

Aerobraking at Venus

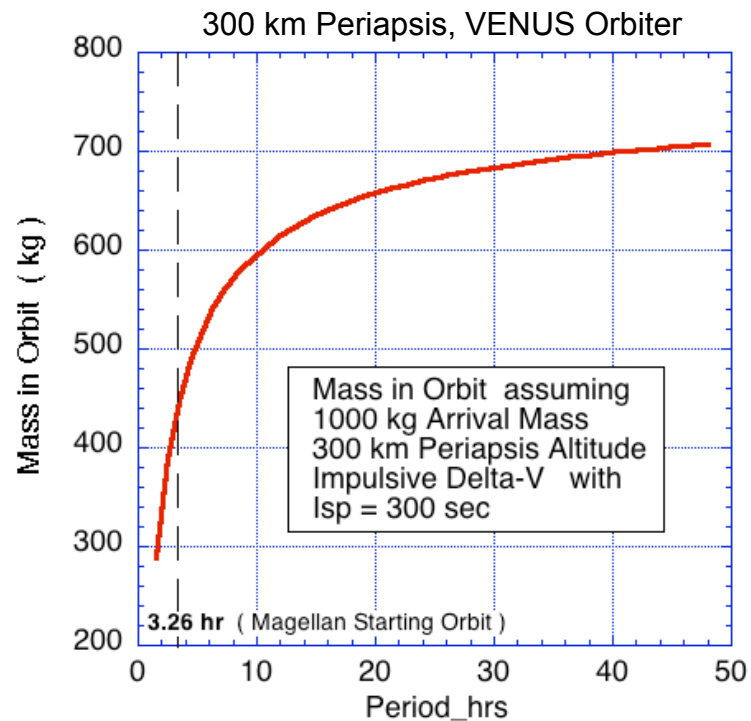
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Introduction

- Why Aerobrake ?
- Magellan at Venus, a Real World Example
 - SAR Image Map of Venus
 - Altimeter Radar Map of Venus
 - Mixed Resolution Gravity Map
 - **AEROBRAKING**
 - High Resolution Gravity Map

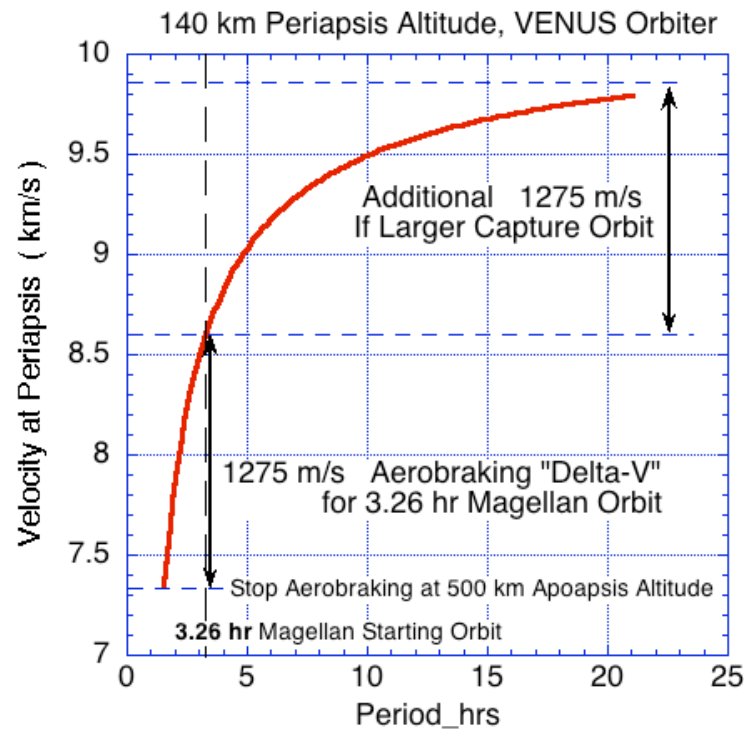
Why Aerobrake ?

More Mass in Orbit



All Propulsive Scenario. The Mass that remains after the capture burn decreases rapidly for lower period orbits.

Aerobraking = Delta-V = Mass



Aerobraking Scenario uses Aerodynamic Drag to supply some of the Delta-V. Less Delta-V means Less Propellant Mass. ($\approx +100$ m/s for Aerobraking.)

The Magellan Spacecraft

3.7 m High Gain Antenna
(Telecom and Radar)

Altimeter Antenna

Star Scanner

1-axis Solar Panel Gimbal
(Only moving part on outside.)

Equipment Bays

White Thermal Blankets

ACS Thruster Modules

Solar Panel

Star-48 Solid Rocket Motor
(Used for Capture at Venus)

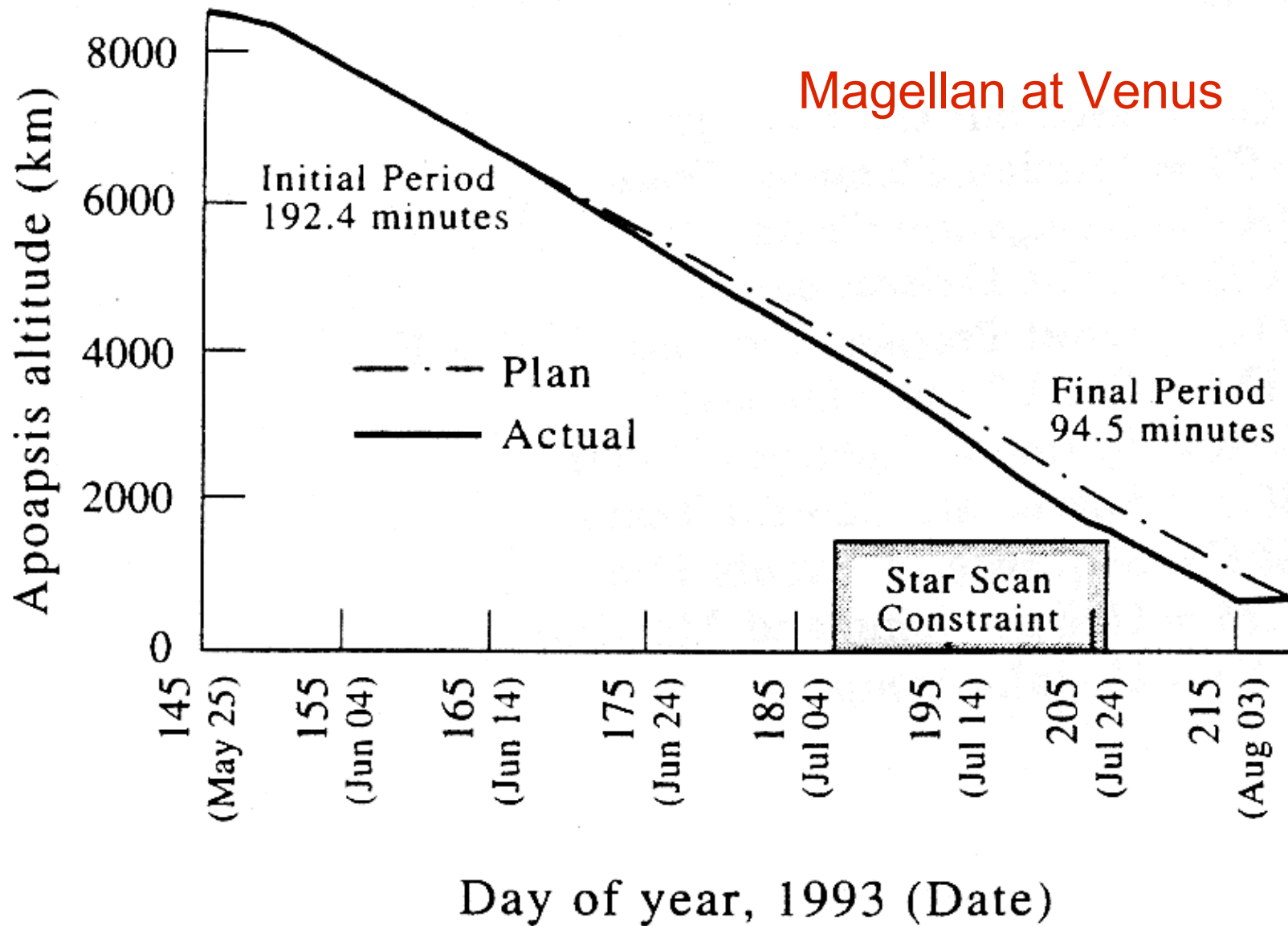


IUS
For Leaving
Earth Orbit

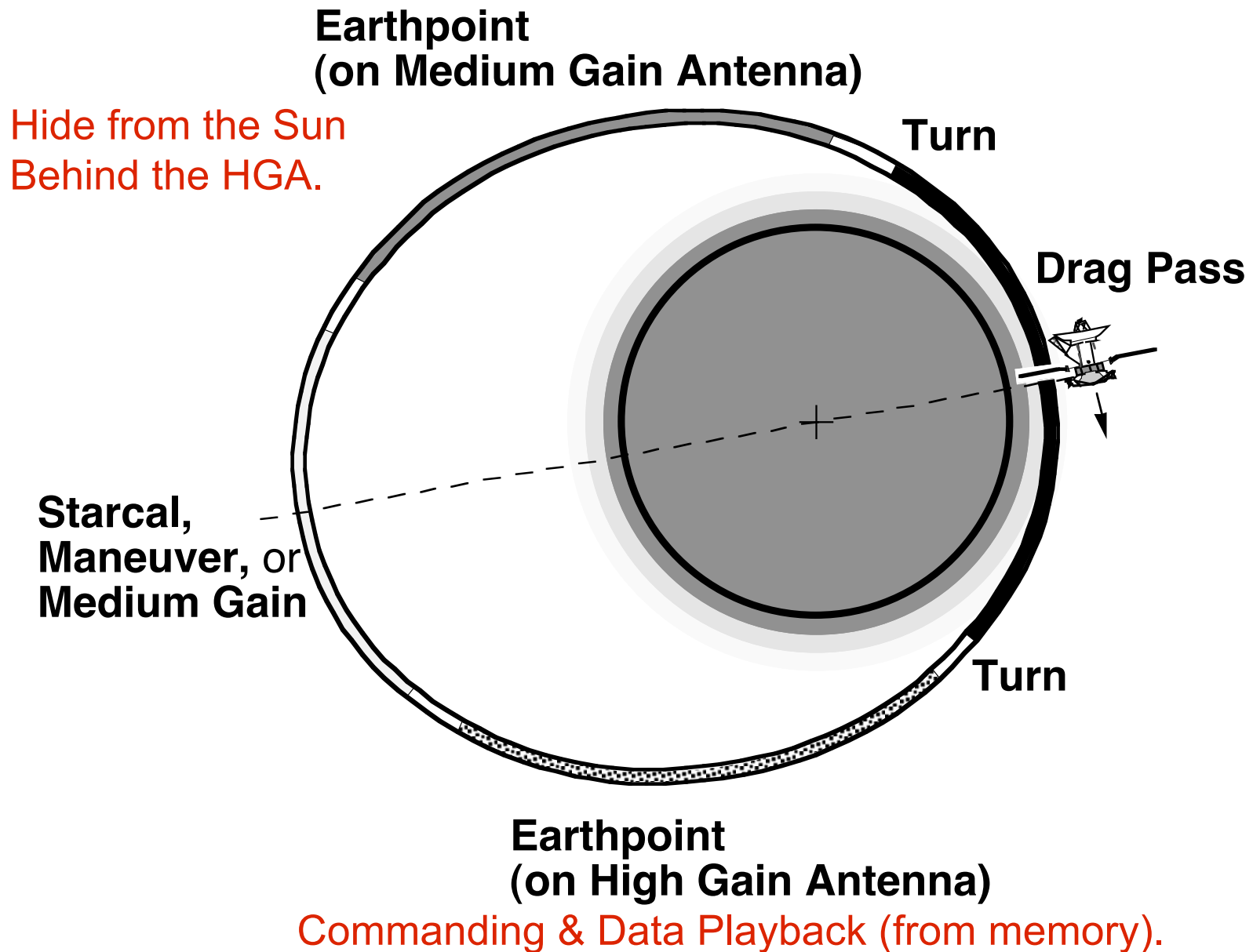
Space
Shuttle
Atlantis



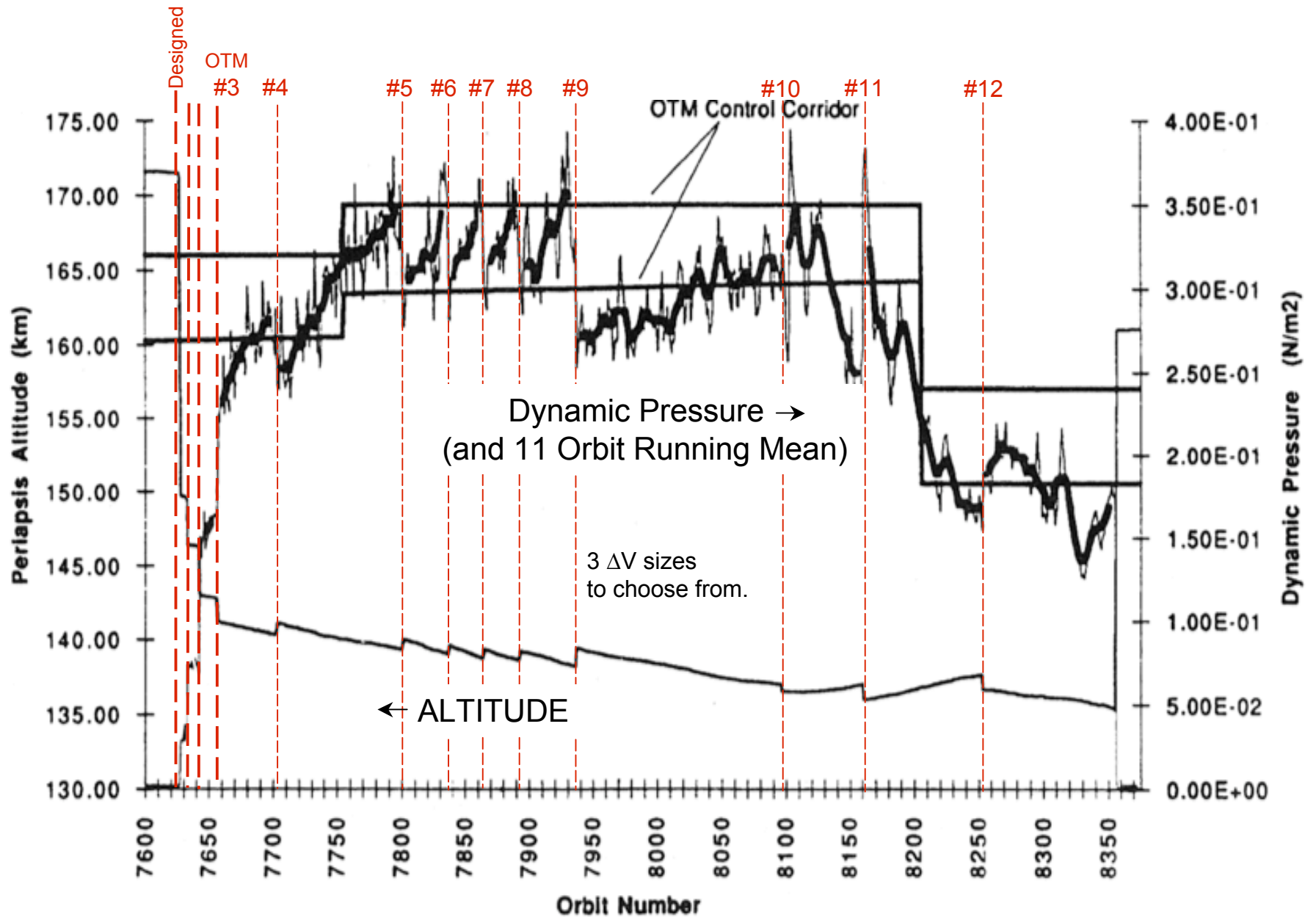
Planned and Actual Apoapsis Altitude



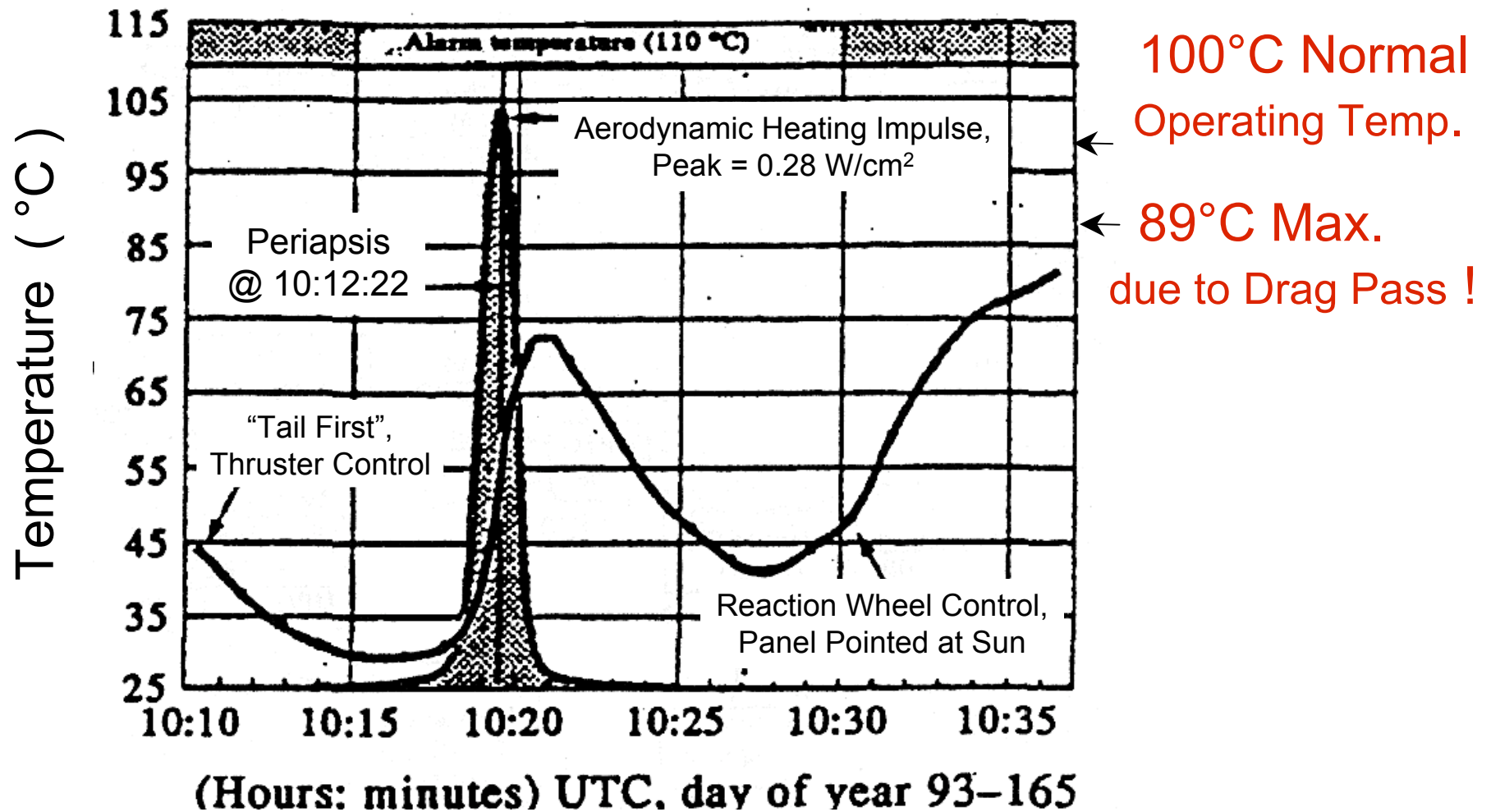
Orbital Events During Aerobraking



Magellan Control "Corridor"



Magellan Solar Panel Temperatures



A Typical "Day in the Life" During Aerobraking

Magellan aerobraking

5

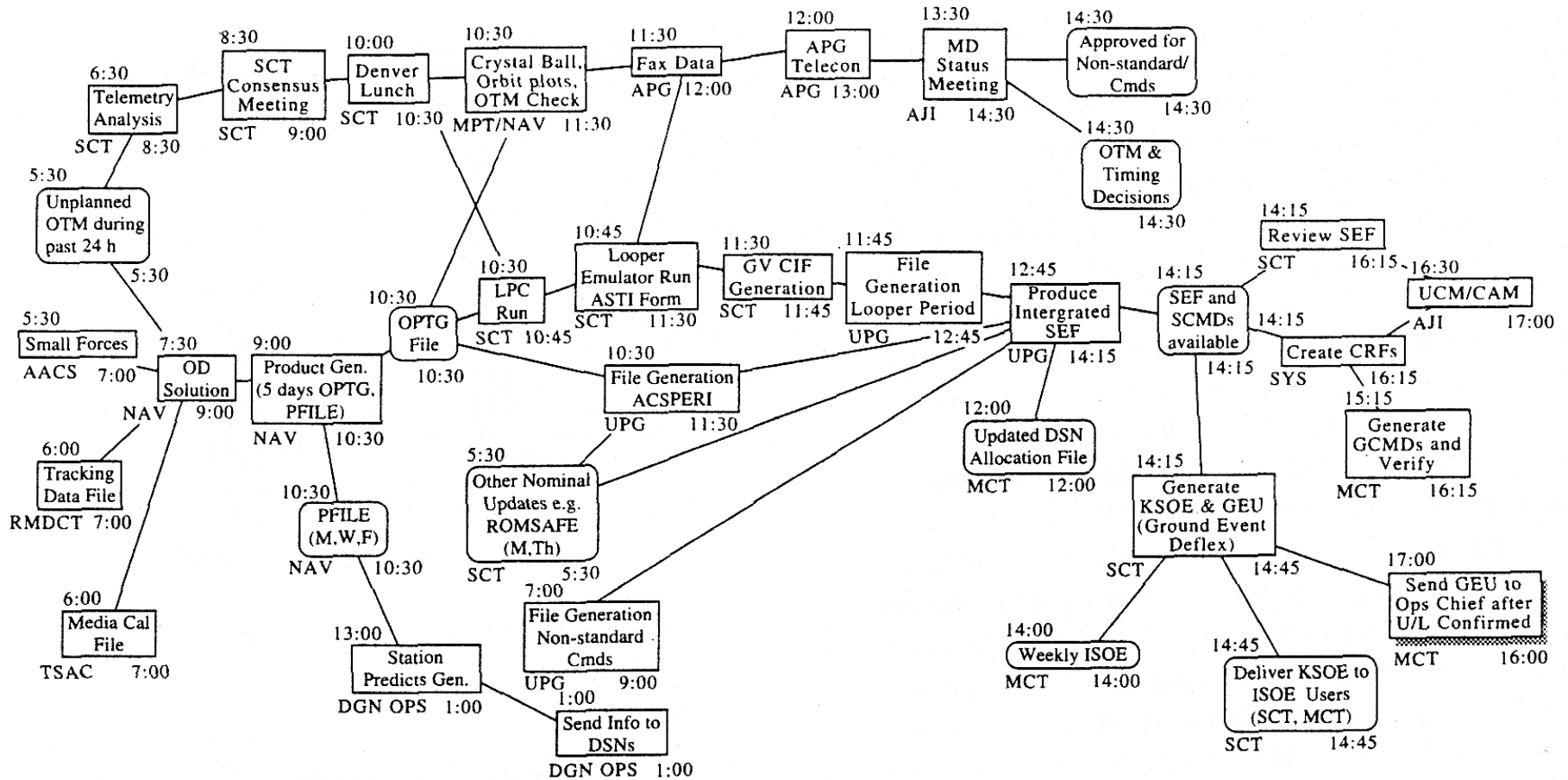


Fig. 5. Ground activities: a "Day in the Life" (for acronyms see Appendix).

Start Early

Finish Late

Key Dates

- 1984
 - I start working at JPL.
 - Mission Design for Magellan Mission to Venus is 1st Assignment
 - Planetary Constants & Models written on Apple][
- 1986
 - Challenger Disaster ... No More Centaur !
- 1987
 - Magellan Assembly & Test begins (Macintosh Released)
- 1988
 - Original Launch date for Shuttle/Centaur (Bush Elected)
- 1989
 - **Magellan Launches** on May 4 on Type 4 to Venus
 - 1st Planetary Mission in 12 years !
 - Galileo Launches on Oct 18 on Type 1 for Venus Gravity Assist.

More Key Dates

- 1990 (Clinton Elected)
 - Gyro B2 fails during cruise.
 - Venus Orbit Insertion on August 10, 1990.
 - “Walkabouts” put S/C into Safing. (Why did S/C survive?)
 - **Cycle 1** begins on Sept. 15, 1991 after checkout. (84%)
 - SAR mapping from Elliptical Orbit.
 - Tape Recorder A Fails.
 - Transmitter B develops “spur”. Switch to Transmitter A.
 - S/C begins Hiding behind Main Antenna to Keep Cool!
- 1991
 - **Cycle 2** begins on May 15, 1991 (95%)
 - Look the other way to Map the South Pole. (Right Looking)
 - Even worse solar geometry during playback, longer Hide.
 - Transmitter A Fails near end of Cycle 2.
 - Transmitter B “Usable” BUT
 - Lower Data Rate, “High” Temperature > 48°C (Rest of S/C Cool!)

More Key Dates

- 1992
 - **Cycle 3** begins on Jan 15, 1992 (98%)
 - Fill in the SAR mapping gaps.
 - Special Ground Processing Needed to Extract Data !
 - **Cycle 4** begins on Sept 15, 1992
 - Gravity Science (Only needs carrier.)
 - Still an Elliptical Orbit, High Resolution only near Equator.
 - Radio Science Occultation Experiments.
- 1993
 - Gyro A1 fails. No More Spares !
 - **AEROBRAKING** begins on May 25, 1994 ... **S/C on the edge !**
 - Lower Periapsis into the Atmosphere to create Drag.
 - Apoapsis Altitude Reduced from 8469 km to 542 km
 - Periapsis Altitude Reduced from 3.24 hours to 94 minutes.
 - Periapsis Speed reduced by **1275 m/s**
 - Aerobraking completed in 70 days, slightly ahead of schedule.
 - **Cycle 5** begins on Aug. 16, 1993
 - High Resolution Gravity Science from Low, Circular Orbit.
- 1994
 - **End of Mission** Oct. 12, 1994

Conclusions

- Aerobraking
 - Proven technique for reducing speed.
 - MGS, Odyssey & MRO used aerobraking at Mars
 - Eliminates huge propellant mass.
 - Requires careful planning.
 - Very Stimulating experience for Flight Team.
- The Sun
 - A major design driver for Venus Orbiters.
 - Hotter operating temperatures than aerobraking.
 - (At least for the Magellan Mission).

Composite Synthetic Array Radar Image

