AMPHIBIOUS ENGINEERING

Living in Two Worlds for Fun and Profit

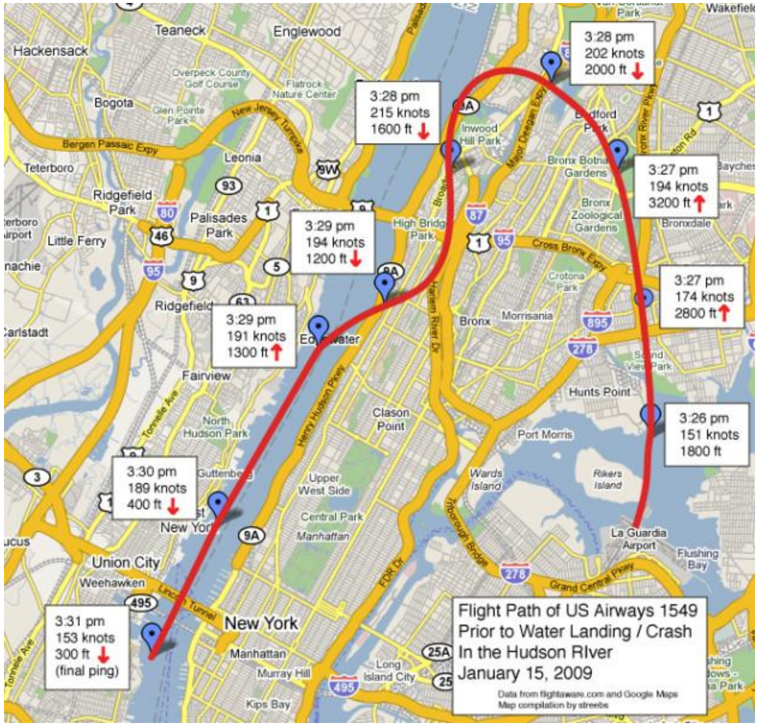
Tolle - 19017

WHEN SYSTEMS THINKING SAVES LIVES

FIRST APOLLO 13, THEN CACTUS 1549

US Air flight 1549

January 15, 2009



Flight Path of US Airways 1549
Prior to Water Landing / Crash
In the Hudson River
January 15, 2009

Data from flightaware.com and Google Maps
Map compilation by streebs

Fly to Seattle?

3:25 – takeoff
9:00 – land

Any Airbus A320 qualified pilot

Land in the Hudson?

3:25:38 – takeoff
3:27:11 – birdstrike
(both engines to zero RPM, attempt restart, no go)
3:27:33 – "Mayday, returning…"
(3,000' altitude, 18:1 glide ratio, 54,000 ft = 10 miles, LaGuardia 7-8 miles behind, Teterboro a/p 12 miles to the east….)
3:28:12 – "unable…."
3:30:43 – 1st successful airline water landing in history, 155 passengers and crew alive.

Airbus A320 pilot with…?

WHAT THIS IS NOT

- Not recipe engineering
- Not “textbook” engineering

Plenty of programs have executed the ‘right’ SE processes to build the ‘right’ SE products and still FAILED

Use judgment to adapt & adjust practices to customer need, circumstance and end user inputs

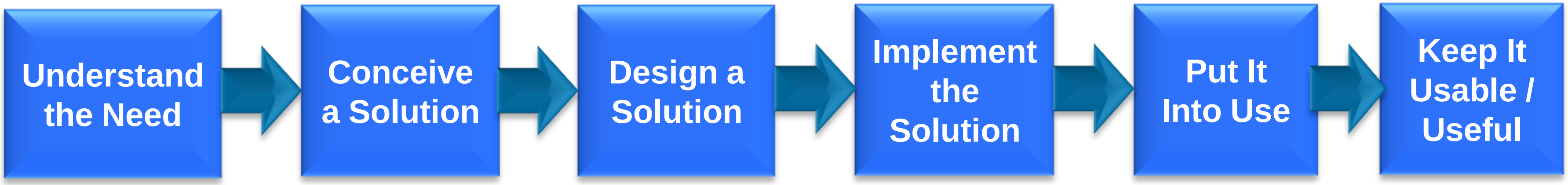
ESSENCE OF A SYSTEMS ENGINEER
THE STARTING POINT

- **Creating solutions to meet customer needs/wants**
- **A bit more formally – putting pieces together in a way so that the value of the whole is greater than the sum of the parts.**
- **Bridging the gap between the problem space and the solution space**
- **Using integrated set of practices**
- **Reducing risk incrementally → confidence building**
- **Fusing the Art and the Science (we're focused on the Art – the science is well thought out)**

Finding the need, understanding the need, meeting the need

ESSENTIAL SE LIFECYCLE FLOW

HOW NEEDS GET MET



What SE's need to be able to accomplish – on the surface

How needs get met – SE perspective

PROBLEM SPACE | SOLUTION SPACE

Consider: Border Surveillance and Interdiction

Drug smuggling

Money laundering

Human trafficking

Terrorist entry

AMPHIBIOUS-NESS

Amphibious relating to or adapted for:

- living on both land and water

  - Webster

- coordinated land and naval forces

  - dictionary.com

- harmonizing the solution space with the problem space

  - experience

Jump in, the water's fine—really!!

AMPHIBIOUS ENGINEERING

A model for flowing between the mission space and the solution space

A chalk talk:
A static academic model

TOOLS OF THE SYSTEMS ENGINEER

Process

- Requirements Management
- Interface Management
- Configuration Management
- Risk Management
- …

Products

- Block diagrams
- Hierarchy diagrams
- Models
- Simulations
- …

Techniques

- Functional Decomposition
- Brainstorming
- DoDAF / Zachman / MODAF
- …

Principles

- Interdependent requirements, operating concept, and architecture
- Architecture fuses structure, behavior, data
- …

WHEN THE PLAN MEETS REALITY….

- accelerated schedule

- budget cutting

- resource conflicts

Knowledge & Skill → knowing the processes, able to build the products isn’t enough.

What needs to be true of the practitioner???

FLOWING BETWEEN PROBLEM SPACE ←→SOLUTION SPACE

Back to the chalk talk:
A dynamic model

Use cases

- new need new program
- Change in mission
- Disruptive change in technology

What still needs to be true of the practitioner???

PRACTICES OF THE SE PRACTITIONER

Use Judgment - Be able to adapt the practices to reality varied/varying circumstances

- **Scale the amount of process rigor & product fidelity**
- **Apply in problem space and solution space**

Understand the need / mission

Function in both worlds (mission / solution) - Translate between human (mission) & techies (engineers)

Ferret out the requirements

Transform the need into a solution

Describe / flesh-out the solution well enough for it to be realized

Think in an integrated fashion – SNA+RA+AD *(more here)*

- ***Not performing atomic pieces***

✓ Apply principals/practices to both Push and Pull paradigm

YOUR GOAL:

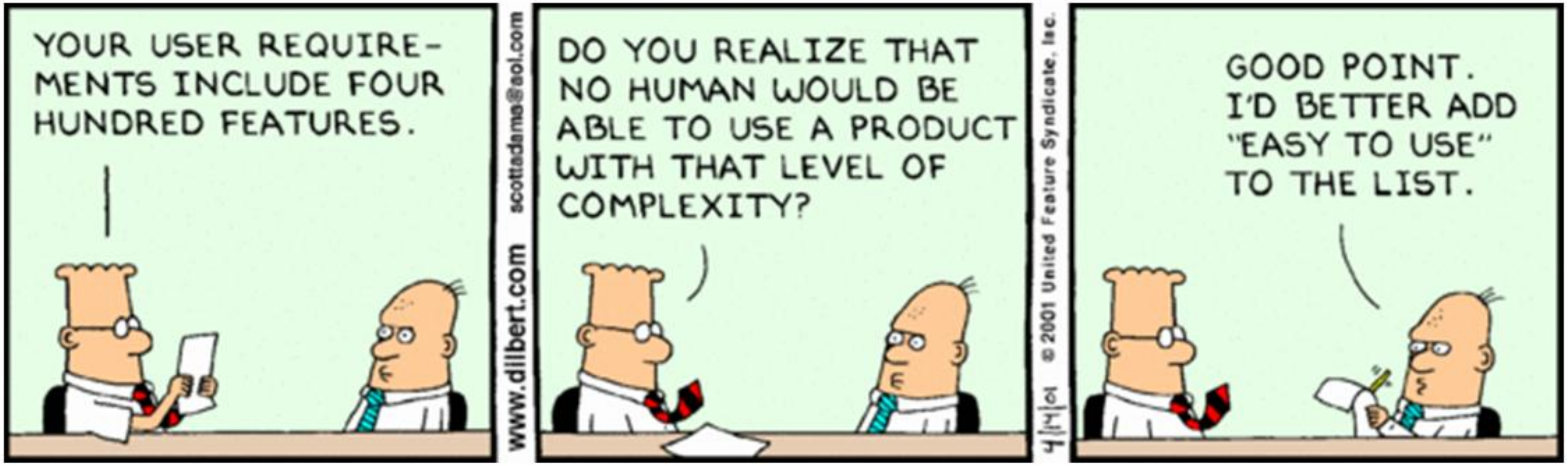
Know "what" needs to true of those you rely on to solve your problems, define/provide your solutions

Determine both funding and time investment in them

- Eventually you want them to be great, but
- To start they need to be able to put your program on the road to accomplishing a successful solution
- Use analogy of Hwy 5 to LA or Hwy 10 to Las Cruces

Pick a model for developing your engineers into SE practitoners ("how") – ends of the spectrum (17 yrs – 1 wk)

- Grow an in-house *?incubator?, or*
- Partner with someone to develop your engineers into SE practitioners, or
- Find a partner to do your SE (someone with real practitioners not knowledgeable, cook books)



YOUR USER REQUIREMENTS INCLUDE FOUR HUNDRED FEATURES.
DO YOU REALIZE THAT NO HUMAN WOULD BE ABLE TO USE A PRODUCT WITH THAT LEVEL OF COMPLEXITY?
GOOD POINT. I'D BETTER ADD "EASY TO USE" TO THE LIST.
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BACKUP

DOD SYSTEMS ENGINEERING SHORTFALLS

Root causes of failures on acquisition programs

- Inadequate understanding of requirements
- Lack of systems engineering discipline, authority, and resources
- Lack of technical planning and oversight
- Lack of subject matter expertise at the integration level
- Availability of systems integration facilities
- Incomplete, obsolete, or inflexible architectures
- Low visibility of software risk
- Technology maturity overestimated

*Source: Technical Planning for Acquisition, Programs: An OSD Perspective, 8th NDIA SE Conference, October 25, 2005

Major contributors to poor program performance

HISTORICAL FAILURE RISKS

Inexperienced domain leadership

External interface complexity (SE)

System complexity (SE)

Incomplete or unstable requirements (SE)

Reliance on immature technology (SE)

Reliance on large amounts of new software

*Source: Pre-Milestone A and Early-Phase Systems Engineering: A Retrospective Review and Benefits for Future Air Force Systems Acquisition, National Research Council (2008)

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