OVERVIEW

LOW EARTH ORBITER TERMINAL (LEO-T) DEVELOPMENT

JPL

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DSN Technology Program

NOVEMBER 1996

OBJECTIVES

- SIGNIFICANTLY REDUCE LIFE CYCLE COST OF TELEMETRY AND UPLINK SUPPORT FOR NEAR EARTH MISSIONS

PROVIDE EARLY DEMONSTRATION OF AUTONOMOUS, UNATTENDED TERMINAL OPERATIONS IN SUPPORT OF LOW EARTH ORBITING M1SS1ONS

TRANSFER TECHNOLOGY TO NASA COMMUNITY AND INDUSTRY

BACKGROUND

- AUTONOMOUS, UNATTENDED TERMINAL OPERATIONS FOR ACQUISITION AND DISTRIBUTION OF TELEMETRY FROM LOW EARTH ORBITING SATELLITE DATA DEMONSTRATED IN CY 94
  - SAMPEX DEMO: August 1994
  - EUVE DEMO: NOVEMBER 1994
- GROUND NETWORK ARCHITECTURE STUDY RECOMMENDED IMPLEMENTATION OF A LEO-T NETWORK TO SUPPORT NEAR EARTH MISSIONS
- QUICK DEVELOPMENT ADDED UPLINK AND VALIDATED
  - TERMINAL READY: OCTOBER 1995
  - AUTOMATED UNATTENDED UPLINK AND TELEMETRY DEMONSTRATION With COBE CONDUCTED SUCCESSFULLY, DECEMBER 22-28, 1995
- SEVERAL DEMONSTRATIONS CONDUCTED FOR INDUSTRY AND NASA COMMUNITY, DURING CY 1996, TO TRANSFER THIS COST EFFECTIVE TECHNOLOGY TO USERS
  - MANY FUTURE NASA MISSIONS ARE PLANNING TO USE LEO-TERMINALS

TERMINAL CAPABILITIES

- LOW-COST, AUTONOMOUS, Unattended TERMINAL OPERATIONS FOR UPLINK COMMAND AND FOR TELEMETRY RECEPTION, PROCESSING, AND DISTRIBUTION OF LOW EARTH ORBITING SATELLITE DATA
- Unattended WORKSTATION PERFORMS
  - REMOTE OR PROGRAMMED SCHEDULING
  - ORBITAL & DOPPLER CALCULATIONS & ANTENNA POINTING
  - POST PASS PROCESSING & DATA DISTRIBUTION
  - REAL TIME TELEMETRY PROCESSING
  - COMMAND BUFFERING
  - UNATTENDED MONITOR & CONTROL OF ALL HARDWARE
- TERMINAL ALSO AVAILABLE AS RECEIVE ONLY SYSTEM

LEO-TERMINAL CONFIGURATION & INTERFACES

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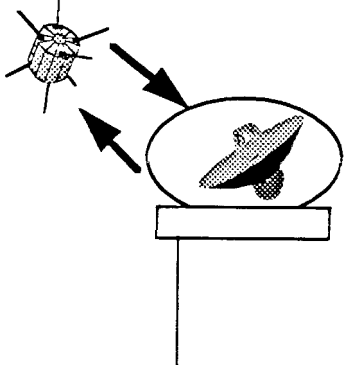


ANTENNA CONTROL
TELEMETRY
COMMAND
EQUIPMENT

TERMINAL
WORKSTATION

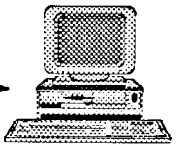
DATA & CONTROL INTERFACE

Unattended AUTONOMOUS
GROUND STATION OPERATIONS

- UNATTENDED M&C
- REMOTE OR PROGRAMMED SCHEDULING
- ORBITAL & DOPPLER CALCULATIONS
- ANTENNA POINTING
- POST PASS PROCESSING & DATA DISTRIBUTION
- REAL TIME TELEMETRY PROCESSING
- COMMAND BUFFERING
- COMMAND AND TELEMETRY ACCOUNTABILITY

COMMUNICATIONS INTERFACE

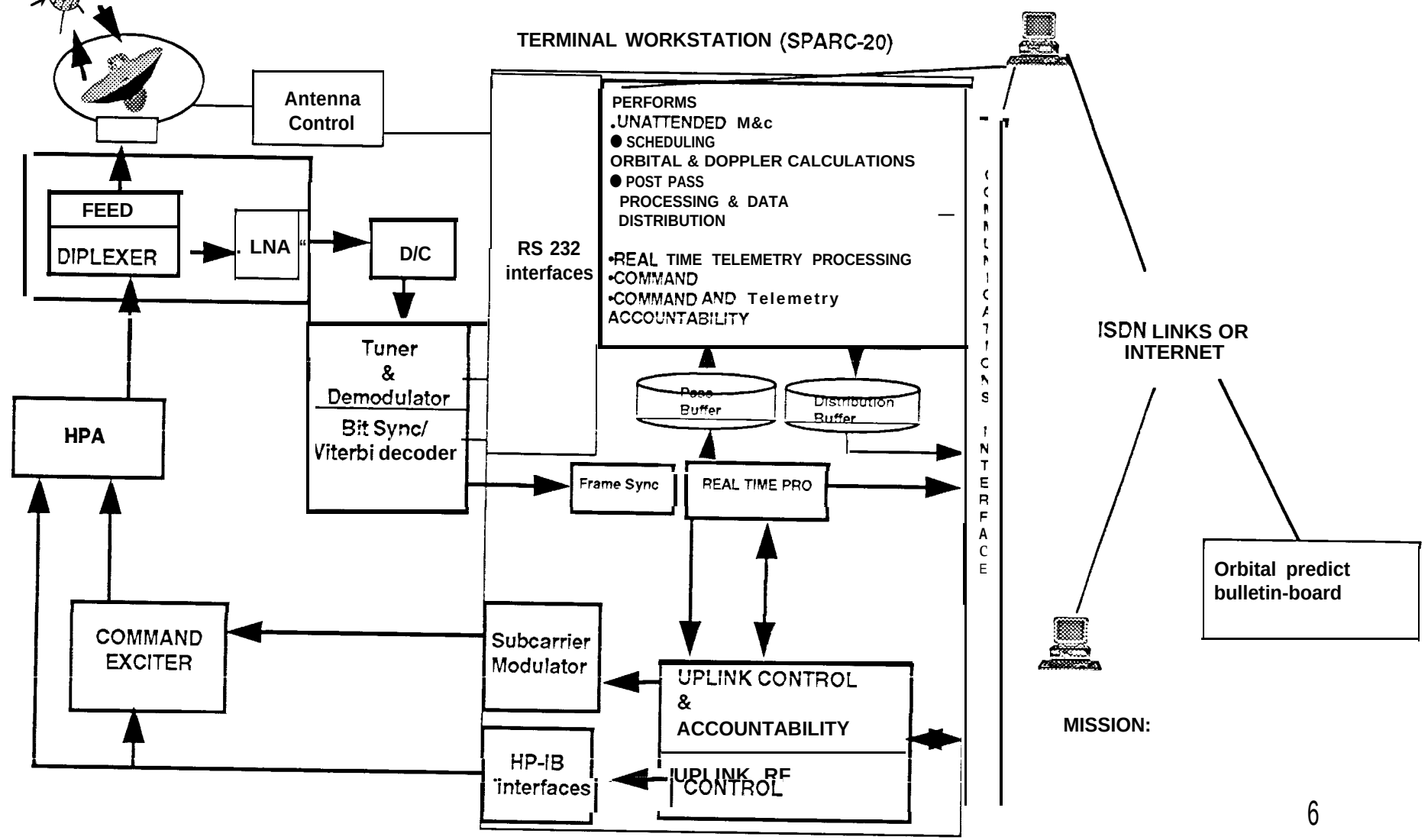
SWITCHED ISDN
LINKS



MISSION TERMINAL
PROVIDES CLIENT
SERVER INTERFACE
WITH GROUND
STATION

Orbital predict
bulletin-board

LEO-TERMINAL DETAILED CONFIGURATION



LEO-TERMINAL SYSTEM
RECEIVE ONLY CONFIGURATION

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TURNKEY TERM NAL ³ Y SEASPACE

ERM WORKSTA ON
S ARC-10)

ANTENNA
SUBSYSTEM
(SEA TEL, SAR-120)

G/T=
12 dB/K

RS232
interface

Antenna
Control

Tuner
&
Demodulator

Bit Sync/
Viterbi decoder

RECEIVER
SUBSYSTEM
(MICRODYNE 1400
RECEIVER & DSI 7700
BIT SYNC)

PERFORMS
• UNATTENDED M&C
•SCHEDULING
•ORBITAL CALCULATIONS
•SIGNAL ACQUISITION
M&C
•POST PASS
PROCESSING & DATA
DISTRIBUTION

Pass
Buffer

Distribution
Buffer

Frame Sync

REAL TIME PRO

COMMUNICATIONS INTERFACE

PI
WORKSTATION

Telephone
network

Orbital predict
bulletin-board

LEO-T PERFORMANCE SUMMARY *

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CHARACTERISTIC	PERFORMANCE
DOWN LINK	
BASEBAND SIGNAL	NRZ, BI-Phase L &S, REMOTELY SELECTABLE
MODULATION	FM, PM, BPSK, QPSK, REMOTELY SELECTABLE
CONVOLUTIONAL DECODING	RATE 1/2 (ON/OFF)
MAX. SYMBOL RATE (KBPS)	4800
MAX. DATA RATE FOR NRZ DATA (KBPS)	2400 (R=1/2 CODED), 4800 (UNCODED)
MAX. DATA RATE FOR BI-PHASE DATA (KBPS)	1200 (R= 1/2 CODED), 2400 (UNCODED)
MAX. DOPPLER. SHIFT TRACKED (kHz)	100
MAX. DOPPLER. RATE TRACKED (kHz/S)	**1.0**
UPLINK	
MAX. UPLINK RATE	2 kBPS
MAX SUBCARRIER FREQUENCY	15 KHz

* LISTED PERFORMANCE IS FOR CURRENT CONFIGURATION. AVAILABILITY OF A WIDE SELECTION OF COTS SUBSYSTEMS ALLOWS MANY OTHER CONFIGURATIONS FOR OTHER OPERATING FREQUENCIES AND DATA RATES

SUMMARY ANTENNA & RF SPECS*

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SYSTEM	*PROOF OF CONCEPT LEO-TERMINAL*
ANTENNA (METER)	3
MAX. AZIMUTH & ELEVATION TRACKING RATES (DEG/S)	5
FEED POLARIZATION	LCP & RCP, REMOTELY SELECTABLE
Enclosure	RADOME
RECEPTION FREQUENCY (MHz)	2210-2295
RECEIVER FIGURE OF MERIT, G/T (dB)	11.0
TRANSMISSION FREQUENCY (MHz)	2025-2120
TRANSMITTER (WATTS)	200
EIRP (dBm)	84

* LISTED PERFORMANCE IS FOR CURRENT CONFIGURATION. AVAILABILITY OF A WIDE SELECTION OF COTS SUBSYSTEMS ALLOWS MANY OTHER CONFIGURATIONS FOR OTHER OPERATING FREQUENCIES, G/T, & EIRP

LEO RECEIVE ONLY TERMINAL DEMONSTRATION WITH SAMPEX (AUGUST 94)

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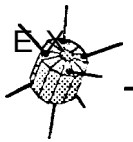
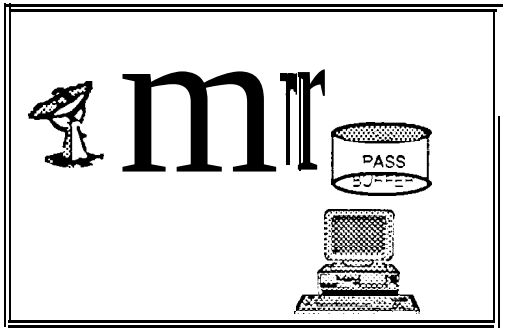
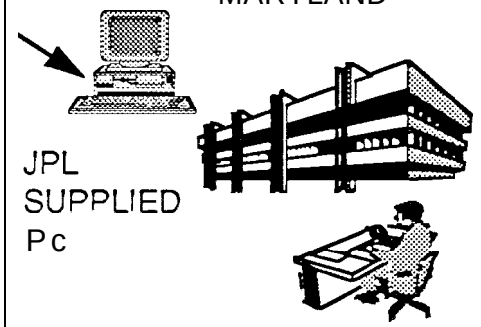


TELEMETRY DATA



PASS FILES VIA ISDN

SAMPEX OFFICE, UNIVERSITY OF MARYLAND

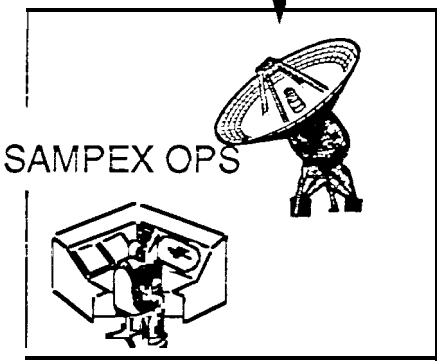


JPL SUPPLIED Pc

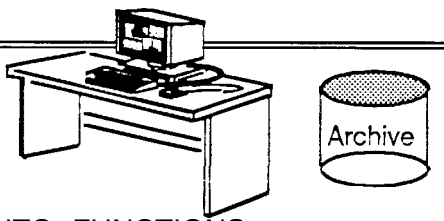
- VALIDATION OF DATA

4 COMMANDS/ DATA

UNATTENDED LEO-TERMINAL AT JPL MESA



ISDN



AUTO FUNCTIONS
Schedule operations
Archive data
OPERATOR FUNCTIONS
. Remote administration

USER WORKSTATION

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DEMO ARTIFACT:
DOWNLINK REQUESTS
& CONFIRMATION VIA FAX

UPLINK COMMAND AND TELEMETRY OPS Demo, DECEMBER 1995

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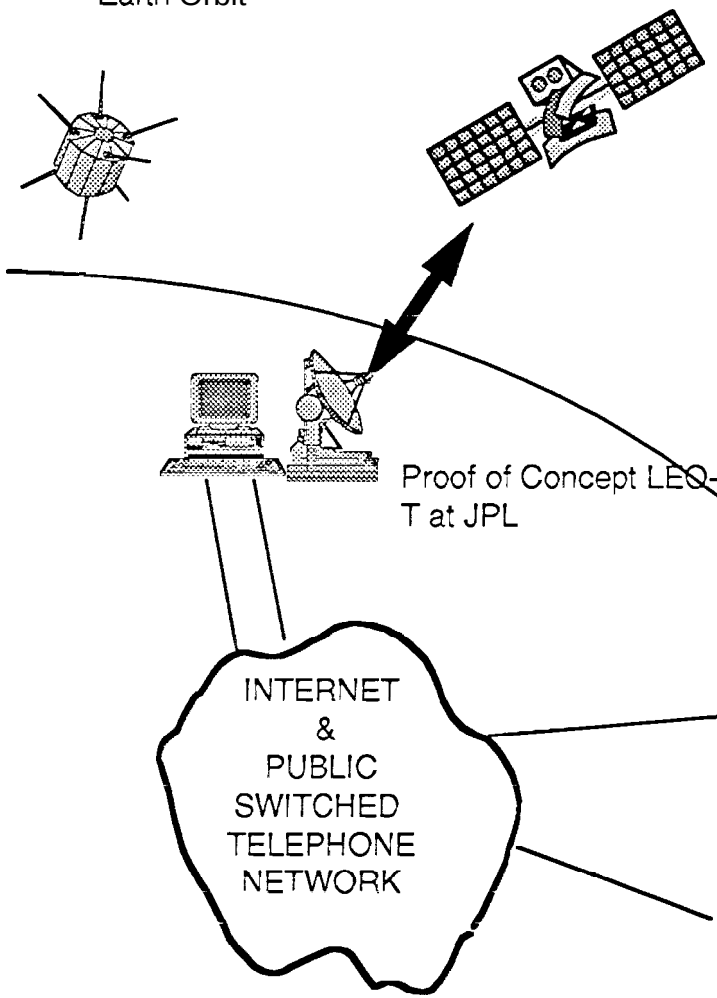
- SPACE SEGMENT
  - COBE and NOAA SATELLITES in Low Earth Orbit



DEMONSTRATION CONCEPT

- *Operate the Proof of Concept LEO-Tin a remote, unattended mode for intervals of- 1 week*
- *Validate terminal operations with two participating missions*
  - *COBE for uplink command and telemetry, NOAA 12& 14 for telemetry only*
  - *LEO-T transmits canned uplink command to start telemetry transmission, receives, processes, and distributes telemetry to "COBE workstation"*
  - *LEO-T receives, processes, and distributes telemetry to "NOAA workstation"*

USER WORKSTATION #1 AT JPL TO SIMULATE LIMITED COBE OPS

USER WORKSTATION # 2 AT JPL TO RECEIVE NOAA TELEMETRY

UPLINK COMMAND AND TELEMETRY OPS Demo, DECEMBER 1995

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- A WEEK LONG DEMONSTRATION OF THE AUTOMATED, UNATTENDED UPLINK AND TELEMETRY OPERATION OF THE LEO-TERMINAL WITH COBE WAS SUCCESSFULLY COMPLETED ON 12/28/96
  - JUST BEFORE THE START OF THE DEMO, THE LEO-T AUTOSCHEDULER WAS USED TO PROGRAM THE TERMINAL TO TRACK AND PERFORM AUTOMATED COMMAND AND TELEMETRY OPERATIONS ON EVERY USEFUL COBE PASS OVER JPL FOR THE FOLLOWING 7.
  - To VALIDATE ITS MULTIMISS1ON CAPABILITIES, THE TERMINAL WAS SCHEDULED ALSO TO TRACK NOAA 12 AND 14 SATELLITES
    - TO RESOLVE CONFLICTS FOR TRACKING THESE MULTIPLE S/C, THE PRIORITY ASSIGNMENT FEATURE OF THE LEO-T SCHEDULER WAS USED TO ASSIGN HIGHEST PRIORITY TO COBE AND A LOWER PRIORITY TO NOAA WEATHER.
    - DURING THE ONE WEEK DEMONSTRATION, THERE WERE 21 UPLINK/TELEMETRY PASSES WITH COBE, AND 37 TELEMETRY PASSES WITH THE NOAA.
  - THE PERFORMANCE OF THE TERMINAL WAS MONITORED BY AUTOMATED LOGGING OF KEY OPERATIONAL PARAMETERS; LOGS INDICATE FLAWLESS OPERATION OF THE TERMINAL DURING THE 7 DAY DEMONSTRATION PERIOD.

LEO-TERMINAL DEMONSTRATIONS: LESSONS LEARNED

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☛ **LEO-T CONCEPT OF FULLY UNATTENDED OPERATIONS AND DIRECT-TO-PI DATA DELIVERY IS TECHNICALLY VIABLE**

- CURRENT WORKSTATION TECHNOLOGY PROVIDES COST-EFFECTIVE AUTOMATION OF LEO-TERMINALS
  - EXTENSIVE AVAILABILITY OF COMMERCIAL-OFF-THE SHELF HARDWARE PERIPHERALS AND SOFTWARE FOR NETWORKING, REMOTE OPERATIONS, DATA COMMUNICATIONS, AND USER INTERFACES
- USE OF TCP/IP PROTOCOLS OVER ISDN LINES PROVIDES A ROBUST AND COST-EFFECTIVE SOLUTION FOR GROUND COMMUNICATIONS
  - ETHERNET/ISDN BRIDGES PROVIDE INTERFACE BETWEEN LAN & ISDN LINES; ALSO PROVIDE LOSS-LESS DATA COMPRESSION
  - LOSS-LESS DATA COMPRESSION HIGHLY RECOMMENDED, GIVEN THE LARGE OVERHEAD IN TELEMETRY/AND TCP/IP PROTOCOLS
  - TYPICAL 40 MBYTES DATA VOLUME PER DAY FOR SAMPEX TRANSMITTED OVER ISDN (128 kBPS RATE) IN 12 MINUTES AFTER 4:1 COMPRESSION
- LIGHT-WEIGHT ANTENNA ENCLOSED IN A RADOME ALLOWS USE OF A VERY COST EFFECTIVE LIGHT-WEIGHT ANTENNA WITH LOW MAINTENANCE

LEO-T ACTIVITY STATUS

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- LEO-TERMINAL PROOF OF CONCEPT **HAS** BEEN SUCCESSFULLY VALIDATED
- WRAP UP WORK IS EXPECTED TO CONTINUE THROUGH FY 97
  - TECHNOLOGY TRANSFER TO NASA COMMUNITY AND INDUSTRY
  - INTEGRATION OF THE TERMINAL WITH INSTITUTIONAL TESTED

- **A** NEW START, DEEP SPACE-TERMINAL, (DS-T), HAS BEGAN TO INTEGRATE LEO-T ELECTRONICS WITH A 34 METER BEAM WAVEGUIDE ANTENNA) FOR AUTOMATED UNATTENDED DEEP SPACE OPERATIONS