

CONTROL CENTER TECHNOLOGY CONFERENCE

MacSPOC: Orbital Trajectory Calculations
On A Laptop Computer

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TOPICS

LAPTOP COMPUTING IN THE SPACE SHUTTLE PROGRAM

CURRENT LAPTOP PROTOTYPING WITH MacSPOC

FUTURE LAPTOP APPLICATIONS

SUMMARY

SPACE SHUTTLE LAPTOP USE BEGAN ONBOARD

BEFORE STS-9 (November 1983 Launch):

- Laptop computer technology was commercially unavailable
- Crew had no orbital position display

ENTER THE SHUTTLE PORTABLE COMPUTER (SPoC)

- Host = GRiD Compass laptop 8086/7
- Proprietary GRiDOS operating system
 - Data entry via menus and forms
 - Primitive windowing capabilities
- World Map application
 - Current Shuttle location and ground track
 - Event timers (sun rise/set, AOS/LOS, etc.)
 - Fixed-format displays
- Crew queries to Mission Control substantially reduced

A PROTOTYPING EFFORT IS IN WORK TO ADVANCE SPOC CONCEPTS

UTILIZE COTS MACINTOSH PORTABLE COMPUTER

- Mature and intuitive graphic user interface
- Applications can address up to several MB RAM
- Reasonably fast 16 Mhz 68000 (no co-processor)
- Cooperative multi-tasking possible
- Minimal safety-of-flight hardware modifications required

DEVELOP MacSPOC APPLICATION

- SPOC = Spacecraft Personal Orbit Computations
- Demonstrate efficient data entry
- Demonstrate reconfigurable display format
- Demonstrate background display updates
- Demonstrate advanced earth observation (EOBS) capabilities
- Demonstrate accurate maneuver and aero drag modeling

MacSPOC RESULTS ARE ENCOURAGING

DETAILED TEST OBJECTIVE (DTO) 1206 COMPLETED

- Inaugural in-flight test during STS-41 (October 1990 launch)
- No anomalies encountered
- Crew requested enhanced attitude-dependent EOBS displays
 - Maintain attitude time line (ATL) onboard
 - Increase world map resolution 10-fold from current 33 nm

DTO 1208 ENHANCEMENTS NEARING READINESS

- In-flight test during STS-43 (July 1991 launch)
- MacSPOC ZoomMap ground testing complete
 - Resolution = 3 nm with $\pm 60^\circ$ latitude coverage
 - Total MacSPOC RAM = 2.6 MB
- Periodic trajectory, maneuver, and ATL uplinks via modem

ONBOARD PORTABLE COMPUTING IS COMING OF AGE

MacSPOC SUCCESS HELPS VALIDATE OTHER EFFORTS

- SPoC rehost to Unix and X-Windows
- Laptop software proliferation at Mission Control
- Emergency Mission Control applications
- Education and public relations

POSSIBLE FUTURE ADVANCEMENTS

- Macintosh laptop w/ 6888x co-processor: 100x more speed
- Expanded ZoomMap landmark database with annotation
- Rendezvous relative motion graphics display
- Space Shuttle TAEM and Landing proficiency trainer
 - Demonstrate real time man-in-the-loop capability
 - Provide piloting practice during extended duration flights

EFFICIENT DATA ENTRY

Edit Liftoff GMT			
Year	DOY or MM-DD	Hr	Min
1991	154	0	0
			Sec
			.000

Edit M50 State Vector			
Year	DOY or MM-DD	Hr	Min
1991	154	0	0
			Sec
			.000
X (Kft)	Orbit #	X (Kfps)	
21127.469	17	1.045089	
Y (Kft)		Y (Kfps)	
-5746.236		14.118448	
Z (Kft)		Z (Kfps)	
2817.149		20.927714	

RECONFIGURABLE DISPLAY FORMAT

File Edit Displays Update Commands

MacSP0C v1.2 @ MacSP0C.cp Checkpoint Default Inputs

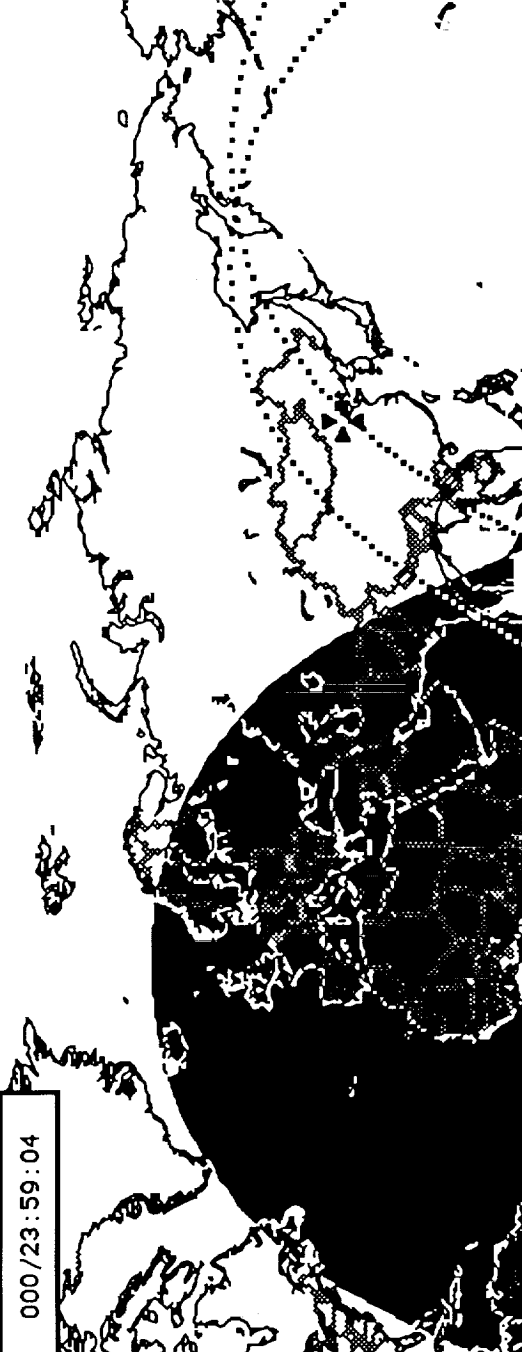
MET
000/23:56:45

Pos	
Lat=	4.01°S
Lon=	86.72°E
Alt=	189.4nm
Orb #	16

BACKGROUND DISPLAY UPDATES

MacSP0C v1.2 @ MacSP0C.cp Checkpoint Default Inputs

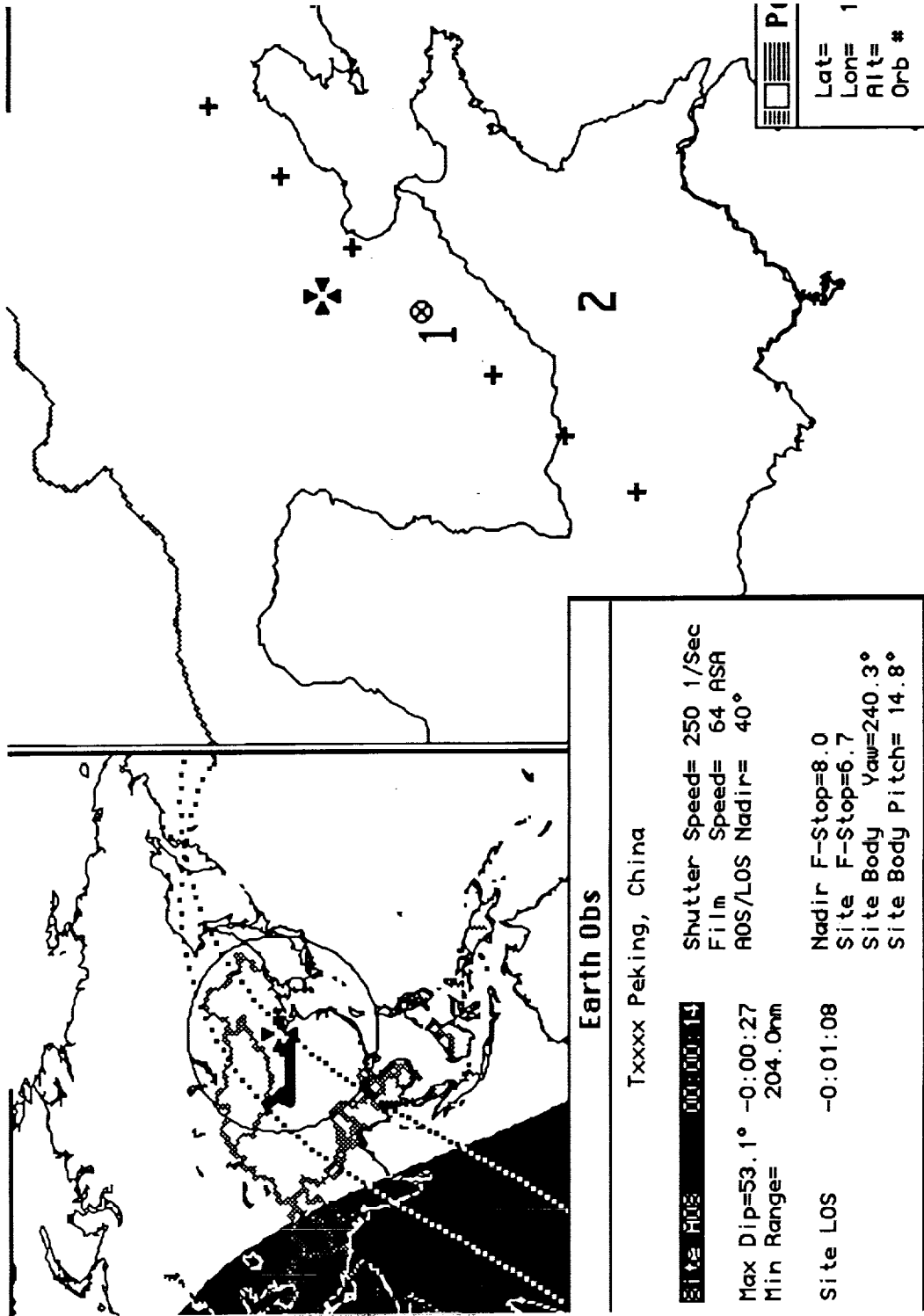
MET
000/23:59:04



HD40:MMCu3.2:Earth Obs

SILJN Siljan, Sweden	61.020	14.520	12
DELEN Dellen, Sweden	61.550	16.390	12
SAAR Saarksjarvi, Finland	61.250	22.230	12
LAPP Lappajarvi, Finland	63.090	23.420	12
JANIS Janisjarvi, USSR	61.580	30.550	12
KARA Kara & Ust-Kara, USSR	69.010	64.250	12
ZAMSN Zhamanshin, USSR	48.210	60.580	12
BIGCH Bigach, USSR	48.340	82.010	12
POPIG Popigai, USSR	71.350	111.000	12
ELGYT Elgytgn, USSR	67.300	172.050	12
PEP Inq. China	89.550	118.280	12

ADVANCED EARTH OBSERVATION CAPABILITIES



Site H08 00:00:14

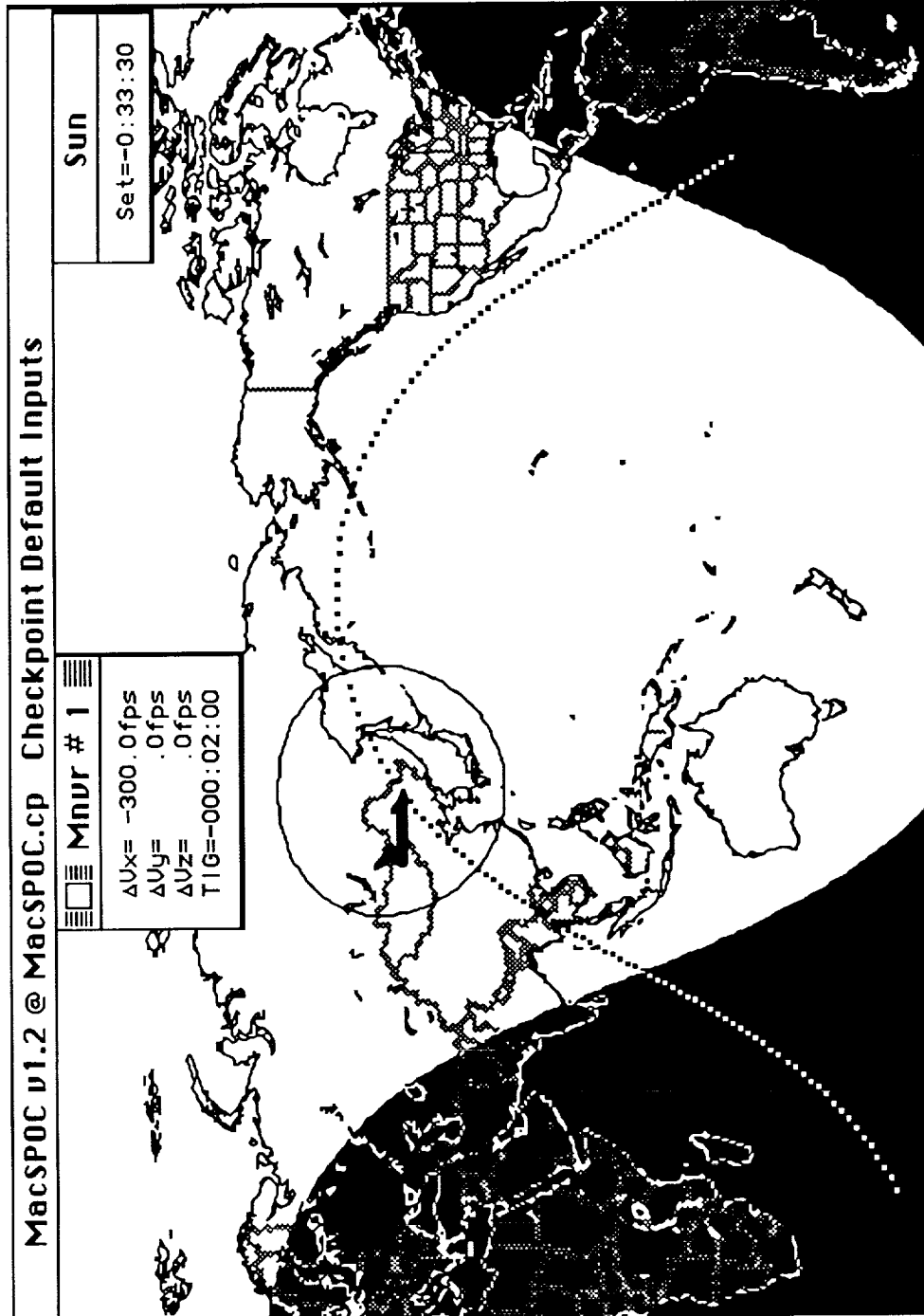
Max Dip=53.1° -0:00:27
Min Range= 204.0nm

Site LOS -0:01:08

Shutter Speed= 250 1/Sec
Film Speed= 64 ASA
AOS/LOS Nadir= 40°

Nadir F-Stop=8.0
Site F-Stop=6.7
Site Body Yaw=240.3°
Site Body Pitch= 14.8°

ACCURATE MANEUVER AND AERO DRAG MODELING



INTENTIONALLY BLANK