NEW TRACKING IMPLEMENTATION IN THE DEEP SPACE NETWORK

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• Two types of tracking data are measured at a station
  — Doppler data
    • A measurement of the carrier phase (both uplink and downlink), which provides a measurement related to the velocity of the spacecraft
  — Range data
    • A measurement of the correlation between a transmitted range code and the received range code (turned around by the spacecraft), which provides a measurement of the round trip light time to the spacecraft
• The raw measurements are processed (e.g., removing ground equipment effects, etc.) into observables, which are the deliverable product to the navigators
• Currently, range is measured by the sequential ranging assembly (SRA) and Doppler is measured by the metric data assembly (MDA)
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EVOLUTION OF THE TRACKING SYSTEM

- TRUE DOPPLER
  - UNRAMPED UPLINK IS SCALED, MIXED WITH RECEIVED DOWNLINK, OFFSET BY 1 MHz, AND FREQUENCY COUNTED BY THE MDA
    - MIXING IS DONE IN THE DOPPLER EXTRACTOR (DE)
  - RESULTS ARE REPORTED AT AN INTERMEDIATE FREQUENCY LEVEL
- RAMPED UPLINK ADDED
  - MDA CONTROLS THE SYNTHESIZER THAT RAMPS THE UPLINK CARRIER TO REDUCE THE FREQUENCY DYNAMICS, AS SEEN BY THE SPACECRAFT (TUNE CANCELS OUT THE UPLINK DOPPLER)
  - FREQUENCY COUNTER OUTPUT IS NO LONGER THE TRUE DOPPLER
    - RAMPING EFFECTS ARE CORRECTED BY POST PROCESSING
    - SIMULATION SYNTHESIZER ADDED TO ALLOW ONE-WAY AND THREE-WAY DOPPLER DATA
- RANGING SYSTEM UPGRADED TO SRA
- DIGITAL RECEIVERS AND EXCITERS REPLACE ANALOG EQUIPMENT
  - RAMP TUNING NOW DONE IN EXCITER
  - PHASE DATA SENT DIRECTLY TO MDA, REMOVING NEED FOR DE
    - MDA ONLY FORMATS DATA FOR TRANSMISSION
    - ORIGINAL INTERFACES MAINTAINED, SO MDA MUST MAKE DATA LOOK LIKE IT CAME FROM THE DE
CURRENT INTERFACES

- THERE ARE THREE MAIN INTERFACES SUPPORTED BY THE CURRENT DSN TRACKING EQUIPMENT
  - REFERRED TO BY THEIR MODULE NUMBER IN THE DSMS (DEEP SPACE MISSION SYSTEM) EXTERNAL INTERFACE DOCUMENT
- TRK-2-15A
  - RAW DATA FROM THE MDA AND SRA
  - BIT PACKED, WHICH LIMITS PRECISION
    - HAS BEEN A SOURCE OF ERRORS
  - SIGNAL FREQUENCIES ARE AT AN INTERNAL INTERMEDIATE LEVEL BASED ON THE ORIGINAL HARDWARE IMPLEMENTATION
    - REQUIRES USERS TO HAVE KNOWLEDGE OF EQUIPMENT THAT IS NO LONGER IN USE
  - ESSENTIALLY, AN INTERNAL INTERFACE THAT HAS BEEN PROVIDED EXTERNALLY
CURRENT INTERFACES (CONT.)

- TRK-2-25
  - ARCHIVAL FORMAT FOR RAW DATA
  - BIT PACKED
  - SIGNAL LEVELS AT SKY OR INTERMEDIATE LEVELS
- TRK-2-18
  - CONTAINS OBSERVABLES (PROCESSED DATA)
    - NO SYSTEM CONFIGURATION DATA ASSOCIATED WITH OBSERVABLES
    - BIT PACKED
    - SIGNAL FREQUENCIES AT S-BAND LEVEL
NEW TRACKING SYSTEM

- NETWORK SIMPLIFICATION PROJECT IS CONSOLIDATING UPLINK AND DOWNLINK FUNCTIONS
  - COMPLETE BY MAY, 2003
  - KEEPS EXISTING RECEIVERS AND EXCITERS; ALL OTHER EQUIPMENT IS NEW
  - UPLINK SUBSYSTEM CONSISTS OF CARRIER GENERATION, COMMAND GENERATION AND MODULATION, AND RANGE CODE GENERATION AND MODULATION
  - DOWNLINK SUBSYSTEM CONSISTS OF CARRIER DEMODULATION, SUBCARRIER AND SYMBOL DEMODULATION, TELEMETRY PROCESSING, AND RANGE CODE CORRELATION
- MDA AND SRA FUNCTIONS ABSORBED INTO NEW SUBSYSTEMS
  - RANGING DONE WITH COMMERCIAL PROCESSORS INSTEAD OF CUSTOM HARDWARE
    - ALLOWS BOTH SEQUENTIAL AND PSEUDO-NOISE (PN) RANGING
  - DATA SENT DIRECTLY TO JPL FOR PROCESSING
    - NO MDA "MIDDLEMAN"
  - ALL DATA IS AT SKY LEVELS
    - NO KNOWLEDGE OF SPECIFIC HARDWARE REQUIRED BY DATA CUSTOMERS
NEW INTERFACE

- THE NEW INTERFACE TO THE CUSTOMER IS TRK-2-34
  - CONTAINS ALL OF THE DATA PROVIDED IN THE PREVIOUS INTERFACES
  - USES STANDARD DATA FORMATS, SUCH AS FIXED WIDTH INTEGERS (8-, 16-, AND 32-BIT) AND IEEE SINGLE AND DOUBLE PRECISION FLOATING POINT
- USES THE CCSDS STANDARD FORMATTED DATA UNIT (SFDU) CONCEPT FOR DATA PACKAGING
  - ORGANIZED INTO HEADERS AND DATA
- ALL DATA IS IN NATURAL UNITS, SUCH AS SKY LEVEL FREQUENCY AND PHASE
  - NO KNOWLEDGE OF EQUIPMENT IMPLEMENTATION IS NEEDED
- TRK-2-18 DATA INTERFACE WILL CONTINUE TO BE SUPPORTED FOR THE NEAR FUTURE
• HEADERS
  - THERE ARE THREE HEADERS FOR EACH SFDU
    • THE LABEL FIELD IDENTIFIES THE DATA TYPE AND THE SFDU LENGTH
    • THE PRIMARY HEADER PROVIDES THE MISSION IDENTIFIER AND THE TYPE OF TRACKING DATA
    • THE SECONDARY HEADER PROVIDES SYSTEM CONFIGURATION AND STATUS, WHICH CAN BE USED FOR SORTING DATA

• DATA BLOCKS
  - THERE ARE 18 DIFFERENT TYPES OF DATA DEFINED IN THE INTERFACE, DIVIDED INTO FIVE DATA CLASSIFICATIONS
    • UPLINK RAW DATA
      - UPLINK CARRIER PHASE
      - UPLINK SEQUENTIAL RANGING PHASE
      - UPLINK PN RANGING PHASE
      - UPLINK RAMPS (A FILTERED VERSION OF THE UPLINK CARRIER PHASE BLOCK)
• DOWNLINK RAW DATA
  - DOWNLINK CARRIER PHASE
  - DOWNLINK SEQUENTIAL RANGING PHASE
  - DOWNLINK PN RANGING PHASE

• DERIVED DATA (CONSISTS OF MEASUREMENTS AND OBSERVABLE DATA)
  - DOPPLER DATA
  - SEQUENTIAL RANGING DATA
  - PN RANGING DATA
  - TONE RANGING DATA (26M ANTENNAS ONLY)
  - ANGLE DATA (26M ANTENNAS ONLY)
  - DRVID (DIFFERENCED RANGE VERSUS INTEGRATED DOPPLER) DATA
  - CARRIER OBSERVABLE (DOWNLINK CARRIER PHASE CHANGE) DATA
  - TOTAL CARRIER PHASE OBSERVABLE (INTEGRATED DOWNLINK CARRIER PHASE) DATA
• INTERFEROMETRIC
  - VERY LONG BASELINE INTERFEROMETRY (VLBI) DATA
  - E.G., DELTA-DIFFERENTIAL ONE-WAY RANGING (DELTA-DOR)
• FILTERED (MEASUREMENTS DERIVED FROM MULTIPLE PREVIOUS MEASUREMENTS)
  - ALLAN DEVIATION DATA
  - SMOOTHED NOISE DATA
CONCLUSIONS

• THE NEW TRACKING SYSTEM SEPARATES THE UPLINK AND DOWNLINK FUNCTIONS
  — MODERNIZES INTERFACES, REMOVING NEED FOR MIDDLEMAN Formatting
• THE NEW CUSTOMER INTERFACE CONSOLIDATES DATA PRODUCTS FROM MULTIPLE INTERFACES AND PRESENTS THE DATA IN NATURAL UNITS, USING STANDARDIZED FORMATS