Lessons Discovered But Seldom Learned

OR

The Need for Systems Thinking

Outline of Session

- Session I
  - What Are Lessons Discovered
  - Are We Using Lessons Discovered
  - Why Are We Not Using Lessons Discovered
  - The Story of the Vasa
  - Example Failures To Consider
  - Key Actions Required for Success

What Are Lessons Discovered

There have been hundreds – thousands – hundreds of thousands - millions of Lessons Discovered over the past 100 years.

Lessons Discovered on “Risks” of Human Errors, Program Management, Design, Technology, External Forces, etc.

One major **Lesson Discovered** is that most people DO NOT USE SYSTEMS THINKING – SYSTEM ENGINEERING in their actions and that leads to failure

Are We Using Lessons Discovered – Thinking in System Terms??

BUT – Does anyone ever read these or learn from them?

HOW many programs have benefited from these Lessons Discovered at such great costs?

DO you know of any – or many????

AND how many programs do you know that did NOT benefit from Lessons Discovered on similar programs?

AND why did they not benefit ????

Why We Are Not Using Lessons Discovered – Thinking in System Terms

When you identify a Lesson Discovered, you are calling into question the wisdom of earlier decisions made by yourself, others or your management. Most managers and organizations do not take kindly to “criticism”. How many people will admit to the details of a wrong decision?

Even if an organization gets the development of Lessons Discovered mandated for their programs, excuses and creative explanations will emerge if a Lesson Discovered threatens some cherished program or mode of operation.

And to consider that one might make the same “bad decisions” in the future is simply out of the question.

Why We Are Not Using Lessons Discovered – Thinking in System Terms?

Another major stumbling block to actual use of Lessons Discovered is that people are very seldom (if ever) held responsible for unsuccessful actions.

Not responsible for simply failing – failure happens and provides people with experience. People should be held responsible for failures that occur from the same or similar root cause(s) every time.

This indicates that people at all levels are refusing to learn from past mistakes – their "Lessons Not Discovered". Change of one's opinion or method of operation is difficult – why do it if nothing bad happens to me when I fail?

Why We Are Not Using Lessons Discovered – Thinking in System Terms

And there are other problems as well. "Lessons Discovered" often become twisted to support - or at least not impact - pet projects.

Who really wants a totally dispassionate look at Lessons Discovered. No one wants the chips to fall where they may. Too much collateral damage that way.

Yet, in the end, the true meaning of each Lesson Discovered will be there on the next program or operation or activity, whether you have come up with the best implementation of the lesson or not. ***But does anyone care?***

EXAMPLES OF ACQUISITION FAILURE IN TRADITIONALLY MANAGED PROGRAMS

Weapons Systems

Aquila UAV
A-12 Avenger
AH-56A Cheyenne
RAH-66 Comanche
Condor AGM
Crusader SPH
Dart SSM
Field Army BMDS
Main Battle Tank (MBT-70)
Rigel SSM
M247 Sgt York DIVAD
Tri-Service Stand-Off Atk Msl

Symptoms

Test Failures
Cost Overruns
Schedule Delays

Causes

Development, Integration, Production of Advanced Technologies
Requirements Creep
Funding Instability
Duplication of Effort

Satellite Failures

Space Systems
Hubble Telescope - $250M (to fix)
Infrared Telescope - $246M (loss)
Deep Probe 2 - $29M (loss)
Mars Express and Beagle 2 - $246M (loss)
Astra 1K Satellite $280M (loss)
Galaxy 4 and 7 Satellites $307M (loss)
Solidaridad Satellite $250M (loss)
Telstar 401 Satellite $132.5M (loss)
Midori II Satellite - $759M (loss)
Gamma Ray Observatory $670M (loss)
EarthWatch Quick Bird 1 $60M (loss)

CGRO

Symptoms
Optics ground incorrectly
Electronics stop functioning
Anomaly occurred
Circuit failures
Faulty connections

Causes
Quality process not followed
Manufacturing process not followed
Faulty design
Production process not followed

Launch Systems Failures

Launch Systems
Ariane 5 Rocket – Initial Launch
Pegasus Booster - NASA X-43A
VLS Rocket - Brazil
Titan 4A Rocket
Titan 4B Rocket
Athena Rocket
Delta 3 Rocket
Trident

Symptoms
Explosions
Loss of launch vehicle and payload
Costs - $50B+

Causes
Software
Design flaw
Electronics fault
Rocket engine and motor problems
Manufacturing flaw

Famous Failures
The Vasa



The Story of the Vasa

Taken from http://www.cise.ufl.edu/~jnw/OOCourse/Lectures/01.05.html

- 1625: King Gustav of Sweden commissions construction of a new flagship, the Vasa.
- Hendrick Hybertszoon (master shipwright from Holland) is selected to build it.
- No written specifications
- Shipbuilder assumes ship will be 108 feet in length.
  - After first review, King Gustav requests a 135 foot ship.
  - Timber is added to make the ship 120 feet.

The Story of the Vasa

Taken from http://www.cise.ufl.edu/~jnw/OOCourse/Lectures/01.05.html

- While on vacation, King Gustav finds out that the Danish king is building a ship with three gun decks.
  - He asks that a third gun deck be added to the two already on the Vasa.
  - 50 brass 24-lb cannons (at one ton each) will be added.
- Stability tests are conducted (involving 30 sailors who run from one side of the ship to the other). The ship appears to be unstable, but the problems are ignored and not communicated up the chain.

The Story of the Vasa

- On a Sunday in August 1628, the Vasa sets sail. One mile from harbor a wind gust catches the main sail and the ship overturns and immediately sinks.
- The Vasa was later brought up from the deep at greater cost than was expended in her manufacture.

Parallels between Shipbuilding in the 1600's and What We Do Now

- Shipbuilding in the 1600's was a craft based on engineering practice.
- Specifications for ships were ad hoc and usually verbally communicated.
- Designs for ships were inadequate to ensure the finished product would satisfy the needs of its users.
- The full implications of changes to the design were not always understood.

Parallels between Shipbuilding in the 1600's and What We Do Now

- Too much time was wasted carving decorative sculpture prior to determining if the ship would sail.

- Success breeds failure. Those who succeeded in building small ships would believe they knew how to do it even though they had no idea of the fundamental physical principles involved.

- Shipwrights in the 1600's (one in particular) did not know how to say ``no'' to customers.

Failures I

Name	Year	Probable cause of failure
Hubble Space Telescope	1990	Lack of total system test. Mirror was too flat on one edge by 1 / 50th of the width of human hair.
Ariane 5 Rocket	1996	Incorrect reuse of software, Faulty scaling up, Faulty software testing, Software operand error
Superconducting Super Collider	1995	Cost overruns, Failure to maintain political and public support
GE rotary compressor refrigerator	1986	Inadequate testing of new technology
Iridium System	1999	Misjudged competition and miss-predicted technology

Failures II

Name	Year	Probable Cause of Failure
IBM PCjr	1983	An attempt to impose customer needs
Space Shuttle Challenger	1986	Failure to communicate, motivation to make client “happy”
War in Vietnam	1967-72	No problem statement, Micromanagement
Edsel automobile	1958	Failure to understand customer needs
Titanic	1912	Poor quality control
Apollo-13	1970	Poor quality control
Tacoma Narrows Bridge	1940	Scaling up an old and successful design

Failures III

Name	Year	Probable Cause of Failure
New Coke	1988	Arrogance, The “wrong question” questionnaire, Underestimating the effects of social influence
A-12 airplane	1980s	Mismanagement ($2B for nothing)
Chernobyl Nuclear Power Plant	1986	Bad design, Bad risk management, Cost cutting
Lewis Spacecraft	1997	Design mistakes, Ineffective assurance processes at NASA
Mars Climate Orbiter	1999	Lack of training of Navigation team, Technical error (use of English and Metric units)

Failures IV

Name	Year	Probable Cause of Failure
Mars Polar Lander	2000	Failure of middle management
NOAA-N Prime Weather Satellite	2004	Lockheed Martin's inadequate training, lax management and absence of or neglect of written procedures; NASA's inadequate QA oversight and excessive reliance on the contractor

Hubble Space Telescope

- **The Hubble was d**esigned in the 1970's and launched in 1990 as the first major orbiting space based observatory.
- **The problem became apparent after receipt of the first photos – they were blurred.** After receiving those first blurred photos, system engineers had to devise ways to perform the appropriate failure analysis on the telescope, even though the instrument was only accessible via radio signals from space.

Hubble Space Telescope

- **The cause was that the** curve to which the primary mirror was ground incorrectly, causing "spherical aberration” . Why this was not found on the ground was that there was no total System Test. Not thought to be required, too expensive.

- **The fix was to perform** 4 costly servicing missions in 1993-2002 at a cost of more than $3 billion.

Ariane 5 Rocket

The failure of the Ariane 501 was caused by the complete loss of guidance and attitude information 37 seconds after start of the main engine ignition sequence. This flight carried $500M of satellites. The loss of information was due to specification and design errors in the software of the inertial reference system. The Ariane 5 was not flight tested because there was so much confidence in the Modeling and Simulation.

Ariane 5 Rocket

A run time error (out of range, overflow), occurred in both the active and the backup computers at about the same time, was detected and both computers shut themselves down. This resulted in the total loss of attitude control. The rocket turned uncontrollably and aerodynamic forces broke the vehicle apart.

Ariane 5 Rocket

This breakup was detected by an on-board monitor which ignited the explosive charges to destroy the vehicle in the air. The code was reused from an earlier vehicle where the measurement would not have become large enough to cause this failure.

The Ford Edsel

The Edsel is most famous for being a marketing disaster. The main reason why the Edsel's failure is so famous was because it flopped after Ford put $400,000,000 into its development.

The Ford Edsel

1958 Edsel Pacer

For the 1958 model year, Edsel produced 4 models, the Citation, Corsair, Pacer and Ranger.

The Edsel included several features that were, at the time, cutting-edge innovations, among which were its "rolling dome" speedometer and its "Teletouch" transmission shifting system, on the center of the steering wheel. 63,110 Edsels sold the first year, below expectations but the second largest car launch for any brand to date. Only the Plymouth introduction in 1928 was better.

The Ford Edsel

For the 1959 model year there were only 2 Edsels: the Ranger and the Corsair.

44891 cars sold in 1959.

1959 Edsel Corsair Convertible

For the 1960 model year, Edsel's last, only the Ranger and Villager were produced. 2848 cars were produced before the Edsel was dropped on November 19, 1959.

The Ford Edsel

After an initial United States sales goal of 100,000 - 200,000 for the model year 1958, the Edsel went on to sell only 100,847 in the U.S. over the course of the three years it was in production.

Several reasons are given for its downfall. One is consumer letdown following the large publicity buildup prior to the model's release.

The Ford Edsel

The pre-release advertising campaign touted the car as having **'...more YOU ideas'** and the teaser advertisements in magazines only revealed glimpses of the car through a highly-blurred lens or wrapped in paper or under tarps. The cars were shipped to the dealerships undercover and remained wrapped on the dealer lots.

After its introduction to the public, it didn't live up to its over-blown hype even though it did have many new features such as self-adjusting rear brakes and automatic lubrication.

The Ford Edsel

When Ford was developing it, they asked consumers what they wanted in a car while not asking how much they were willing to pay for it.

When it actually came out, the price tag was much higher than many customers were expecting despite all the model's features. When many potential buyers saw the base price tag, they simply left the dealership and others were frightened by the price for a fully loaded, top of the line model.

The Ford Edsel

The name of the car, Edsel, is also often cited as a further reason for its unpopularity. Ford ran internal studies to decide on a name. They reached no conclusions.

Ford hired the advertising firm Foote, Cone and Belding to come up with a name. Ford also asked poet Marianne Moore for suggestions, and she submitted a list which included "The Intelligent Whale," "The Utopian Turtletop," "The Pastelogram," and "The Mongoose Civique."

The Ford Edsel

All these outside ideas were rejected, and at the behest of Ernest Breech, who was chairing a meeting in the absence of Henry Ford II, the car was finally called "Edsel" in honor of Edsel Ford, former company president and son of Henry Ford.

Marketing surveys later found the name was thought to sound odd and therefore was unpopular with the public.

Perhaps the most important factor in the Edsel's failure, however, was that when the car was introduced, the U.S. was entering a period of recession.

The Ford Edsel

Sales for all car manufacturers were down; consumers entered a period of preferring less-expensive, more fuel-efficient automobiles.

Edsels were fast, but required premium fuel and did not make the gas mileage desired during a recession.

Mechanics disliked the bigger engine because of its unique design. The cylinder head had no combustion chamber and was perfectly flat, with the head set at an angle and "roof" pistons forming both a squish zone on one side and a combustion chamber on the other.

The Ford Edsel

This design reduced the cost of manufacture and possibly carbon buildup, but appeared strange to mechanics.

Many drivers disliked having the automatic transmission as push-buttons mounted on the steering wheel hub: this was the traditional location of the horn.

Drivers ended up shifting gears instead of honking the horn.

The Ford Edsel

Various other problems were cited, including the unpopularity of the Edsel's trademark "horsecollar" grille, which made it stand out from other cars of the period.

A widely circulated wisecrack at the time was that "It looked like a Merc sucking on a lemon."

The grille was discontinued for the 1960 models, which were almost indistinguishable from Ford models of the same year.

The Ford Edsel

There were also reports of mechanical flaws in the models originating in the factory, due to lack of quality control and confusion of parts with other Ford models.

Edsels in their first model year were made in both Mercury and Ford factories; There was never a stand-alone Edsel factory devoted solely to Edsel model production. The desired quality control of the different Edsel models was difficult to achieve for the new make of car.

Forces That Cause Failures

- Poor determination of requirements and system scope
- Poor visibility into and across the program
- Poor communications across the program
- Poor integration of elements
- Poor understanding of what the system is to do

We can address all of these by Systems Thinking and Systems Engineering

Summary of Session 1 - Why Are We Doing This?

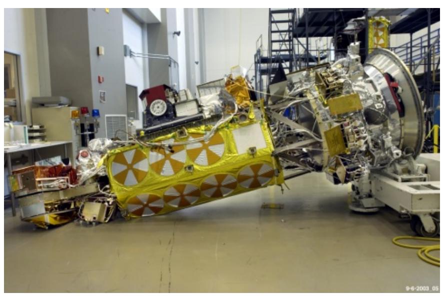
What Causes Failures/Mishaps/Problems/Issues ?

90+% - Human Error

~5% - Unknown Situation – Concatenation of Circumstances

~5% - Unexpected Change of Environment

Have We Learned From Past Failures/Mishaps/Problems? ?



Next Sessions

- Systems Engineering Life Cycle
- Requirements Management
- Systems Design and Architecture Development
- Risk Management
- Quality Management
- Systems Integration
- Test and Evaluation
- Validation and Verification