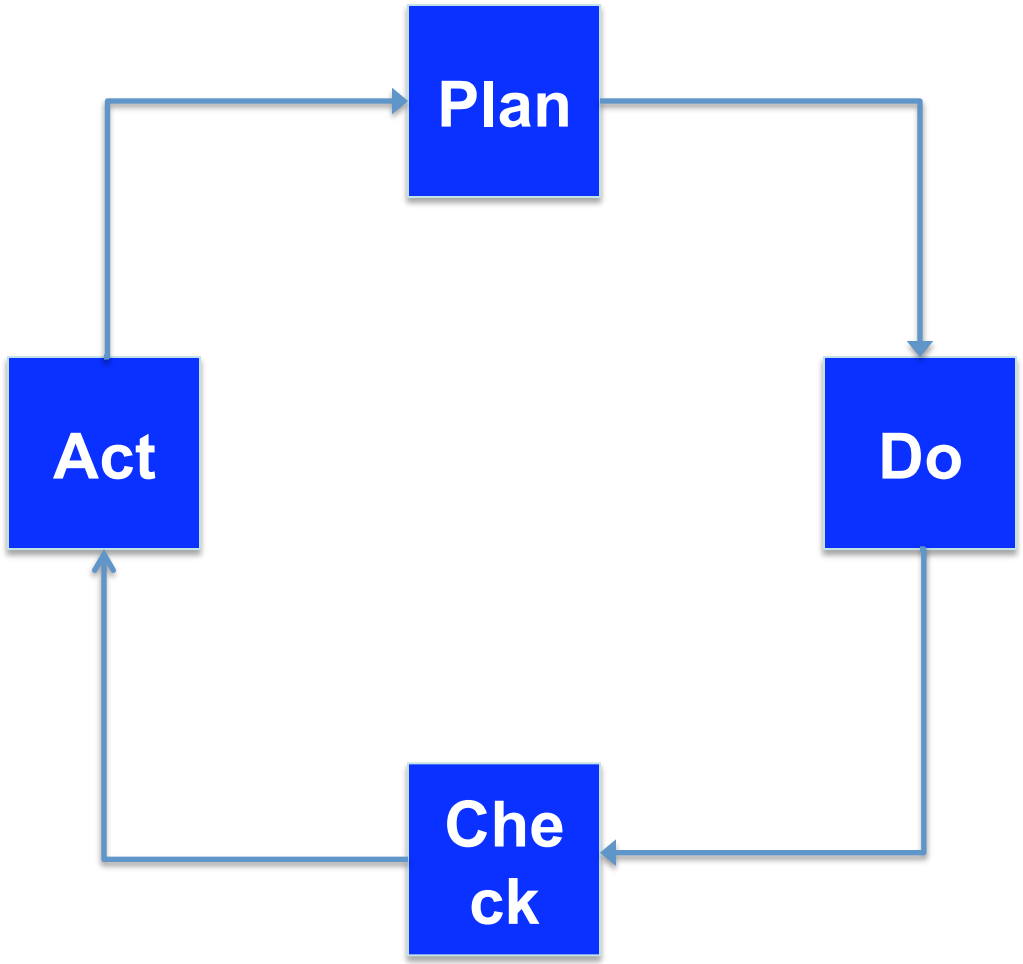
Learning from Breakdowns

Glenn Ballard

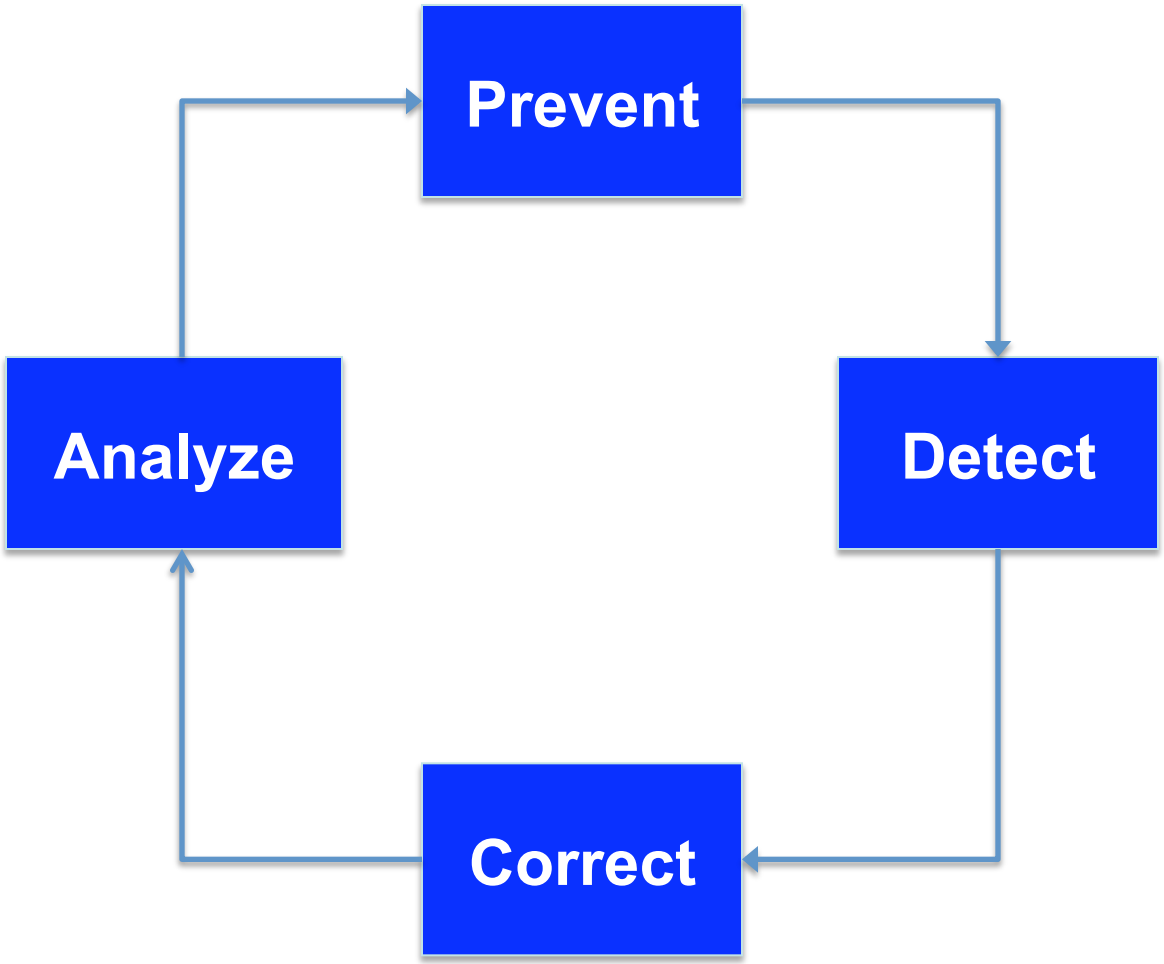
October 2008

Boulder, Colorado

Walter Shewhart's PDCA Cycle



A PDCA Cycle for Learning from Breakdowns



Prevent

- Preventive action depends on our understanding of causation; what causes various types of breakdowns.
- When breakdowns occur despite our efforts to prevent, that tells us we have something more to learn about cause and effect.

Detect

When breakdowns do occur, we want to detect them as close to their point of origin as possible, to contain the damage. That is one of the good arguments for small batches and for self inspection.

Correct

Once detected, the first step is to take corrective action. For example, if we have an error in a drawing, we correct the error and replace the drawing.

Analyze

But corrective action is not enough if we want to prevent reoccurrence. We must analyze the breakdown to understand why it happened in order to understand causality. That's the only way we can prevent reoccurrence.

Breakdowns

- Plan failures
- Defects
- Accidents

Two sources of inspiration

- Sidney Dekker's thinking about accident investigations—*A Field Guide to Understanding Human Error*
- VA Hospital's success in reducing medical errors through apology rituals

The Royal Majesty Accident

On June 10, 1995, a passenger ship named Royal Majesty left St. Georges in Bermuda. On board were 1509 passengers and crewmembers who had Boston as their destination—677 miles away, of which more than 500 would be over open ocean. Innovations in technology have led to the use of advanced automated systems on modern maritime vessels. Shortly after departure, the ship's navigator set the ship's autopilot in the navigation (NAV) mode. In this mode, the autopilot automatically corrects for the effects of set and drift caused by the sea, wind and current in order to keep the vessel within a preset distance of its programmed track.

Not long after departure, when the Royal Majesty dropped off the St. Georges harbor pilot, the navigator compared the position data displayed by the GPS (satellite-based) and the Loran (ground/radio-based) positioning systems. He found that the two sets of data indicated positions within about a mile of each other—the expected accuracy in that part of the world. From there on, the Royal Majesty followed its programmed track (336 degrees), as indicated on the automatic radar plotting aid. The navigator plotted hourly fixes on charts of the area using position data from the GPS. Loran was used only as a back-up system, and when checked early on, it revealed positions about 1 mile southeast of the GPS position.

About 34 hours after departure, the Royal Majesty ran aground near Nantucket Island. It was about 17 miles off course. The investigation found that the cable leading from the GPS receiver to its antenna had come loose and that the GPS unit (the sole source of navigation input to the autopilot) had defaulted to dead- reckoning (DR) mode about half an hour after departure. Evidence about the loss of signal and default to DR mode was minimal, contained in a few short beeps and a small mode annunication on a tiny LCD display meters from where the crew normally worked. In DR mode, there was no more correction for drift. A northeasterly wind had blown the Royal Majesty further and further west.

From the investigation board's report:

"Thus, had the officers regularly compared position information from the GPS and the Loran-C, they should not have missed the discrepant coordinates, particularly as the vessel progressed farther from its intended track."

What do you make of the investigation board's report?

What needs explaining is why normal, professional seamen are liable to misinterpret cues, especially somewhat ambiguous cues. The report does not provide an explanation. It simply says that the 2nd officer did not do what a good seaman would have done.

The Swissair 111 accident

During the Swissair 111 flight, the crew noticed smoke in the cockpit. A diversion airport (Halifax) was in their vicinity, but they did not make an emergency descent, and never made it there. Instead, the pilots took time sizing up the situation, going through checklists, and making preparations for fuel dumping to reduce their landing weight. The developing fire caught up with them and rendered the aircraft uncontrollable. It crashed into the sea, killing everybody onboard.

How to analyze this breakdown? The following statements are from the accident investigation report.

"When the pilots started their descent toward Halifax at 0115:36, they had assessed that they were faced with an air conditioning smoke anomaly that did not require an emergency descent. Based on their perception of the limited cues available, they took steps to prepare the aircraft for an expedited descent, but not an emergency descent and landing."

What do you make of this analysis?

Field Guide to Understanding Human Error
By Sidney Dekker

1. Systems are not inherently safe or stable. Safety and stability is created by human action.
2. “Human error” is not a useful finding from breakdown analysis. It doesn’t explain why what was done made sense to those who did it. If it made sense to them, it’s likely to make sense to others in similar circumstances.
3. Beware analysis based on hindsight. Knowing what would have prevented the breakdown does not amount to knowing how to prevent future breakdowns of the same kind.

Shouldn’t we analyze breakdowns in our processes and systems this same way?

5 Why's Experiment

Ask supervisors to agree and train them how to do 5 Why's analysis on their own plan failures before the weekly coordinating meeting, to state their own commitments to preventive action when those are in their control, and to make requests of others to act on causes outside their control. When the request is to someone else on the project team, it should be made in time for the other supervisor to do his 5 Why's analysis prior to the weekly coordinating meeting.

Have GC superintendents review plan failures and 5 Why's analyses with each supervisor individually before the weekly coordinating meeting, and help them improve their analyses.

In the weekly coordinating meeting:
•Review plan failures: 'Why was this task not completed? What will be done to prevent reoccurrence?'
•Record all commitments to preventive action and requests for preventive action.
•Review progress reports on previous requests, if any.
•While viewing the PPC chart for the project, ask if anyone has any other suggestions for improving PPC.

After the weekly coordinating meeting, the project superintendent forwards requests for preventive action to the appropriate party, updates the project's 5 Why's log (spreadsheet with these column headings: request, date of request, sent to, status, comments), and posts it where it can be seen by all supervisors.

Results of 5 Why's analysis of plan failures from multiple small residential projects in Finland

Intralling rebar	Sikuri	Fundia	A boom is needed when lifting otherwise mesh bends
Intralling rebar	Sikuri	Fundia	"Rebar shelf" needed, speeds up off loading
Plastering	Sikuri	Loimaa	Horisontal shafts has plaster inside (protection has fallen)
Foundation	**Reimantorni**	**Skanska**	**Pump specs and ordering late**
Foundation	**Käpytikka**	**Skanska**	**Pump specs and ordering late**
Rebar	Reimantorni	Skanska	Bomb shelter floor NOT from bars either mesh or BAMTEC
Rebar	Reimantorni	Skanska	Bomb shelter walls from mesh
Rebar	Reimantorni	Skanska	Bomb shelter roof can be done by BAMTEC
Structure	Reimantorni	Skanska	Penetration supports should be TimTEK boxes
Structural engineering	Reimantorni	Finnmapcons	Contrete elements should be placed direclty on Bomb shelter without poring a separet "foundation for the elements
Raudoitus	Reimantorni	Skanska	The rebar in cellar and 1 floor should be layed so that it can be pored in sections
Rebar	Reimantorni	Skanska	When using BAMTEC, make sure contrete element columns can be tied to the slab
Structure	Reimantorni	Skanska	In PV walls prefabricated steel pieces has to be used.
Structure	**Reimantorni**	**Skanska**	**Ducts on wrong place, measurement from first floor**
Structure	Reimantorni	Skanska	No Aqua-panel in bathroom walls, slow and expensive to install
Plumbing/ Sturcture	Reimantorni	Skanska	Sprinkler installation first after plumbimg
Structural engineering	Reimantorni	Finnmapcons	The roof in balcony elements was not levelled - timber should not be used
Engineering	**Reimantorni**	**Rakennesuunnittelu**	**Balcony walls planned to build on site-> change to prefabrication**
Structural engineering	**Reimantorni**	**Rakennesuunnittelu**	**Specs are missing "vapaita" reunoja**
Structural engineering	Reimantorni	Elem. suunnittelu	Round columns should be cast at site using disposable formworks
			Chnage squre columns to round if possible
Plumbing/ Sturcture	Sikuri	Skanska	Sewatek penetration have wrong slope or place
Structural	Reimantorni	Skanska	Beam rebar shoud be dense so that boots does not slip into the beam while poring
Plumbing/ Sturcture	**Reimantorni**	**LVI- suunnittelu**	**Pipes measurement should be taken from load carring stuctures**
Interior phase	Reimantorni	Skanska	Fire doors should be installed first after painting
Change order	Reimantorni	Skanska Kodit	Household equipment has to be re-checked before call-off (plenty of changes by customers)
Interior phase	Reimantorni	Skanska	Bathroom ventilation has be checked so that it does not hit the "shower wall"
Interior phase	Reimantorni	Skanska	Balcony slabs should have hooks for the firemen
Interior phase	Reimantorni	Skanska	In front of the elevator shaft there should be hooks for firemen
Interior phase	Reimantorni	Skanska	Shafts door (type and size) has be included in specs
Changer order	Reimantorni	Skanska Kodit	Outlets for steamroom and jacuzzi has to be verified prior to acctepting CO
Change order	Reimantorni	Skanska Kodit	Specialty lighting specs has to be given to the ceiling sub as well (sauna & bathroom)
Structural	Kartio	Skanska	ONTELOTALO: holvin päältä lähtevien elpojen kohdat kylpyhuoneissa valetaan mataliksi
			1. elpoon sijoitettava valuputki viemärinmutkavalua varten.
Interior phase	Reimantorni	Skanska	The holes for heating pipes has to be filled prior to building the ceiling (acustics)

Apology: a preparation for Analysis and Learning?

- *How to say I'm sorry: a study of the Veterans Administration Hospital Association's apology and disclosure program,* Heather Carmac, PhD Dissertation, Scripps College of Ohio University, 2008
- Aaron Lazzare, *On Apology,* Oxford University Press, 2004

Experiments Underway

- 5 Why's analysis of plan failures-Pankow, Skanska Finland
- Quality breakdowns (defects)-DPR
- Accidents-Rosendin Electric

Let me know if you would like to participate

Takeaways

Questions