



InterPlanetary Network and Information Systems Directorate



**TELEMETRY, TRACKING,
AND COMMAND
CONSOLIDATION IN
NASA'S DEEP SPACE
NETWORK**

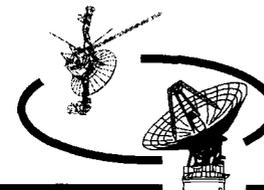
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SUSAN C. KURTIK**

***JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF
TECHNOLOGY***



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TYPES OF ACTIVITIES

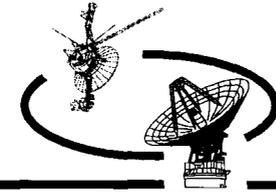


- **THE MAIN ACTIVITIES FOR A TELEMETRY, TRACKING, AND COMMAND (TTC) PASS ARE:**
 - **TELEMETRY**
 - **REQUIRES LOCKING TO THE DOWNLINK CARRIER, DEMODULATING THE SUBCARRIER AND SYMBOL, DECODING AND FRAME SYNCHRONIZING THE BITS**
 - **COMMANDING**
 - **REQUIRES RECEIVING COMMANDS FROM THE PROJECT, MODULATING THEM ONTO A CARRIER, AND TRANSMITTING THE CARRIER**
 - **TRACKING (DOPPLER)**
 - **REQUIRES GENERATING AND TRANSMITTING AN UPLINK CARRIER AND MEASURING ITS PHASE**
 - **REQUIRES LOCKING TO THE DOWNLINK CARRIER AND MEASURING ITS PHASE**
 - **TRACKING (RANGING)**
 - **REQUIRES GENERATING THE RANGING CODE, MODULATING AND TRANSMITTING THE UPLINK CARRIER**
 - **REQUIRES LOCKING TO THE DOWNLINK CARRIER, DEMODULATING AND CORRELATING THE RECEIVED RANGING CODE**
- **OBVIOUSLY, THESE ACTIVITIES CAN BE DONE TOGETHER**



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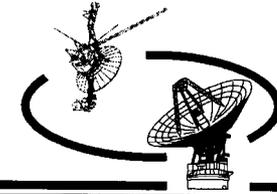
CURRENT EQUIPMENT



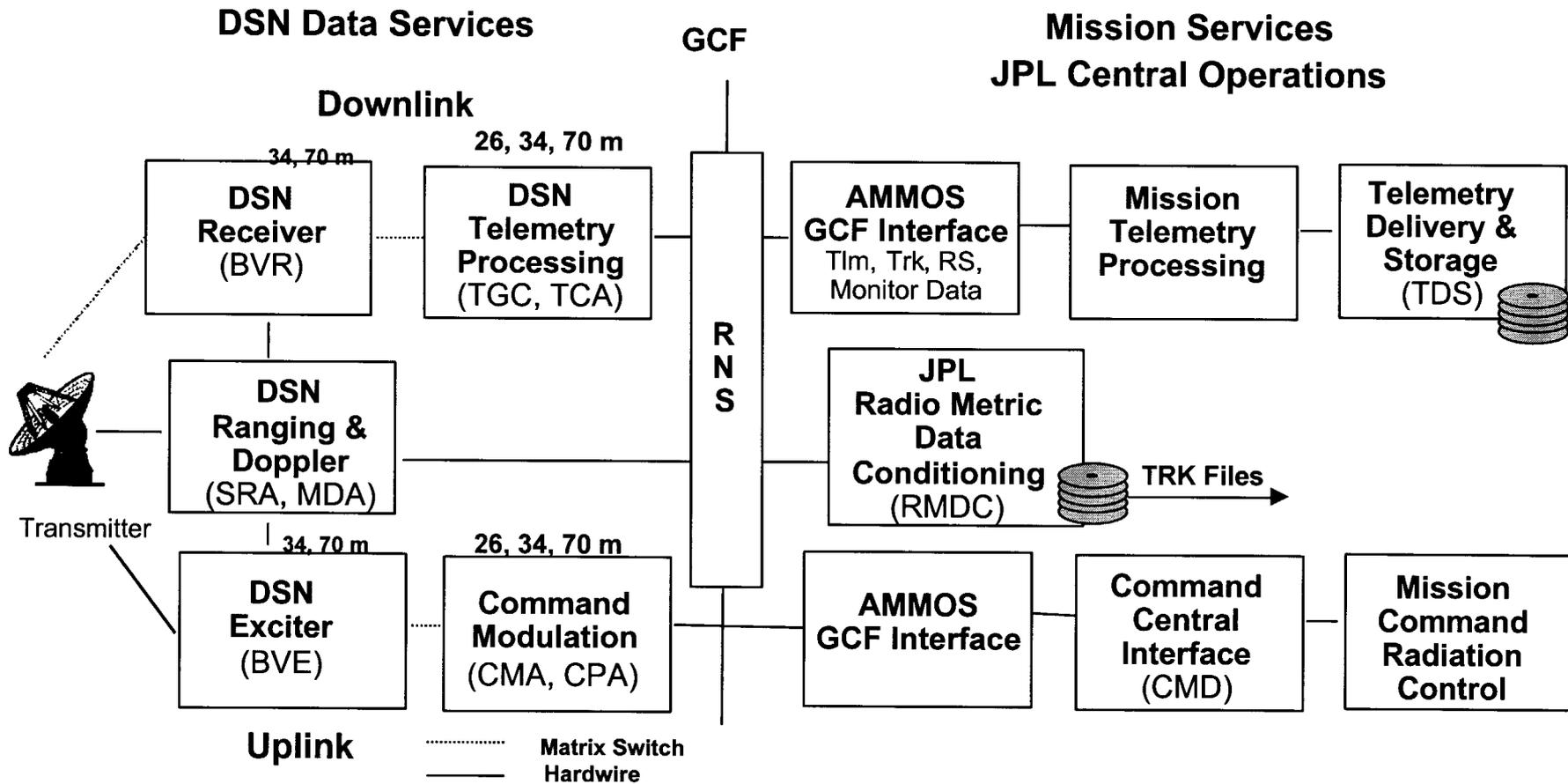
- **CURRENT EQUIPMENT WAS DESIGNED AROUND SPECIFIC FUNCTIONS, INSTEAD OF AN ACTIVITY**
 - FOR EXAMPLE, THE TELEMETRY EQUIPMENT ONLY DOES THE DECODING AND SYNCHRONIZATION
- **FOR THE TTC ACTIVITIES, FIVE CONTROLLERS ARE CURRENTLY USED**
 - EACH ONE REQUIRES CONFIGURATION AND CONTROL
- **SOME OF THE EQUIPMENT IS STILL IN USE, EVEN THOUGH ITS FUNCTION HAS BEEN REMOVED**
 - FOR EXAMPLE, THE METRIC DATA ASSEMBLY (MDA) USED TO MEASURE DOPPLER, BUT NOW IT JUST FORMATS DATA FROM THE RECEIVER AND EXCITER TO BE SENT TO JPL
- **SOME EQUIPMENT IS HARDWIRED TO ANTENNAS IN GROUPS OF TWO (E.G., RECEIVERS) OR CONTROLLED AS PAIRS (E.G., TELEMETRY EQUIPMENT)**
 - WASTES EQUIPMENT IF ONLY ONE STRING IS REQUIRED
- **RANGING EQUIPMENT IS HARDWIRED BETWEEN RECEIVER AND EXCITER**
 - TIES EQUIPMENT TO THE ANTENNA
- **CONNECTIONS BETWEEN EQUIPMENT ARE NOT RELIABLE**
 - MANUAL PATCH PANEL BETWEEN RECEIVER AND TELEMETRY EQUIPMENT IS A SOURCE OF ERROR
 - MATRIX SWITCH BETWEEN EXCITER AND COMMAND EQUIPMENT



CURRENT EQUIPMENT (FUNCTIONAL)

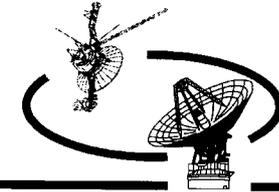


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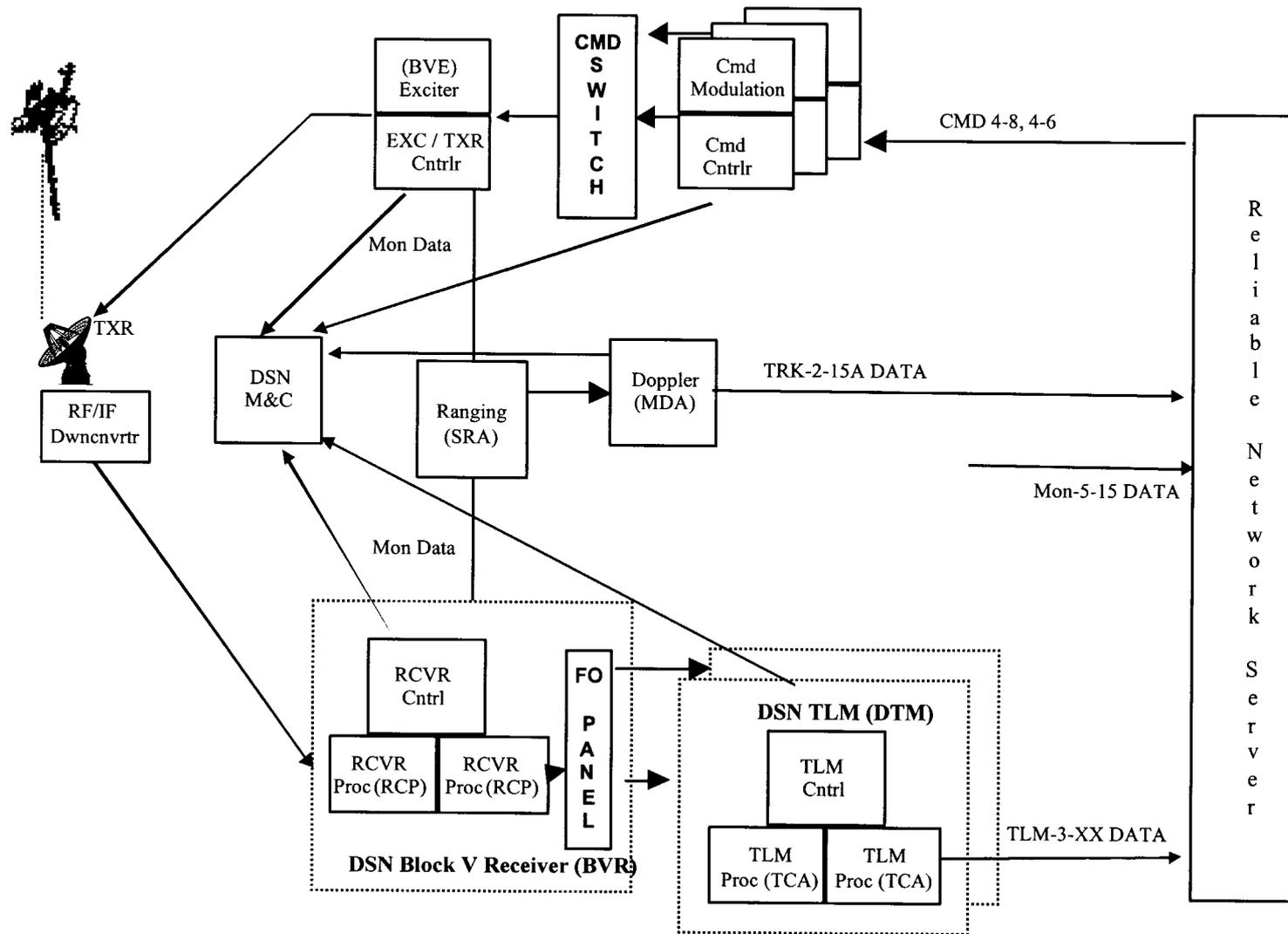




CURRENT EQUIPMENT (PHYSICAL)



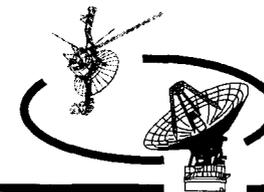
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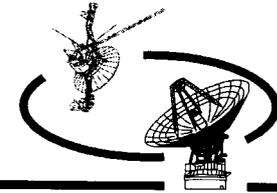
NEW EQUIPMENT



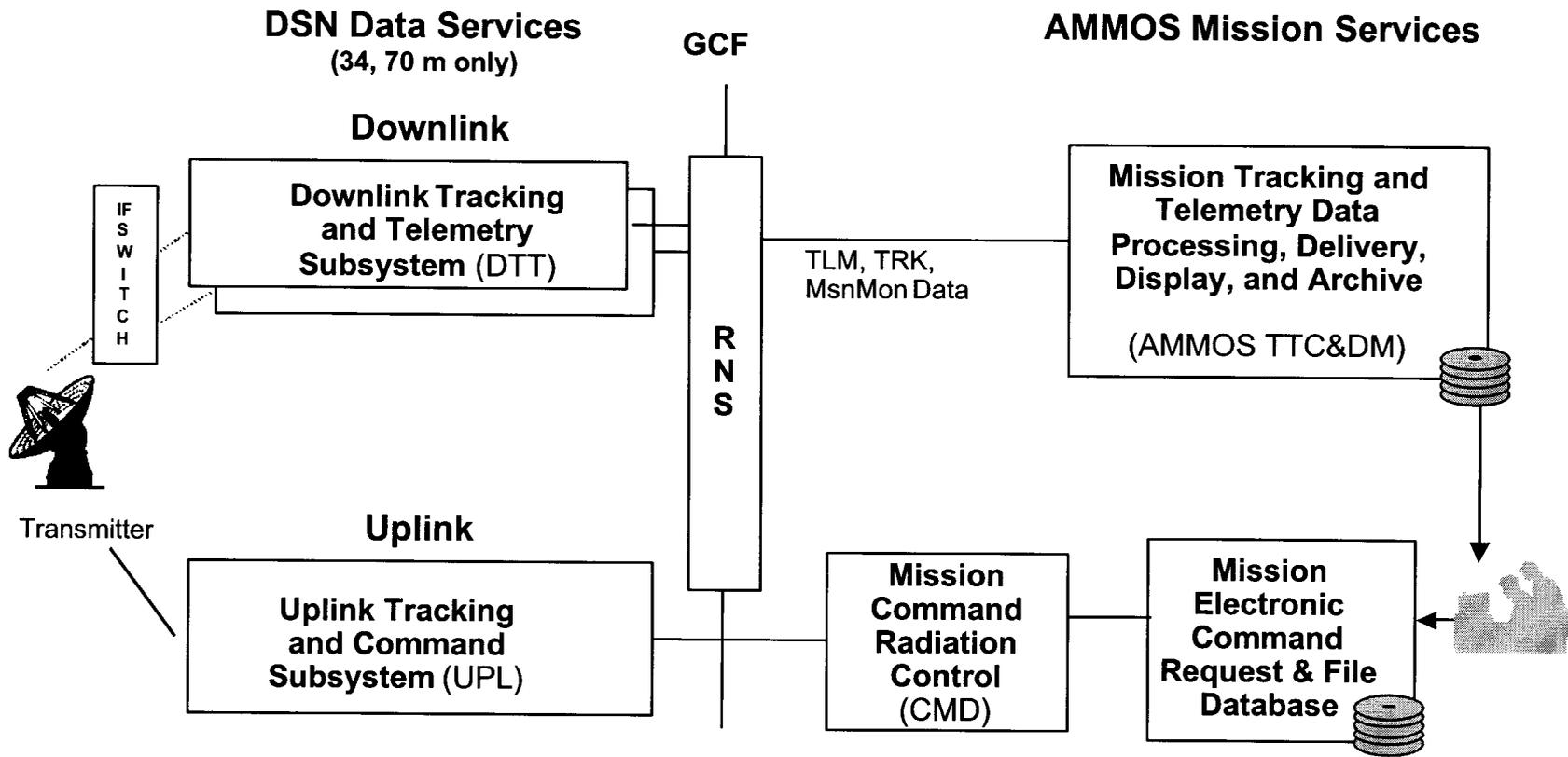
- **THE NEW DESIGN CONSOLIDATES FUNCTIONS INTO UPLINK AND DOWNLINK**
 - ONLY TWO CONTROLLERS, INSTEAD OF FIVE
 - HIGH LEVEL DIRECTIVES FOR ACTIVITIES, INSTEAD OF ONES FOR FUNCTIONS
 - E.G., ACQUIRE COMMAND ON DOWNLINK ACQUIRES CARRIER, SUBCARRIER, SYMBOL, DECODERS, AND FRAME SYNC
- **RANGING IS SPLIT BETWEEN UPLINK AND DOWNLINK**
 - REMOVES HARDWARE CONNECTION BETWEEN RECEIVER AND EXCITER
 - DATA PASS OVER LAN
- **RECEIVER AND TELEMETRY EQUIPMENT HARDWIRED TOGETHER (INTO A DOWNLINK CHANNEL OR DC), BUT SWITCHABLE TO ANY ANTENNA**
 - ALLOWS BETTER USE OF RESOURCES
- **INTEGRATION ALLOWS BETTER USE OF SEQUENCE OF EVENTS (SOE) DRIVEN PREDICTS**
 - CONFIGURATION CHANGES (E.G., DATA RATE, CODE TYPE) CAN BE CONTROLLED VIA ONE SET OF PREDICTIONS
 - ALSO ALLOWS AUTOMATION OF THE RANGING SYSTEM DELAY CALIBRATION



NEW EQUIPMENT (FUNCTIONAL)



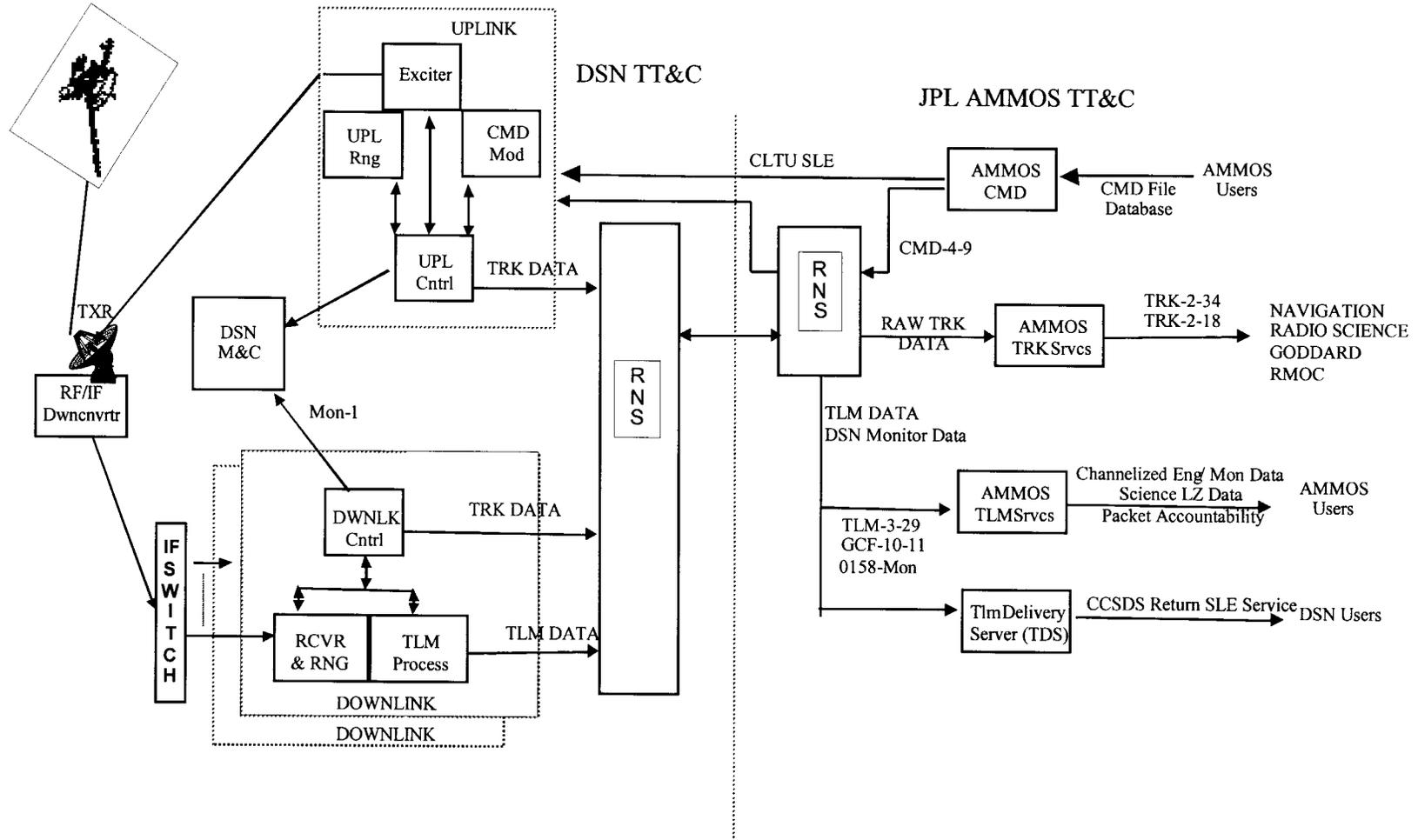
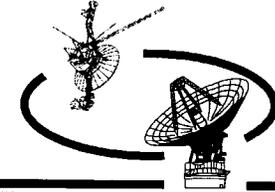
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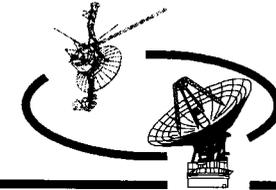
NEW EQUIPMENT (PHYSICAL)





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UPLINK EQUIPMENT

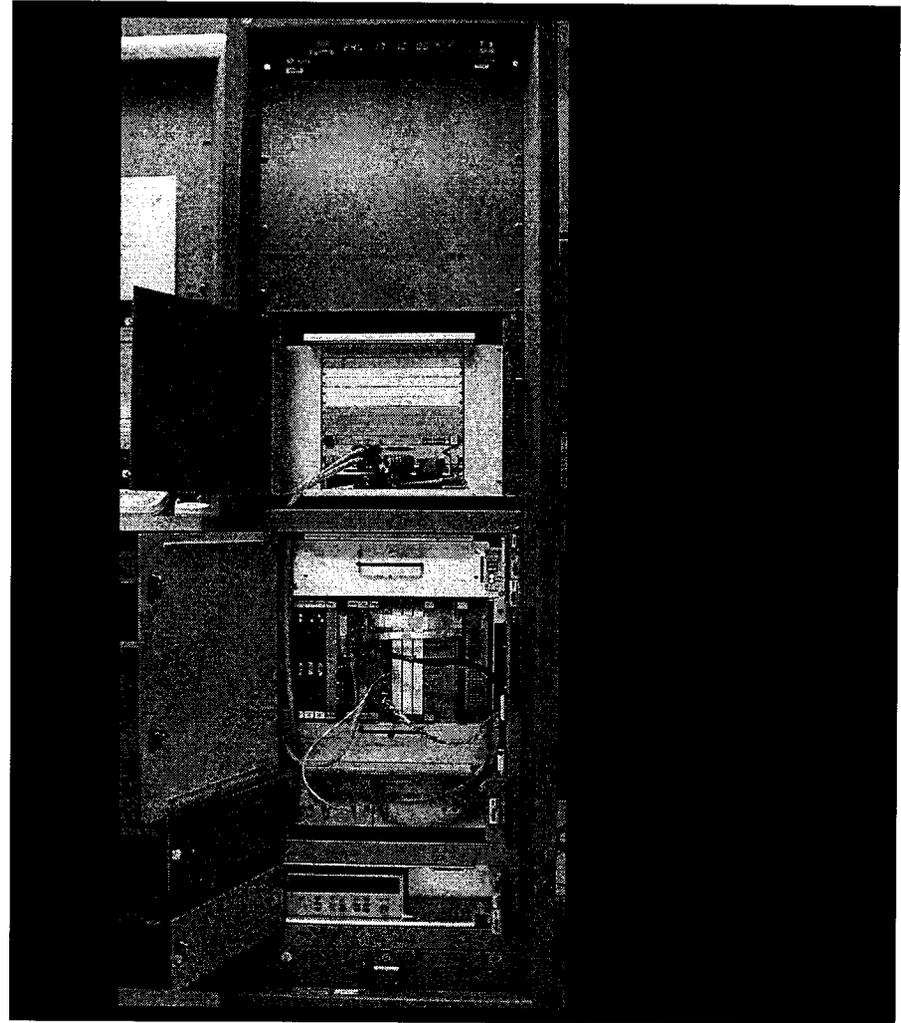
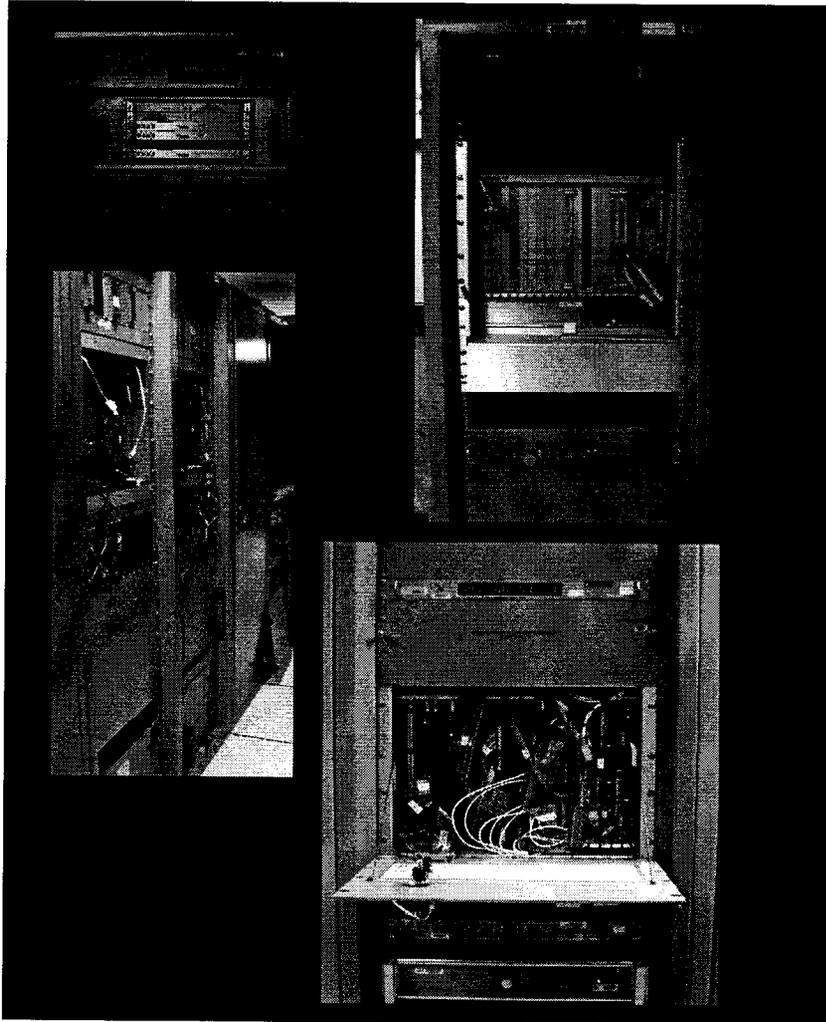
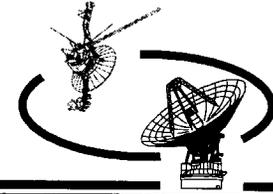


- **THE UPLINK SUBSYSTEM CONSISTS FOR THE FOLLOWING**
 - **EXISTING EXCITERS AND TRANSMITTERS**
 - **NEW COMMAND MODULATION GENERATORS (CMG)**
 - **NEW RANGE CODE GENERATION EQUIPMENT**
- **THERE ARE TWO CMGs CONNECTED TO EACH EXCITER**
 - **PROVIDES REDUNDANCY WITHOUT A MATRIX SWITCH**
 - **INTEGRATION WITH EXCITER ALLOWS CONTINUAL SELF CHECK WHICH COULD NOT BE DONE WHEN CONTROLLED SEPARATELY**
 - **SPACE LINK EXTENSION (SLE) IS USED FOR THE INTERFACE BETWEEN THE SOURCE OF COMMANDS AND THE COMMAND EQUIPMENT**
 - **PROVIDES A COMMON INTERFACE THAT ALLOWS CROSS SUPPORT**
- **THE RANGING ASSEMBLY IS BASED ON A COMMERCIAL DIGITAL SIGNAL PROCESSOR (DSP) BOARD**
 - **NO CUSTOM HARDWARE**
 - **GENERATES RANGING CODE INDEPENDENT OF DOWNLINK**
 - **CAN DO EITHER SEQUENTIAL OR PSEUDO NOISE (PN) RANGE CODES**



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INTERPLANETARY NETWORK AND INFORMATION SYSTEMS DIRECTORATE
Downlink Tracking and Telemetry (DTT)
Channel



Daniel Lee Rascoe, 6/19/2002 03:54 PM, Re: VG Clearance

Date: Wed, 19 Jun 2002 15:54:21 -0700
To: Kathleen.A.Lynn@jpl.nasa.gov,
Jeff B Berner <Jeff.B.Berner@jpl.nasa.gov>
From: Daniel Lee Rascoe <drascoe@mail1.jpl.nasa.gov>
Subject: Re: VG Clearance

I concur,
Dan Rascoe

Kathy,

Attached is the clearance form and the Viewgraphs for a paper entitled "Telemetry, Tracking, and Command Consolidation in NASA's Deep Space Network", for Space Ops 2002. This conference is backwards - they want the viewgraphs a month before the actual paper, so I'm doing them out of order. The abstract was previously cleared by my co-author (who is on vacation, so I do not know the clearance number). My supervisors are either Dan Rascoe or Mark Gatti.

Dan or Mark - could you email Kathy your concurrence? Thanks.

Jeff

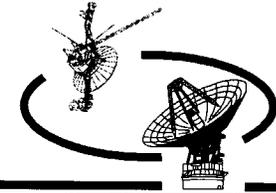
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Attachment converted: Macintosh HD:Consolidation Space Ops.ppt (SLD3/PPT3) (00032ED3)

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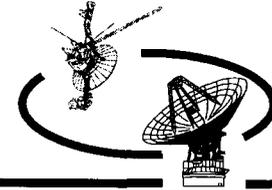
DOWNLINK EQUIPMENT



- **THE DOWNLINK SUBSYSTEM CONSISTS OF THE FOLLOWING**
 - **EXISTING DIGITAL RECEIVER**
 - **PERFORMS CARRIER (RESIDUAL, SUPPRESSED, AND QPSK/OQPSK), SUBCARRIER, AND SYMBOL DEMODULATION**
 - **A NEW TELEMETRY PROCESSOR (TLP)**
 - **NEW RANGING CORRELATION EQUIPMENT**
- **THE TLP IS BASED ON COMMERCIAL EQUIPMENT**
 - **PROVIDES STANDARD CONVOLUTIONAL DECODING, FRAME SYNCHRONIZATION, REED/SOLOMON DECODING, CRC CHECK, PSEUDO DERANDOMIZATION, AND DIFFERENTIAL DECODING**
 - **SUPPORTS EXTERNAL DECODERS, SUCH AS THE BLOCK 3 MAXIMUM LIKELIHOOD CONVOLUTIONAL DECODER (MCD3), WHICH DECODES CONVOLUTIONAL CODES UP TO CONSTRAINT LENGTHS OF 15 AND RATES UP TO 1/6**
 - **ALLOWS FOR THE ADDITION OF TURBO DECODING**



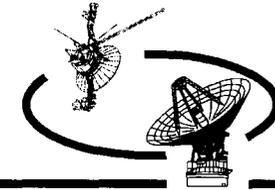
DOWNLINK EQUIPMENT (CONT.)



- **RANGING CORRELATION DONE IN SOFTWARE ON THE SAME DSP BOARDS USED BY THE UPLINK**
 - **NO CUSTOM HARDWARE FOR CORRELATIONS, WHICH ALLOWS NEW RANGING CODES TO BE IMPLEMENTED**
- **CHANNELS ARE SWITCHED TO AN ANTENNA AND CONTROLLED INDIVIDUALLY**
 - **ALLOWS TRACKING OF MULTIPLE SPACECRAFT PER ANTENNA**
- **MONITORING IS SIMPLIFIED**
 - **COMPLETE DOWNLINK STATUS CAN BE PROVIDED WITH ONE INDICATOR**
 - **KEY PARAMETER (E.G., P_c/N_0) RESIDUALS (MEASURED MINUS PREDICTED) ARE COMPARED WITH A PROJECT SUPPLIED THRESHOLD, ALLOWING GREEN/RED STATUS INDICATION**

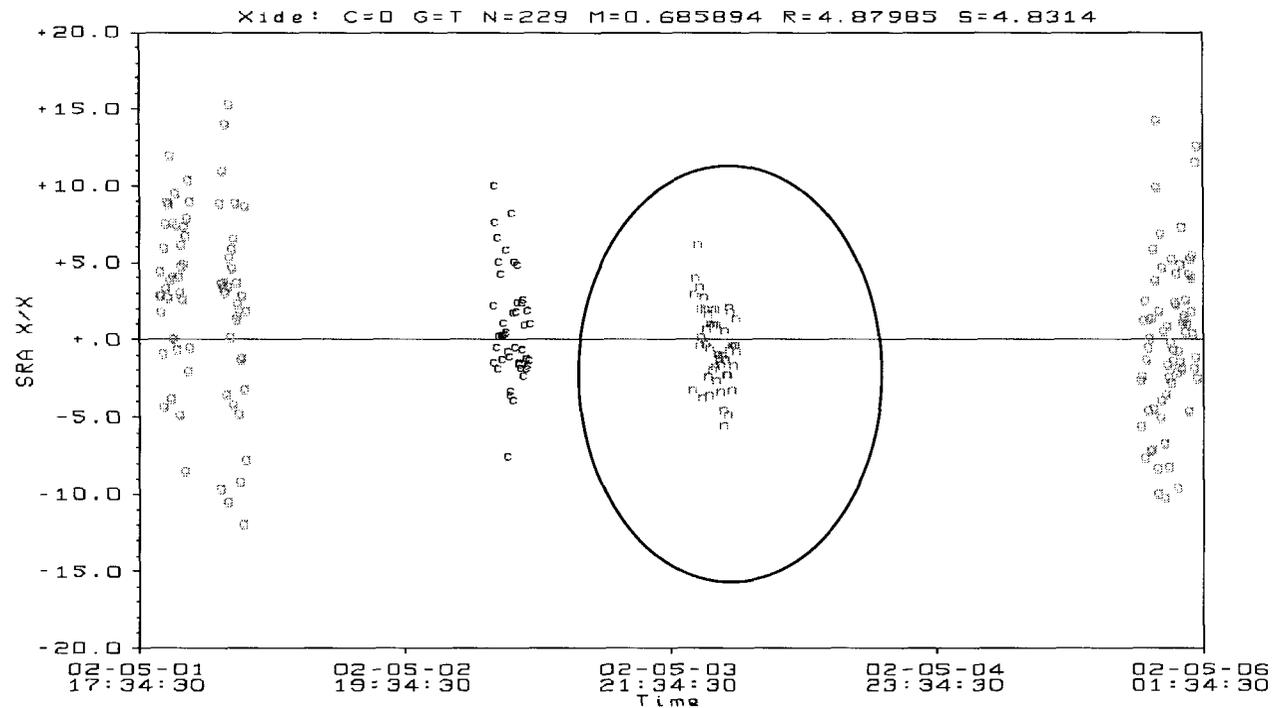


NSP CASSINI RANGING RESULTS



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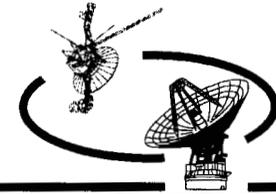
- SINCE RANGING IMPLEMENTATION IS COMPLETELY NEW, TESTING WITH A LIVE SPACECRAFT IS HIGH PRIORITY
- FIRST RANGING TEST TO A LIVE SPACECRAFT WAS CONDUCTED FROM DSS 26, ON 5/3/02, USING CASSINI
 - EXTENSIVE TESTING WAS PREVIOUSLY CONDUCTED IN THE DEVELOPMENT LABS AND DTF-21 TEST FACILITY
- NAVIGATION COMPARED THE NSP RESULTS TO DATA CAPTURED BY LEGACY EQUIPMENT AT THE THREE DSCC'S
 - IDENTICAL BIAS, SMALLER SCATTER (BENEFIT OF STREAMLINED/DIGITAL, NOT ANALOG, PROCESSING)





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CONCLUSIONS



- **UPLINK AND DOWNLINK CONSOLIDATION PROVIDES:**
 - **SIMPLER CONTROL INTERFACE (FIVE CONTROLLERS REDUCED TO TWO)**
 - **HIGHER LEVEL DIRECTIVES, BASED ON ACTIVITIES, NOT FUNCTIONS**
 - **INTEGRATED OPERATOR INTERFACES**
- **INITIAL TESTING SHOWS EXPECTED PERFORMANCE FOR NEW RANGING IMPLEMENTATION**
- **THESE NEW SUBSYSTEMS WILL BE INSTALLED STARTING IN JULY, 2002, AND WILL BE FULLY OPERATIONAL BY MAY, 2003**
 - **ANTENNA BY ANTENNA IMPLEMENTATION**