ICEAA International Cost Estimating and Analysis Association

Design to Cost (DTC)
What it is and Why You Should Care

Authored & Presented by
Hank Apgar, Dr. Lisa Colabella, Karen Mourikas
with support from the
2022 Southern California ICEAA Chapter Board
May 2023

Abstract

Design to Cost: What it is and Why You Should Care

- Design to Cost (DTC) has been around since the 1970s, falling in and out of favor. But what exactly is DTC? And will it help control program or product costs? Googling it yields various definitions, sometimes contradictory. Examples fluctuate from large defense programs to mass-produced commercial components. Implementation differs depending upon company, life-cycle phase, and objectives. This presentation is the culmination of an effort by the SoCal ICEAA Chapter to educate our community on DTC.
- This presentation was prepared by the Southern California Chapter of ICEAA during 2022

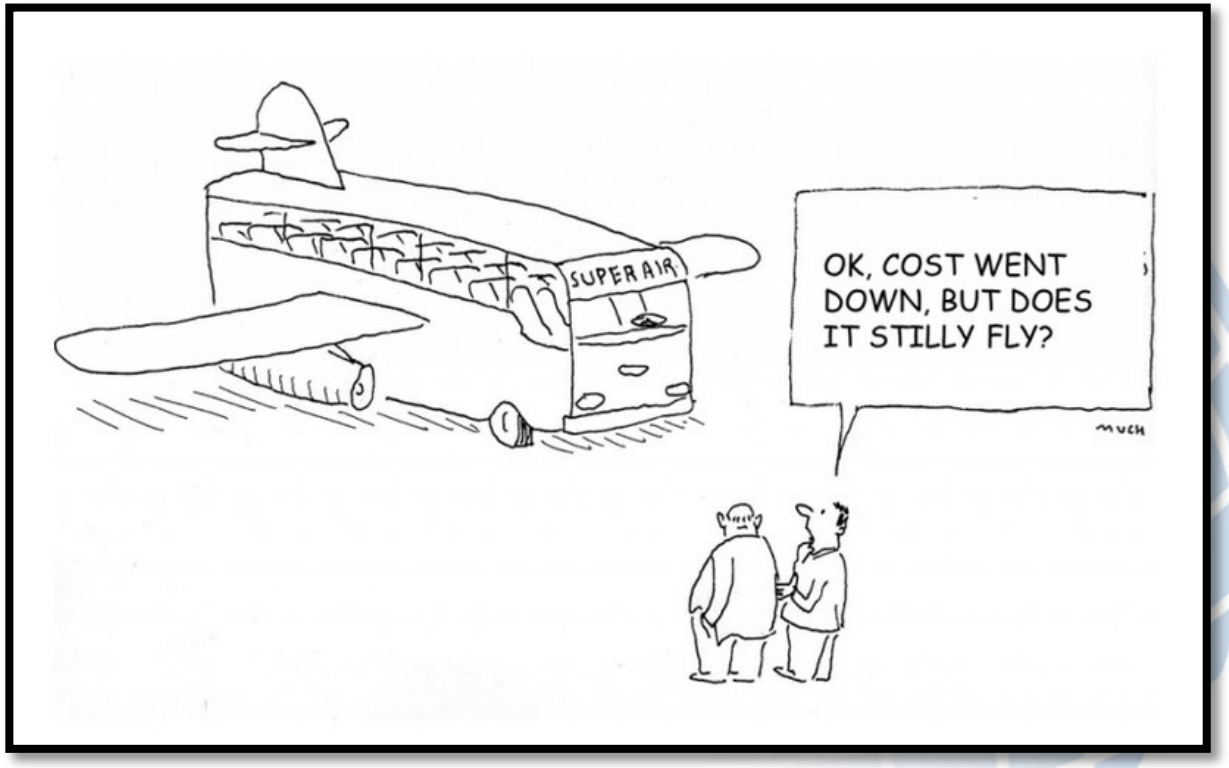
- The main authors include SoCal Members:

Hank Apgar
Director-at-Large
hapgar@frontier.com

Dr. Lisa Colabella
Vice President
pelled@rand.org

Karen Mourikas
President
karen.mourikas@boeing.com

Contents



Design to Cost – more than just cutting costs

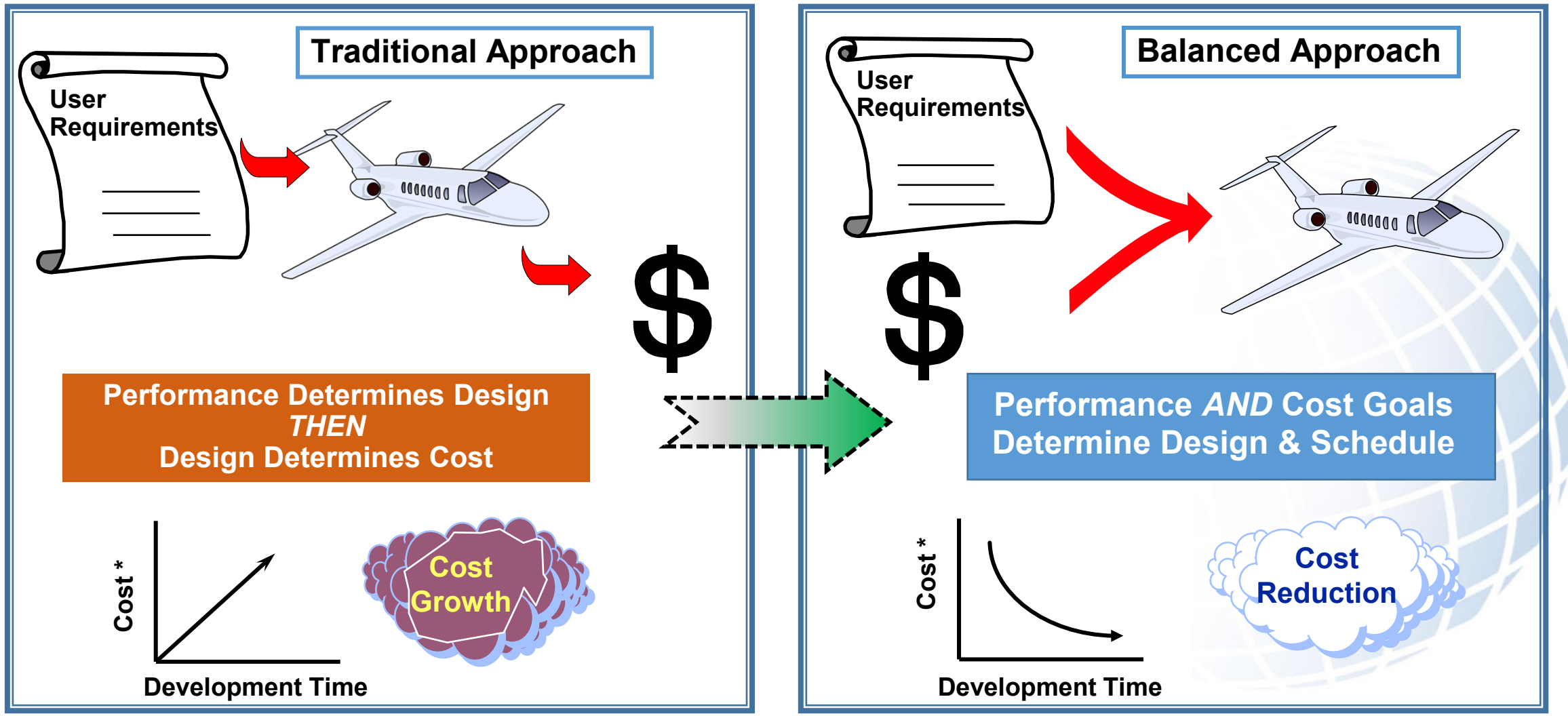
What is Design To Cost (DTC)?

- Systematic approach for **controlling costs of products** by considering **cost as a technical design parameter**, one on **equal footing** with performance and schedule in order to **meet stated cost goals**
  - *Starts early* in the design phase, and *continues* throughout the life cycle
  - Includes *early* establishment of *challenging but achievable cost targets*
  - Consists of *Design trades, cost benefit analyses*, continuous *tracking & controlling costs*, . . .
  - May focus only on *Unit Production Cost* OR on *Total Life Cycle Cost*
- **History:**

1970	1990s	2010s
DTC introduced	CAIV – Cost as an Independent Variable	Better Buying Power & Should-cost
original DoD initiative to motivate government / industry managers to *continually focus on production cost*	cost objectives for the *total life cycle* of the program and *trade offs between cost, performance, and schedule*	multiple initiatives mandating affordability as a requirement, focus on O&S, and *eliminating cost-drivers*

DTC: Controlling Cost while Achieving Performance

Shift from Sequential to Concurrent "Balanced" Analysis



DTC: Consider Design and Cost in Parallel and Early On

* Cost = Often Production, but could be Operations / Maintenance Costs, Flying Cost per Passenger Mile, ...

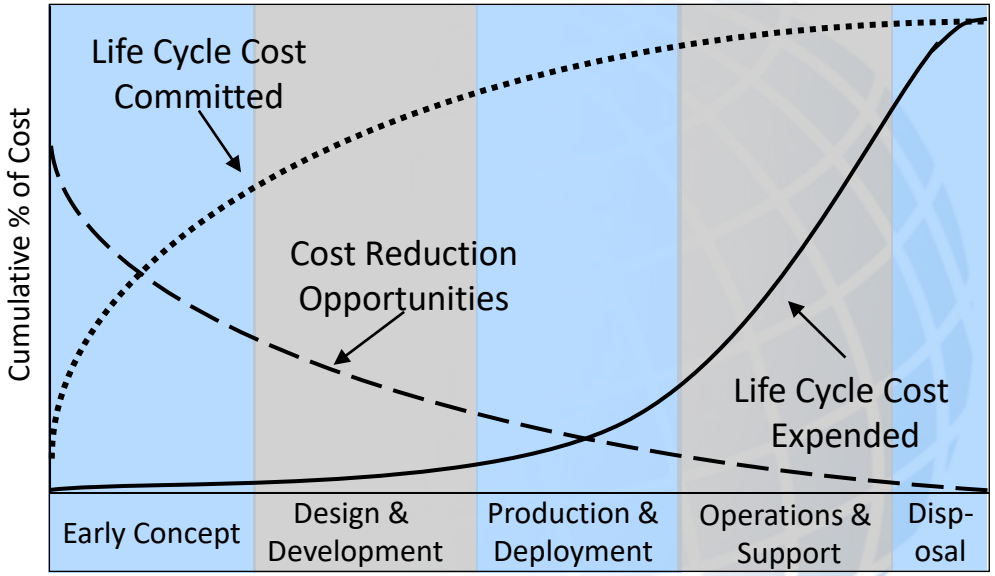
Timing and Focus of DTC

Early and Often

- Early: The Earlier, the more opportunities
- Often: Throughout the life cycle for continuous improvements and to measure progress

Typical Analyses

- Determine costs for every element
- Conduct cost trade studies* to identify CRIs



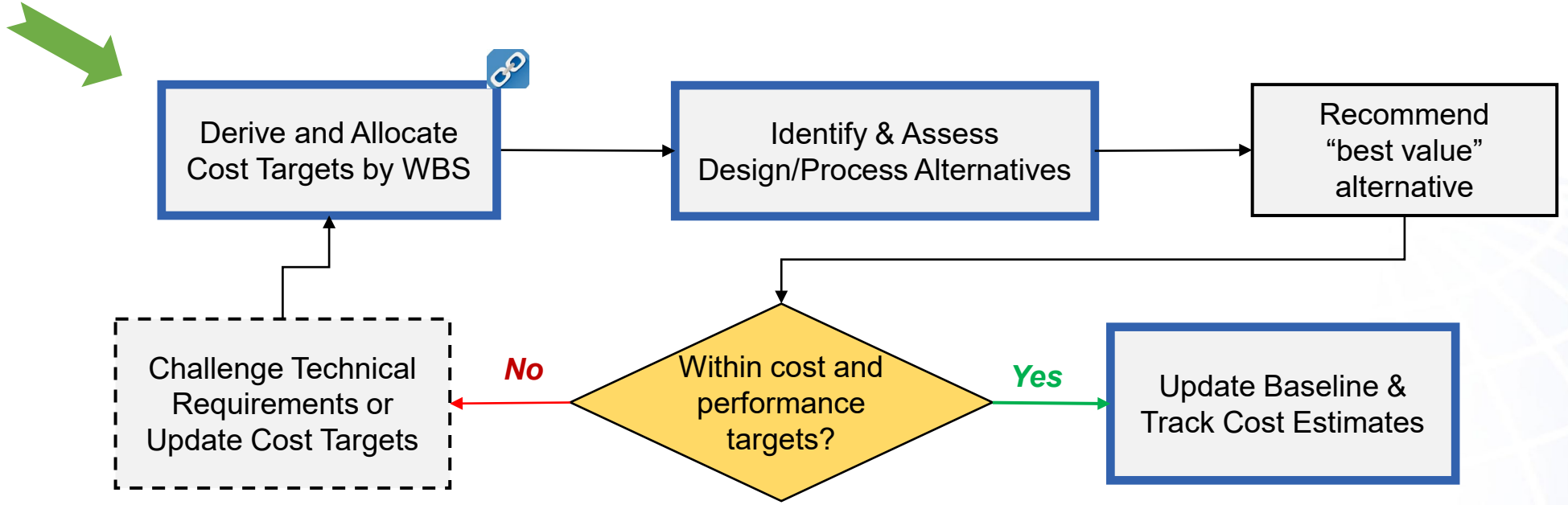
Focus varies depending upon life cycle phase

- Early design –Market/Portfolio Analysis, Price-to-win
- Development – Overall Design Decisions, Large Trades
- Production – Continuous Process Improvements, Detailed Trades
- O&S – Inventory, Obsolescence, Supply Chain

- Also known as cost-performance, cost-design, CAIV, ...
- CRI = Cost Reduction Initiative

Early phases provide largest opportunities to reduce Life Cycle Costs and to meet cost goals

'Design to Cost' Process Flow Chart

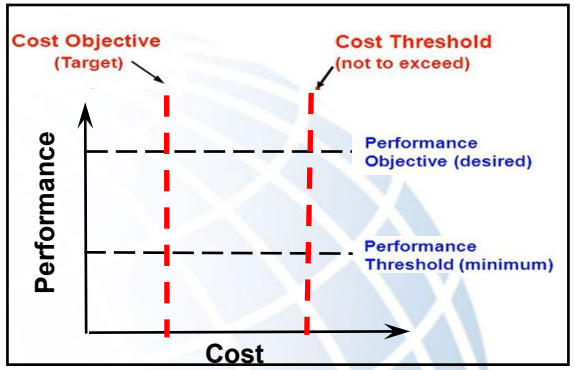


- Generic DTC Trade process which can be tailored to your program/environment
- Iterative process, typically starting at a top-level and repeating for lower-level decisions
- A disciplined process including documented results
- Customer and Supplier work together, especially if requirements are challenged

Subset of the Systems Engineering / Design Process

Derive and Allocate Cost Targets by WBS

- "Buyer" determines top-level cost objective (target), and cost threshold.*
  - Defense: Government (often based on Contractor proposals and past performance)
  - Commercial: Consumer (often based on market research)
- "Supplier" allocates top-level target to lower-level element targets
  - Supplier = Producer (Prime Contractor, Subcontractors, lower tier suppliers)
  - Based on design legacy, predicted design difficulty, budgeted design hours
  - Often applies target 'risk budget'
- Proposal (or Price to Win) effort follows similar process to determine best proposal offer
- If design fails to meet initial cost and performance targets, the buyer and supplier may
  - Relax the performance requirement(s), and/or
  - Increase the top-level target cost

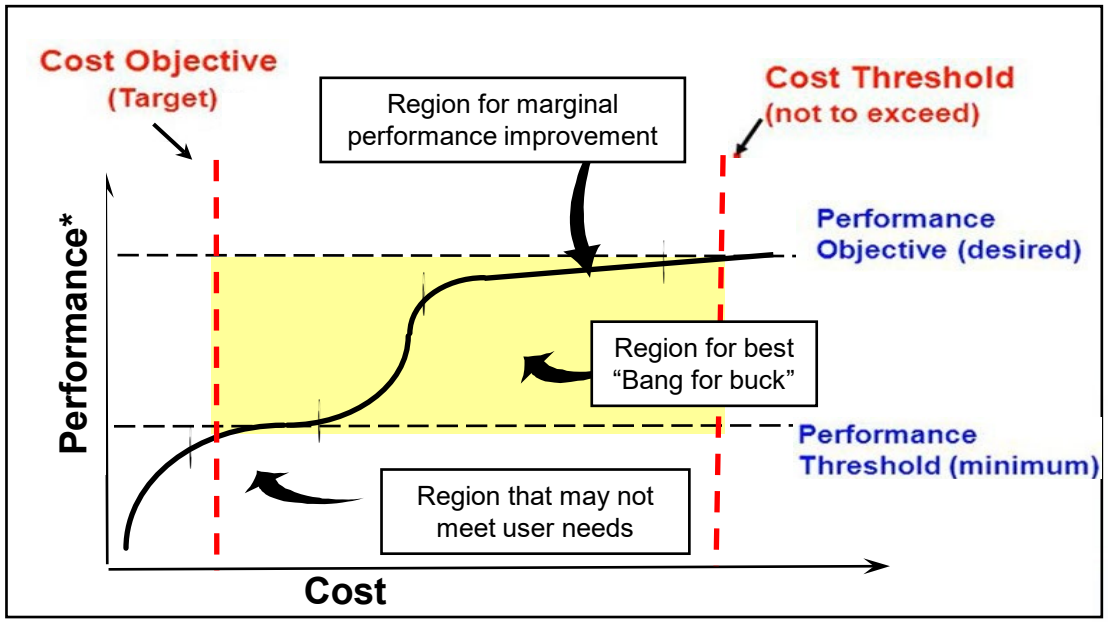


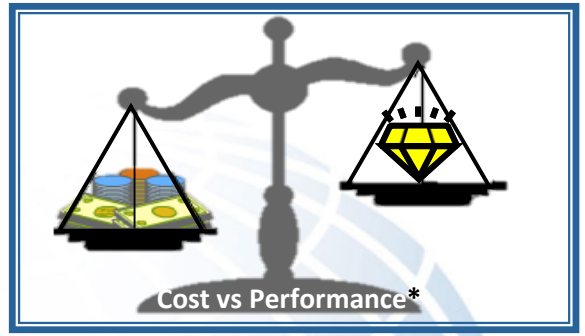
Cost targets are the responsibility of both buyer and supplier

* = Often Production, but could be Operations / Maintenance Costs, Flying Cost per Passenger Mile, ...

Assess Design/Process Alternatives

- "Cost-Performance" Trade Studies help determine performance and cost bounds**
  - Explore "Biggest Bang for the Buck" Region in trade space
  - Trade performance* for cost for each trade
    - Focus on cost drivers
      - Technology
      - Firepower
      - Availability
  - Consider impact on
    - Life Cycle Cost
    - Risk
    - Schedule
  - Challenge Requirements





*** "Performance" Features**

- Physical Attributes
- Functional Capabilities
- Manufacturing Operations
- Producibility Measures
- Operational Factors
- Support or Services
- Programmatics

Cost-Performance Trade Studies are the heart of DTC

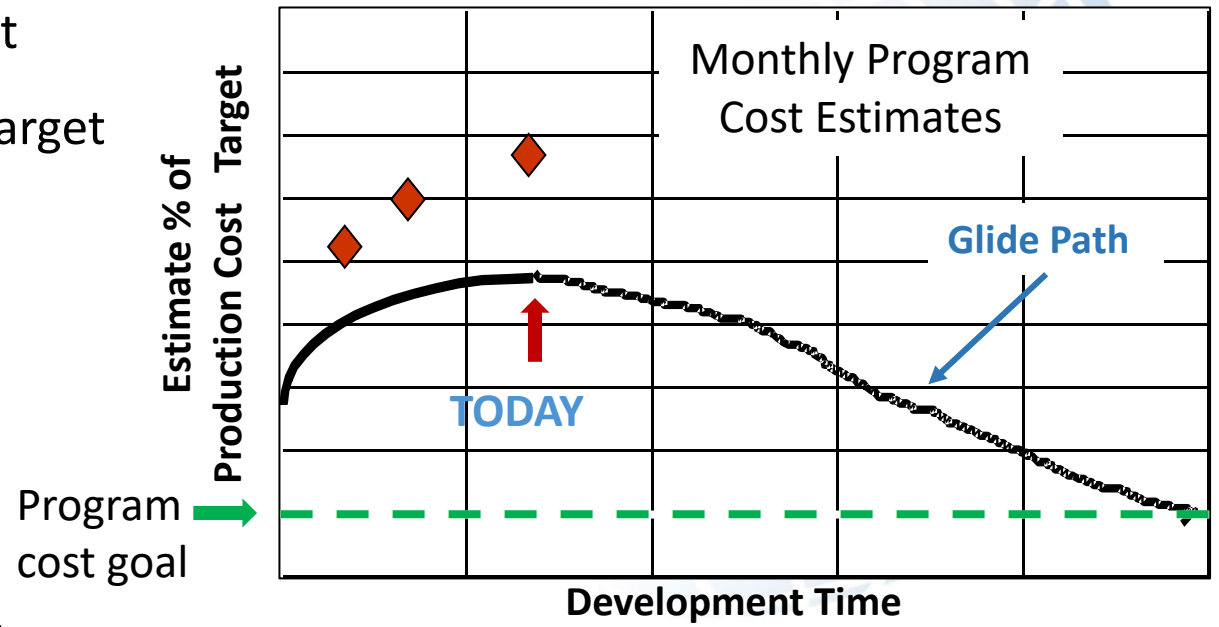
** = Often Production, but could be Operations / Maintenance Costs, Flying Cost per Passenger Mile, ...

Track Cost Estimates

- Establish glide path of expected top-level cost estimates throughout the development period
- Then compare to actual cost estimates ◆ periodically through the development effort
  - Based on trade studies and Cost Reduction Initiatives (CRIs) during the development period

- Identifies likely success or failure early enough to act
  - Request requirements change or larger top-level target
  - Corrective action plans may be required

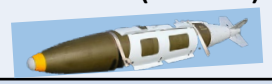
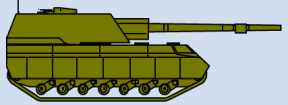
- Historical example of glide path
  - What is happening with this program?
    - Are we on target?



🔗Example of Historical CRI

Analogous to landing an airplane in the fog

Design to Cost Examples

	Program / Process	Situation	Method / Solution	Result
Program Level	• Joint Direct Attack Munitions (JDAM) 	• Simple design • High volume • Steep learning curve	• Willing to trade performance to achieve low cost • Limited performance requirements	• Successful in controlling costs and achieving performance
Program Level	• Crusader Howitzer 	• Contractor estimate unaffordable • Rate of fire requirement - cost driver (12 rounds / min)	• Cost/Performance analysis • Recommended 10 rounds per min (slightly reducing performance)	• Eliminated costly barrel cooling and complex shell loading, reducing cost • Still too expensive • Program cancelled
Program Level	• Commercial Airplane 	• Requirement for parking brake to hold for 12 hours cost driver	• Trade studies on time requirement • Negotiated with customer	• Parking brake never used for 12 hrs • Reduced requirement performance and hence cost
Component	• Electronics Part Count Reduction 	• Goal to reduce manufacturing costs of electronic parts	• DTC • DFMA – Design for Manufacturing & Assembly	• Reduce part count & assembly time • Eliminated fasteners & clamps • Consolidated parts by 30%+
Component	• Design Details (Aerospace Company) 	• Non-structural parts exceeded cost targets by 10%	• DTC • DFM – Design for Manufacturing	• Identified “cosmetic” details increasing complexity • Simplified design & reduced cost

DTC in use in various markets, domains, functions, phases, ...

DTC Challenges

- Lack of incentive to develop a lower cost product or meet cost goals [1,2]
  - Overly complex designs or new/unproven technologies
- Prioritizing performance over cost - or vice-versa
  - "Performance, schedule, and risk often take precedence over affordability" [3]
  - Lower cost may result in products that function poorly
- Unrealistic assumptions
  - "…there may be no system that can meet stated cost objective for the required set of product features" [4]
- Cost targets not flowed down and hence not managed at appropriate levels
- Additional workload on an overburdened workforce or additional requirements without adjusting budget
- Mandating a single tool may limit analysis capabilities

1) Vasek, J. (2020) Leveraging Design-to-Cost in Public Procurement
2) Comptroller General of the United States (1975) *Application of Design-to-Cost Concept to Major Weapon System Acquisitions* https://www.gao.gov/assets/psad-75-91.pdf
3) Price et al. (2018) An Implementation of Automated Structural Design-to-Cost in a Model Based Engineering Environment https://www.iceaaonline.com/wp-content/uploads/2018/07/AG07-An-Implementation-of-Automated-Structural-Design-To-Cost-Price.pdf
4) Favato and Mills (2007) "Identifying Best Practices in Cost Management," *Henley Manager Update,* 18(3), p. 43-52. https://journals.sagepub.com/doi/pdf/10.1177/174578660701800405

Implementation is an important factor determining success or failure of DTC

DTC Suggested Best Practices

- Systems engineering leadership prioritizing DTC and promoting Cross-functional teams for buy-in & participation
  - e.g., "person, team, or teams dedicated solely or primarily to cost-reduction work" [1]
  - "[While] DTC activities are often driven by engineering or research and development departments, it is imperative not to overlook the importance of cross-functional team collaboration"[2]; Involve suppliers and partners [5]
- Prioritizing both cost and performance – and making trades across the system life cycle
  - "If cost trends indicate that the system cannot be produced within the goal, some tradeoff in desired performance may be necessary"[3]
- Parametric modeling for a shared understanding of cost drivers [4, 5]
  - Clear, structured, holistic approach to cost-reduction with repeatable process(es) [1]
  - Accessibility of cost data with context and use of existing estimating & analysis, risk, and optimization tools
- Culture change such as shift from "perfection at any price" [5]; encouraging engineers to consider product cost

1) Campbell, M. (2022) Why Engineering-Led Cost Reduction is Essential to Hitting Your Targets. https://www.colabsoftware.com/post/why-engineering-led-cost-reduction-essential-to-hitting-your-targets
2) Staack & Moebius (2015) *Strategic Product Value Management: How Companies Can Improve Innovation, Reduce Costs, and Mitigate Risk.* *https://www.strategyand.pwc.com/gx/en/insights/2015/strategic-product-value-management/strategic-product-value-management.pdf*
3) Comptroller General of the United States (1975) *Application of Design-to-Cost Concept to Major Weapon System Acquisitions* https://www.gao.gov/assets/psad-75-91.pdf
4) Price et al. (2018) An Implementation of Automated Structural Design-to-Cost in a Model Based Engineering Environment https://www.iceaaonline.com/wp-content/uploads/2018/07/AG07-An-Implementation-of-Automated-Structural-Design-To-Cost-Price.pdf
5) Pradet, Pellé, Péran (2017) Combining Cost Custting and Customer Value in the Search for Competitiveness: The 'Design to Cost' Perspective https://www.capgemini.com/consulting-fr/wp-content/uploads/sites/31/2017/08/design_to_cost.pdf

Best Practices per DTC Practitioners and Real-world cases

Summary

- DTC is a method to reduce and control costs through cost-performance design trades
- Provides opportunities to meet cost targets while still achieving required performance
- Best implemented early in the life cycle for larger cost reduction opportunities before design determined
  - Carry on throughout life cycle for continuous improvement
- DTC activities include
  - DTC Planning, Cost Modeling and Analysis, Cost Driver Identification, Target Allocation
  - Cost-Performance Design Trade Studies, Cost Reduction Initiatives, Cost Tracking, Training
- Multiple Methods and Tools support DTC
- Successful DTC may result in
  - Controlling costs & achieving performance, simpler designs, relaxed performance requirements
  - Program recognition, and even program cancellation

DTC goal: Inform decisions to develop and produce affordable products

Acronyms and References

Acronym	Term
BBP	Better Buying Power
BL	Baseline
CAD	Computer Aided Design
CAIV	Cost As an Independent variable
CRI	Cost Reduction Initiative
DTC	Design to Cost
IPT	Integrated Product Team
JDAM	Joint Direct Attack Munition
LCC	Life Cycle Cost
MDAO	Multi-disciplinary Design, Analysis, & Optimization
PtW	Price to Win
O&S	Operations and Support
RIOs	Risks, Issues, and Opportunities
TOC	Total Ownership Cost

References
DODD 5000.1 , DODD 5000.28; DODI 5000.02
ICEAA CEBoK Unit 16
DAU – Defense Acquisition University www.dau.edu
IDA P-5123: “Implementing Effective Affordability Constraints for Defense Acquisition Programs”, Kneece, et al, March 2014
Thesis: “DESIGN-TO-COST: CONCEPT AND APPLICATION”, Horn and Dabbierei, Jr; Naval Post Graduate School, December 1974
“Application of Design-to-Cost to Major Weapon system Acquisition”, DoD, Report to Congress, 1975
“Principles of Cost As an Independent Variable (CAIV) Applied to the Reduction of Total Operating Cost (TOC) in Weapon System Acquisition”, Training Course, MCR Federal
“Cost As an Independent Variable (CAIV) From the Contractor’s Perspective”, DODCAS, Hank Apgar, MCR Technologies, 2002
ICG – Integrated Consulting Group www.integratedconsulting.cz

Various Definitions in Backup

Acknowledgements

- Thanks to
  - David Bloom, Raytheon Technologies and SoCal Chapter VP, for suggesting this topic and for developing the initial outline
  - Hank Apgar, retired, formerly of MCR (SPA) and SoCal Chapter Director-at-Large, for significant content and guidance
  - Dr. Lisa Colabella, from The Rand Corporation and SoCal Chapter Director-at-Large, for finding examples of DtC and for providing feedback and suggestions
  - Justin Knowles, from Northrop-Grumman and SoCal Chapter Director-at-Large, for reviewing and for providing feedback throughout the effort
  - Karen Mourikas, from The Boeing Company and SoCal Chapter President, for content, graphics, and pulling the team together
  - Multiple reviewers from various companies and ICEAA members for reviewing and providing feedback of draft content
    - Boeing: Denise Nelson
    - Galorath Inc: Dan Kennedy
    - L3-Harris: Taryn Anne Reilly, Theresa Parker, Lou Muniz, Bill Losapio, Lisa Snover, Brian Howe
    - Lockheed Martin: Ralph Smith, John Deem, Greg Kiviat (Sikorsky)
    - Northrop-Grumman: Wendy Robello
    - Tecolote Research Inc: Jennifer Kirchhoffer, Madeline Teller
  - And more ...

Thank you all for your help in developing this DTC content!!!

Questions?

Back up

Definitions: DTC

Design to Cost (DTC) is

- A management concept wherein rigorous cost goals are established during development and the control of systems costs (acquisition, operating and support) to these goals is achieved by practical tradeoffs between operational capability, performance, cost, and schedule.
- Cost, as a key design parameter, is addressed on a continuing basis and as an inherent part of the development and production process. *(DODD 5000.1 and 5000.28)*

Design To Cost, or **DTC**, is a method to ensure that product designs meet a stated cost objective. Cost is addressed on a continuing basis as part of product or process design. The technique embodies early establishment of realistic but difficult cost objectives, goals, and thresholds and then manages the design until it converges on these objectives. *(ICEAA CEBoK Unit 16)*

Design to Cost (sometimes called **Design for X**) is a special approach, which combines several strategies with a common goal. Typical strategies are: Design for Assortment Costs, Design for Assembly Costs, Design for Manufacture Costs, Design for Quality Costs, and Design for Robustness…
(*ICG - https://www.integratedconsulting.cz/en/consulting/innovation/design-to-cost/)*

Definitions

Affordability analysis and affordability constraints are not synonymous with **cost estimation** and approaches for reducing costs.

- **Affordability Constraints** are determined in a **topdown manner** by the resources a Component can allocate for a system, given inventory objectives and all other fiscal demands on the Component. Constraints then provide a threshold for procurement and sustainment costs that cannot be exceeded by the Program Manager.
- **Cost estimates** are generated in a **bottom-up or parametric manner** and provide a forecast of what a product will cost for budgeting purposes.
- The difference between the affordability constraints and the cost estimates indicates whether actions must be taken to further reduce cost in order to remain within affordability constraints.
  (DAU - https://www.dau.edu/acquipedia/pages/ArticleContent.aspx?itemid=548)

Should Cost is

- A management tool designed to proactively target cost reduction and drive productivity improvement into programs. Should cost management challenges managers to identify and achieve savings below budgeted most likely costs.
- Should-cost goals are thus well below affordability constraints and serve very different operational ends.
- Better Buying Power (BBP) makes a clear distinction between aggressive should-cost goals, and more conservative and realistic program baselines. *(DODI 5000.02)*

Definitions

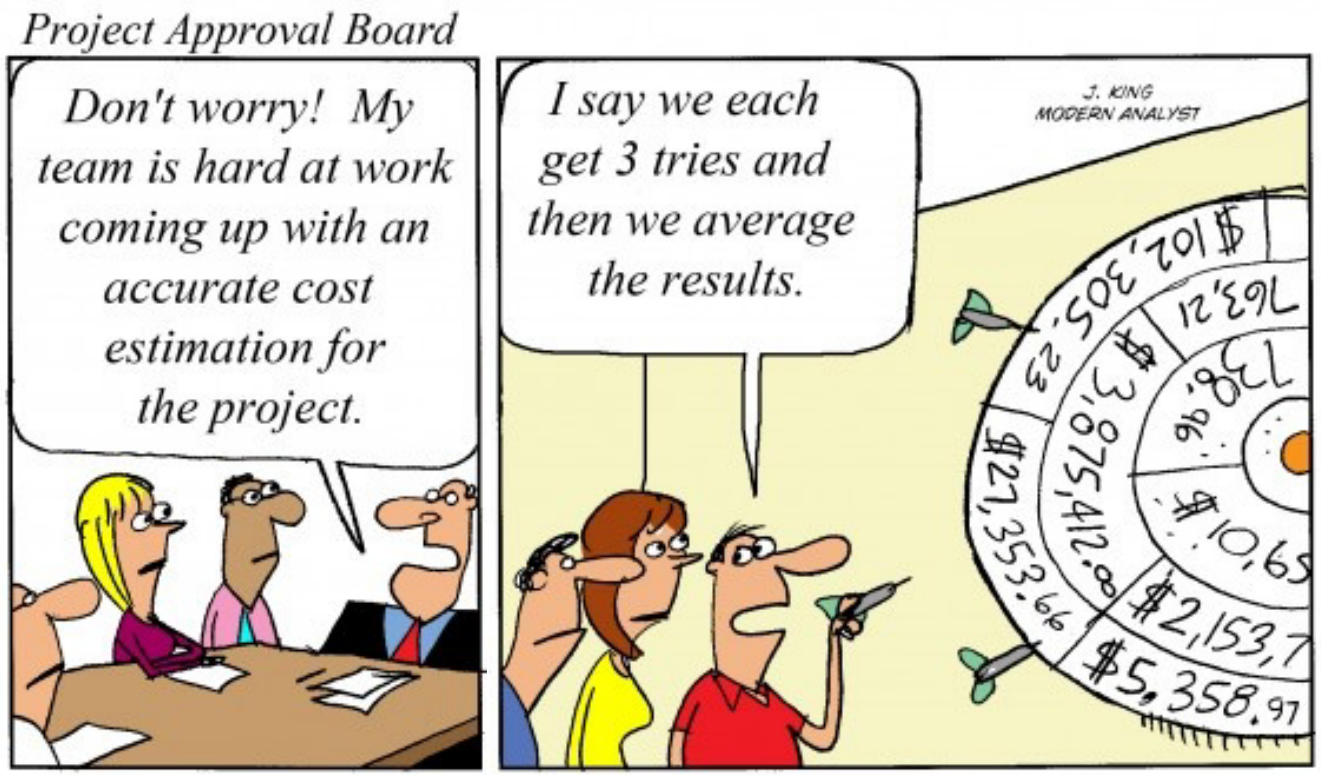
- **Cost as an Independent Variable,** or **CAIV,** involves using better business practices, allowing trade space for industry to meet user requirements, and considering operations and maintenance costs early in requirements definition in order to acquire systems which are designed to meet requirements at a lower life cycle cost. CAIV is a strategy that entails setting *aggressive, yet realistic cost objectives* when defining operational requirements, and managing achievement of these objectives. Cost objectives must balance mission needs with projected out-year resources, taking into account existing technologies as well as the high-confidence matriculation of new technologies. In essence, the CAIV concept means that, once the system performance requirements and cost targets are decided (via cost/*requirement* trade-offs), then the acquisition process will make cost more of a constraint (input), and less of a variable (output), while nonetheless obtaining the needed capability of the system. *(ICEAA CEBoK Unit 16)*

- **Design For Manufacture and Assembly**, or **DFMA**, is a simultaneous engineering process that optimizes the relationship between materials, manufacturing technology, assembly process, functionality, and economics. It seeks to ease manufacture and assembly of parts or eliminate parts. *(ICEAA CEBoK Unit 16)*

- **Value Engineering**, or **VE**, is a systematic method of evaluating the functions of a product to determine whether they can be provided at a lower cost without sacrificing the features, performance, reliability, or usability of the product. It is generally used at the design stage of a product to improve customer value and reduce costs before production has begun. *(ICEAA CEBoK Unit 16)*

How Cost Targets are Set – Part 1

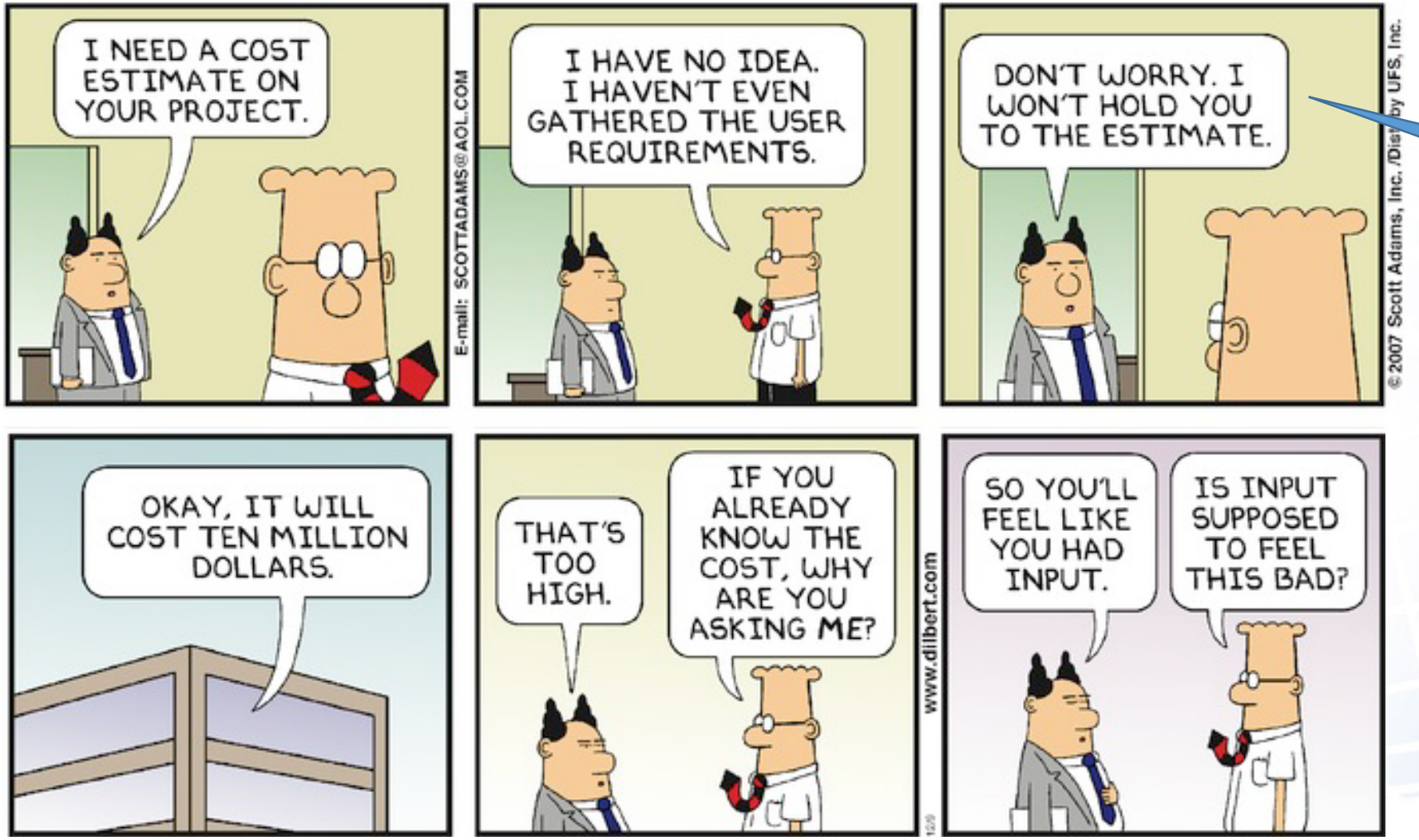
Back



At least they are using some math!

How Cost Targets are Set – Part 2

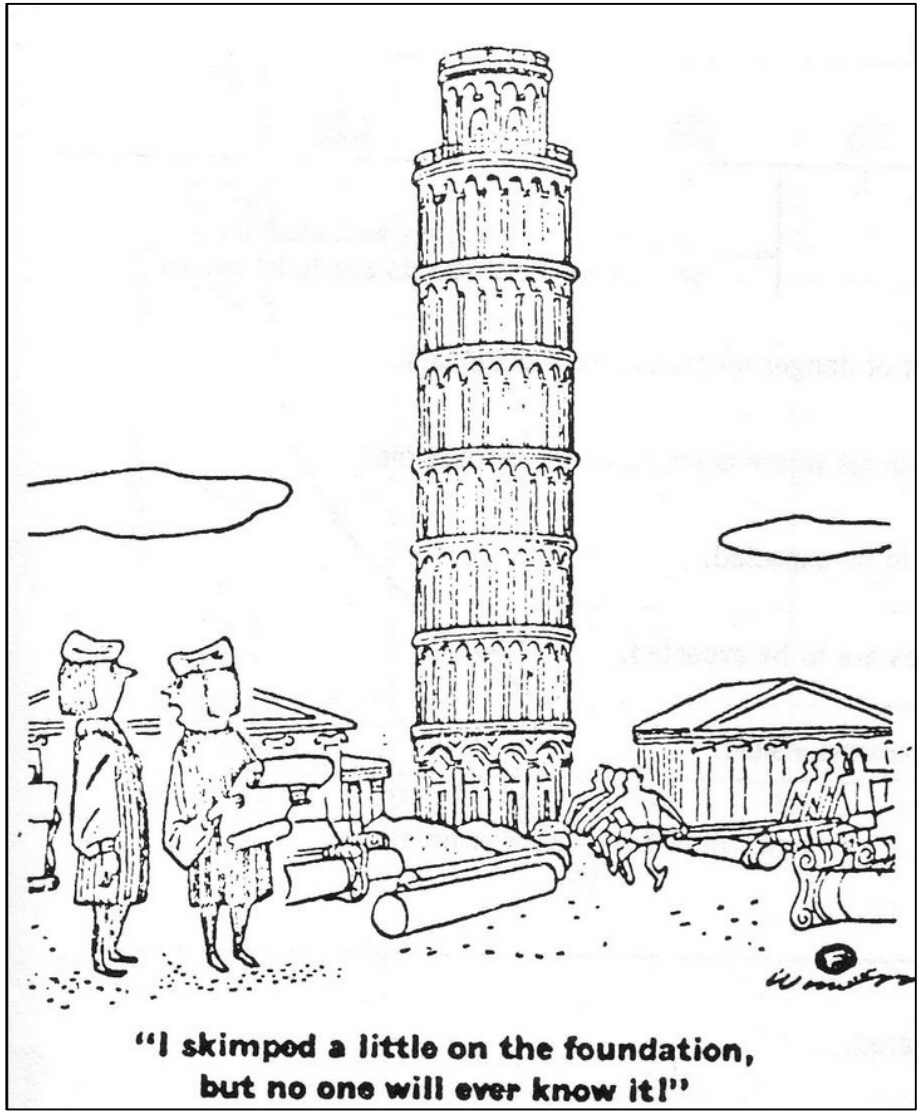
Back



According to Dilbert!

Cost Reduction Initiatives

Back



https://blog.geotechpedia.com/wp-content/uploads/2013/07/Pizza.jpg