The Importance of Requirements: A Case Study

Lecture Objectives:

1) Explain the importance of consistent requirements in a software system.

About the instructor

- **Instructor:** Dr. Walter W. Schilling, Jr.
- **Office:** Walter Schroeder Library 335
- **Office Hours:**
  - MTWRF 10:00-10:50
  - While I post office hours, I keep an open door policy. If I am in my office and the door is open, please feel free to stop in.
- **Telephone:** 414 277 7370
- **E-mail:** schilling@msoe.edu
  - Best method to contact me during non-class days
  - Please prefix subject with SE3821.
- **Course Web Page:**
  - http://www.walterschilling.org/msoe/fall2012se3821/fall2012se3821.php

About the Instructor (Continued)

- Ohio Northern University graduate in Electrical Engineering
  - Computer Science Minor
- Masters and PhD. from University of Toledo
  - Specialized in Computer Systems Design and Software Reliability
- Worked in Automotive Industry for approximately 6 years
  - Audio Software Engineer – Embedded Systems Design
    - US Patent 6,707,768
    - "Randomized Playback of Tracks in a Multimedia Player"

- Personal Website: http://www.walterschilling.org

Catalog Description

- This course covers activities that relate to the determination and documentation of software system requirements. Topics covered include requirements elicitation, object-oriented analysis techniques, prototyping, requirements tracking and re-engineering. (prereq: SE-2030)

Getting the reqs from the customer.

Outcomes

- understand the role of requirements engineering in a variety of software development models
- be able to elicit requirements from system stakeholders and to overcome common obstacles to the elicitation process
- be able to analyze and negotiate software requirements
- be able to specify software requirements using industry standard documentation techniques (e.g. UML, Use Cases etc.)
- be able to specify requirements that are verifiable, traceable, measurable and testable
- be able to verify that specified requirements are accurate, unambiguous, complete and consistent
- understand the importance and common methods of managing software requirements
- be able to communicate software requirements in written documents and oral presentations

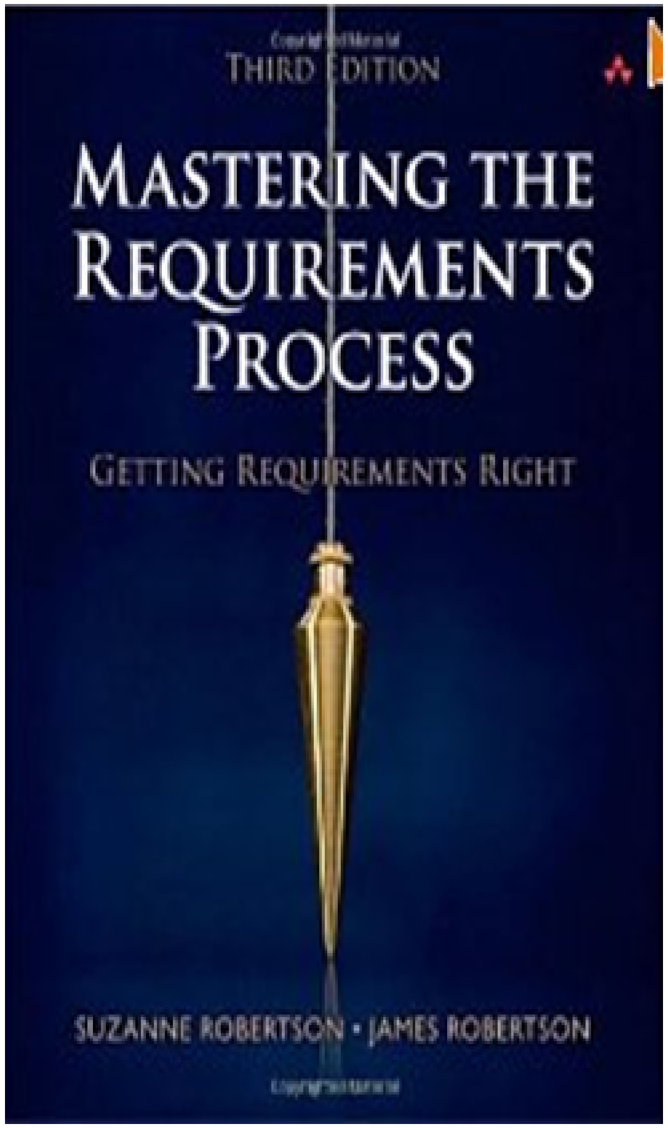
Prerequisites

- SE2030 Software Engineering Tools and Practices

Textbook

- *Mastering the Requirements Process, 3rd ed. Suzanne Robertson and James Robertson, Addison-Wesley, 2012*

- Textbook will occasionally be supplemented with articles and other handouts.



Class Materials

- Textbook
- Laptop Computer with standard MSOE image
  - You are responsible for completing the assignments on time, even if your computer malfunctions. No extensions will be granted due to computer problems.

Grading

Midterm Exams (1)	30%
Lab Work	30%
Homework / Quizzes	10%
Final Exam	30%
Total	100%

General Notes

- **Assignment Due Dates**
  - Late Penalty
    - 10% per business day late penalty for all written work
    - No work will be accepted more than 5 business days late for credit.

Grading Challenges

- Any grading challenges, unless specifically noted by the professor, shall be submitted in writing within 5 days of the assignment being returned to the student.
- Challenge must clearly delineate the problem with the assignment grade as well as justify the need for the grade change.

Student Integrity

- All students are expected to abide by MSOE's policy on student integrity. If at any point in the semester you have a question about an assignment, please come discuss it with me.
- Violations of this policy will be dealt with seriously, and may result in significant penalty, up to and including failure of the course.

Lecture Notes / Handouts

- Lecture notes and handouts may be made available on my course website.
  - These are for your own personal usage and are not to be circulated outside of the MSOE domain.
- Lecture notes and handouts are subject to copyright law.

General Notes

- **Laptop Usage**
  - Laptops may be used in class to view the lecture presentations live in Ubiquitous Presenter
  - Random responses may be required at various times using Ubiquitous Presenter.
- **Class Participation and Activities**
  - Class attendance is mandatory.
  - Attendance is required at all lab sessions.
    - You must stay for the entire lab period unless the current assignment is complete and turned in.

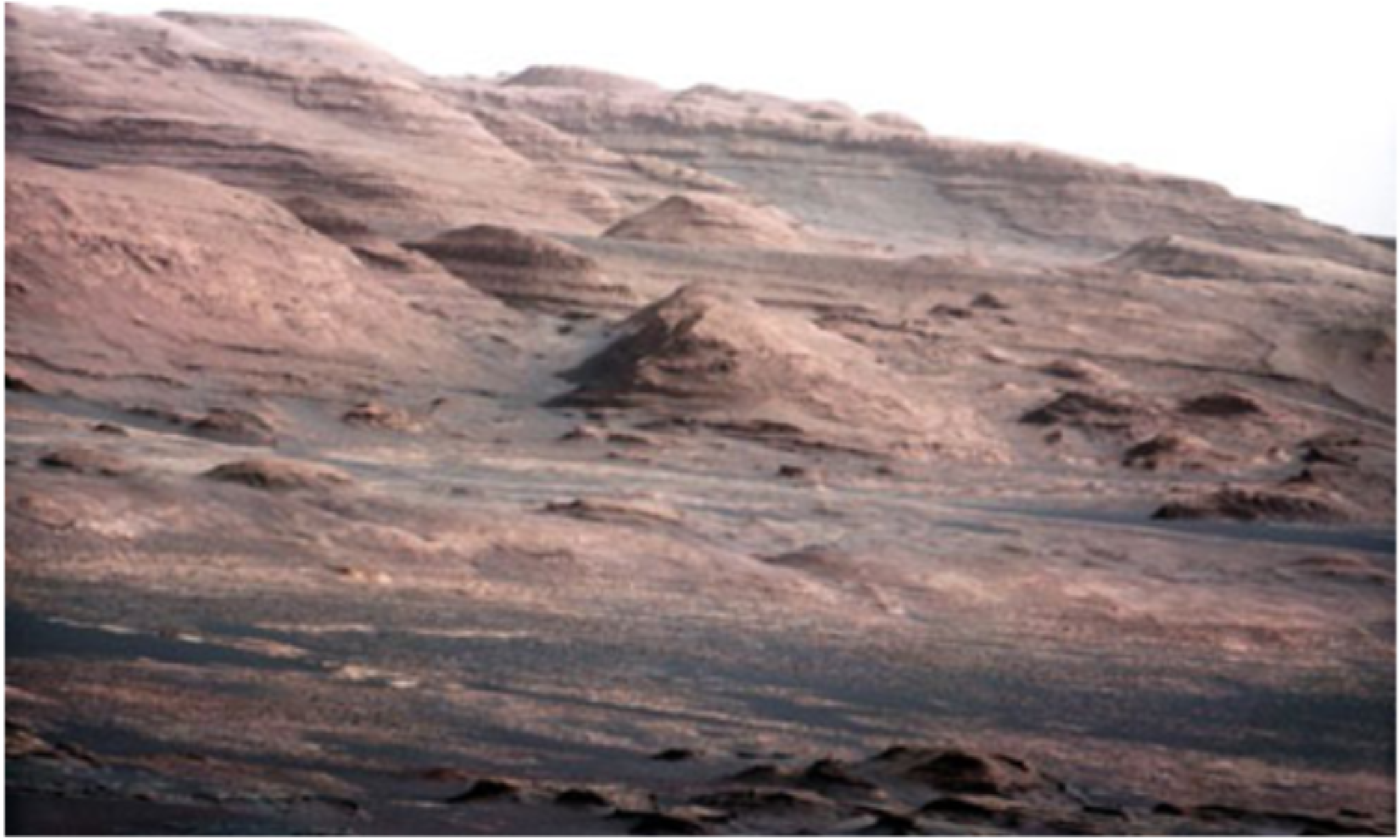
Etiquette

- Cell Phones
  - Please turn off all cell phones and pagers during class.
    - Cell phones can be disruptive to the professor as well as fellow students.
  - No text messaging in class!
- If you must miss a class or lab for an acceptable reason, please let the professor know in advance and follow-up afterwards.

Course Coverage

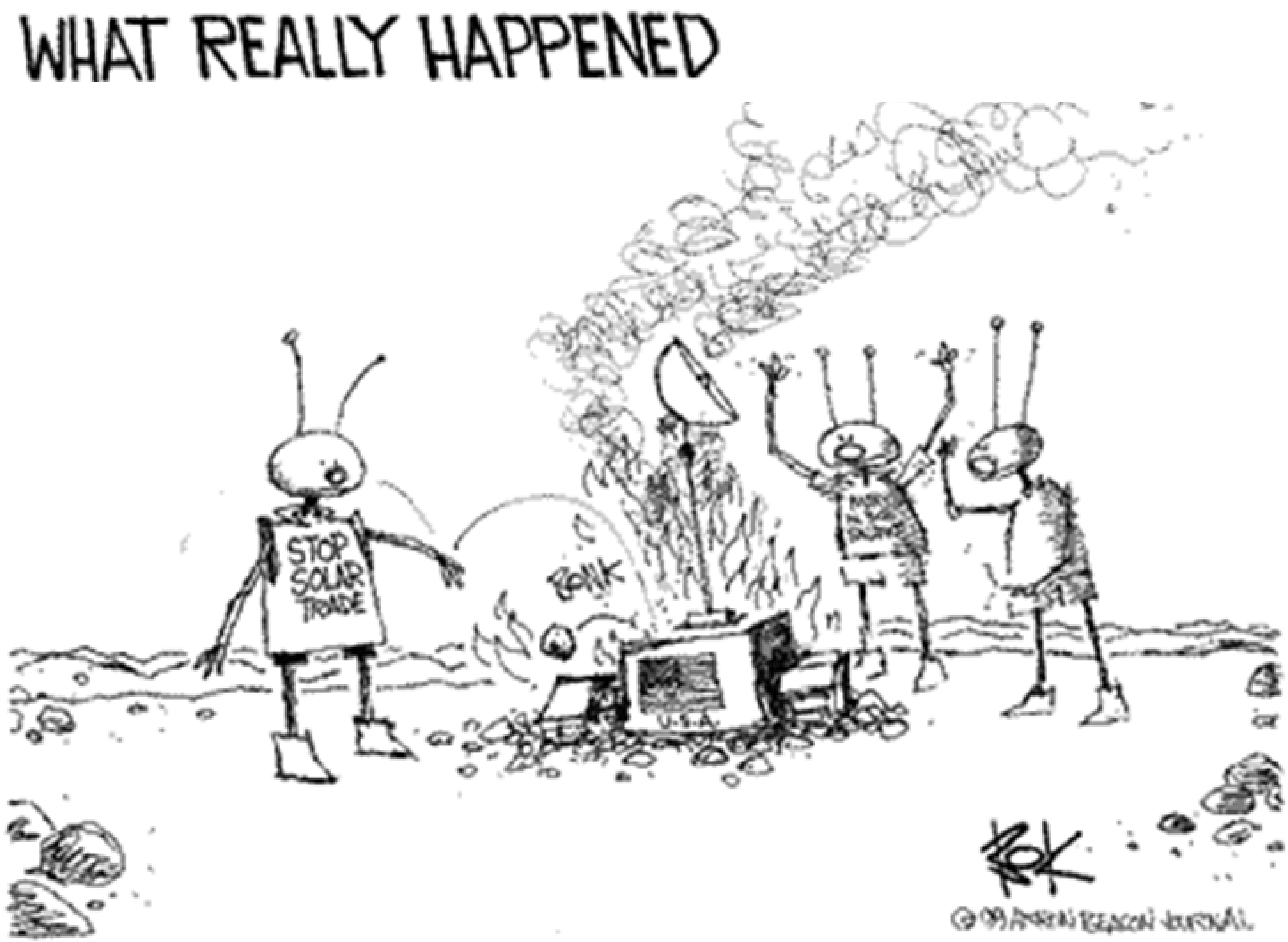
- See Syllabus

Mars: The Red Planet



Videos of Mars Landings

A Case Study as to what happened



Mars Climate Orbiter

- NASA started Mars Surveyor Program in 1993.
- Mars Climate Orbiter was launched on Dec. 11, 1998.

Scope

- Develop and launch two spacecrafts to Mars during the 1998 Mars transfer opportunity.
  - Development cost was estimated at $183.9 Million.
- Collect and return to Earth, science data resulting from the water and remote investigations of the Martian environment by the Lander.

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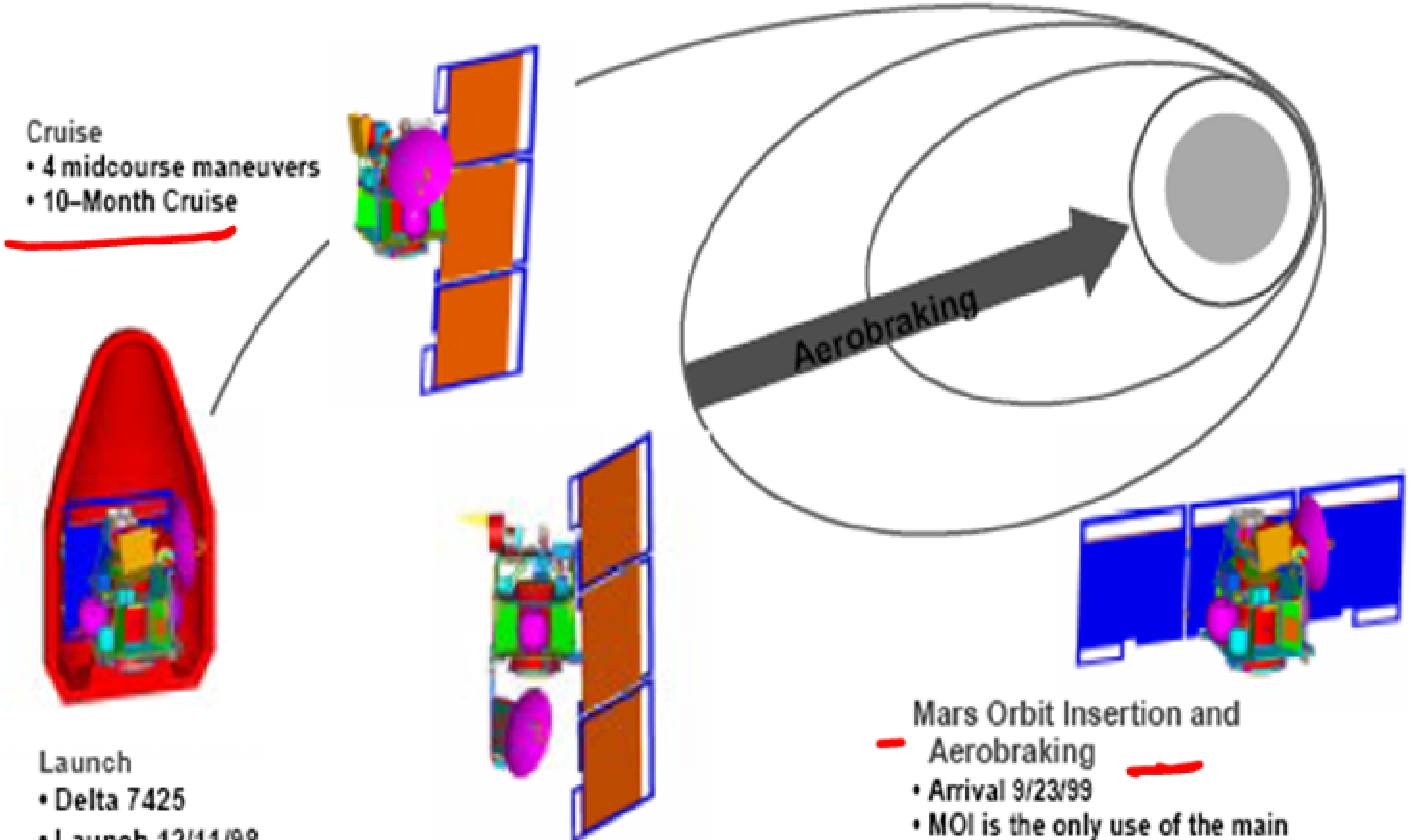
Mars Climate Orbiter

Scope



Cruise
- 4 midcourse maneuvers
- 10–Month Cruise

Launch
- Delta 7425
- Launch 12/11/98
- 629 kg launch mass

Mapping/Relay
- 12/3/99 –3/1/00: Mars Polar Lander Support Phase
- 3/00 – 1/02 Mapping Phase
  - PMIRR and MARCI Science
- Relay for future landers

Mars Orbit Insertion and Aerobraking
- Arrival 9/23/99
- MOI is the only use of the main [biprop] engine. The 16- minute burn depletes oxidizer and captures vehicle into 13–14 hour orbit.
- Subsequent burn using hydrazine thrusters reduce orbit period further.
- Aerobraking to be completed prior to MPL arrival [12/3/99].

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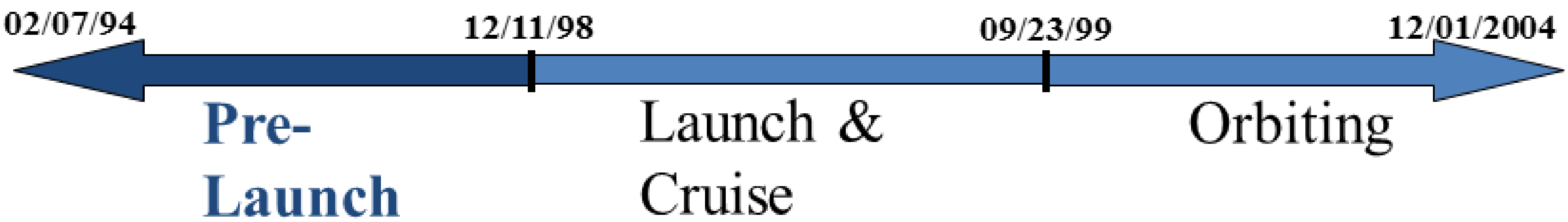
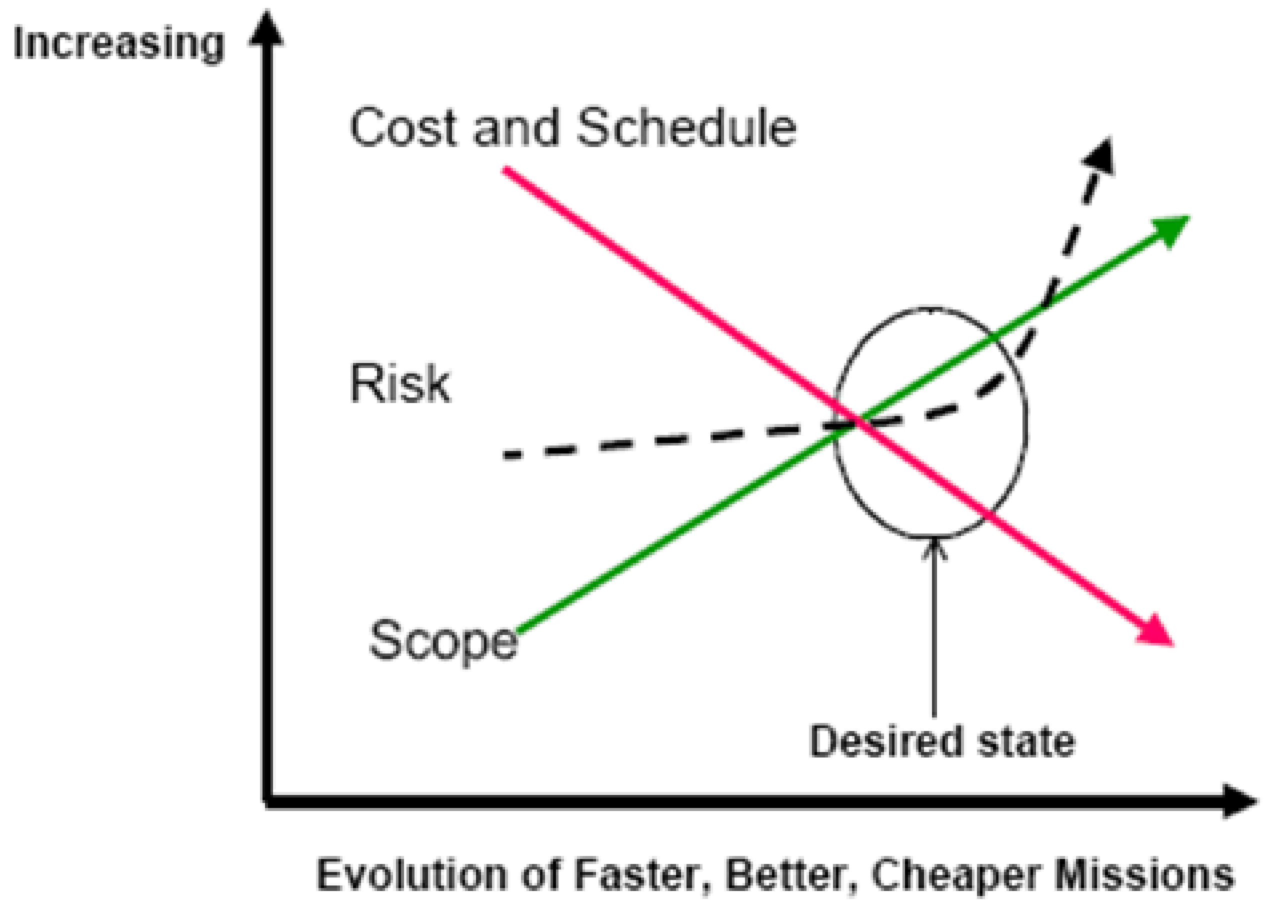


- Feb 7, 1994: Program Started.
- May 1, 1995: Project Manager Named.
  - JPL names John B. McNamee manager of the newly-formed Mars Surveyor '98 Project.
- May 8, 1995: Instrument Proposals Solicited.
- Oct 20, 1995: Instruments Selected.
- Dec 1, 1995: Project Scientist Named.
  - Richard Zurek
- Jan 4, 1997: Orbiter Design Reviewed.
- Aug 1, 1997 - Sep 30, 1998: Orbiter Assembled and Tested.
- Feb 1, 1998: Lander and Orbiter Renamed.
- Dec 11, 1998: Orbiter Launched.

- Dec 11, 1998: Lander Leaves Earth.
- Dec 11, 1998 - Sept 11, 1999: Mars Orbiter Interplanetary Cruise.
- Feb 3, 1999: New Management.
  - Richard A. Cook is the MSOP project manager.
- September 1999, the spacecraft was to fire its main engine to achieve an elliptical orbit around Mars.
- Sept. 23, 1999: The Mars Climate Orbiter mission was lost when it entered the Martian atmosphere on a lower than expected trajectory.

Faster, Better, Cheaper

- Costs were reduced and program scope — including both content and the infusion of new technology — increased at the same time.
- The the focus on cost and schedule reduction increased risk beyond acceptable levels on some NASA projects.



Mission Success First

Schedule Recommendations:

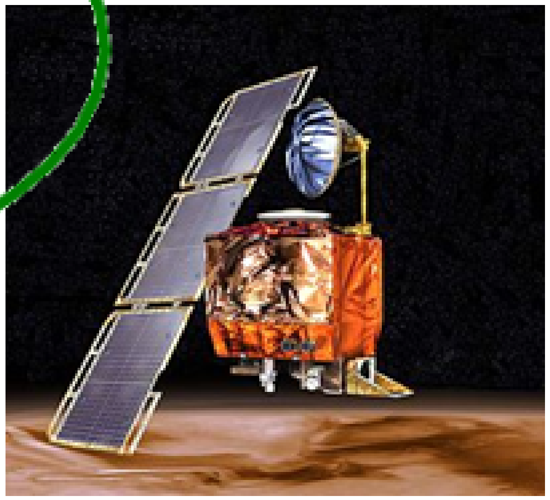
- Number One Priority Should be Mission Success over Cost and Schedule.
- "bottoms up" budget and schedule should be developed.
- The team should take ownership of the schedule
- There should be adequate schedule slack available to solve problems.
- Check if mission success has been compromised as a result of schedule?

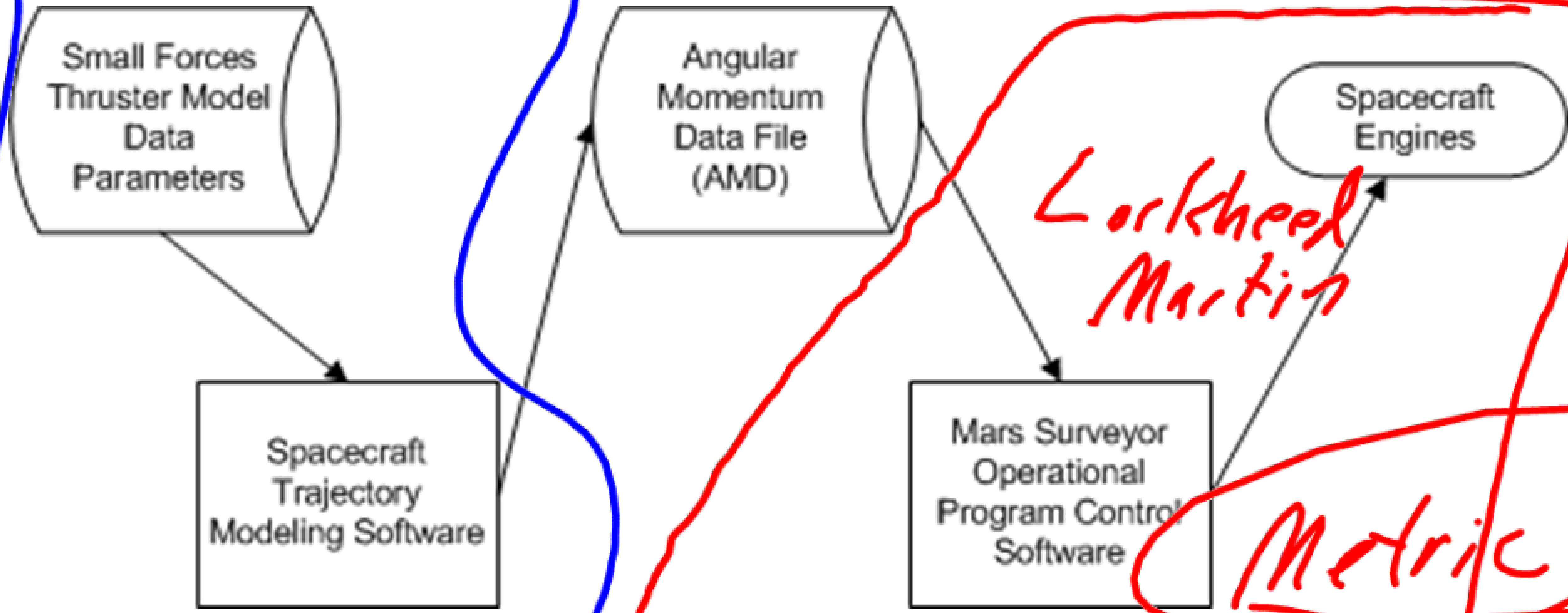
Operational Structure

NASA
JPL

Interface

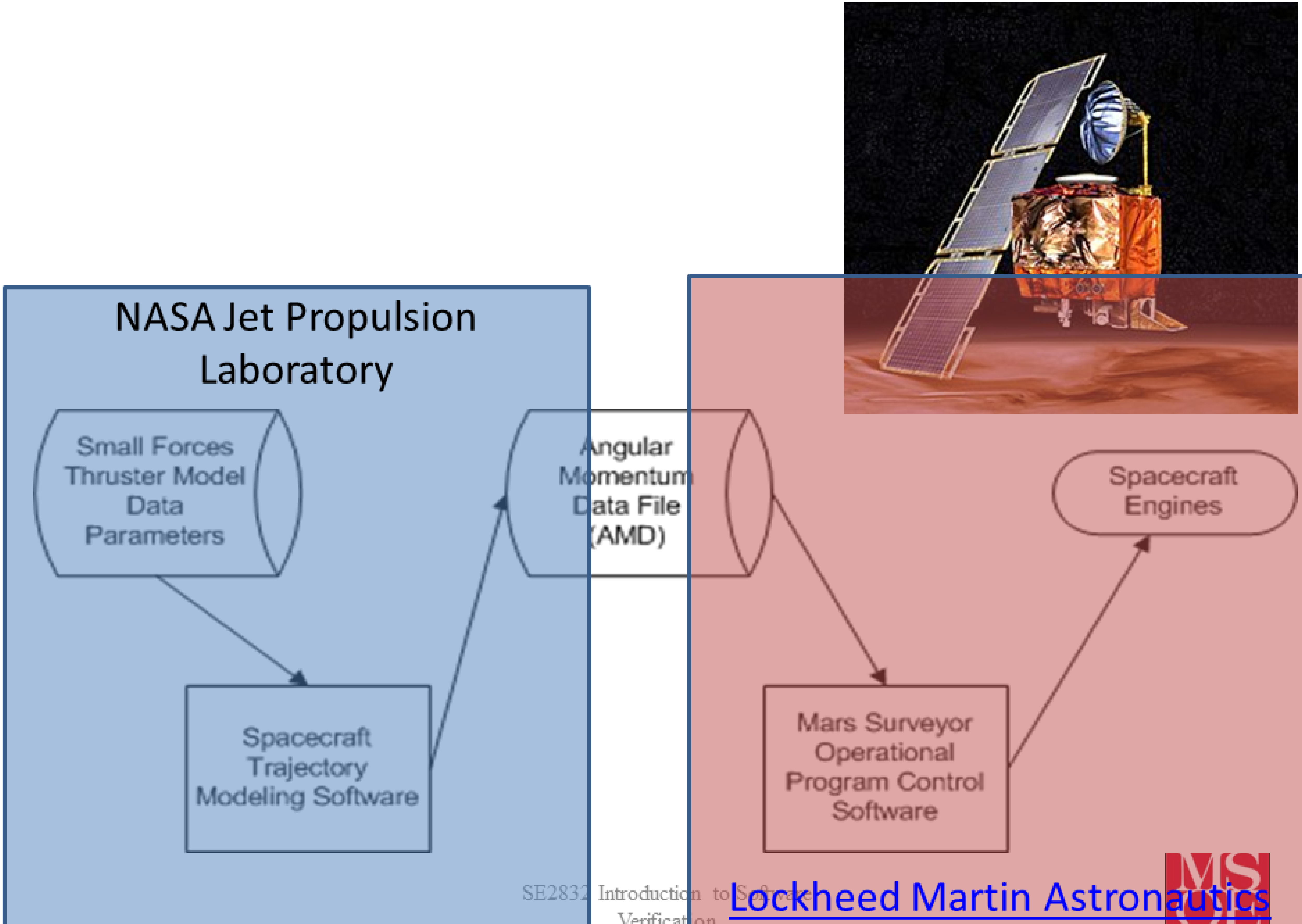
x4x





English

~~McDonnell Douglas~~



NASA Jet Propulsion Laboratory
Small Forces Thruster Model Data Parameters
Spacecraft Trajectory Modeling Software
Angular Momentum Data File (AMD)
Mars Surveyor Operational Program Control Software
Spacecraft Engines
Lockheed Martin Astronautics

Project Management

- The official report cited the following "contributing factors" to the loss of the spacecraft
  - undetected errors in ground-based models of the spacecraft the
  - operational navigational team was not fully informed on the details of the way that Mars Climate Orbiter was pointed in space
  - a final, optional engine firing to raise the spacecraft's path relative to Mars before its arrival was considered but not performed

Project Management

Summary

- One Technical Problem
  - failed conversion of unit
- Many Process and Social Problems
  - No review (e.g. verification), insufficient training, informal processes in place, formal processes ignored
- Led to a destroyed spacecraft

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Cause of Failure

"The MCO MIB has determined that the root cause for the loss of the MCO spacecraft was the failure to use metric units in the coding of a ground software file, "Small Forces," used in trajectory models. Specifically, thruster performance data in Imperial units instead of metric units was used in the software application code titled SM_FORCES (small forces). The output from the SM_FORCES application code as required by a MSOP Project Software Interface Specification (SIS) was to be in metric units of newton-seconds (N-s). Instead, the data was reported in Imperial units of pound-seconds (lbf-s). The Angular Momentum Desaturation (AMD) file contained the output data from the SM_FORCES software. The SIS, which was not followed, defines both the format and units of the AMD file generated by ground-based computers. Subsequent processing of the data from AMD file by the navigation software algorithm therefore, underestimated the effect on the spacecraft trajectory by a factor of 4.45, which is the required conversion factor from force in pounds to newtons. An erroneous trajectory was computed using this incorrect data."

— Mars Climate Orbiter Mishap Investigation Phase I Report[16]

The root cause…

"The Software Interface Specification (SIS), used to define the format of the AMD file, specifies the units associated with the impulse bit to be Newton-seconds (N-s). Newtonseconds are the proper units for impulse (Force x Time) for metric units. The AMD software installed on the spacecraft used metric units for the omputation and was correct. In the case of the ground software, the impulse bit reported to the AMD file was in English units of pounds (force)-seconds (lbf-s) rather than the metric units specified. Subsequent processing of the impulse bit values from the AMD file by the navigation

software underestimated the effect of the thruster firings on the spacecraft trajectory by a

factor of 4.45 (1 pound force=4.45 Newtons)."

What does this mean?

An SRS should be

a) Correct;

b) Unambiguous;

c) Complete;

d) Consistent;

e) Ranked for importance and/or stability;

f) Verifiable;

g) Modifiable;

h) Traceable.