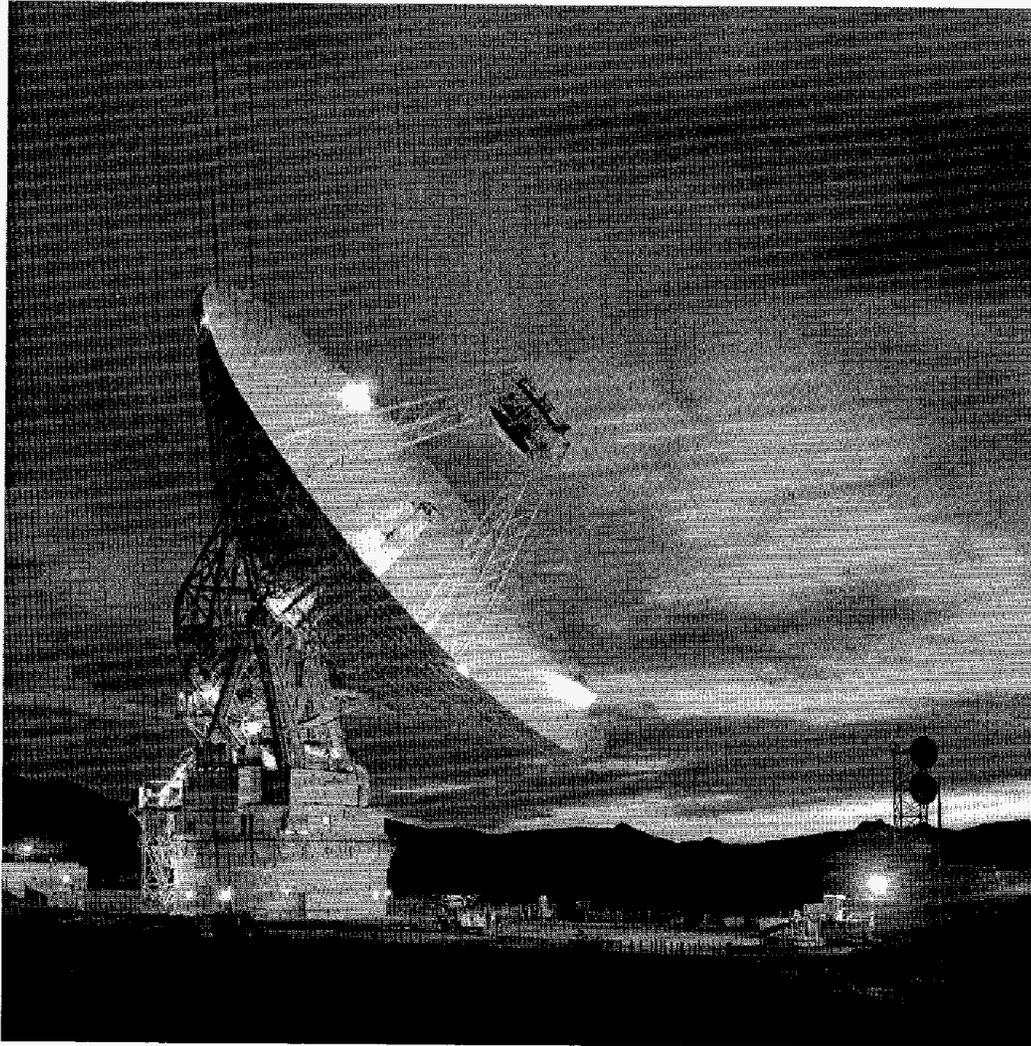




InterPlanetary Network and Information Systems Directorate



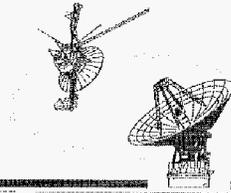
## **NEW TRACKING IMPLEMENTATION IN THE DEEP SPACE NETWORK**

**JEFF B. BERNER  
SCOTT H. BRYANT**

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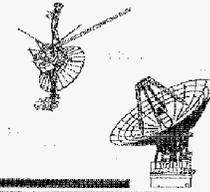
## TRACKING DATA



- **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)**



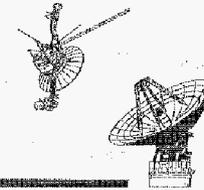
# EVOLUTION OF THE TRACKING SYSTEM



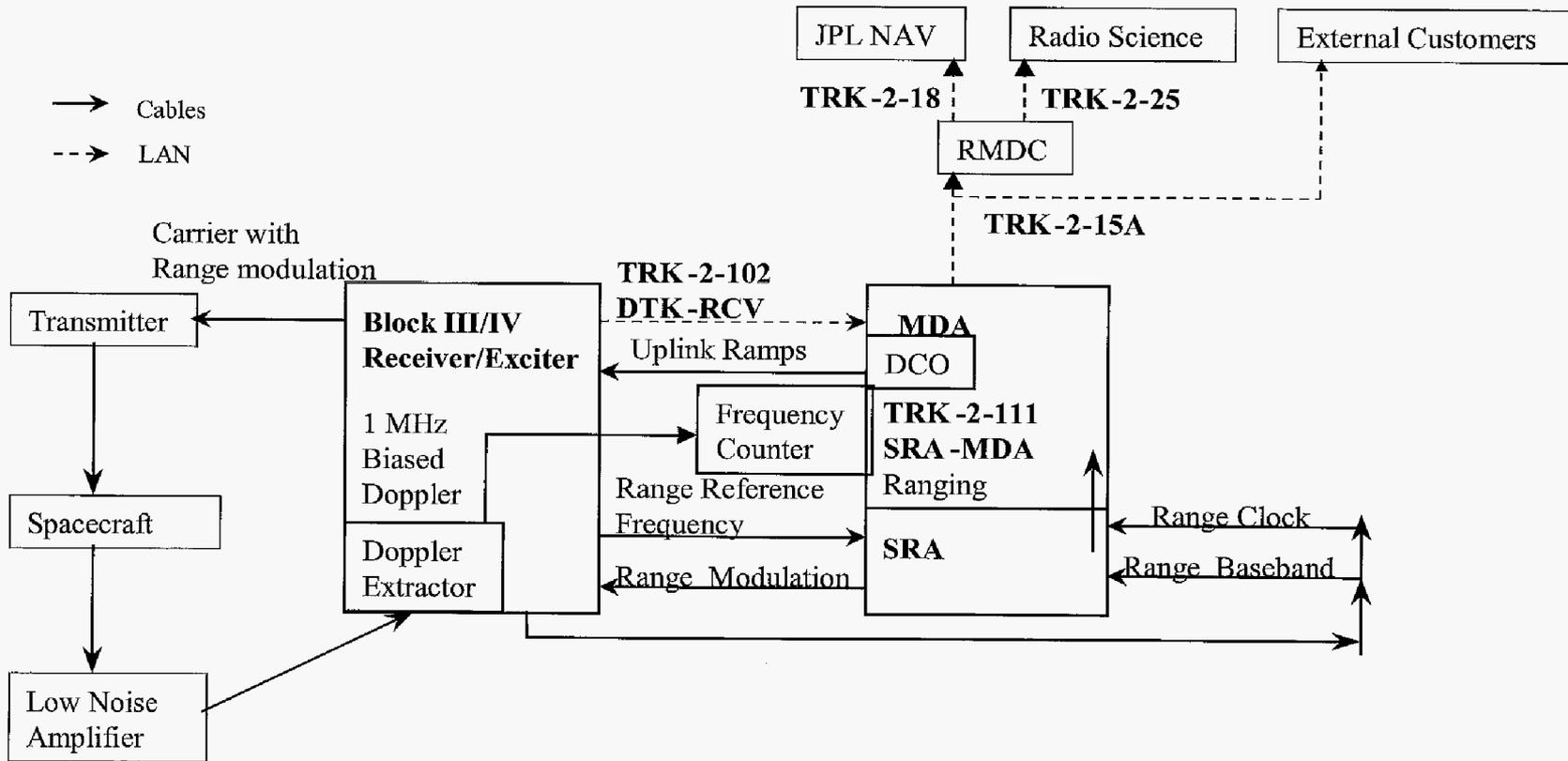
- **TRUE DOPPLER**
  - UNRAMPED UPLINK IS SCALED, MIXED WITH RECEIVED DOWNLINK, OFFSET BY 1 MHz, AND FREQUENCY COUNTED BY THE MDA
    - MIXING IS DONE IN THE DOPPLER EXTRACTOR (DE)
  - RESULTS ARE REPORTED AT AN INTERMEDIATE FREQUENCY LEVEL
- **RAMPED UPLINK ADDED**
  - MDA CONTROLS THE SYNTHESIZER THAT 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



# EARLY DSN TRACKING ARCHITECTURE

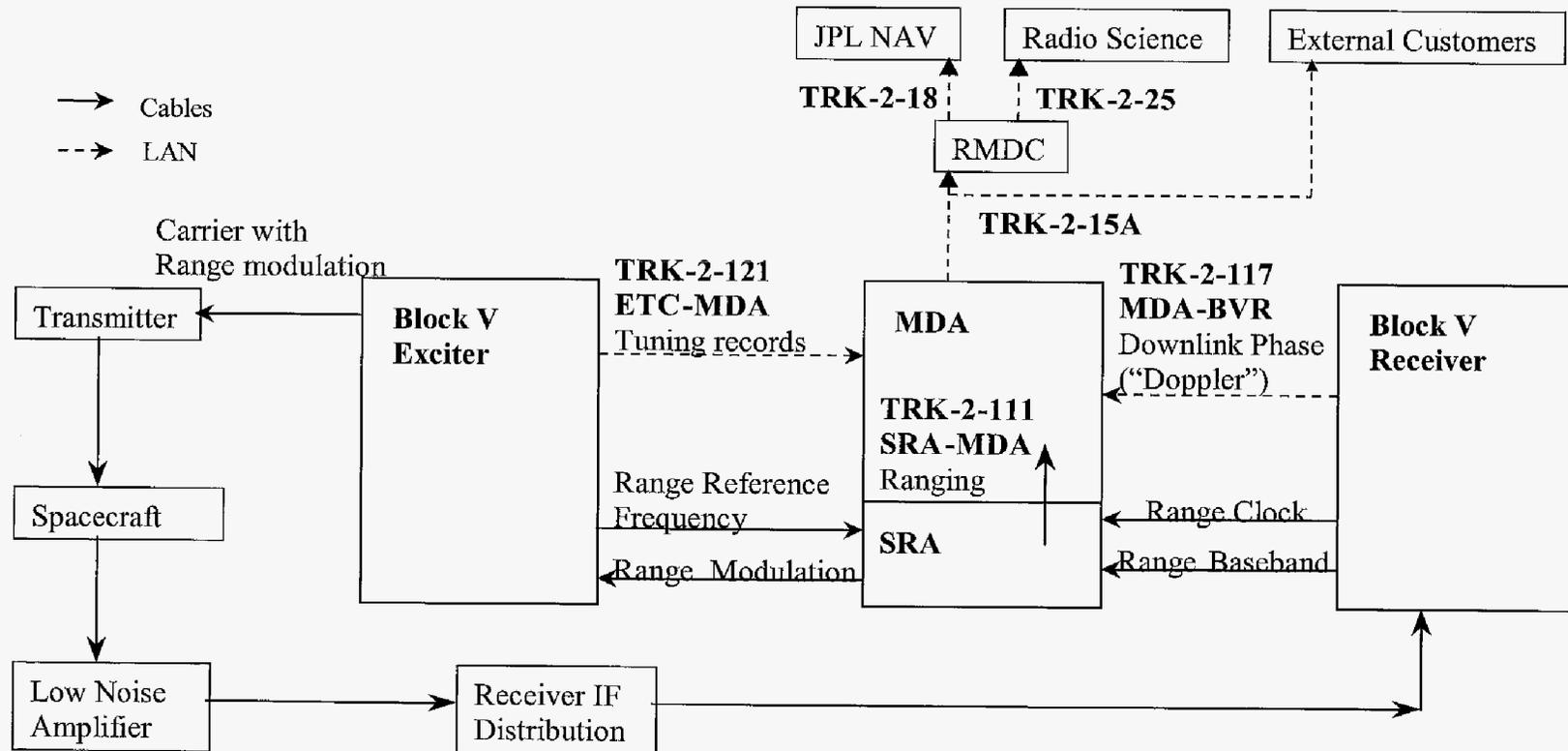
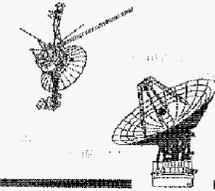


JPL



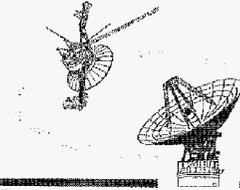


# CURRENT DSN TRACKING ARCHITECTURE





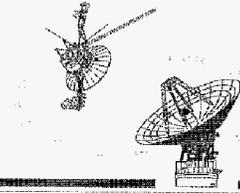
## CURRENT INTERFACES



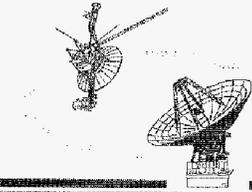
- **THERE ARE THREE MAIN INTERFACES SUPPORTED BY THE CURRENT DSN TRACKING EQUIPMENT**
  - REFERRED TO BY THEIR MODULE NUMBER IN THE DSMS (DEEP SPACE MISSION SYSTEM) EXTERNAL INTERFACE DOCUMENT
- **TRK-2-15A**
  - RAW DATA FROM THE MDA AND SRA
  - BIT PACKED, WHICH LIMITS PRECISION
    - HAS BEEN A SOURCE 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

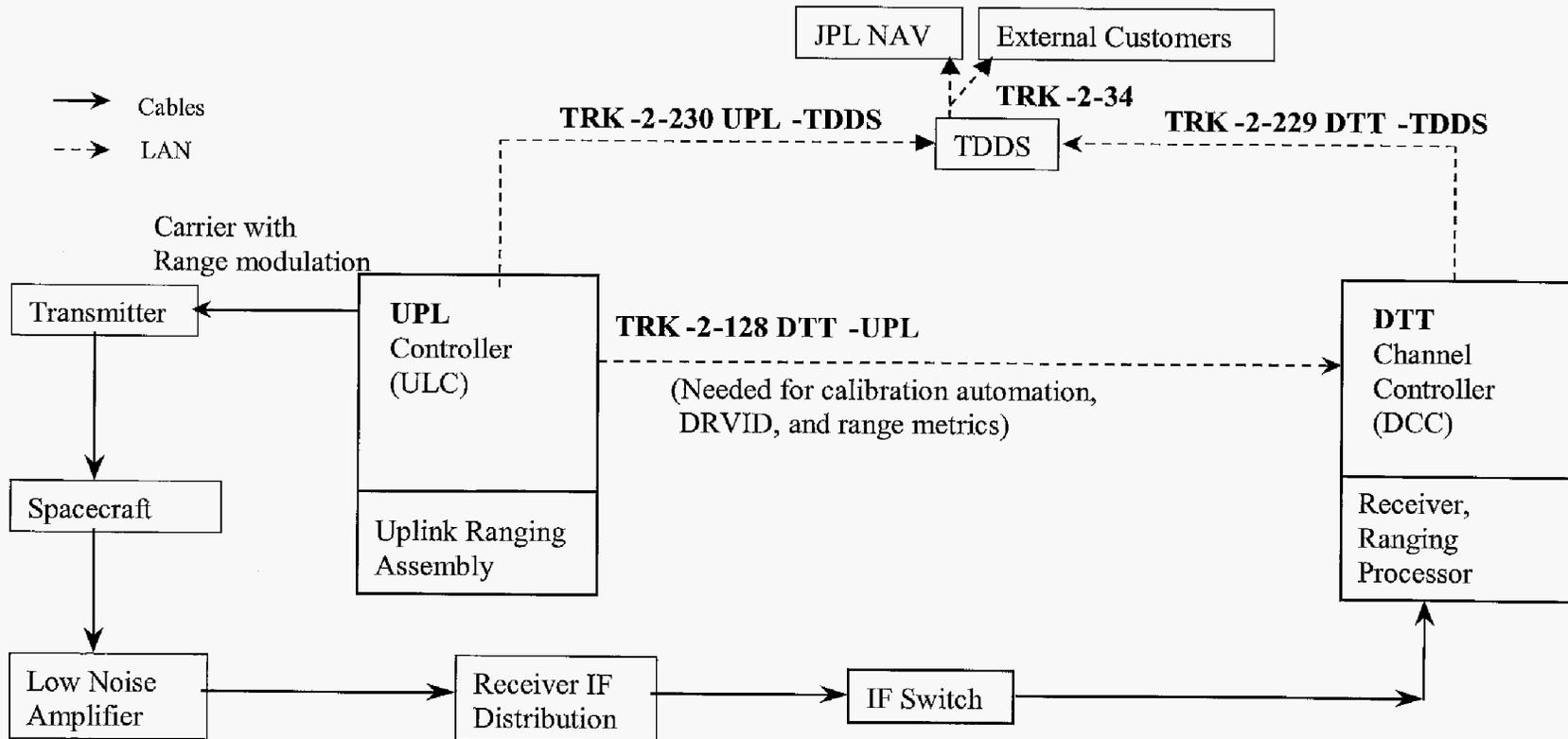
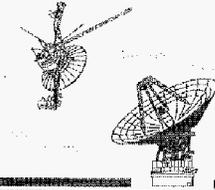


## NEW TRACKING SYSTEM

- **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



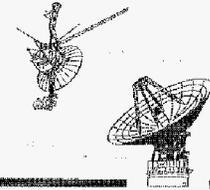
# NSP TRACKING SYSTEM ARCHITECTURE





**JPL**

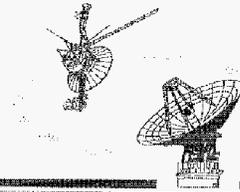
## NEW INTERFACE



- **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**



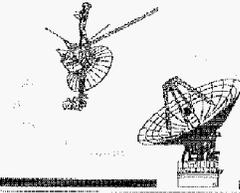
## TRK-2-34



- **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)**



## TRK-2-34 (CONT.)



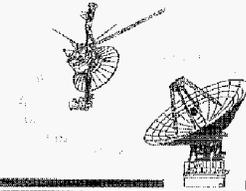
**JPL**

- **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**



**JPL**

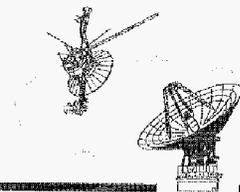
## TRK-2-34 (CONT.)



- **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**