Lecture 10: Managing Risk

General ideas about Risk

Risk Management

- Identifying Risks
- Assessing Risks

Case Study:

- Mars Polar Lander

Risk Management

About Risk

- Risk is "the possibility of suffering loss"
- Risk itself is not bad, it is essential to progress
- The challenge is to manage the amount of risk

Two Parts:

- Risk Assessment
- Risk Control

Useful concepts:

- For each risk: Risk Exposure
  - RE = p(unsat. outcome) X loss(unsat. outcome)
- For each mitigation action: Risk Reduction Leverage
  - RRL = (RE_{before} - RE_{after}) / cost of intervention

Risk Assessment

Quantitative:

- Measure risk exposure using standard cost & probability measures
- Note: probabilities are rarely independent

Qualitative:

- Develop a risk exposure matrix
  - Eg for NASA:

		Likelihood of Occurrence		
		Very likely	Possible	Unlikely
Undesirable outcome	(5) Loss of Life	**Catastrophic**	**Catastrophic**	**Severe**
	(4) Loss of Spacecraft	**Catastrophic**	**Severe**	**Severe**
	(3) Loss of Mission	**Severe**	**Severe**	**High**
	(2) Degraded Mission	**High**	**Moderate**	**Low**
	(1) Inconvenience	**Moderate**	**Low**	**Low**

Identifying Risk: Checklists

Source: Adapted from Boehm, 1989

Personnel Shortfalls
- use top talent
- team building
- training

Unrealistic schedules/budgets
- multisource estimation
- designing to cost
- requirements scrubbing

Developing the wrong Software functions
- better requirements analysis
- organizational/operational analysis

Developing the wrong User Interface
- prototypes, scenarios, task analysis

Gold Plating
- requirements scrubbing
- cost benefit analysis
- designing to cost

Continuing stream of requirements changes
- high change threshold
- information hiding
- incremental development

Shortfalls in externally furnished components
- early benchmarking
- inspections, compatibility analysis

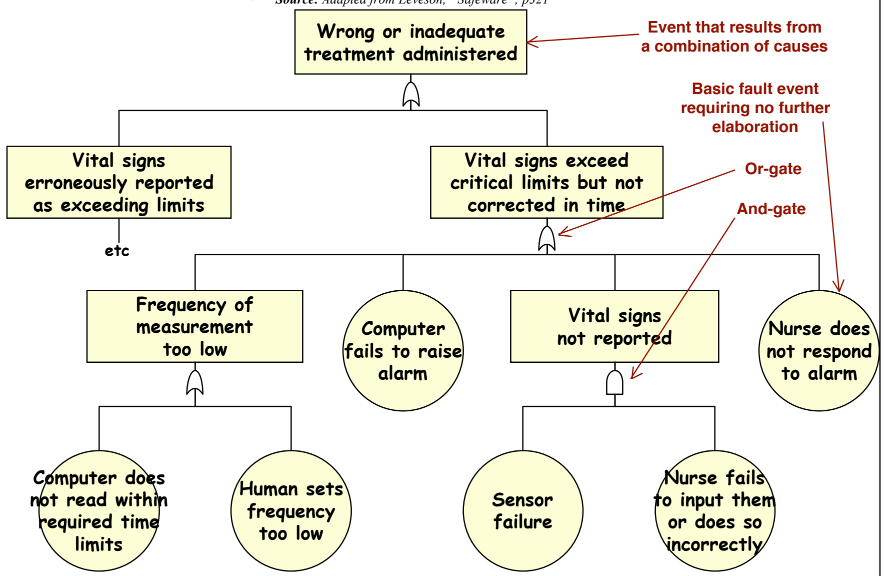
Shortfalls in externally performed tasks
- pre-award audits
- competitive designs

Real-time performance shortfalls
- targeted analysis
- simulations, benchmarks, models

Straining computer science capabilities
- technical analysis
- checking scientific literature

Identifying Risks: Fault Tree Analysis

Source: *Adapted from Leveson, "Safeware", p321*



Continuous Risk Management

Source: *Adapted from SEI Continuous Risk Management Guidebook*

Identify:
- Search for and locate risks before they become problems
  - Systematic techniques to discover risks

Analyse:
- Transform risk data into decision-making information
- For each risk, evaluate:
  - Impact
  - Probability
  - Timeframe
- Classify and Prioritise Risks

Plan
- Choose risk mitigation actions

Track
- Monitor risk indicators
- Reassess risks

Control
- Correct for deviations from the risk mitigation plans

Communicate
- Share information on current and emerging risks

Principles of Risk Management

Source: *Adapted from SEI Continuous Risk Management Guidebook*

Global Perspective

- View software in context of a larger system
- For any opportunity, identify both:
  - Potential value
  - Potential impact of adverse results

Forward Looking View

- Anticipate possible outcomes
- Identify uncertainty
- Manage resources accordingly

Open Communications

- Free-flowing information at all project levels
- Value the individual voice
  - Unique knowledge and insights

Integrated Management

- Project management is risk management!

Continuous Process

- Continually identify and manage risks
- Maintain constant vigilance

Shared Product Vision

- Everybody understands the mission
  - Common purpose
  - Collective responsibility
  - Shared ownership
- Focus on results

Teamwork

- Work cooperatively to achieve the common goal
- Pool talent, skills and knowledge

Case Study: Mars Climate Orbiter

Launched

- 11 Dec 1998

Mission

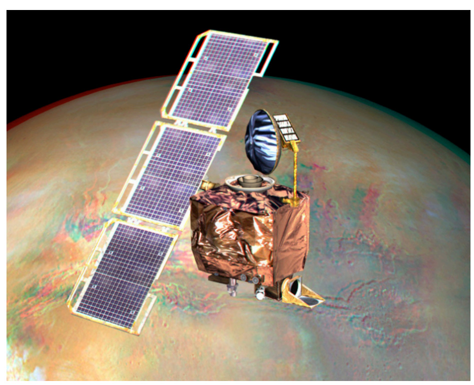
- interplanetary weather satellite
- communications relay for Mars Polar Lander

Fate:

- Arrived 23 Sept 1999
- No signal received after initial orbit insertion

Cause:

- Faulty navigation data caused by failure to convert imperial to metric units



MCO Events

Locus of error

- Ground software file called "Small Forces" gives thruster performance data
  - data used to process telemetry from the spacecraft
- Angular Momentum Desaturation (AMD) maneuver effects underestimated
  - (by factor of 4.45)

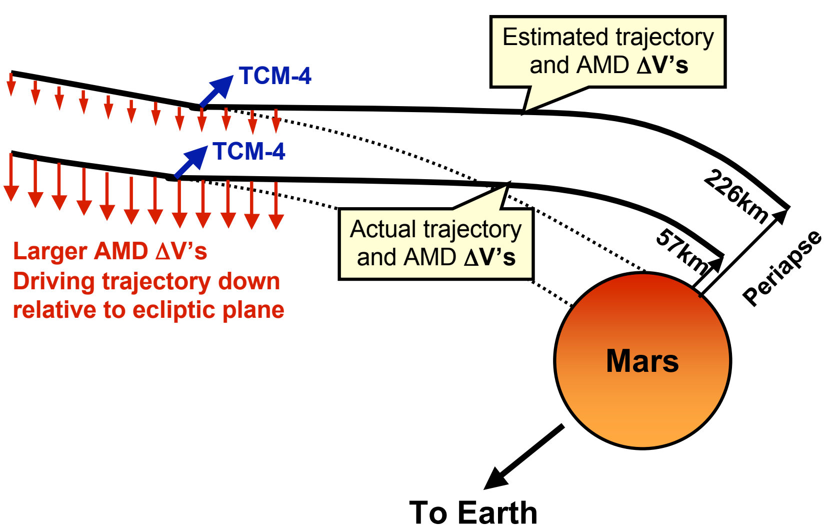
Cause of error

- Small Forces Data given in Pounds-seconds (lbf-s)
- The specification called for Newton-seconds (N-s)

Result of error

- As spacecraft approaches orbit insertion, trajectory is corrected
  - Aimed for periapse of 226km on first orbit
- Estimates were adjusted as the spacecraft approached orbit insertion:
  - 1 week prior: first periapse estimated at 150-170km
  - 1 hour prior: this was down to 110km
  - Minimum periapse considered survivable is 85km
- MCO entered Mars occultation 49 seconds earlier than predicted
  - Signal was never regained after the predicted 21 minute occultation
  - Subsequent analysis estimates first periapse of 57km

MCO Navigation Error



Contributing Factors

For 4 months, AMD data not used (file format errors)
- Navigators calculated data by hand
- File format fixed by April 1999
- Anomalies in the computed trajectory became apparent almost immediately

Limited ability to investigate:
- Thrust effects measured along line of sight using doppler shift
- AMD thrusts are mainly perpendicular to line of sight

Poor communication
- Navigation team not involved in key design decisions
- Navigation team did not report the anomalies in the issue tracking system

Inadequate staffing
- Operations team monitoring 3 missions simultaneously (MGS, MCO and MPL)

Operations Navigation team unfamiliar with spacecraft
- Different team from development & test
- Did not fully understand significance of the anomalies
- Surprised that AMD was performed 10-14 times more than expected

Inadequate Testing
- Software Interface Spec not used during unit test of small forces software
- End-to-end test of ground software was never completed
- Ground software considered less critical

Inadequate Reviews
- Key personnel missing from critical design reviews

Inadquate margins…

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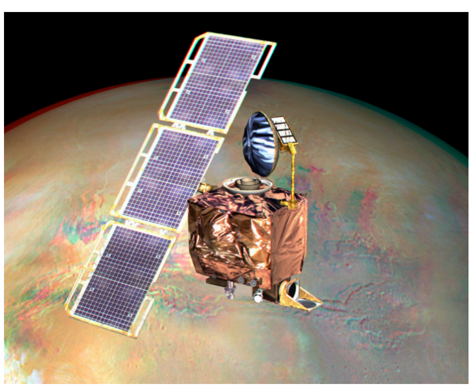
Mars Climate Orbiter



Mars Global Surveyor

Lessons?

If it doesn't behave how you expect, it's not safe
(yes, really!)

If your teams don't coordinate,
neither will their software
(See: Conway's Law)

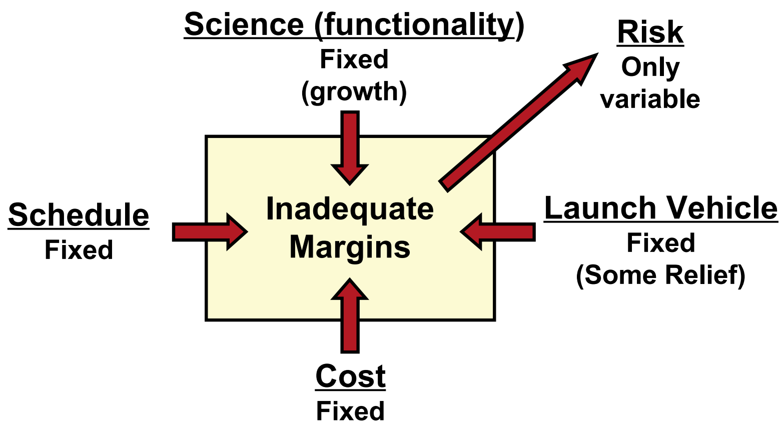
With software, everything is connected
to everything else -- every subsystem is critical

Sidetrack: SNAFU principle

Full communication is only possible among peers;
Subordinates are too routinely rewarded for telling
pleasant lies, rather than the truth.

Not a good idea to have the
IV&V teams reporting to the program office!!

Failure to manage risk



Adapted from MPIAT - Mars Program Independent Assessment Team Summary Report, NASA JPL, March 14, 2000.
See http://www.nasa.gov/newsinfo/marsreports.html

Symptoms of failure to manage risk:

Are overconfidence and complacency common?
- the Titanic effect - "it can't happen to us!"
- Do managers assume it's safe unless someone can prove otherwise?

Are warning signs routinely ignored?
- What happens to diagnostic data during operations?
- Does the organisation regularly collect data on anomalies?
- Are *all* anomalies routinely investigated?

Is there an assumption that risk decreases?
- E.g. Are successful missions used as an argument to cut safety margins?

Are the risk factors calculated correctly?
- E.g. What assumptions are made about independence between risk factors?

Is there a culture of silence?
- What is the experience of whistleblowers? (Can you even find any?)