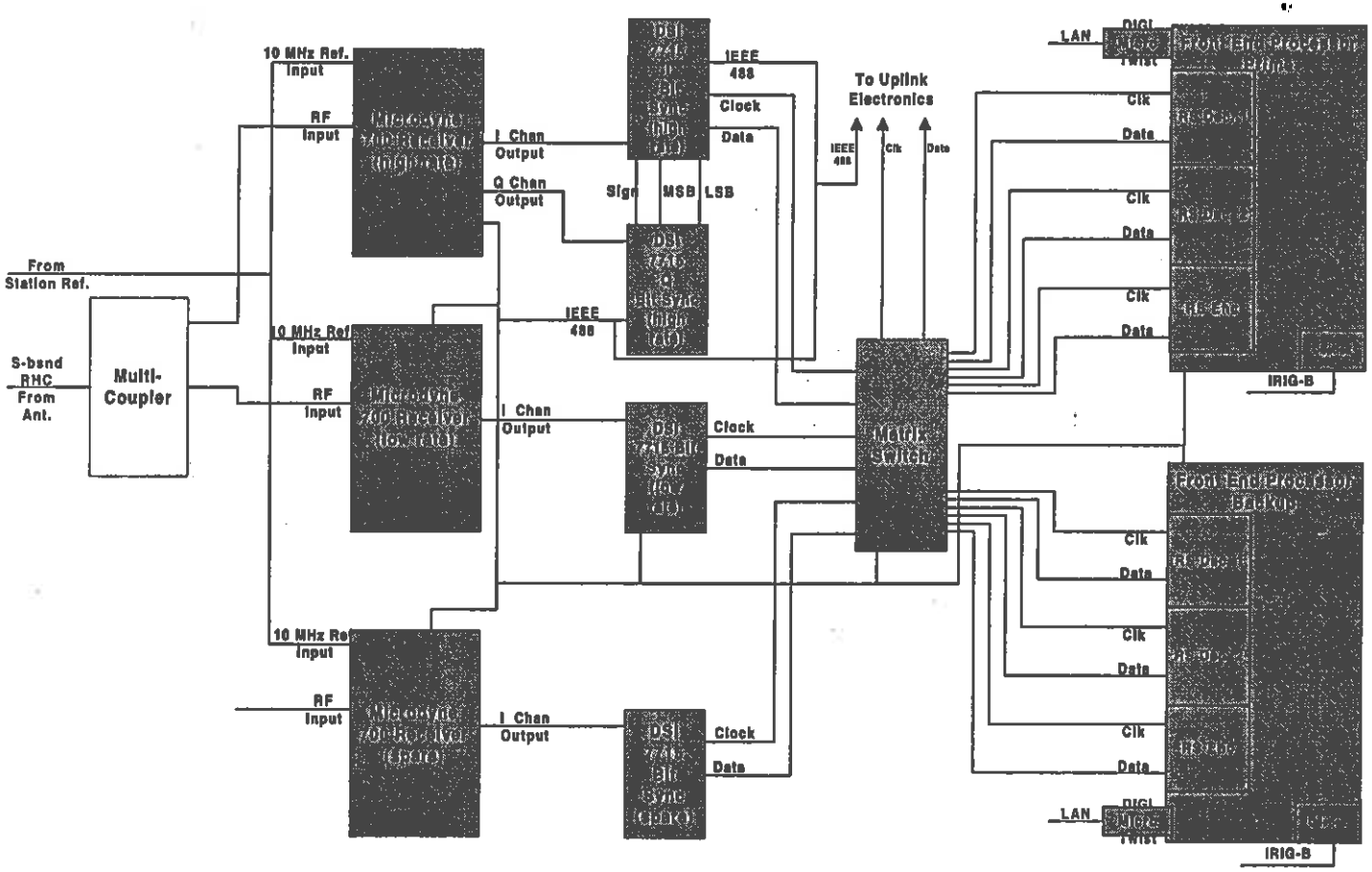
Station Detailed Block Diagram

Downlink



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Station Detailed Block Diagram

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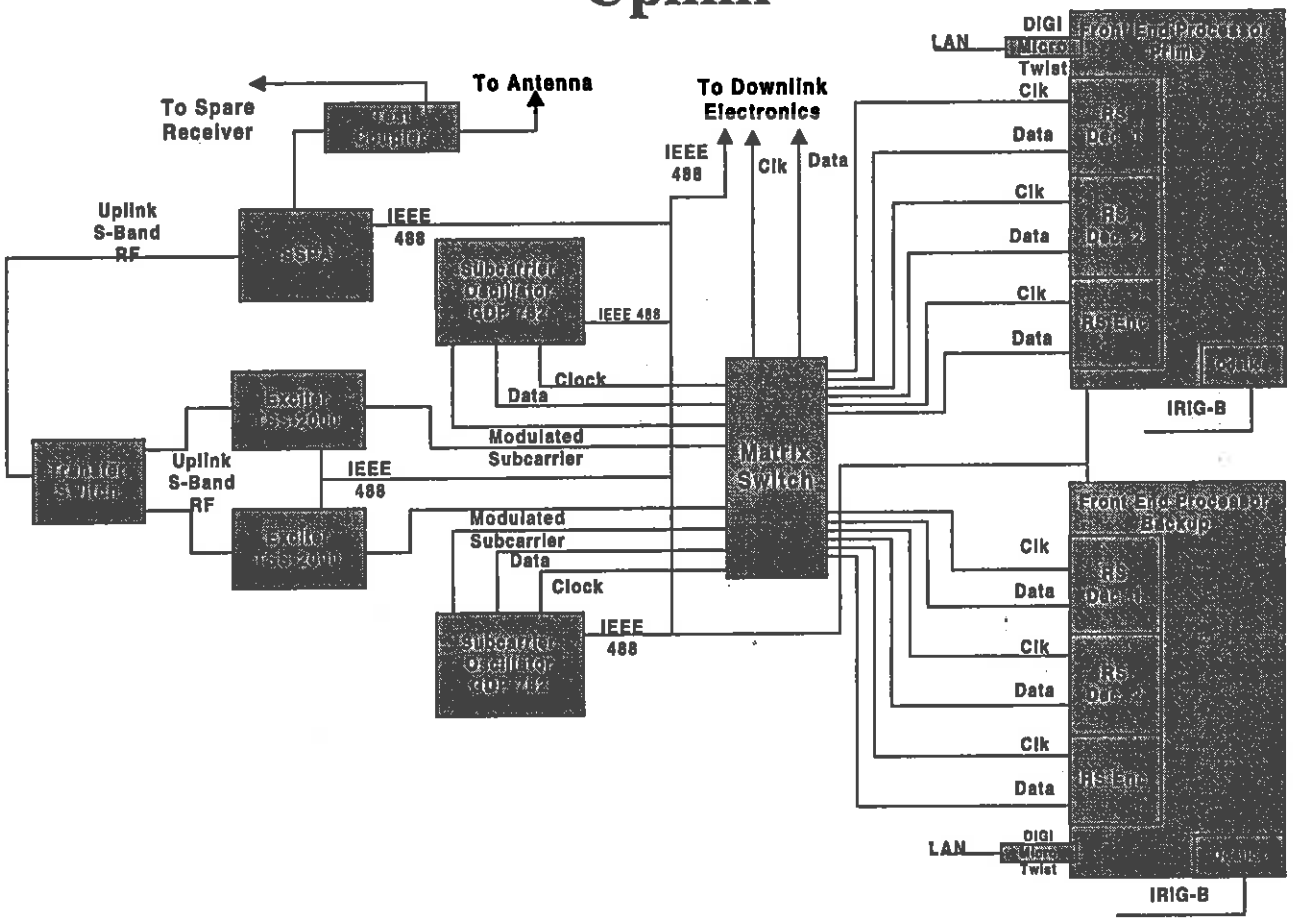

Front End Processor

- **The primary interface to the rest of the Ground System**
- **Identical to the FEP to be used by LEO-T Ground Stations being developed for NASA Wallops Flight Facility.**
- **Provides all the real-time functions of the Ground Station.**
- **Comprised of commercial off the shelf components**
- **Controlled by EPOCH 2000 version 2, the same software found in the MOC**

Downlink Duties

- **Ingests TTL telemetry data from the DSI 7715 bit synchronizers**
- **Process telemetry data via the Avtec telemetry processor**
  - » **Frame synchronization**
  - » **De-randomization**
  - » **De-interleaving**
  - » **Reed-Solomon decoding**
  - » **Adds Ground Receipt header with time tag**
- **Store Telemetry data on the 18 GB hard disk**
- **Established real-time sockets and post-pass FTP connections with MOC/MDC**

Command related duties

- **Accepts Telecommand Transfer Frames from MOC via TCP/IP**
- **Generates CCSDS compliant CLTUs and simulated telemetry for test inject testing**
- **Outputs TTL serial data**
  - **Coherent with external clock from subcarrier generator**
  - **Pseudo-randomization**
  - **BCH encoding**
  - **Interleaving**
  - **Sync marker insertion**

Station related duties

- **Remains synchronized to UTC within 1 microsecond**
- **Provides for monitor and control for all TIMED specific Ground Station equipment**
- **Handles scheduling of all TIMED contacts**
- **Control of the antenna related functions is provided by separate equipment accessed via TCP/IP**

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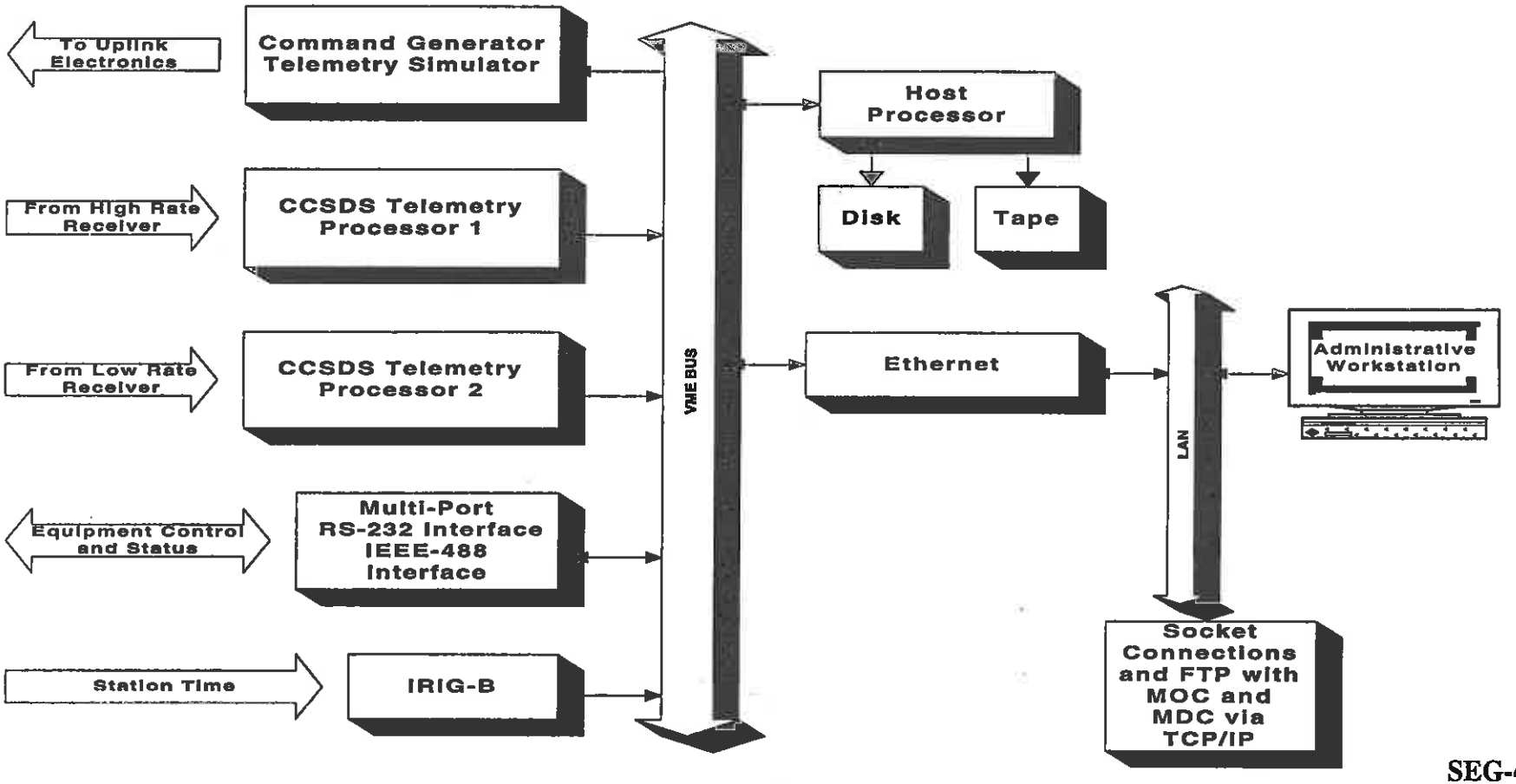
Block Diagram

Front End Processor



Front End Processor
Components

- A MODCOMP 12 slot rack mountable VME chassis
- 50 Mhz 88110 CPU Card
  - REAL/IX Real Time UNIX
  - 64 MB RAM
  - SCSI Controller
  - Ethernet Controller
  - 4 ASYNC Ports
- Avtek model AV-RSENC serializer
- Avtec AV-RSDEC CCDS/TDM telemetry processor
- CCSDS/TDM telemetry simulator card (Motorola WME1300 PowerBase PowerPC)
- 18 GB of storage for telemetry data
  - 2 Modcomp model 2417 9GB hard drives.
- 150 MB cartridge Tape Drive
- DAT Drive
- Fast Ethernet Transition Module for connection to the LAN
  - Modcomp MVME712B
- IRIG-B Time Code Interface Card
  - Odetics Model TPRO-VME synchronizable time code generator
- IEEE-488 Interface Card
  - Modcomp Model 2453
- 8 port ASYNC serial interface card
  - Modcomp Model 2448 Eight Port asynchronous RS-232 Serial Controller

Scheduling a Pass

- **MOC submits weekly schedule**
- **Final schedule posted on Schedule Server**
- **Scheduler accessible remotly by the MOC**
  - **Passes can be added up to 30 min. prior to a pass**
  - **Pass deletions at any time**
- **Automatically downloads ELSET from MOC server**
- **Transfers ELSET and configuration file to Antenna Control System via FTP**
- **Announces pass to Antenna Control System via Socket**