CONSTRUCTION SCIENCE
TEXAS A&M UNIVERSITY

Introduction to Lean-Integrated Project Delivery for the Built Environment

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Acknowledgements to:

The Construction Industry Advisory Council (CIAC)
Department of Construction Science
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Mr. Alan Mossman
The Business Change Ltd.
http://www.thechangebusiness.co.uk/home

the ReAlignment Group of California, LLC
http://danzpage.com/

Education & Professional Experience

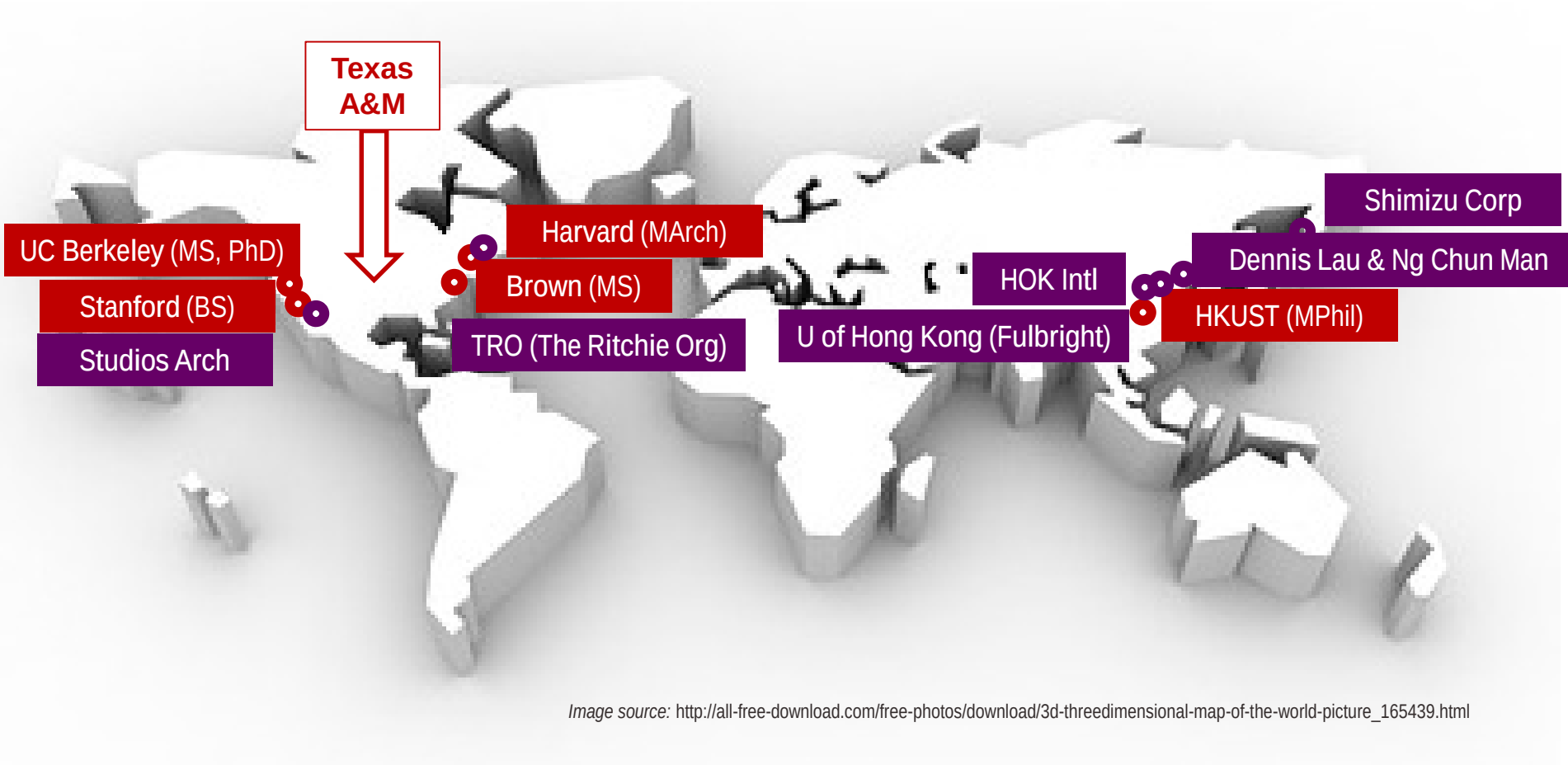


Image source: http://all-free-download.com/free-photos/download/3d-threedimensional-map-of-the-world-picture_165439.html

Learning Objectives

→ Understand the developmental history of Lean thought

→ Understand and apply the basic elements of Target Value Design

→ Apply continuous improvement to a current Hong Kong challenges

How can we make BETTER QUALITY buildings FINANCIALLY FEASIBLE?

Why

Lean Construction

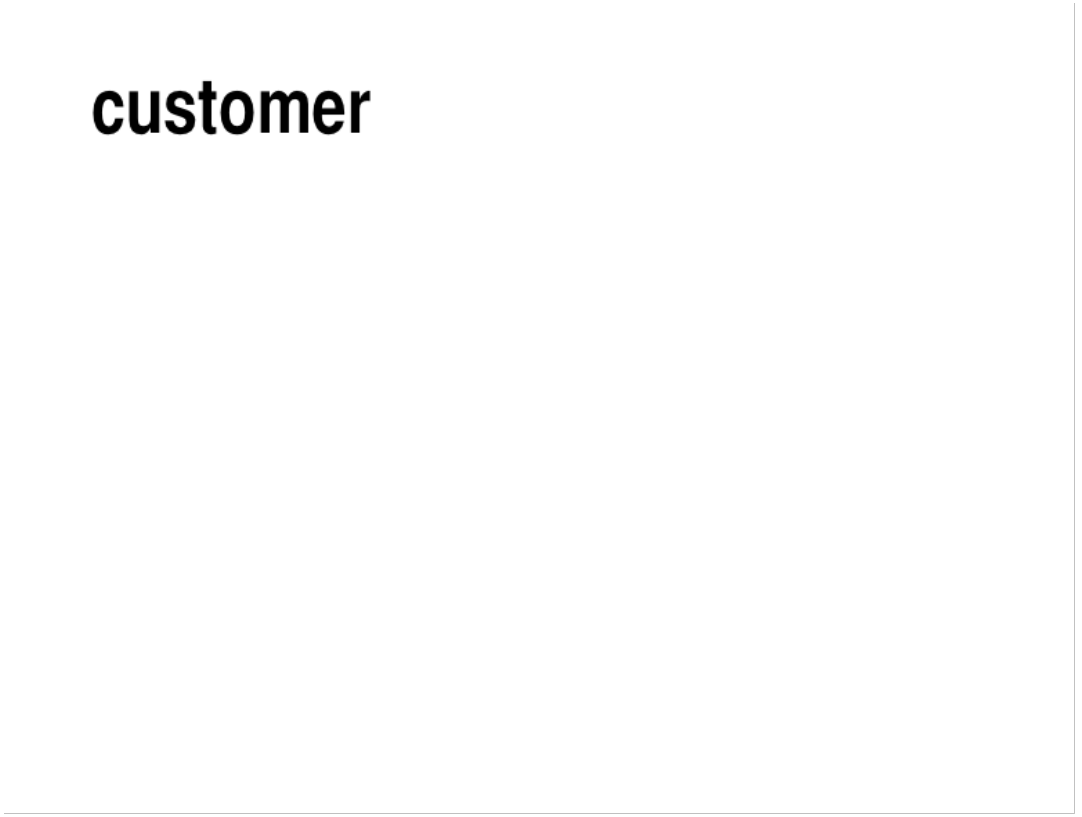
Came

About

repairman

Source: Alan Mossman:

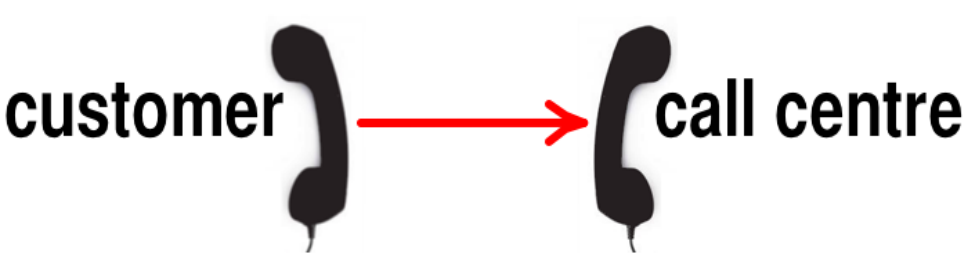
repairman



Source: Alan Mossman:

repairman

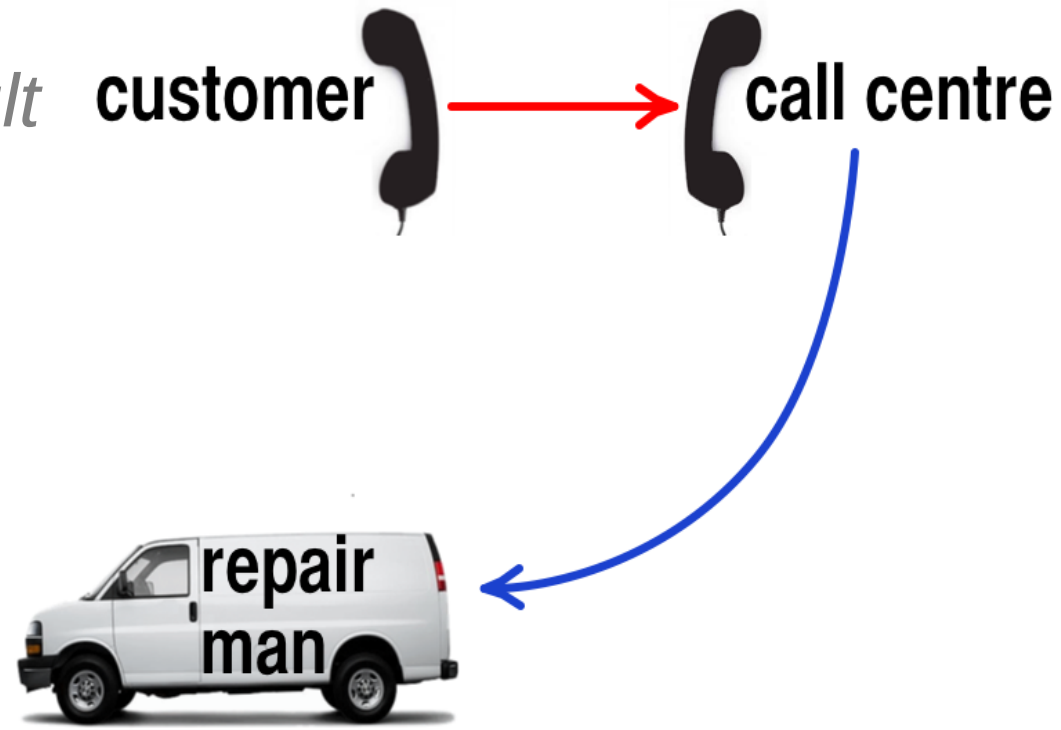
reports a fault



Source: Alan Mossman:

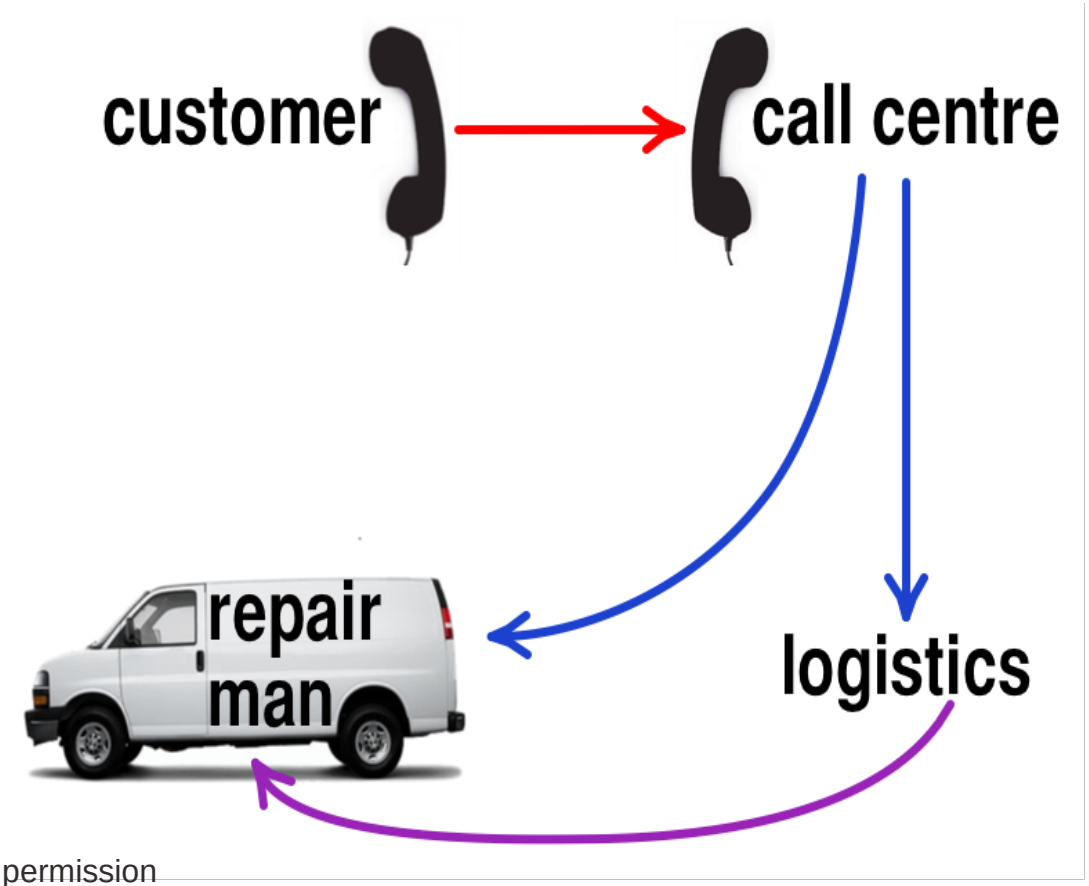
repairman

reports a fault



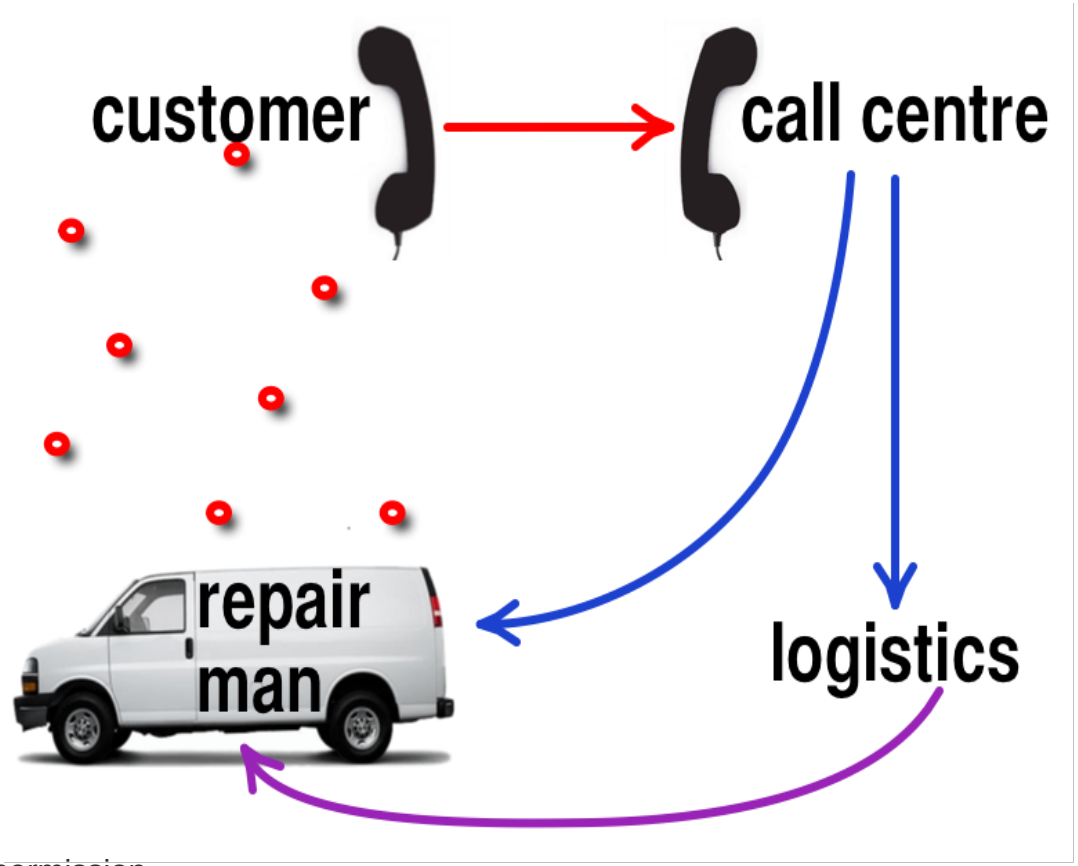
Source: Alan Mossman:

repairman



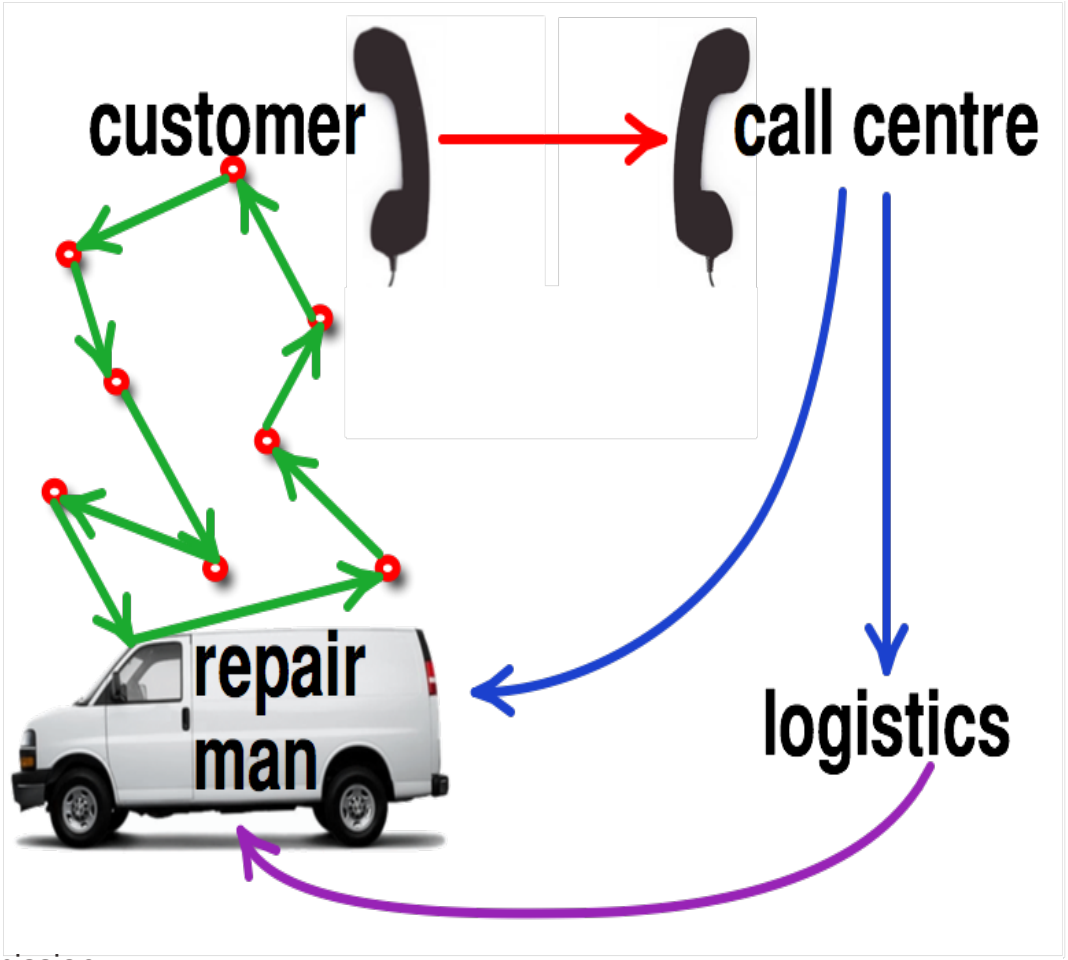
Source: Alan Mossman:

repairman



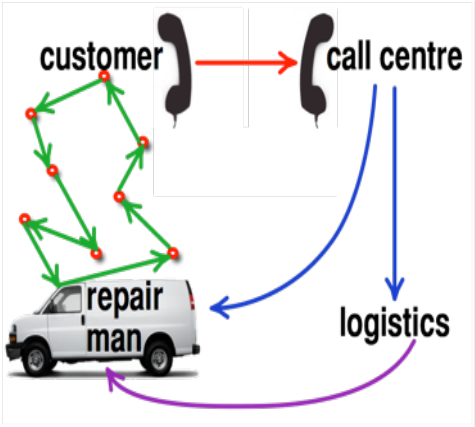
Source: Alan Mossman:

repairman



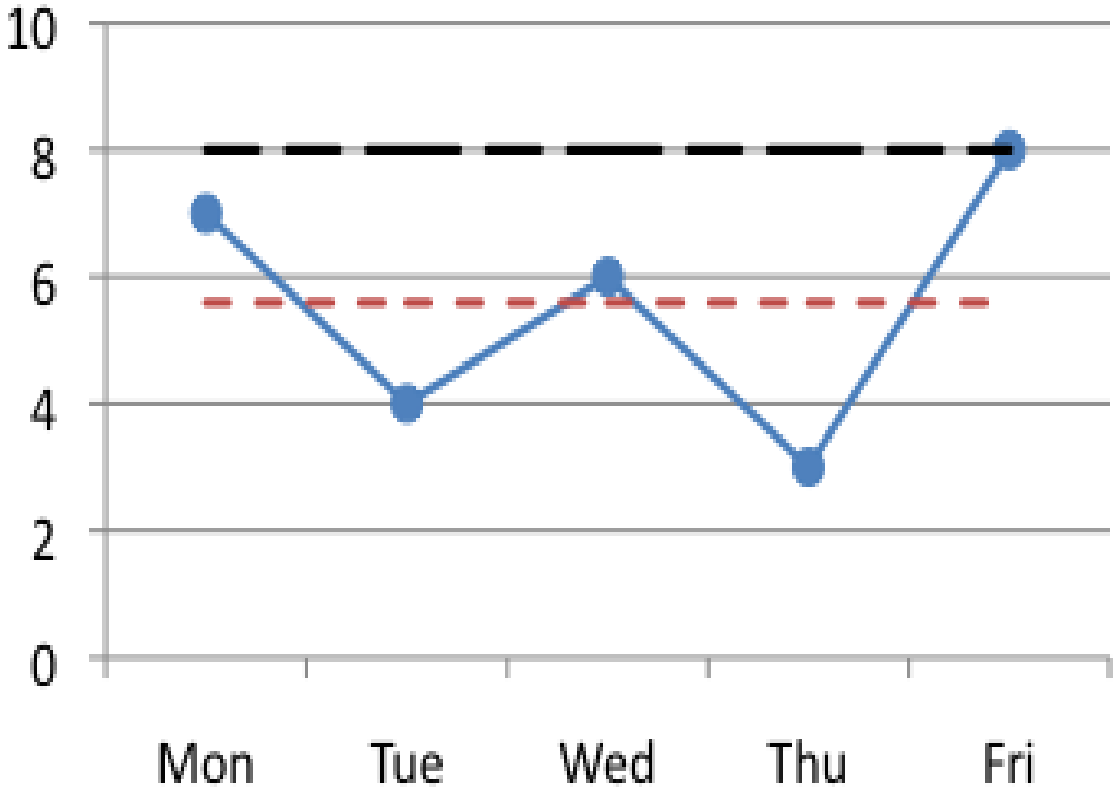
Source: Alan Mossman:

repairman



Why does his performance vary from day to day?

Brainstorm 10 reasons



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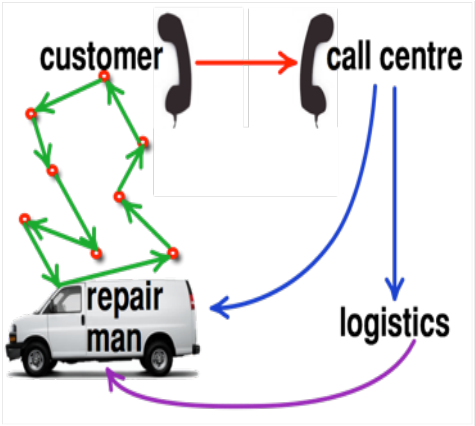
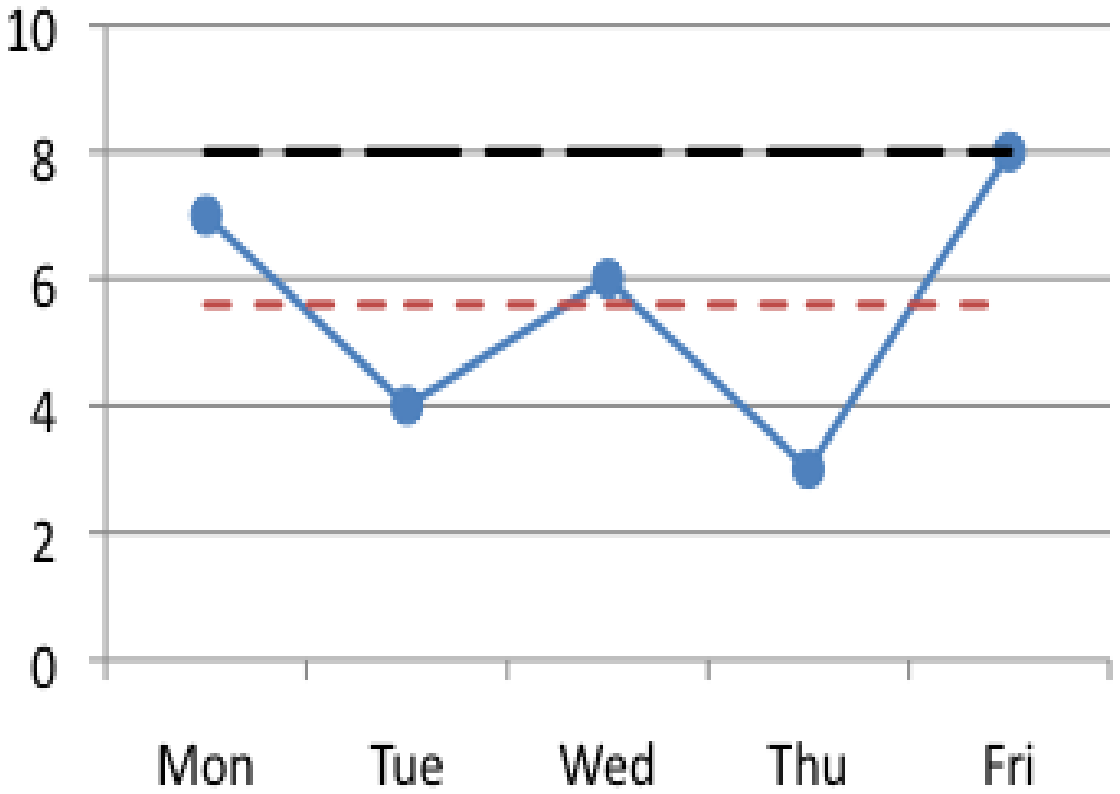


What % of performance is due to the system?

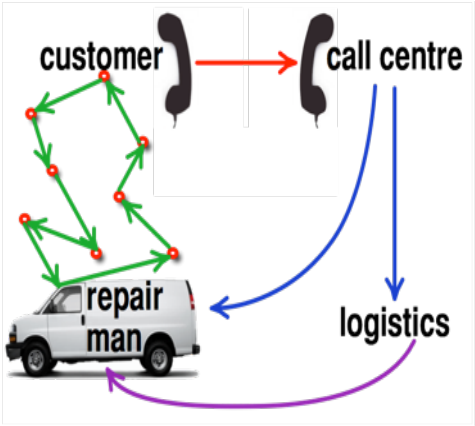
What % due to the worker?

Where do we put most of the focus? Why are we focusing there?

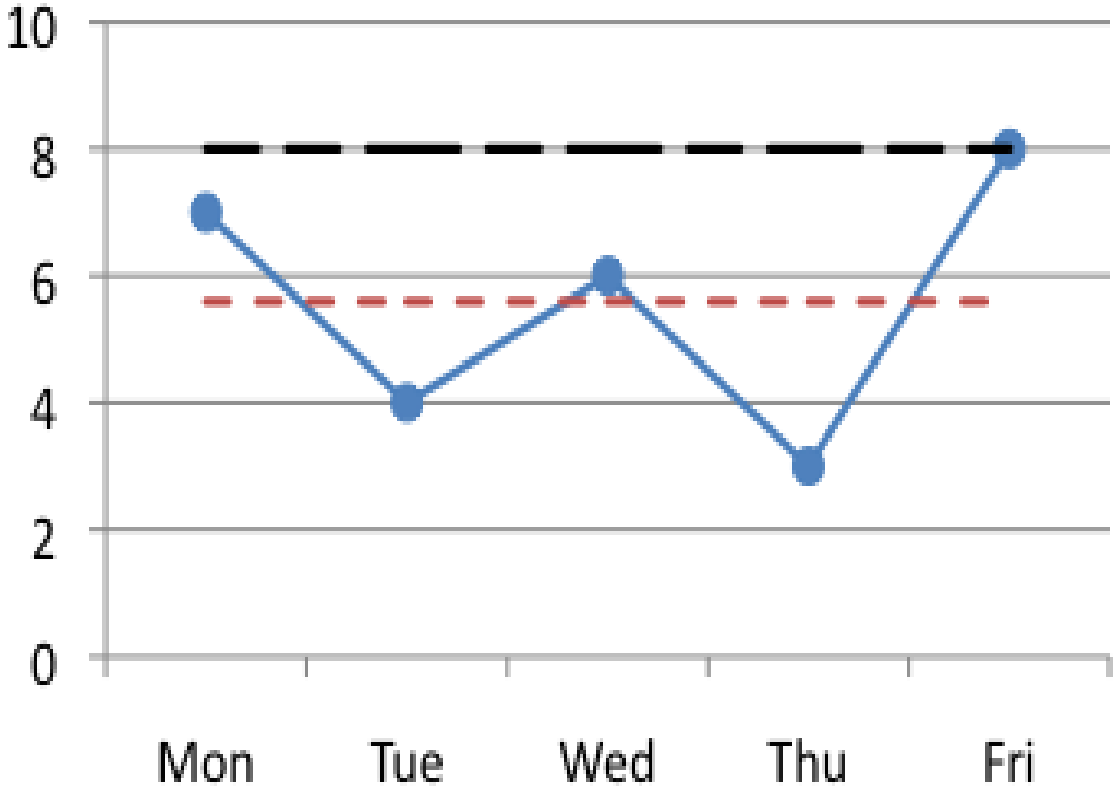


Source: Alan Mossman:

repairman

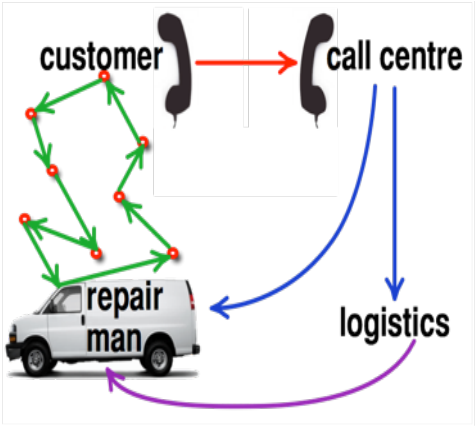


To improve is to work on the system

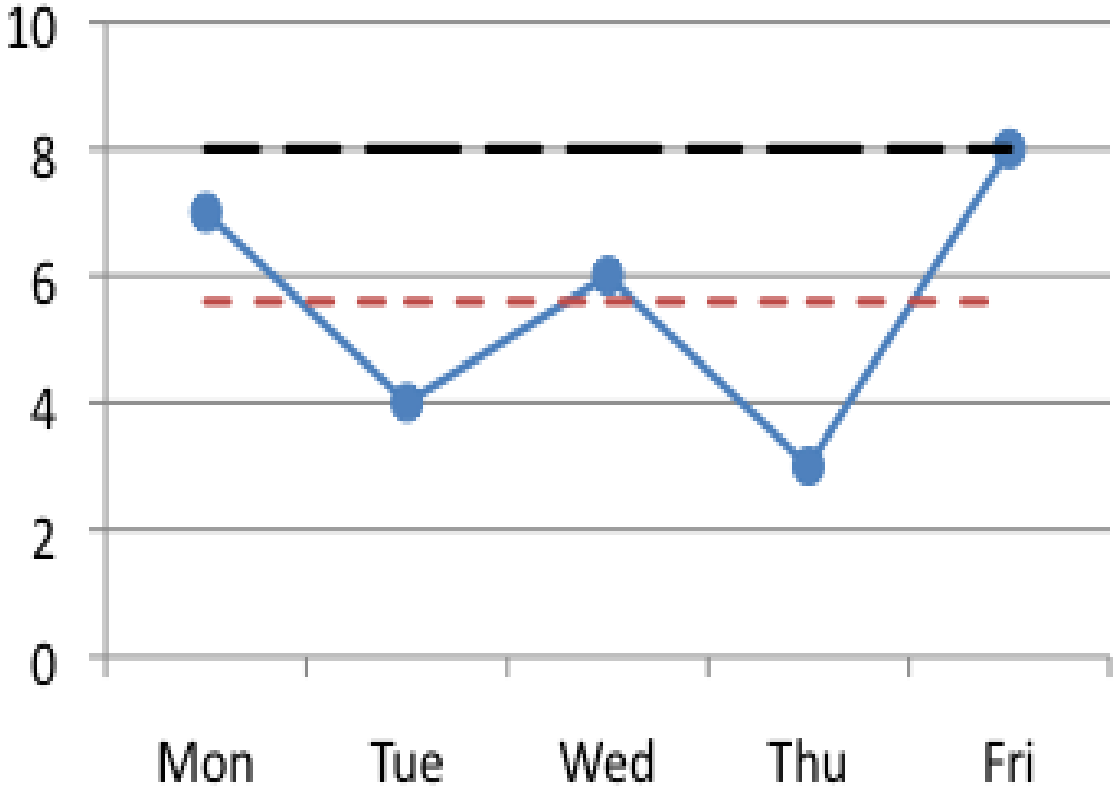


Source: Alan Mossman:

repairman



What are you doing to remove obstacles that prevent your people doing a good job?



Source: Alan Mossman:

The big %

People work in a system.
The role of the manager
is to work on the system
to improve it -
with their help.

Source: Alan Mossman:

How can we change the system?

Source: Alan Mossman:

Time, cost, quality, safety, or morale--

Which of these would you like to most improve for your company's projects?

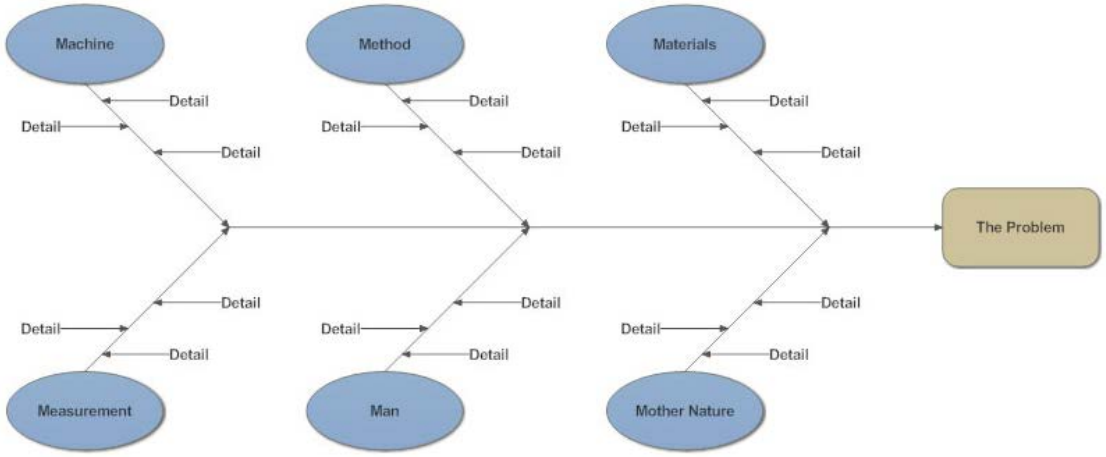
Source: Alan Mossman:

Brainstorm at least 10 possible reasons, then use these tools in this order:

(1) Ishikawa fishbone diagram
(2) Pareto chart
(3) 5 Why's Root Cause Analysis
(4) Use the root cause countermeasure to feed into the P-D-C-A Cycle and measure the change in outcome

Source: Alan Mossman:

“Fixing the system”: Key tools



Cause and Effect Diagram

Where to put your greatest effort

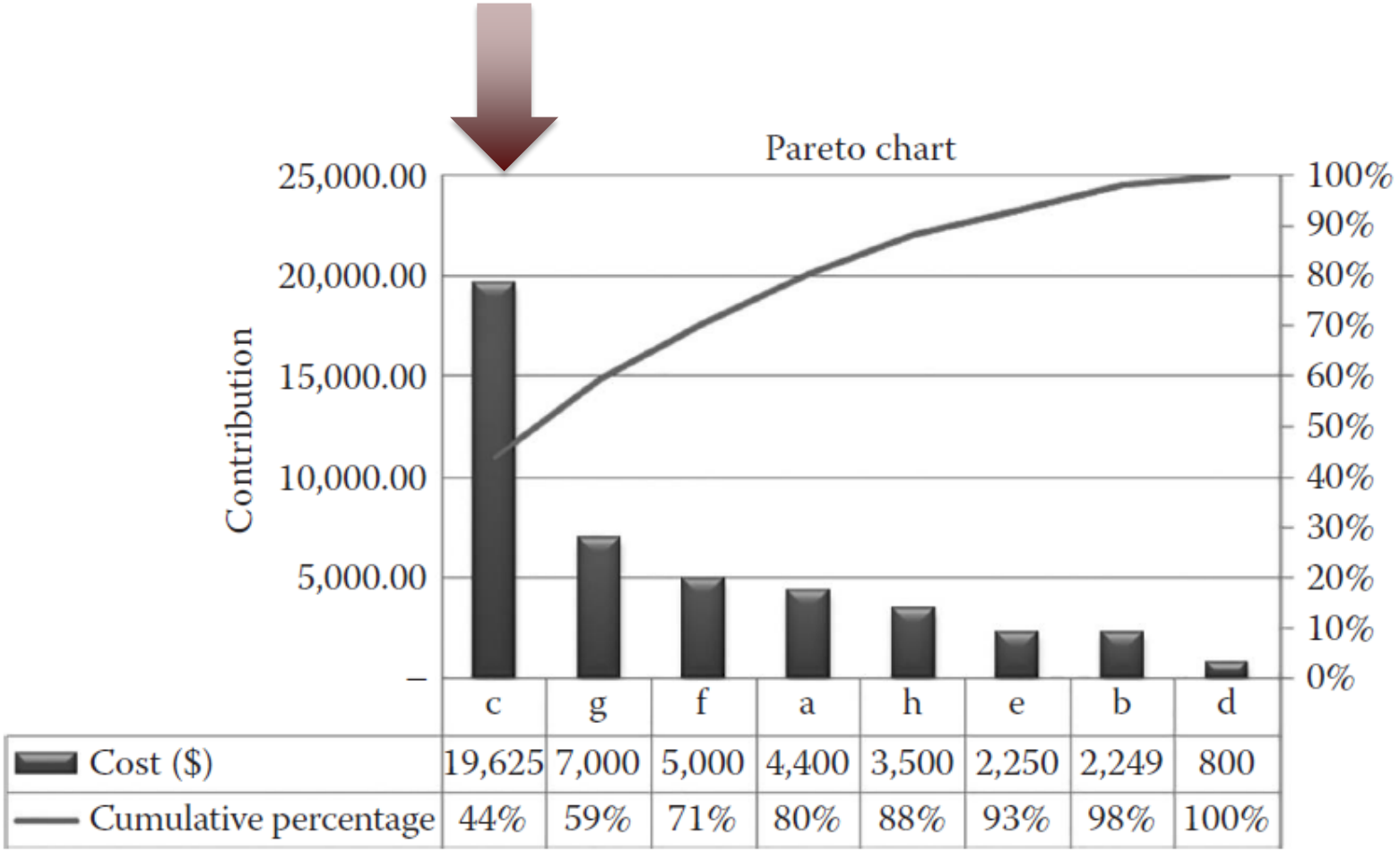
(i.e. Measure and then focus on the largest cause)

Example of Table Used to Develop a Pareto Chart

Item*	Category	Cost ($)	Percentage	Cumulative Percentage
c	Not finished on time	19,625.00	44%	44%
g	Wrong window installed	7,000.00	16%	59%
f	Job not done properly	5,000.00	11%	71%
a	Code infraction	4,400.00	10%	80%
h	Damage during installation	3,500.00	8%	88%
e	Not starting on time	2,250.00	5%	93%
b	Leave job site dirty	2,249.00	5%	98%
d	Crew very rude	800.00	2%	100%
		44,824.00	100%	

Source: Adapted from Forbes, L.H., and Ahmed, S.M., *Modern Construction: Lean Project Delivery and Integrated Practices*, CRC Press, Boca Raton, FL, 2010 [as cited in Figure 9.13, p. 270]. Reprinted with permission from Taylor & Francis Group.

**Note:* Items have been re-sorted in the order of decreasing magnitude to help the project manager focus on items responsible for the largest magnitude of impact.



Pareto Chart

Fix the *Root* Cause (this offers the long-term solution!)

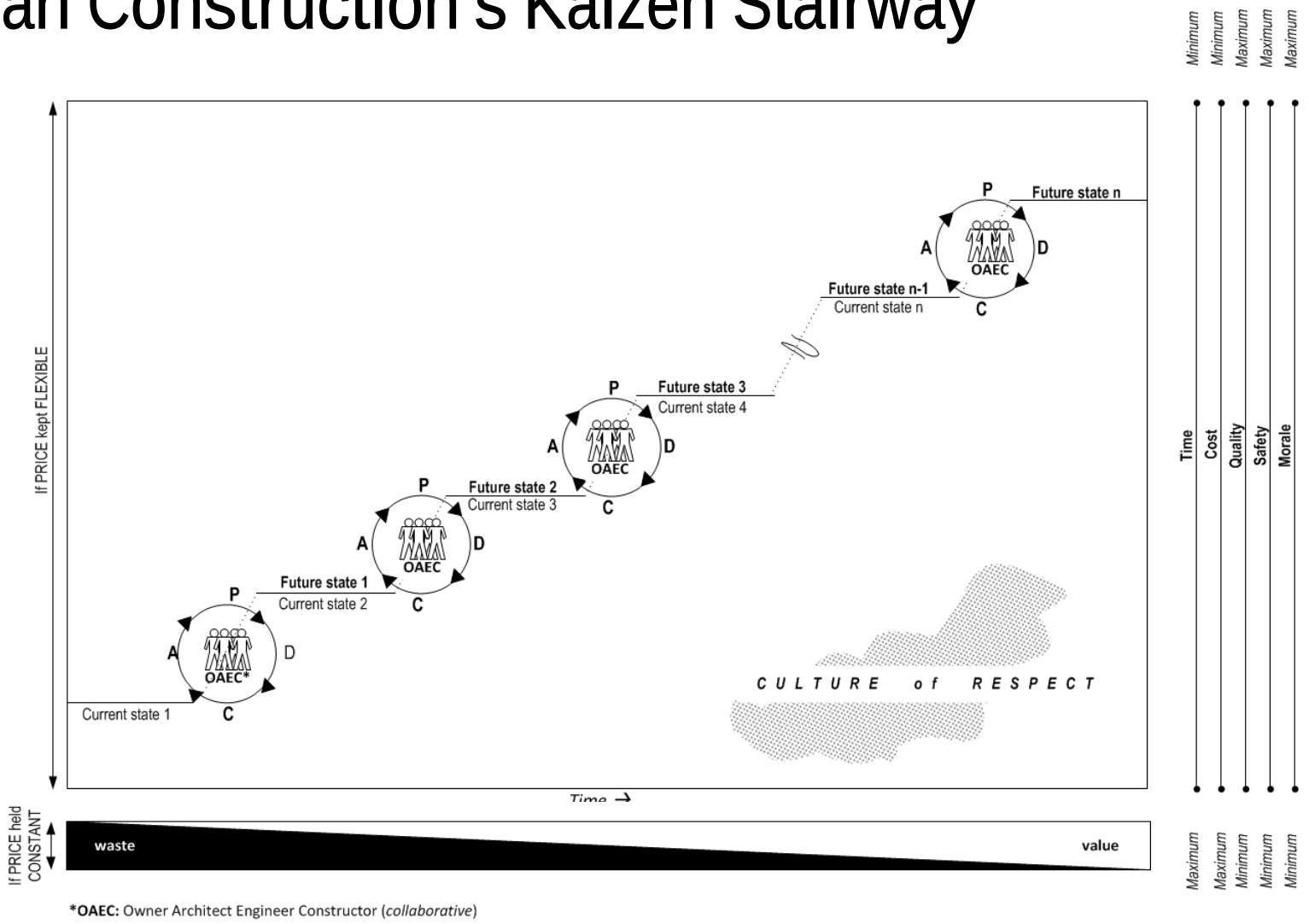
Example of Root Cause Analysis Using 5 Whys/Root Cause Analysis

Level of Problem	Corresponding Level of Countermeasure	Result If Action Taken at This Point
There is a puddle of oil on the shop floor	Clean up the oil	Short-term solution
Because the machine is leaking oil	Fix the machine	"
Because the gasket has deteriorated	Replace the gasket	Mid-term solution
Because we bought gaskets made of inferior material	Change gaskets specifications	"
Because we got a good deal (price) on those gaskets	Change purchasing policies	"
Because the purchasing agent gets evaluated on short-term cost savings	Change the evaluation policy for purchasing agents	Long-term solution

Source: Liker, J.K., *The Toyota Way*, McGraw-Hill, New York, 2004 (as cited in Figure 20.1, p. 253). Reprinted with permission from McGraw-Hill.

The 5 Whys

Lean Construction's Kaizen Stairway



***OAEC:** Owner Architect Engineer Constructor (*collaborative*)

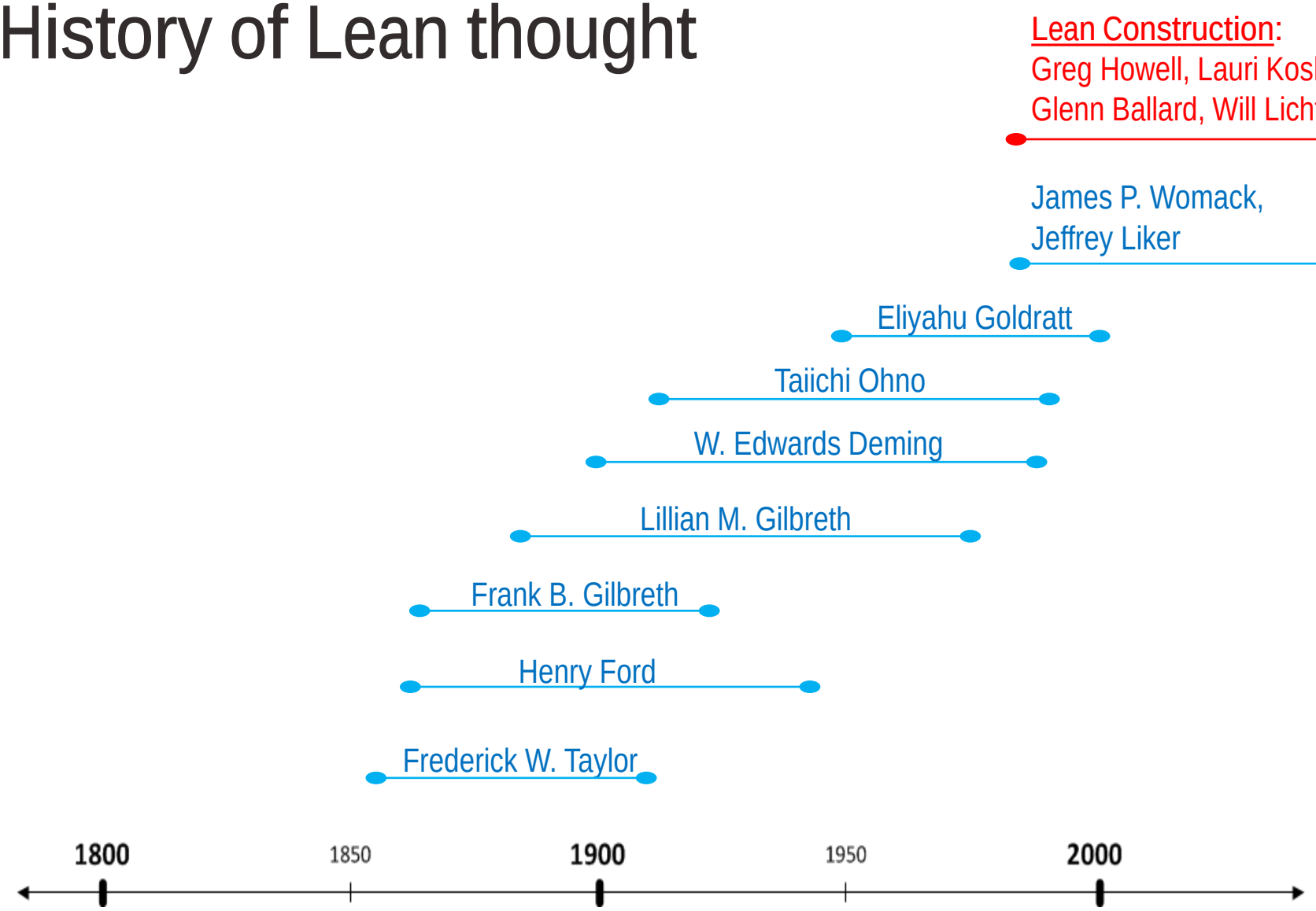
Source: **Rybkowski, Z. K.**, Abdelhamid, T., and Forbes, L. (2013). "On the back of a cocktail napkin: An exploration of graphic definitions of lean construction," Proceedings of the 21th annual conference for the International Group for Lean Construction; July 31-August 2, 2013: Fortaleza, Brazil, 83-92.

History

of

Lean

History of Lean thought



Source: Alan Mossman:

Antecedent Contributors to Lean Thinking





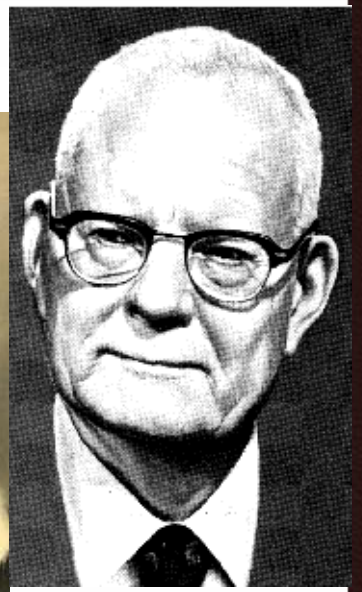


Photo sources:

Frederick Taylor: http://en.wikipedia.org/wiki/Frederick_Winslow_Taylor
Henry Ford: http://www.spartacus.schoolnet.co.uk/USAford.htm
Frank B. Gilbreth: http://www.lib.purdue.edu/spcol/manuscripts/fblg/
Lillian M. Gilbreth: http://en.wikipedia.org/wiki/Lillian_Moller_Gilbreth
W. Edwards Deming: http://en.wikipedia.org/wiki/W._Edwards_Deming



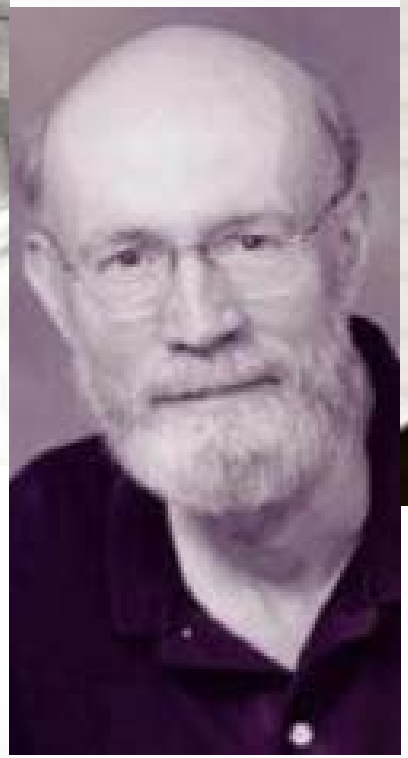
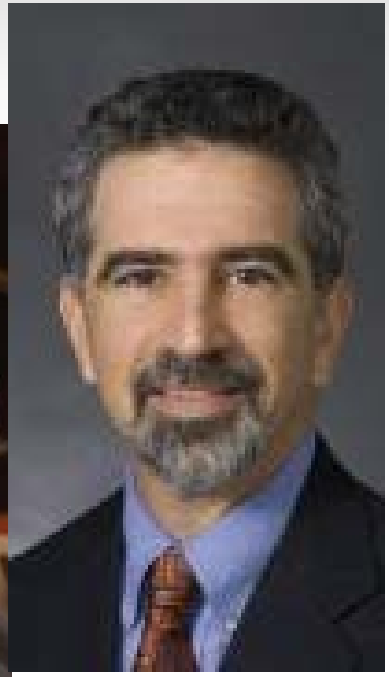



Photo sources:

Taiichi Ohno: http://www.gembapantarei.com/2012/03/masaaki_imai_remembers_taiichi_ohno.html
Eliyahu M. Goldratt: http://alumnieen.wordpress.com/2011/06/19/fallece-eliyahu-m-goldratt-autor-de-la-teoria-de-las-limitaciones/
James P. Womack: http://www.amazon.com/James-P.-Womack/e/B000APGWAM
Jeffrey Liker: http://www.strategy-business.com/article/08210?gko=60476

Pioneers of Lean Construction



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Might YOU be here ?

Photo sources:

Lauri Koskela: http://www-edc.eng.cam.ac.uk/kim/people/laurie-koskela.html
Greg Howell: http://www.leanconstruction.org/howellbio.htm
Glenn Ballard: http://www.youtube.com/watch?v=dJyCpuR9xck
Will Lichtig: http://www.centralvalleybusinesstimes.com/stories/001/?ID=17475

What

is

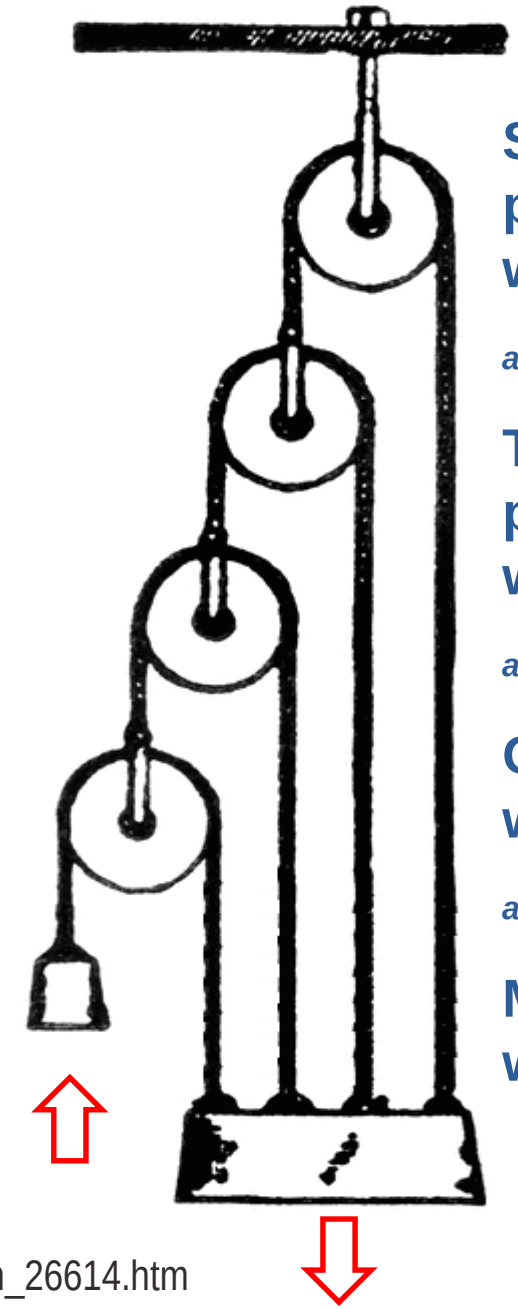
Lean Construction

?

Metrics of success

Photo source: http://c12solutions.com/blog1/sustainability-green-business-models-fdu/

With TRADITIONAL delivery systems



Safety performance worsens

and/or

Time performance worsens

and/or

Quality worsens

and/or

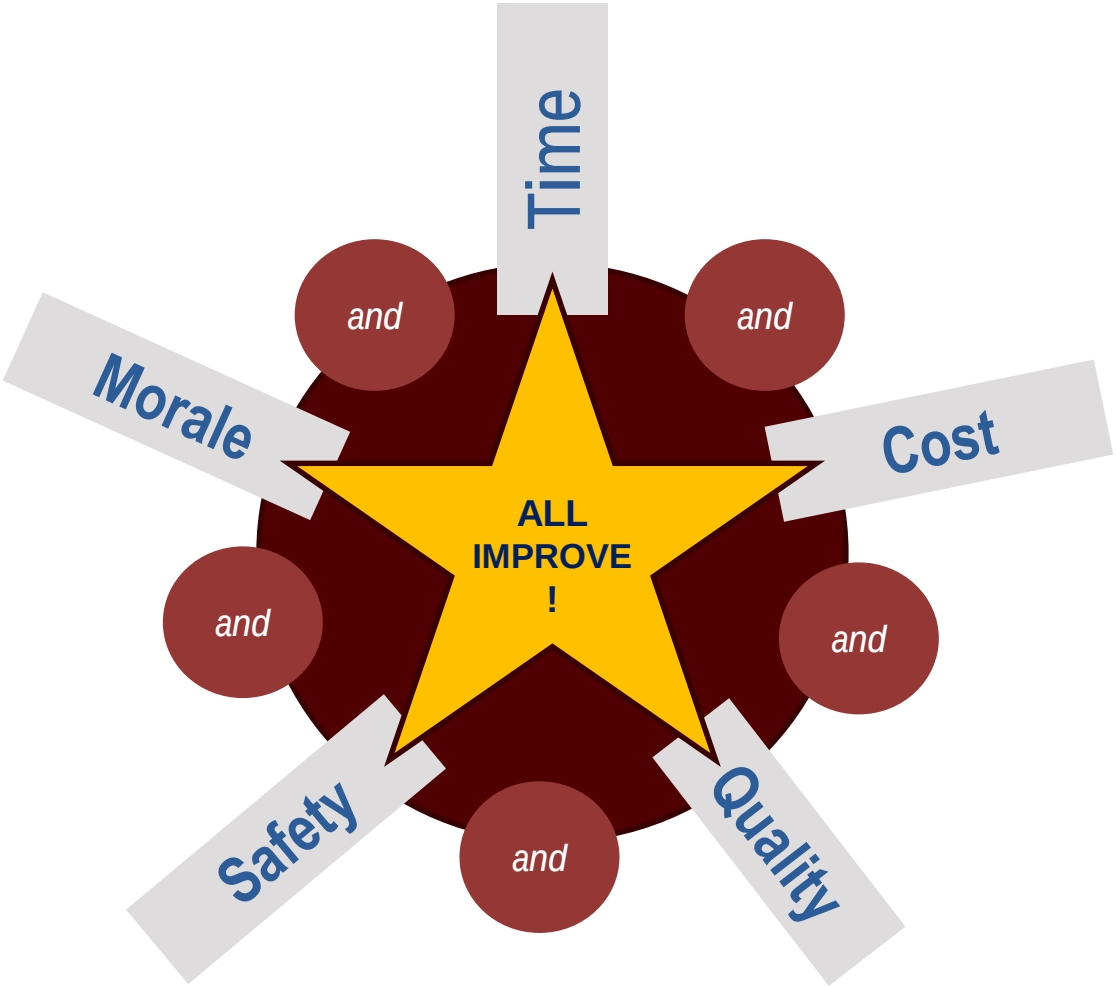
Morale worsens

If cost performance is improved

Image source:
http://etc.usf.edu/clipart/26600/26614/pulleysysten_26614.htm

By contrast,

With Lean Delivery System…

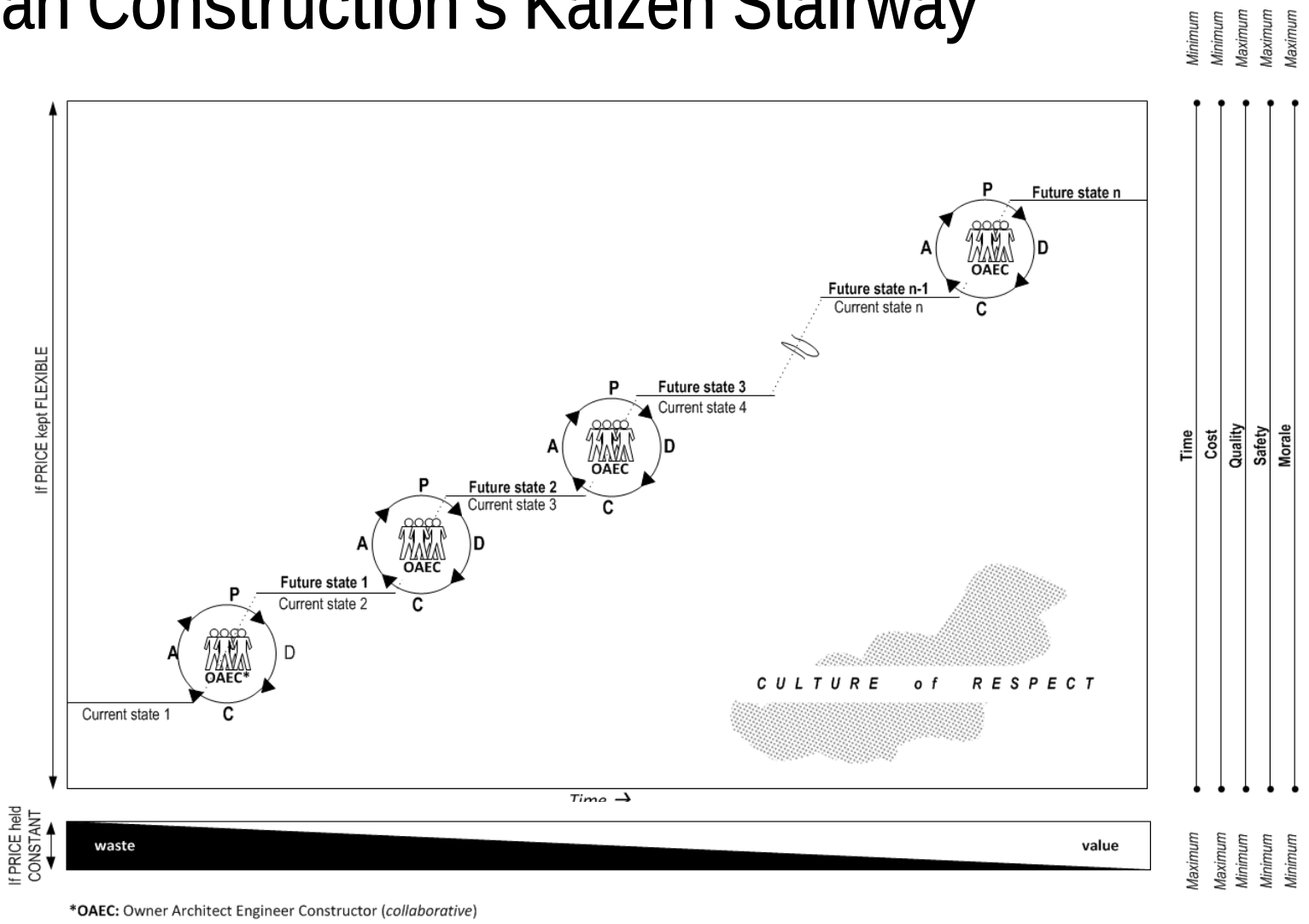


Here's a succinct definition of **Lean Construction**:

Reduce waste and add value
using continuous improvement
in a culture of respect.

Source: **Rybkowski, Z. K.**, Abdelhamid, T., and Forbes, L. (2013). "On the back of a cocktail napkin: An exploration of graphic definitions of lean construction," Proceedings of the 21th annual conference for the International Group for Lean Construction; July 31-August 2, 2013: Fortaleza, Brazil, 83-92

Lean Construction's Kaizen Stairway



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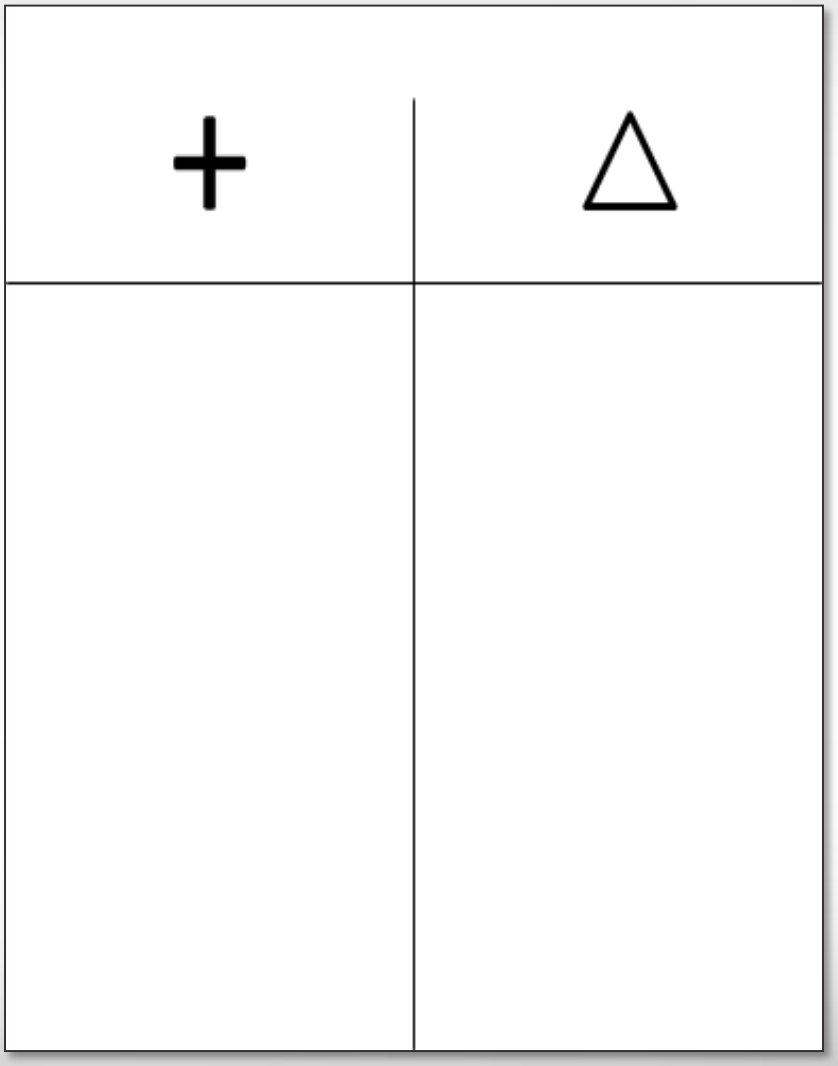
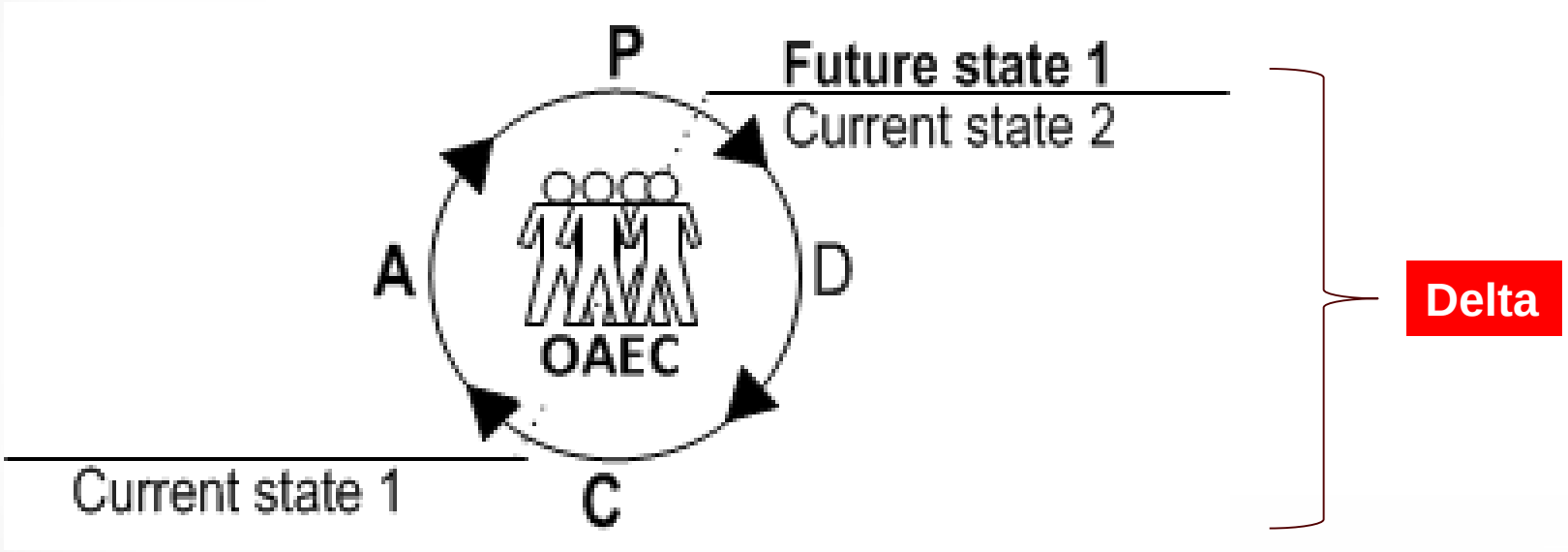
Source: **Rybkowski, Z. K.**, Abdelhamid, T., and Forbes, L. (2013). "On the back of a cocktail napkin: An exploration of graphic definitions of lean construction," Proceedings of the 21th annual conference for the International Group for Lean Construction; July 31-August 2, 2013: Fortaleza, Brazil, 83-92.

Critical tool for Lean



Engine of Lean Construction



Source: **Rybkowski, Z. K.**, Abdelhamid, T., and Forbes, L. (2013). "On the back of a cocktail napkin: An exploration of graphic definitions of lean construction," Proceedings of the 21th annual conference for the International Group for Lean Construction; July 31-August 2, 2013: Fortaleza, Brazil, 83-92.

Present growth of Lean-IPD (Internationally)

1. AUSTRALIA
- http://www.leanconstruction.org.au
- http://linkd.in/LCI-Sydney
- Marton Marosszeky

2. BOLIVIA
- http://bit.ly/LC-Bolivia
- J. Waldo Marquez

3. BRAZIL
- http://bit.ly/LC-Brasil
- Universities: UFRGS, UNICAMP, UFC

4. CANADA
- CoPs: http://linkd.in/LCI-US + CoPs

5. CHILE
- http://www.gepuc.cl
- Prof Luis Alarcon

6. COLOMBIA
- Jose A Guevara Maldonado
- Universities : Universidad de los Andes; EAFIT University

7. DENMARK
- http://www.leanconstruction.dk
- http://linkd.in/LC-DK
- Universities: DTU

8. ECUADOR
- Mario Fiallo

9. ESTONIA
- http://www.etet.ee/
- Universities : Tallinn University of Applied Sciences

10. FINLAND
- Universities : VTT, Espoo

11. FRANCE
- http://linkd.in/LCFrance
- Patrick Dupin

12. GERMANY
- www.lean-im-bauwesen.de
- http://www.lean-management-im-bauwesen.de
- http://www.lean-construction-institut.de
- http://bit.ly/LC-de
- www.tmb.kit.edu/lean

13. HONG KONG
- Dr Jose Jorge Ochoa Paniagua
- Universities: Hong Kong Polytechnic University

14. INDIA
- http://www.ilce.in
- http://bit.ly/ILCE-in
- Universities : Indian Institute of Technology Madras

15. INDONESIA
- http://on.fb.me/htzWVI
- http://www.petra.ac.id/
- http://magister-sipil.petra.ac.id/
- Martin Prilla Chandrawinata
- Universities: Petra Christian University, Surabaya

16. IRAN
- www.leanconstruction.blogfa.com

17. ISRAEL
- Prof Rafael Sacks, Technion

18. LEBANON
- Dr Farook Hamzeh
- Universities: American University of Beirut

19. LUXEMBOURG
- http://linkd.in/Lux-CE
- Lahcene Harbouche, CRP Henri-Tudor

20. MEXICO
- www.leanconstructionmexico.com
- http://bit.ly/LC-Mexico
- Edgar Reyes Carrasco and Luis Teran, MARHNOS

21. NETHERLANDS
- http://www.lcn-nl.org
- http://bit.ly/LC-nl
- Rudy Gort, Heembouw, Ype Cuperus, TU Delft
- Universities: TU Eindhoven, TU Delft

22. NEW ZEALAND
- http://bit.ly/LCI-NZ
- Dr Vicente Gonzalez
- Universities: The University of Auckland

23. NIGERIA
- http://bit.ly/LC-Nigeria
- Arc. David A. Adio-Moses, Dr Olatunji Oladiran
- Universities: University of Lagos (UNILAG)

24. NORWAY
- http://www.leanconstruction.no
- Universities : FAFO; University of Agder

25. PERU
- https://www.facebook.com/lciperu
- Jorge Luis Izquerdo

26. PORTUGAL
- http://bit.ly/LCPG-pt
- Universities: University of Minho, Universidade Nova de Lisboa

27. RUSSIA
- http://bit.ly/LC-Russia
- Andrey Glaubermann

28. SINGAPORE
- Prof David Chua Kim Huat, Gao Shang
- Universities: National University of Singapore

29. SOUTH AFRICA
- http://bit.ly/LC-za
- Fidelis Emuze,Head of Built Environment Department at Central University of Technology, Free State

30. SPAIN
- www.leanconstruction.es
- http://linkd.in/flYuAv
- Prof Eugenio Pellicer and Jose L. Ponz at Universidad Politecnica de Valencia

31. SRI LANKA
- Dr. Sepani Senaratne, University of Moratuwa

32. SWEDEN
- www.leanforumbygg.se
- Universities: Chalmers University of Technology, Luleå University of Technology

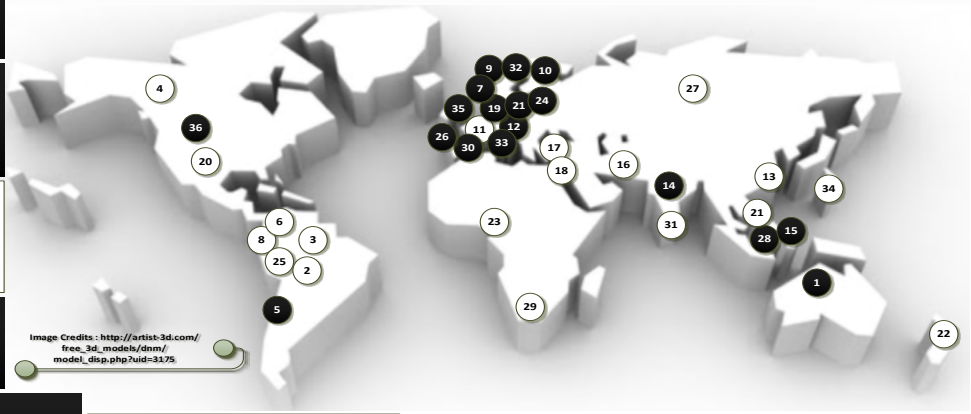
33. SWITZERLAND
- Ivo Lenherr, Bergitta Schock

34. TAIWAN
- http://www.ppml.url.tw/LCI_Taiwan/
- Universities: National Pingtung University of Science and Technology

35. UK
- http://www.leanconstruction.org.uk + chapters: NW
- http://linkd.in/LCI-UK
- Universities: Salford, Nottingham Trent, Northumbria, Dundee

36. USA
- http://www.leanconstruction.org chapters: most states
- http://linkd.in/LCI-US+ regional CoPs
- Universities: U Berkeley http://p2sl.berkeley.edu, Washington, SDSU, MSU http://www.c2p2ai.msu.edu, TAMU, CSU

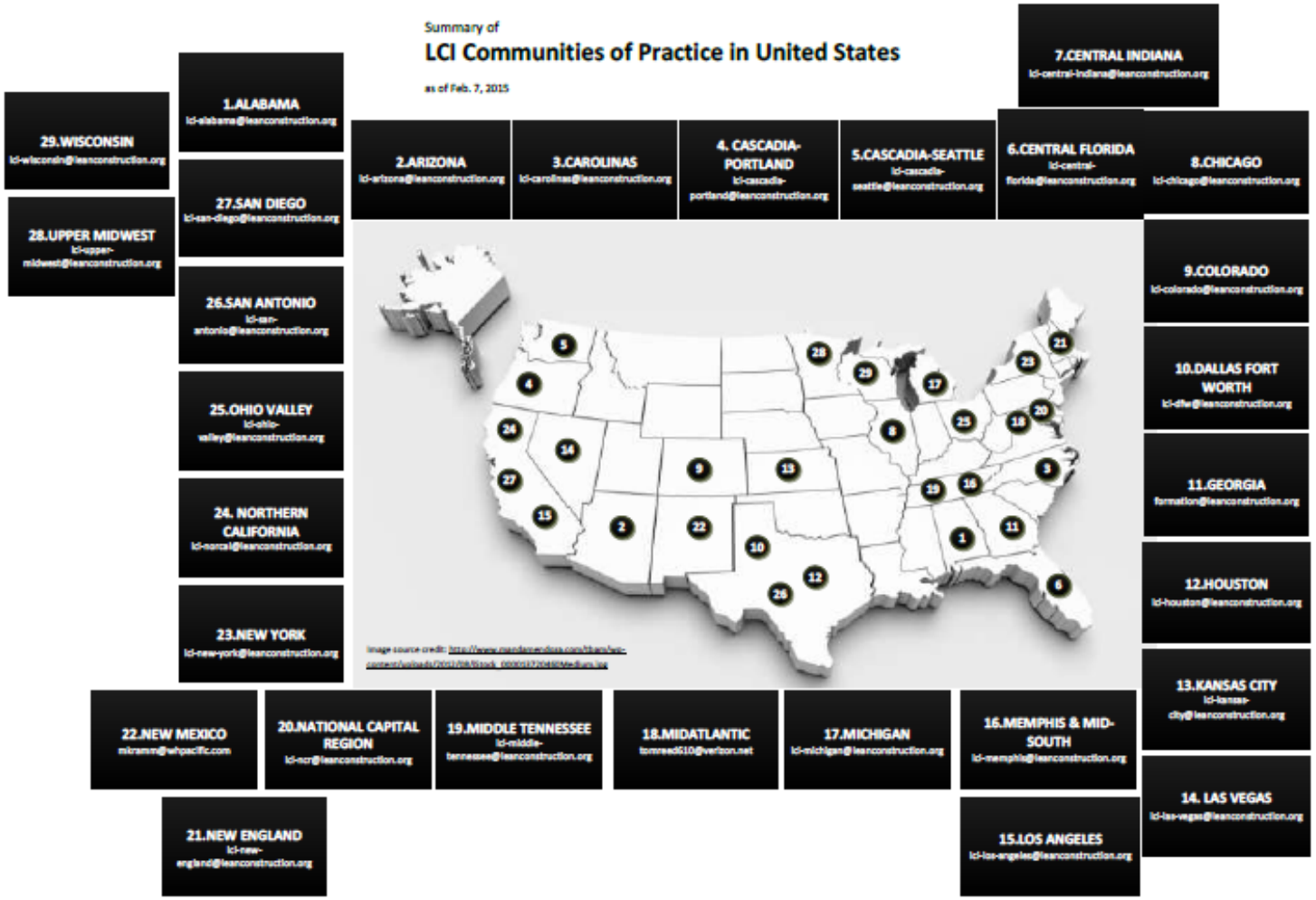
37. VIETNAM
- Long Duy Nguyen



Formal Lean Construction presence/office

Published research on Lean Construction

Source credit (as of 2015): Alan Mossman



Present growth of Lean-IPD (in US)

Cost performance on some typical construction projects

Problematic construction projects (adapted from Forbes and Ahmed 2011, p. 57)

Name of Project	Budgeted cost ($ millions)	Final Cost ($ millions)	Growth of cost (%)
Hanford Nuclear Facility (2001)	715	1,600	120
Capitol Hill Visitor Center (2008)	265	621	134
Denver Airport (1995)	1,700	4,800	180
Boston Big Dig (2005)	2,600	14,600	460

Cost performance on construction projects using TVD

Examples of cost results following Target Value Design exercises on reduction of capital cost (Glenn Ballard, *personal communication*, 2012)

Name of Project (SF)	Market cost ($ millions)	Final Cost ($ millions)	Reduction of cost (%)
Project A (368,882 SF)	98,000,000	89,200,000	9.0
Project B (114,000 SF)	13,533,179	11,717,000	13.4
Project C (75,362 SF)	13,600,000	11,200,000	17.6
Project D: (230,000 SF)	22,000,000	17,900,000	18.6

Cost performance comparing traditional versus Lean-IPD case studies

Adapted from: Forbes, L. H., and Ahmed, S. M. (2011). *Modern Construction: Lean Project Delivery and Integrated Practices*, CRC Press, Boca Raton. *Adapted from:* Ball. (personal communication, 2012) . http://www.lcicanada.ca/communities/

Lean

applied to

Real Projects

Lean-Integrated Project Delivery (Lean-IPD) is rich and expansive, but currently focuses on:

- the **Last Planner System of Production Control** (LPS); and
- and **Target Value Design** (TVD).

Present practice of Lean-IPD

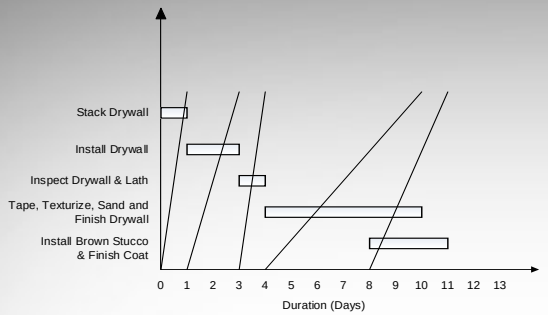
Last Planner System of Production Control (LPS)

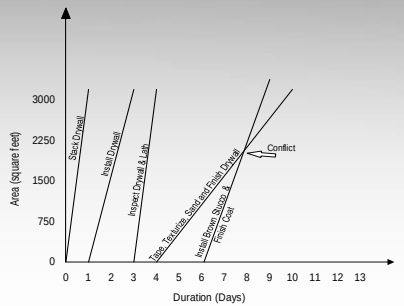
Last Planner System of Production Control

Image Source: the ReAlignment Group of California, LLC
http://danzpage.com/

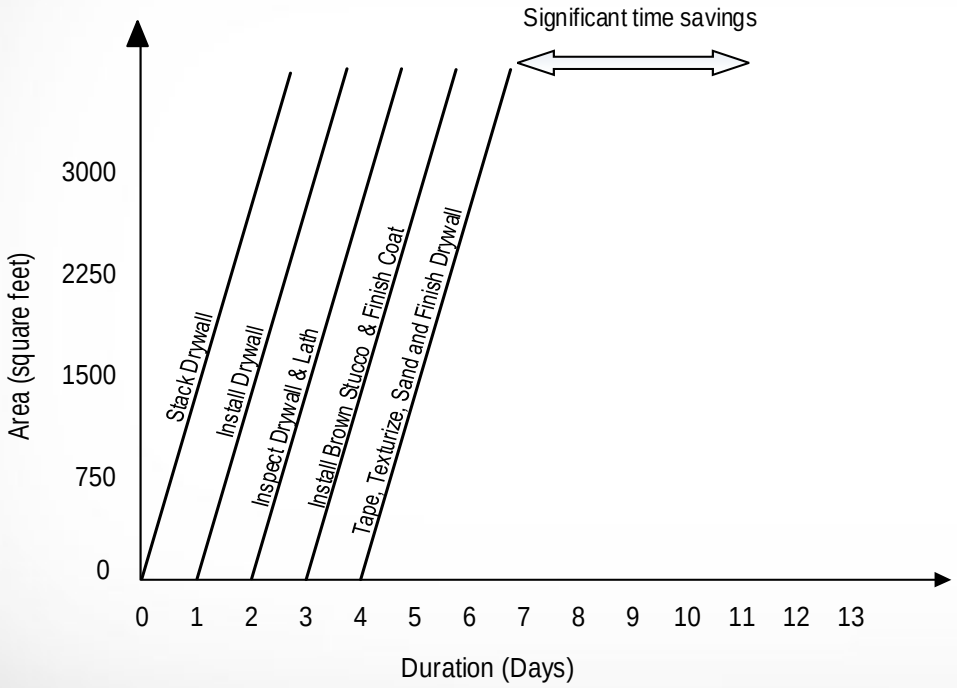
Last Planner System of Production Control

Images Credit: the ReAlignment Group of California, LLC
http://danzpage.com/





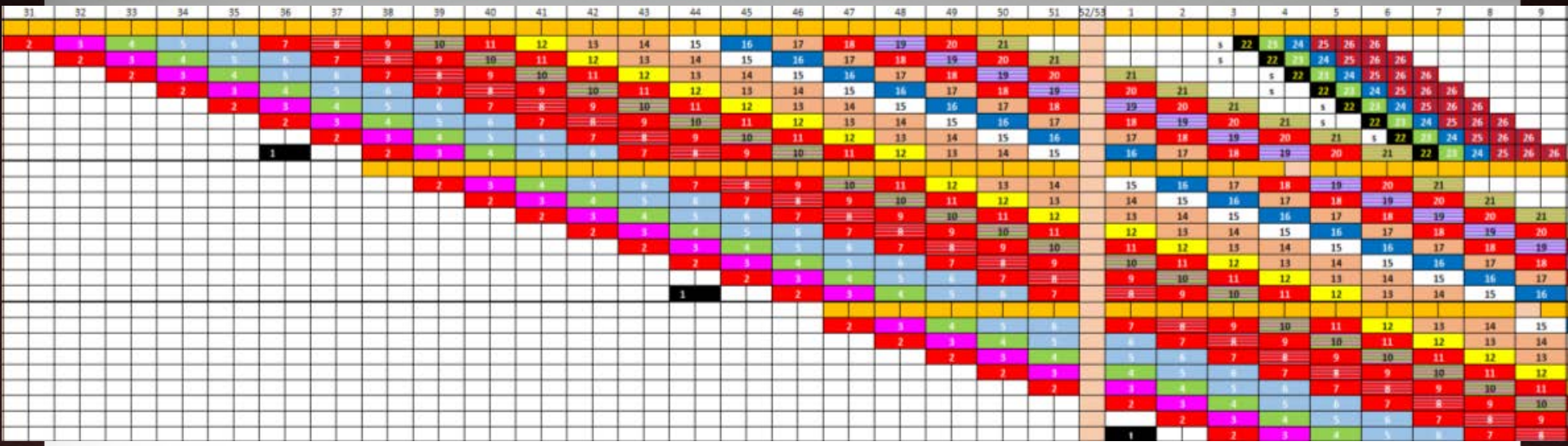
Without LPS

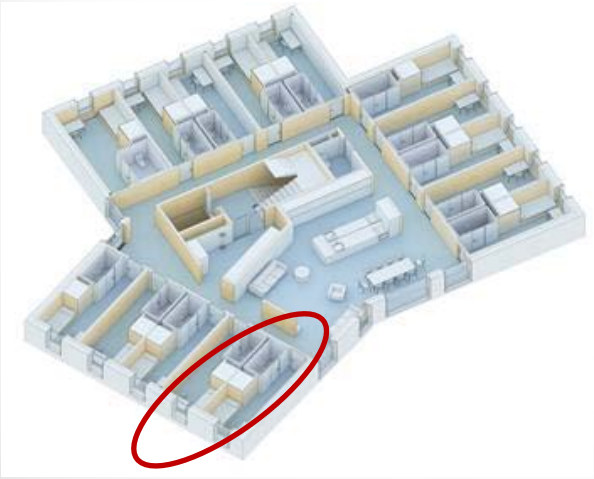


***With* LPS**

Last Planner: Flow and Takt Time

(Rybkowski, Z. K. and Forbes, L. 2016)





With LPS

(Takt time)

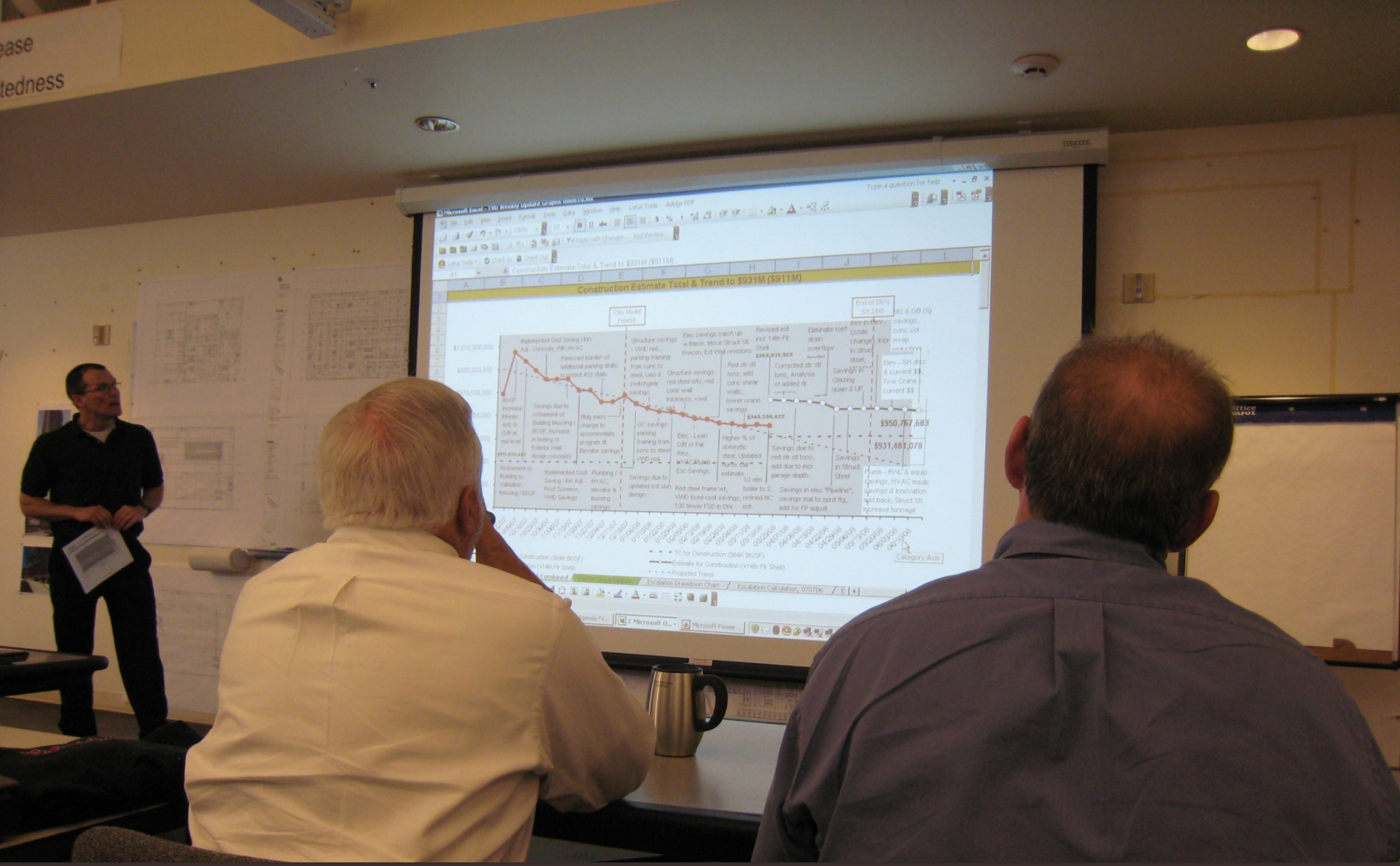
Last Planner: Flow and Takt Time

(Vatne and Drevland 2016)

Target Value Design (TVD)

Target Value Design (Sutter Health)

Image Source: Rybkowski 2009



Target Value Design (Sutter Health)

Image Source: Rybkowski 2009

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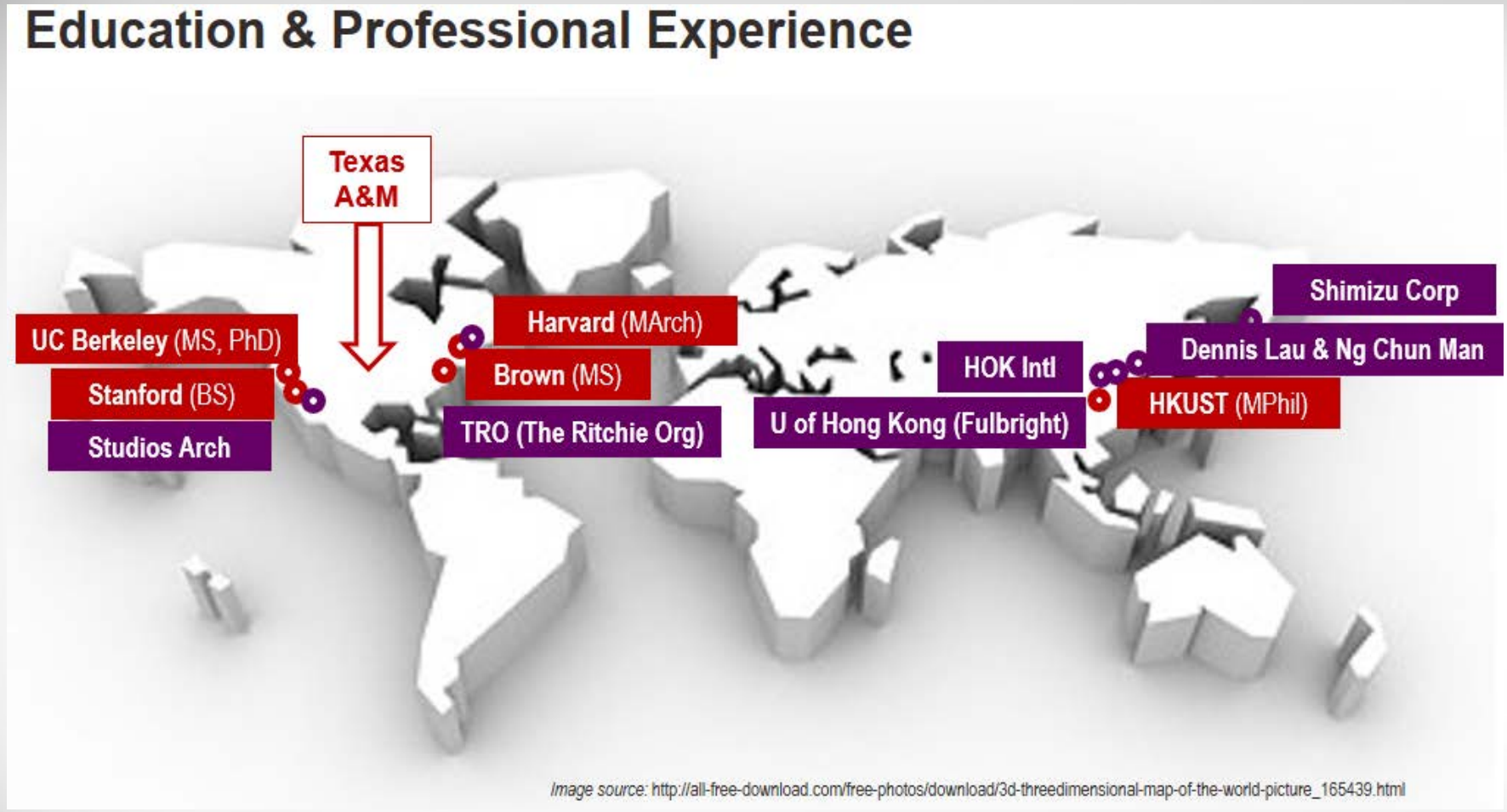

Image source: http://all-free-download.com/free-photos/download/3d-threedimensional-map-of-the-world-picture_165439.html