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PDS_VERSION_ID      = PDS3
RECORD_TYPE          = FIXED_LENGTH
RECORD_BYTES         = 80
SPACECRAFT_NAME      = "CLEMENTINE 1"
TARGET_NAME          = {EARTH, MOON, SKY}
OBJECT               = TEXT
 INTERCHANGE_FORMAT  = ASCII
 PUBLICATION_DATE    = 1994-10-1
 NOTE                = "CLEMENTINE MISSION"
END_OBJECT           = TEXT
END
```

Clementine Mission

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1. Introduction

During the past decade, the Department of Defense and the Ballistic Missile Defense Organization, BMDO (formally the Strategic Defense Initiative, SDIO) of the US Department of Defense (DOD) have invested heavily in space technology, focused on the development of lighter, more cost effective components and systems for spacecraft. In May of 1990, the NASA Discovery Science Working Group endorsed a study of incorporation of SDIO developed technology into civilian scientific missions. In September 1990, NASA Administrator Richard Truly formally inquired of Deputy Secretary of Defense Donald Atwood as to the possibility of utilizing the advanced, lightweight technologies being developed by the Department of Defense in a joint space exploration mission. After a six month effort by NASA, DOD, and industry, it was concluded that a mission to a near-Earth-asteroid was desirable and feasible from both organizations' standpoint. In addition to the scientific value of an asteroid flyby and of the potential benefit of technology transfer between the agencies for NASA, there was clear benefits to DOD. In early 1992 the mission was incorporated into the Ballistic Missile Defense Organization Sensor Integration Program. The mission was subsequently expanded by two months to include mapping of the Moon to demonstrate spacecraft and sensor performance prior to the demanding asteroid flyby mission. The interstage adapter of the spacecraft, housing the solid rocket motor, was also designated as a platform to remain in highly eccentric earth orbit as a radiation experiment platform and additional sensor target.

The Clementine spacecraft was built at the US Naval Research Laboratory in Washington, DC, and carried sensors, attitude control systems and software designed and built by the Lawrence Livermore National Laboratory (LLNL). The USAF supplied advanced lightweight composite structures and the launch vehicle, a Titan II B refurbished ICBM. Several other organizations were involved, especially NASA with communications support, through the Jet Propulsion Laboratory's (JPL) Deep Space network, and orbit determination and operations support from both the Goddard Space Flight Center and JPL. Supporting these laboratories were scores of industrial contractors, both large and small.

The spacecraft consists of an octagonal prism about 2 meters high. A 110-pound thruster for delta-V maneuvers is on one end of the prism and a high-gain fixed dish antenna is on the other end. The spacecraft propulsion system consists of a nonpropellant hydrazine system for attitude control and a bipropellant nitrogen tetraoxide and monomenthyl hydrazine system for the maneuvers in space. The bipropellant system had a total capability of about 1.9 km/s with about 550 m/s required for lunar insertion and 540 m/s for lunar departure. The power system consists of a gimbaled, single axis, GaAs/Ge solar array providing a total spacecraft power of 360 watts at 30 Vdc, with a specific power of 240 w/kg, based on lightweight construction. Two arrays of the rotating solar panels protrude from opposite sides; by rolling the spacecraft and rotating the panels, full solar illumination of the panels would be achieved. The solar array was used to charge a 15 A-h, 47-w hr/kg, Nihau common pressure vessel battery. The total mass of the spacecraft in the launch configuration was 1690 kg, with most of the weight in the solid rocket motor required for translunar insertion. The spacecraft dry mass is about 227 kg, with a roughly equal mass for liquid fuel. This weight

was achieved by incorporating many of the previously discussed lightweight technologies.

The main instrumentation on Clementine consists of four cameras, one with a laser-ranging system. The cameras include an ultraviolet-visual (UV-VIS) camera, a long-wave infrared (LWIR) camera, the laser-ranger (LIDAR) high-resolution (HiRes) camera, and a near-infrared (NIR) camera. The spacecraft also has two star tracker cameras, used mainly for attitude determination, but they also serve as wide-field cameras for various scientific and operational purposes. The sensor package has a mass of 8 kg and represents the state-of-the-art at the initiation of the Clementine program. The sensors are all located on one side, 90 degrees away from the solar panels. Clementine has 12 small attitude control jets that were used to orient the spacecraft to point the cameras to desired targets. The attitude control system includes the two star tracker cameras and two lightweight inertial measurement units, based on a ring laser gyro and an interferometric fiber optic gyro. During initial deployment at low-earth-orbit, the full size spacecraft was 3-axis stabilized. The spacecraft was 3-axis stabilized in lunar orbit via reaction wheels, with a precision of 0.05 Deg. in control and 0.03 in knowledge.

The spacecraft data processing was performed by 3 computing systems. A MIL-STD-1750A computer with a capacity of 1.7 million instructions per second was used for save mode, attitude control system, and housekeeping operations. A reduced instruction set computer (RISC) 32-bit processor with 18 million instructions per second was used for image processing and autonomous operations. The Clementine mission represents the first long duration flight of a 32 bit RISC processor. Also incorporated is a state-of-the-art image compression system provided by the French Space Agency CNES. A data handling unit with its own microcontroller sequenced the cameras, operated the image compression system, and directed the data flow. During imaging operations, the data were stored in a 3 kg, 2 Gbit dynamic solid state data recorder and later transferred to the ground stations using a 128 kb/s downlink. The spacecraft was commanded from the ground using a 1 kb/s uplink from the NASA Deep Space Network and DOD stations. Demonstration of autonomous navigation including autonomous orbit determination was a major goal of the Clementine mission. Autonomous operations were conducted in lunar orbit.

2. Clementine EDR Image Archive

The Clementine EDR (Engineering Data Record) Image Archive will contain approximately 100 CD-ROM volumes for distribution to the science community. Each volume will contain approximately 3 lunar orbits but may vary in the number of orbits depending on the size of each orbit. The first volume in the series begins with orbit 32--the start of the lunar mapping phase of the mission. The Low Earth orbit, and earth phasing loop image data will be generated on the volumes at the end of the volume series.

Additional documentation exists on the CD-ROM volume series that describe the organization and content of the Clementine EDR Image Archive. Please see the EDRSIS and ARCSIS documents located in the <document> directory. The EDRSIS document provides a detailed description of the format of the image files that are contained in the archive. The ARCSIS document describes the organization of the volumes.

3. Mission Time Line

Clementine was launched on January 25, 1994 from Vandenburg Air Force Base aboard a Titan IIG rocket. After two Earth flybys, lunar insertion was achieved on February 19-th. Lunar mapping took place over approximately 2 months in two systematic mapping passes over the Moon (See Lunar Orbital Dynamics section for more details on systematic mapping and Appendix I showing a table of the Lunar orbit time lines.) Table 1 provides a synopsis of the mission time line.

After successfully completing the Lunar mapping phase of the mission, Clementine suffered an on-board malfunction at 9:39 AM EST, Saturday, May 7, 1994. The result of the malfunction prevented Clementine from performing the planned close flyby of the near-Earth asteroid Geographos scheduled for August 1994. Preliminary analysis traced the cause of the malfunction to the on-board computer which controls most of the satellite's systems including the attitude control thrusters. The computer activated several thrusters during a 20 minute telemetry interrupt with the ground station, thus depleting all the fuel in the Attitude Control System (ACS) tanks. With the depletion of the ACS tanks, the spacecraft was left spinning at 80 revolutions per minute with no remaining fuel left to despin the spacecraft.

Table 1 - Mission Time line Summary

3/24/1992	-	Clementine Design Begins
1/25/1994	-	Spacecraft launched at Vandenburg Air Force Base
2/ 3/1994	-	Departure from low Earth orbit following an eight day checkout period
2/19/1994	-	Following two phasing loop orbits, Clementine injected into lunar orbit. Lunar orbit shake down period begins.
2/26/1994	-	Start of systematic mapping for first cycle.
3/26/1994	-	First mapping cycle complete, start of second cycle
4/21/1994	-	Second mapping cycle complete, begin special observations.
5/ 5/1994	-	Leave Lunar Orbit
5/ 7/1994	-	Clementine satellite suffered on-board malfunction that prevents planned close fly-by of the near-Earth asteroid Geographos
8/31/1994	-	Planned Geographos Fly-by (not accomplished)

4. The Scientific Payload

UV-Visible Camera: The UV-Visible camera has a catadioptic telescope using fused silica lenses focusing onto a metachrome-coated CCD imager. Active wavelength response is limited on the short wavelength end by the transmission of fused silica and the optical blur of the lens. Wavelength response on the long end is limited by the response of the CCD. Six spectral bands can be selected from a filter wheel which is controlled through the same serial-addressable synchronous interface (SASI).

The Thomson focal plane array (FPA) used is a frame-transfer device, accomplishing electronic shuttering by rapidly shifting the active pixel area into the storage area, pausing for the (13-bit programmable) integration time, then rapidly shifting the captured image into a storage buffer from which the image is read out. Post-FPA electronics allow three gain states followed by 5 bits of offset that span 248

counts in the analog regime to augment the basic 8-bit A/D conversion. Gain is A/D digitization noise limited, so proper exposure is critical. Working against the day side of the Moon as a target, typical integration times were as short as several milliseconds in the lowest gain state (1000 electrons/bit) near sub-solar illumination points at the brighter spectral bands, increasing to 40 msec near the polar regions in the mid-gain setting for the weaker 415 and 1000 nm spectral bands. The UV-Visible Performance specifications are shown in Table 2.

Wide Field of View Star Trackers: The star tracker cameras have a concentric optics design with a fiber optic field flattener to couple the image surface to a CCD array. The CCD is kept cleared by continuously shifting lines and reading out pixels at the 5 MHz base rate, which is approximately 100 microseconds per line. Integration is accomplished by stopping this clearing process for the specific time (13-bit programmable), then proceeding with a second line-shifting operation into a readout buffer line and completing readout at 5 MHz. Camera electronics are identical to those of the UV-VIS camera, with the gain circuit resistors selected to be slightly more sensitive.

The primary function of the star tracker cameras was to provide stellar images that were processed against an onboard star catalog to find pointing, thus establishing absolute angular references for navigation. The scientific uses of the cameras were secondary. Only broad band operation was available. Owing to the line-transfer electronic shuttering, imaging was limited to dim targets such as the lunar surface illuminated by earth shine. System noise is about 1.0 bits rms at the highest sensitivity setting. The star tracker camera performance specifications are provided in Table 3.

High Resolution Imaging (HiRes) camera: The HiRes camera combines a lightweight beryllium telescope with an image intensifier-coupled frame transfer CCD imager. Image shuttering is accomplished through voltage gating of the image intensifier. Maximum integration time is 733 milliseconds in 10.67 microsecond increments. Spectral response is limited in the system by the S-2 photocathode between 0.4 and 0.8 microns. Five spectral bands can be selected from a filter wheel which is controlled through the same SASI interface. A sixth filter position is allocated to an opaque filter for the image intensifier's protection.

The post-FPA electronics circuitry is identical to that used in the UV-VIS camera. Images of the day side of the moon used intensifier gate times with relatively low gain settings on the order of 1 millisecond. Lifetime concerns about the photocathode and micro channel plates in the intensifier unit drove operational settings to low exposures. This resulted in photon shot noise significantly contributing to the overall noise in the HiRes sensor. The HiRes performance specifications are provided in Table 4.

Laser Rangefinder (LIDAR): The LIDAR unit shares the telescope of the HiRes camera, splitting the 1064 nm return signal from the NdYag source off to an avalanche photodiode (APD) detector with dichroic filter. The optics are non-imaging, providing an exit pupil through simple relay optics at the APD. The APD electronics includes a temperature compensation feature for the APD bias voltage and programmable thresholding of the output signal. The APD current is amplified and inverted to a voltage by a transimpedance amplifier with a gain of 230X, a low frequency cutoff of 3 MHz, and a high frequency cutoff of 23 MHz. The APD current is amplified, then discriminated for changes (increase) through 14 MHz discriminator. Voltage changes exceeding the programmed threshold are flagged as returns.

Range value is determined by the clock cycles since a laser output sampled start pulse is received. The clock counter has only 14 bits owing to the hardware availability limitations. In order to allow returns up to the 640 km maximum range required in the lunar mission, returns from the discriminator are binned 4 to a clock count, turning the 23 MHz response into a 40 meter height bin. Internal memory in the LIDAR unit saves up to 6 "returns" per laser firing, with up to 4 saved between programmable search range minimum/maximum values. Threshold is set for the best compromise between missed detection and false alarms. The LIDAR components are summarized in Table 5.

Near Infrared Camera (NIR): The NIR camera uses a catadioptric lens with a 256x256 indium antimonide (InSb) FPA mechanically cooled to cryogenic temperature. The FPA operated at 70 plus-or-minus 0.5 K at the Moon and showed excellent stability over the more than 500 hours of operation in space. The lens design features all ZnSe refractive elements with a relay to provide an external pupil for 100% efficient cold shielding. This lens design was chosen for image quality and focus stability. Wavelength range was constrained by the optics and the InSb response to somewhat less that 1.0 to 5.5 microns. Six wavebands were selected by the NASA advisory committee, all falling well inside this range.

Camera electronic programmable variables allow 4 integration times, 5 bits of gain, and 8 bits of offset. Gain states are spaced approximately evenly from 0.5 to 36 factors of voltage multiplication. Offset is subtracted before gain is applied with 0 V to full well range that can be set in 1/255 full well increments. The NIR camera performance specifications are shown in Table 6.

Longwave Infrared Camera (LWIR): The LWIR camera uses a catadioptric lens with a 128 x 128 mercury cadmium telluride (HCT) FPA. The FPA was mechanically cooled to cryogenic temperatures during operation with a temperature set point goal of 65 K. The optics design incorporates an internal relay with 100% cold shield efficiency. Wavelength ranges was controlled by the cold filter to 8.0 to 9.5 microns.

Camera electronic design is virtually identical to the NIR camera, with a minor alteration in line readout to compensate for the difference in column count between the two arrays (256 for the NIR, 128 for the LWIR). The NIR and LWIR cameras also share a common cryocooler and dewar design, with minor modifications made to accommodate cold shield and cold filter differences. The LWIR Performance Specifications are shown in Table 7.

Table 2 UV/Visible Performance Specifications

Focal Plane Array:	
Type	Si Charge Coupled Device Thomson TH7863-CRU-UV
Pixel format	288x384
Pixel size	23x23 microns
Readout rate	4MHz
Optics:	
Clear aperture	46nm
Speed	F/1.96
Imaging:	
Wavelength	0.3 to 1.1 microns
Field of view	4.2 deg. x 5.6 deg.
Pixel IFOV	255 microradians
Point spread	1.1 to 1.5 pixels
Filters	415nm cw (plus-or-minus 20 nm bw) 750nm (plus-or-minus 5) 900nm (plus-or-minus 10) 950nm (plus-or-minus 15) 1000nm (plus-or-minus 15) 400 to 950 broad band
Camera Electronics:	
A/D resolution	8 bits
Frame rate	10 Hz
Readout time	27.4 ms
Integration time	0.2-733 ms
Digitization gain	150,350,1000 electrons/count
Offset control	248 gray levels
Power	4.5 W
Mechanical:	
Mass	410 grams
Envelope	15.5cm x 11.7 cm x 10.4 cm
Common Module Filter Wheel System:	
Type	6 position, 90 deg. stepper motor driven, Hall effect position sensors
Step and Settle time	< 250ms
Position repeatability	< 10mr
Power	0.15 W quiescent, 11.0 W stepping

Table 3 Star Tracker Performance Specifications

Focal Plane Array:	
Type	Si Charge Coupled Device Thomson TH7863
Pixel format	576x384
Pixel size	23x23 microns
Readout rate	5MHz
Optics:	
Clear aperture	14nm
Speed	F/1.3
Imaging:	
Wavelength	0.5 to 1.1 microns
Field of view	43 deg. x 28 deg.
Pixel IFOV	1.3 microradians
Point spread	2 pixels
Camera Electronics:	
A/D resolution	8 bits
Readout time	54.8 ms
Integration time	0.2-733 ms
Digitization gain	75, 150, 350 electrons/count
Offset control	248 gray levels
Power	4.5 W
Mechanical:	
Mass	290 grams
Envelope	11.7 cm x 11.7 cm x 13.2 cm

Table 4 HiRes Imaging Receiver Performance Specifications

Focal Plane Array:
See UV/Visible specifications in Table 1, except arrays are not UV enhanced.

Optics:

Clear aperture	131 nm
Speed	F/9.5

Imaging:

Wavelength	0.4 to 0.8 microns
Field of view	0.4 deg. x 0.3 deg.
Pixel IFOV	18 microradians
Point spread	4 pixels
Filters	415 nm cw (plus-or-minus 20 nm bw)
	560 nm cw (plus-or-minus 5)
	650 nm cw (plus-or-minus 5)
	750 nm cw (plus-or-minus 10)
	400 to 800 nm broad band

Image intensifier:

Image intensifier module	General Atomics 0131-Z12-2-009
Useful photocathode diameter	12 mm
Luminous gain	1000 fL/fC
Limiting resolution	40 lp/mm
Gain control	8 bits

Camera Electronics:
See UV/Visible specifications in Table 1

Power	9.5 W

Mechanical:

Mass	1120 grams
Envelope	17.0 cm x 18.1 cm x 36.4 cm

Table 5 LIDAR Components

Detector:

Type	Si APD C30954E, 0.4 to 1.1 micron
Pixel format	single APD
Pixel size	0.5 mm2
Pixel FOV	1.0 mrad diameter
APD gain	100 X nominal
Transimpedance amplifier	230 X gain; 3 MHz to 23 MHz response

Optics:

Shared path wit HiRes Camera. Dichroic beamsplitter. Exit pupil matched to APD. Mass and envelope included in HiRes description.

Camera Electronics:

Range Resolution	40 meter
Detection	signal derivative
Detection criteria	programmable threshold (8 bits)

Laser Transmitter:

Wavelengths	532 nm/1064 nm
Pulse energy	171 mJ @ 1064, 9 mJ @ 532 nm
Pulse width	< 10ns
Beam divergence	< 500 mrad @ 064 nm, 4 mrad @ 532 nm
Shot profile	Continuous @ 1 Hz, 400 shots @ 8 Hz

Laser Transmitter Optics:

Type	5X Galilean-type telescope
Clear Aperture	38 mm exit diameter
Start pulse detector	Analog Modules, Inc. Model 754
Pockels cell driver	Analog Modules, Inc. Model 824
Laser diode heater	Minco Kapton film resistance type; 16C to 18C
Power	6.8 W at 1 Hz; 2.6 W quiescent

Laser Transmitter Mechanical:

Mass	635 grams laser head; 615 grams power supply
Envelope	13.3 cm x 15.2 cm x 3.9 cm high (power supply)

Table 6 NIR Performance Specifications

Focal Plane Array:

Type	Amber PV InSb
Pixel format	256x256
Pixel size	38x38 microns
Non-operable pixels	< 0.5%
FPA operating temp.	70 K
FPA well capacity	11.7 million electrons

Optics:

Clear aperture	29nm
Effective focal length	96 mm
Cold stop	F/3.33, 6.0 mm diameter
Cold shield efficiency	100%

Imaging:

Field of view	5.6 deg. x 5.6 deg.
Pixel IFOV	400 x 400 microrad
Point spread	> 50% energy in 30 micrometer slit
Filters	1100 nm (plus-or-minus 30 nm)
	1250 nm (plus-or-minus 30 nm)
	1500 nm (plus-or-minus 30 nm)
	2000 nm (plus-or-minus 30 nm)
	2600 nm (plus-or-minus 30 nm)
	2690 nm (plus-or-minus 60 nm)

Camera Electronics:

A/D resolution	8 bits
Frame rate	7.1 Hz (single frame mode)
Integration times	11, 33, 57, and 95 ms
Digitization gain	0.5 to 36 X voltage multiplication
Offset control	8 bits
Power	13.0 W

Cryocooler:

Type	Ricor K506B integral Stirling with H-10 FPA temperature closed-loop control electronics
Avg. power	11.0 W steady-state

Mechanical:

Mass	1920 grams
Envelope	10.4 cm x 11.5 cm x 36.5 cm long

Table 7 LWIR Performance Specifications

Focal Plane Array:

Type	Amber PV HgCdTe
Pixel format	128x128
Pixel size	50x50 microns
Non-operable pixels	< 5%
FPA operating temp.	65 K nominal
FPA well capacity	42 million electrons

Optics:

Equivalent clear aperture	29nm
Effective focal length	96 mm
Cold stop	F/2.67, 7.47 mm diameter
Cold shield efficiency	100%

Imaging:

Field of view	1 deg. x 1 deg.
Pixel IFOV	143 x 143 microrad
Point spread	> 60% energy in 79 micrometer slit

Camera Electronics:

A/D resolution	8 bits
Frame rate	52.9 Hz (single frame mode)
Pixel rate	500kHz
Integration times	0.115, 0.92, 2.30, and 4.60 ms
Digitization gain	0.5 to 36 X voltage multiplication
Offset control	8 bits
Power	13.0 W

Cryocooler:

See NIR cryocooler specifications in Table 5.

Mechanical:

Mass	2100 grams
Envelope	14.7 cm diameter x 36.1 cm long

Preflight Calibration: Extensive pre-flight calibration data were acquired using an automated calibration facility at LLNL. In a typical calibration configuration, a sensor was mounted inside an environmental chamber whose temperature was set from -20 to 20 deg. C which were the expected operating temperatures for the mission. Depending on the measurement types, the sensors saw either a flat diffused light source or an off-axis collimator with various pinholes as the point source. A custom board controlled the sensor parameters from the host computers; the video signal was acquired using a commercial image processor. During data acquisition many thermal parameters such as FPA and chamber temperatures were monitored and recorded as part of the image structure. All calibration processes were fully automated enabling rapid data acquisition and minimization of operator error. Pre-flight calibration attempted to cover similar light levels expected from the lunar surface and spanning the same camera settings required for the lunar mapping phase.

The pre-flight calibration measurements included radiometric sensitivity; FPA uniformity; gain and offset scale factors; temporal/spatial noise; dark noise dependence on FPA temperatures, integration times or input voltage levels, spectral response of FPA; optical distortion map; point spread function; electronic warm-up time and cryocooler cool down time. For the thermally sensitive sensors such as LWIR camera, the noise measurement was performed using a vacuum chamber to simulate the space thermal environment.

Many pre-flight calibration coefficients were applied to lunar data showing reasonable agreement with expected performance. In-flight calibration data will allow minor corrections for vacuum flight condition and sensor degradation over mission lifetime to be added to the pre-flight calibration results. The final calibration is expected to be better than 5%.

Data Compression: Data compression was done onboard using the CNES compression chip. The processing was performed on a completed, framed image prior to storage on the solid state data recorder (SSDR) when the appropriate compression flag is set.

The compression chip developed by MATRA under CNES specifications is used in two modes, which could be selected via a software uplink command. The first mode optimized rms error for a nominal compression. The second (JPEG) provided visual optimization at a fixed compression rate. In the first mode, blocks of 8x8 pixel 8-bit data are transformed to a best fit cosine series expansion in the orthogonal row and column directions. This algorithm tends to preserve high frequency information with less data loss than does JPEG at the same compression ratio for the lunar data. Total signal from the 8x8 block is preserved exactly. The nominal amount of compression was set by limiting the scene error induced by compression to a fraction of the camera's temporal noises. Analysis of lunar images during the first part of the mission showed that the quantization matrix used by the chip was optimum for the imaging cameras. The HiRes camera, however, was operated in JPEG mode. The high frequency information in the HiRes scenes was spurious (it was caused by gain non-uniformity of the intensifier tube); eliminating high frequency content allowed higher compression without harming the information content of the scenes. The average compression rate for all images obtained during the mission was 5.5.

5. Lunar Orbital Dynamics

Based on the characteristics of the baseline sensor complement, the mapping of 100% of the lunar surface was done in two lunar days (two Earth months). During the nominal two month mapping mission, the required image overlap for the UV/VIS and NIR cameras was ~15% in the down track and ~10% in the cross track directions. This required that the periselene of the lunar orbit be maintained at an altitude of 425 plus-or-minus 25 km. In order to image 100% percent of the moon's surface during the two months, the spacecraft was required to be in a polar orbit. This requirement was satisfied with the inclination of the orbit at 90 degrees plus-or-minus 1 degree with reference to the lunar equator. To provide the necessary separation for the alternating imaging strips to cover the entire surface of the moon during the two months, the orbital period was approximately 5 hours. During this orbital period the moon rotated approximately 2.7 degrees beneath the spacecraft. The orbit also was a sufficiently long period to allow the transmission to Earth of data collected during the imaging phase of each orbit.

During the lunar mapping phase of the mission, there were four separate observational periods. The first, orbits 1-31, was a shakedown and testing period where the spacecraft observation sequences were tested and refined. Observations of special targets, such as Apollo landing sites, were additionally acquired during this period. The second period, orbits 32-168, was the first month's systematic mapping with periselene in the southern hemisphere. The third period, orbits 169-297, was the second month's systematic mapping with periselene at the northern hemisphere. In the fourth period, orbits 298-348, periselene remained in the northern hemisphere. In this period, observations were made to cover gaps in coverage, acquire observations of special targets, acquire stereo observations over Orientale Basin, and obtain calibration data. Clementine left lunar orbit soon after orbit 348.

The best data for lunar mineral mapping is obtained if the solar phase angle is less than 30 degrees. The solar phase angle is defined as the angle between the vector to the Sun and the vector to the spacecraft from a point on the Moon's surface. To maximize the time period in which the solar phase angle is within 30 degrees, the plane of the lunar orbit should contain the Moon-Sun line half way through the two-month lunar mapping period. Therefore, insertion into the lunar orbit was selected so that, as the Moon-Sun line changes with Earth's motion about the Sun, the Moon-Sun line will initially close on the orbital plane, and then lie in the orbital plane half-way through the mapping mission. The angle between the Moon-Sun line and the orbital plane was close for approximately five weeks before becoming zero. Table 8 contains a list of Clementine's orbital parameters

Table 8 Clementine Orbital Parameters

Orbital Period:	4.970 hr < P < 5.003 hr
Radius of Periselene:	2138 km < radius < 2188 km
Eccentricity:	0.35821 < e < 0.37567
Right Ascension:	-3 deg < Omega <+3 deg (J2000)
Inclination:	89 deg < i < 91 deg
Periselene:	-28.4 deg < w < -27.9 deg (1st month)
	29.6 deg < w < 29.2 deg (2nd month)

Orbit determination and monitoring was done on a continuous basis throughout the lunar pre-mapping phase. The gravitational potential

field of the moon has not been fully mapped, and large lunar mass concentrations may have had a significant perturbation effect on the orbit. Maintenance burns were required to maintain the orbit within the required envelope. The number of these burns was minimized to avoid unnecessary disruptions to the systematic mapping. To this end, any required periapsis burns were performed away from periselene in the direction of the near pole.

Attitude measurement accuracy was necessary to determine spacecraft pointing to within 0.03 degree, 0.5 milliradians. This accuracy was achieved in real-time, in darkness or sunlight throughout the lunar mapping phase. The spacecraft was three-axis stabilized and capable of autonomous, open loop inertial pointing with an accuracy of 0.05 degree, 0.87 milliradian, or better. This accuracy was required to support use of the high resolution camera because of its narrow field of view for imaging selected target sites during the lunar mapping mission.

The spacecraft was able to execute controlled, relative pointing motion about a pointing vector for scanning across targets. The relative pointing was capable of controlled motion of 75 microradians.

During lunar imaging, the spacecraft had to maintain a NADIR pointing attitude. This required a greater than 180 degree rotation over the approximately 1.5-2.0 hour period during each lunar orbit. The spacecraft was also required to maintain an angular bias about the X-axis from NADIR to permit an imaging groundtrack parallel but offset from the NADIR groundtrack.

The spacecraft was required to point to the Earth center, and to a specified tracking station site on the Earth, for the dumping of data using the high-gain directional antenna.

To help accomplish attitude determination, the spacecraft had two inertial measurement units (IMU) and two star trackers. Because of a solar exclusion angle constraint, one of the two star trackers had to be covered during lunar orbit. To meet the aforementioned pointing requirements, during lunar orbit a star tracker image was processed and the spacecraft attitude knowledge was updated at 10 second intervals or less.

6. Initial Scientific Results

Over the course of 71 days in lunar orbit, Clementine systematically mapped the 38 million square kilometers of the Moon in eleven colors in the visible and near infrared parts of the spectrum (nearly 1,000,000 images). In addition, the spacecraft took 620,000 high resolution and about 320,000 mid-infrared thermal images, mapped the topography of the moon with a laser ranging experiment, improved our knowledge of the surface gravity field of the Moon through radio tracking, and carried a charged particle telescope to characterize the solar and magnetospheric energetic particle environment. All sensors on the spacecraft met or exceeded expectations of their performance. The first global color view of the Moon was acquired, major compositional provinces were identified, and geology and composition details were mapped.

The images from Clementine constitute the first color global digital data set of the Moon. The NASA Science Team advised the project on the selection of color filters for the two principal mapping cameras: the UV/Visible camera and the NIR camera. The color of the Moon in the

visible to near-infrared part of the spectrum is sensitive to variations in both the composition of the surface material and the amount of time material has been exposed to space. The Clementine filters were selected to characterize the broad lunar continuum and to sample parts of the spectrum that are known to contain absorption bands diagnostic of iron-bearing minerals and plagioclase feldspar, the dominant mineral constituents of the lunar crust. By combining information obtained through several filters, multispectral image data are being used to map the distribution of rock and soil types on the Moon.

Clementine was successful in systematically mapping the Moon in these 11 colors at an average surface resolution of about 200 meters per pixel. The initial examination of the data attests to its excellent quality.

APPENDIX I – Lunar Orbit Time Line

The table shown below provides a timeline for each Clementine lunar orbit. The table shows the orbit number (ORB), Day of Year (DOY), Date, UTC, Longitude of orbit at the equator (LONG), and altitude at periapsis (ALT).

ORB	DOY	DATE	UTC	LONG	ALT
1	50	02/19/94	20:25:0	103.5	401.8
2	51	02/20/94	04:19:2	99.2	402.2
3	51	02/20/94	12:13:3	94.8	402.3
4	51	02/20/94	20:04:4	90.5	401.6
5	52	02/21/94	03:56:0	86.2	401.5
6	52	02/21/94	11:47:1	81.9	401.5
7	52	02/21/94	16:46:0	79.2	396.6
8	52	02/21/94	21:44:5	76.4	396.6
9	53	02/22/94	02:43:4	73.7	396.6
10	53	02/22/94	07:42:4	71.0	396.6
11	53	02/22/94	12:41:3	68.2	382.5
12	53	02/22/94	17:39:5	65.5	382.6
13	53	02/22/94	22:38:2	62.8	382.7
14	54	02/23/94	03:36:4	60.0	382.9
15	54	02/23/94	08:35:0	57.3	383.2
16	54	02/23/94	13:33:3	54.6	383.6
17	54	02/23/94	18:31:5	51.8	384.0
18	54	02/23/94	23:30:2	49.1	384.5
19	55	02/24/94	04:28:4	46.3	385.1
20	55	02/24/94	09:27:0	43.6	385.8
21	55	02/24/94	14:25:3	40.9	386.5
22	55	02/24/94	19:23:5	38.1	387.4
23	56	02/25/94	00:22:2	35.4	388.4
24	56	02/25/94	05:20:4	32.7	389.5
25	56	02/25/94	10:19:1	29.9	390.7
26	56	02/25/94	15:17:3	27.2	391.9
27	56	02/25/94	20:15:5	24.5	393.3
28	57	02/26/94	01:14:2	21.7	394.8
29	57	02/26/94	06:12:4	19.0	396.3
30	57	02/26/94	11:11:1	16.3	398.0
31	57	02/26/94	16:09:3	13.5	399.7
START OF SYSTEMATIC MAPPING					
32	57	02/26/94	21:08:0	10.8	401.5
33	58	02/27/94	02:06:2	8.1	403.2
34	58	02/27/94	07:04:5	5.3	405.1
35	58	02/27/94	12:03:1	2.6	406.9
36	58	02/27/94	17:01:4	359.9	408.7
37	58	02/27/94	22:00:0	357.2	410.5
38	59	02/28/94	02:58:3	354.4	412.3
39	59	02/28/94	07:57:0	351.7	414.1
40	59	02/28/94	12:55:2	349.0	415.8
41	59	02/28/94	17:53:5	346.2	417.5
42	59	02/28/94	22:52:1	343.5	419.2
43	60	03/01/94	03:50:4	340.8	420.8
44	60	03/01/94	08:49:0	338.1	422.3
45	60	03/01/94	13:47:3	335.3	423.7
46	60	03/01/94	18:45:5	332.6	425.0

47	60	03/01/94	23:44:2	329.9	426.3
48	61	03/02/94	04:42:4	327.2	427.4
49	61	03/02/94	09:41:1	324.4	428.4
50	61	03/02/94	14:39:3	321.7	429.4
51	61	03/02/94	19:37:5	319.0	430.2
52	62	03/03/94	00:36:2	316.2	430.9
53	62	03/03/94	05:34:4	313.5	431.5
54	62	03/03/94	10:33:1	310.8	432.0
55	62	03/03/94	15:31:3	308.1	432.4
56	62	03/03/94	20:30:0	305.3	432.8
57	63	03/04/94	01:28:2	302.6	433.0
58	63	03/04/94	06:26:4	299.9	433.2
59	63	03/04/94	11:25:1	297.2	433.3
60	63	03/04/94	16:23:3	294.4	433.4
61	63	03/04/94	21:21:5	291.7	433.4
62	64	03/05/94	02:20:2	289.0	433.4
63	64	03/05/94	07:18:4	286.2	433.3
64	64	03/05/94	12:17:0	283.5	433.3
65	64	03/05/94	17:15:3	280.8	433.2
66	64	03/05/94	22:13:5	278.1	433.1
67	65	03/06/94	03:12:1	275.3	433.0
68	65	03/06/94	08:10:4	272.6	432.9
69	65	03/06/94	13:09:0	269.9	432.8
70	65	03/06/94	18:07:2	267.2	432.8
71	65	03/06/94	23:05:5	264.4	432.7
72	66	03/07/94	04:04:1	261.7	432.7
73	66	03/07/94	09:02:4	259.0	432.8
74	66	03/07/94	14:01:0	256.2	432.9
75	66	03/07/94	18:59:2	253.5	433.0
76	66	03/07/94	23:57:5	250.8	433.2
77	67	03/08/94	04:56:1	248.1	433.4
78	67	03/08/94	09:54:4	245.3	433.8
79	67	03/08/94	14:53:0	242.6	434.1
80	67	03/08/94	19:51:3	239.9	434.6
81	68	03/09/94	00:49:5	237.2	435.1
82	68	03/09/94	05:48:1	234.4	435.6
83	68	03/09/94	10:46:4	231.7	436.3
84	68	03/09/94	15:45:0	229.0	437.0
85	68	03/09/94	20:43:3	226.3	437.7
86	69	03/10/94	01:41:5	223.5	438.6
87	69	03/10/94	06:40:2	220.8	439.5
88	69	03/10/94	11:38:4	218.1	440.4
89	69	03/10/94	16:37:1	215.3	441.5
90	69	03/10/94	21:35:3	212.6	442.6
91	70	03/11/94	02:34:0	209.9	443.7
92	70	03/11/94	07:32:2	207.1	444.9
93	70	03/11/94	12:30:5	204.4	446.1
94	70	03/11/94	17:32:1	201.7	401.4
95	70	03/11/94	22:30:3	198.9	402.7
96	71	03/12/94	03:29:0	196.2	404.0
97	71	03/12/94	08:27:2	193.5	405.3
98	71	03/12/94	13:25:4	190.7	406.7
99	71	03/12/94	18:24:0	188.0	408.0
100	71	03/12/94	23:22:3	185.3	409.3
101	72	03/13/94	04:20:5	182.5	410.6
102	72	03/13/94	09:19:1	179.8	411.8
103	72	03/13/94	14:17:4	177.1	413.1
104	72	03/13/94	19:16:0	174.3	414.3
105	73	03/14/94	00:14:2	171.6	415.5
106	73	03/14/94	05:12:5	168.9	416.7
107	73	03/14/94	10:11:1	166.1	417.8

108	73	03/14/94	15:09:3	163.4	418.9
109	73	03/14/94	20:07:5	160.7	420.0
110	74	03/15/94	01:06:2	157.9	421.0
111	74	03/15/94	06:04:4	155.2	422.0
112	74	03/15/94	11:03:0	152.5	422.9
113	74	03/15/94	16:01:3	149.7	423.8
114	74	03/15/94	20:59:5	147.0	424.7
115	75	03/16/94	01:58:1	144.3	425.5
116	75	03/16/94	06:56:3	141.6	426.3
117	75	03/16/94	11:55:0	138.8	427.0
118	75	03/16/94	16:53:2	136.1	427.7
119	75	03/16/94	21:51:4	133.4	428.3
120	76	03/17/94	02:50:0	130.6	428.9
121	76	03/17/94	07:48:2	127.9	429.4
122	76	03/17/94	12:46:5	125.2	429.8
123	76	03/17/94	17:45:1	122.5	430.2
124	76	03/17/94	22:43:3	119.7	430.6
125	77	03/18/94	03:41:5	117.0	430.9
126	77	03/18/94	08:40:1	114.3	431.1
127	77	03/18/94	13:38:4	111.5	431.3
128	77	03/18/94	18:37:0	108.8	431.4
129	77	03/18/94	23:35:2	106.1	431.5
130	78	03/19/94	04:33:4	103.4	431.6
131	78	03/19/94	09:32:0	100.6	431.6
132	78	03/19/94	14:30:3	97.9	431.6
133	78	03/19/94	19:28:5	95.2	431.5
134	79	03/20/94	00:27:1	92.4	431.5
135	79	03/20/94	05:25:3	89.7	431.4
136	79	03/20/94	10:23:5	87.0	431.3
137	79	03/20/94	15:22:1	84.3	431.3
138	79	03/20/94	20:20:3	81.5	431.2
139	80	03/21/94	01:19:0	78.8	431.1
140	80	03/21/94	06:17:2	76.1	431.1
141	80	03/21/94	11:15:4	73.3	431.0
142	80	03/21/94	16:14:0	70.6	431.0
143	80	03/21/94	21:12:2	67.9	431.1
144	81	03/22/94	02:10:4	65.1	431.2
145	81	03/22/94	07:09:0	62.4	431.3
146	81	03/22/94	12:07:3	59.7	431.5
147	81	03/22/94	17:05:5	56.9	431.7
148	81	03/22/94	22:04:1	54.2	432.0
149	82	03/23/94	03:02:3	51.5	432.4
150	82	03/23/94	08:00:5	48.7	432.8
151	82	03/23/94	12:59:1	46.0	433.4
152	82	03/23/94	17:57:3	43.3	434.0
153	82	03/23/94	22:56:0	40.5	434.7
154	83	03/24/94	03:54:2	37.8	435.5
155	83	03/24/94	08:52:4	35.1	436.4
156	83	03/24/94	13:51:0	32.3	437.4
157	83	03/24/94	18:49:2	29.6	438.5
158	83	03/24/94	23:47:5	26.9	439.8
159	84	03/25/94	04:46:1	24.1	441.1
160	84	03/25/94	09:44:3	21.4	442.5
161	84	03/25/94	14:42:5	18.7	444.0
162	84	03/25/94	19:41:2	15.9	445.6
163	85	03/26/94	00:39:4	13.2	447.2
164	85	03/26/94	06:36:5	11.3	1007.9
165	85	03/26/94	13:00:1	9.5	449.8
166	85	03/26/94	17:59:0	6.8	448.6
167	85	03/26/94	22:58:0	4.0	447.3
168	86	03/27/94	03:56:5	1.3	446.0

169	86	03/27/94	08:55:5	358.6	444.7
170	86	03/27/94	13:54:5	355.8	443.3
171	86	03/27/94	18:53:4	353.2	447.8
172	86	03/27/94	23:52:1	350.4	446.4
173	86	03/28/94	04:50:4	347.7	445.1
174	87	03/28/94	09:49:1	345.0	443.8
175	87	03/28/94	14:47:4	342.2	442.5
176	87	03/28/94	19:46:1	339.5	441.3
177	87	03/29/94	00:44:3	336.8	440.0
178	88	03/29/94	05:43:0	334.0	438.9
179	88	03/29/94	10:41:3	331.3	437.8
180	88	03/29/94	15:40:0	328.5	436.7
181	88	03/29/94	20:38:3	325.8	435.7
182	88	03/30/94	01:36:5	323.1	434.8
183	89	03/30/94	06:35:2	320.3	434.0
184	89	03/30/94	11:33:5	317.6	433.2
185	89	03/30/94	16:32:1	314.8	432.5
186	89	03/30/94	21:30:4	312.1	431.9
187	89	03/31/94	02:29:1	309.4	431.3
188	90	03/31/94	07:27:4	306.6	430.8
189	90	03/31/94	12:26:0	303.9	430.4
190	90	03/31/94	17:24:3	301.1	430.1
191	90	03/31/94	22:22:5	298.4	429.8
192	90	04/01/94	03:21:2	295.7	429.5
193	91	04/01/94	08:19:5	292.9	429.3
194	91	04/01/94	13:18:1	290.2	429.2
195	91	04/01/94	18:16:4	287.5	429.0
196	91	04/01/94	23:15:0	284.7	428.9
197	91	04/02/94	04:13:3	282.0	428.8
198	92	04/02/94	09:11:5	279.3	428.8
199	92	04/02/94	14:10:2	276.5	428.7
200	92	04/02/94	19:08:5	273.8	428.7
201	92	04/03/94	00:07:1	271.1	428.6
202	93	04/03/94	05:05:4	268.4	428.6
203	93	04/03/94	10:04:0	265.6	428.5
204	93	04/03/94	15:02:3	262.9	428.4
205	93	04/03/94	20:01:0	260.2	428.3
206	93	04/04/94	00:59:2	257.5	428.1
207	94	04/04/94	05:57:5	254.7	428.0
208	94	04/04/94	10:56:2	252.0	427.7
209	94	04/04/94	15:54:4	249.3	427.5
210	94	04/04/94	20:53:1	246.6	427.2
211	94	04/05/94	01:51:4	243.8	426.9
212	95	04/05/94	06:50:0	241.1	426.6
213	95	04/05/94	11:48:3	238.4	426.2
214	95	04/05/94	16:47:0	235.7	425.8
215	95	04/05/94	21:45:2	232.9	425.4
216	95	04/06/94	02:43:5	230.2	425.0
217	96	04/06/94	07:42:2	227.5	424.5
218	96	04/06/94	12:40:5	224.8	424.0
219	96	04/06/94	17:39:1	222.0	423.4
220	96	04/06/94	22:37:4	219.3	422.8
221	96	04/07/94	03:36:1	216.6	422.2
222	97	04/07/94	08:34:4	213.9	421.5
223	97	04/07/94	13:33:0	211.1	420.8
224	97	04/07/94	18:31:3	208.4	420.1
225	97	04/07/94	23:30:0	205.7	419.4
226	97	04/08/94	04:28:3	203.0	418.6
227	98	04/08/94	09:26:5	200.2	417.9
228	98	04/08/94	14:25:2	197.5	417.0
229	98	04/08/94	19:23:5	194.8	416.2

230	98	04/09/94	00:22:2	192.1	415.4
231	99	04/09/94	05:20:5	189.3	414.6
232	99	04/09/94	10:19:1	186.6	413.7
233	99	04/09/94	15:17:4	183.9	412.8
234	99	04/09/94	20:16:1	181.1	412.0
235	99	04/10/94	01:14:4	178.4	411.1
236	100	04/10/94	06:13:1	175.7	410.3
237	100	04/10/94	11:11:4	172.9	409.4
238	100	04/10/94	16:10:0	170.2	408.6
239	100	04/10/94	21:08:3	167.5	407.7
240	100	04/11/94	02:07:0	164.7	406.9
241	101	04/11/94	07:05:3	162.0	427.7
242	101	04/11/94	12:04:0	159.3	426.9
243	101	04/11/94	17:02:3	156.5	426.1
244	101	04/11/94	22:01:0	153.8	425.2
245	101	04/12/94	02:59:3	151.1	424.4
246	102	04/12/94	07:58:0	148.3	423.6
247	102	04/12/94	12:56:3	145.6	422.8
248	102	04/12/94	17:55:0	142.9	422.0
249	102	04/12/94	22:53:3	140.1	421.3
250	102	04/13/94	03:52:0	137.4	420.5
251	103	04/13/94	08:50:3	134.7	419.9
252	103	04/13/94	13:49:0	131.9	419.2
253	103	04/13/94	18:47:2	129.2	418.6
254	103	04/13/94	23:45:5	126.5	418.1
255	103	04/14/94	04:44:2	123.7	417.5
256	104	04/14/94	09:42:5	121.0	417.1
257	104	04/14/94	14:41:2	118.3	416.6
258	104	04/14/94	19:39:5	115.5	416.3
259	105	04/15/94	00:38:1	112.8	415.9
260	105	04/15/94	05:36:4	110.1	415.6
261	105	04/15/94	10:35:1	107.3	415.3
262	105	04/15/94	15:33:4	104.6	415.1
263	105	04/15/94	20:32:1	101.9	414.9
264	106	04/16/94	01:30:4	99.1	414.7
265	106	04/16/94	06:29:1	96.4	414.6
266	106	04/16/94	11:27:3	93.7	414.5
267	106	04/16/94	16:26:0	90.9	414.4
268	106	04/16/94	21:24:3	88.2	414.3
269	107	04/17/94	02:23:0	85.5	414.2
270	107	04/17/94	07:21:3	82.8	414.2
271	107	04/17/94	12:19:5	80.0	414.1
272	107	04/17/94	17:18:2	77.3	414.1
273	107	04/17/94	22:16:5	74.6	414.1
274	108	04/18/94	03:15:2	71.9	414.0
275	108	04/18/94	08:13:4	69.1	414.0
276	108	04/18/94	13:12:1	66.4	413.9
277	108	04/18/94	18:10:4	63.7	413.9
278	108	04/18/94	23:09:1	61.0	413.8
279	109	04/19/94	04:07:3	58.2	413.6
280	109	04/19/94	09:06:0	55.5	413.5
281	109	04/19/94	14:04:3	52.8	413.3
282	109	04/19/94	19:03:0	50.1	413.1
283	110	04/20/94	00:01:3	47.3	412.8
284	110	04/20/94	04:59:5	44.6	412.4
285	110	04/20/94	09:58:2	41.9	412.0
286	110	04/20/94	14:56:5	39.2	411.6
287	110	04/20/94	19:55:2	36.4	411.1
288	111	04/21/94	00:53:5	33.7	410.5
289	111	04/21/94	05:52:2	31.0	409.8
290	111	04/21/94	10:50:5	28.3	409.1

291	111	04/21/94	15:49:1	25.6	408.3
292	111	04/21/94	20:47:4	22.8	407.4
293	112	04/22/94	01:46:1	20.1	406.5
294	112	04/22/94	06:44:4	17.4	405.5
295	112	04/22/94	11:43:1	14.7	404.4
296	112	04/22/94	16:41:4	11.9	403.2
297	112	04/22/94	21:40:1	9.2	402.0

START OF POST-MAPPING ACTIVITIES

298	113	04/23/94	02:38:4	6.5	400.8
299	113	04/23/94	07:37:1	3.7	399.5
300	113	04/23/94	12:35:4	1.0	398.2
301	113	04/23/94	17:34:1	358.3	396.8
302	113	04/23/94	22:32:5	355.6	395.4
303	114	04/24/94	03:31:2	352.8	394.0
304	114	04/24/94	08:29:5	350.1	392.6
305	114	04/24/94	13:28:2	347.4	391.2
306	114	04/24/94	18:26:5	344.6	389.8
307	114	04/24/94	23:25:2	341.9	388.4
308	115	04/25/94	04:23:5	339.2	387.1
309	115	04/25/94	09:22:2	336.4	385.8
310	115	04/25/94	14:20:5	333.7	384.5
311	115	04/25/94	19:19:2	330.9	383.3
312	116	04/26/94	00:17:5	328.2	382.1
313	116	04/26/94	05:16:2	325.5	381.0
314	116	04/26/94	10:14:5	322.7	380.0
315	116	04/26/94	15:13:2	320.0	379.0
316	116	04/26/94	20:11:5	317.2	378.1
317	117	04/27/94	01:10:2	314.5	377.4
318	117	04/27/94	06:08:4	311.8	376.7
319	117	04/27/94	11:07:1	309.0	376.0
320	117	04/27/94	16:05:4	306.3	375.5
321	117	04/27/94	21:04:1	303.5	375.0
322	118	04/28/94	02:02:4	300.8	374.6
323	118	04/28/94	07:01:1	298.1	374.3
324	118	04/28/94	11:59:3	295.3	374.0
325	118	04/28/94	16:58:0	292.6	373.8
326	118	04/28/94	21:56:3	289.9	373.6
327	119	04/29/94	02:55:0	287.1	373.5
328	119	04/29/94	07:53:2	284.4	373.3
329	119	04/29/94	12:51:5	281.7	373.3
330	119	04/29/94	17:50:2	278.9	373.2
331	119	04/29/94	22:48:4	276.2	373.1
332	120	04/30/94	03:47:1	273.5	373.1
333	120	04/30/94	08:45:4	270.7	373.0
334	120	04/30/94	13:44:1	268.0	373.0
335	120	04/30/94	18:42:3	265.3	372.9
336	120	04/30/94	23:41:0	262.6	372.8
337	121	05/01/94	04:39:3	259.8	372.7
338	121	05/01/94	09:38:0	257.1	372.6
339	121	05/01/94	14:36:2	254.4	372.4
340	121	05/01/94	19:34:5	251.7	372.2
341	122	05/02/94	00:33:2	248.9	371.9
342	122	05/02/94	05:31:5	246.2	371.6
343	122	05/02/94	10:30:2	243.5	371.2
344	122	05/02/94	15:28:5	240.8	370.9
345	122	05/02/94	20:27:2	238.0	370.5
346	123	05/03/94	01:25:4	235.3	370.1
347	123	05/03/94	06:24:1	232.6	369.6
348	123	05/03/94	11:22:4	229.9	369.1
349	123	05/03/94	16:21:1	227.2	368.5

350 123 05/03/94 21:19:4 224.4 367.9