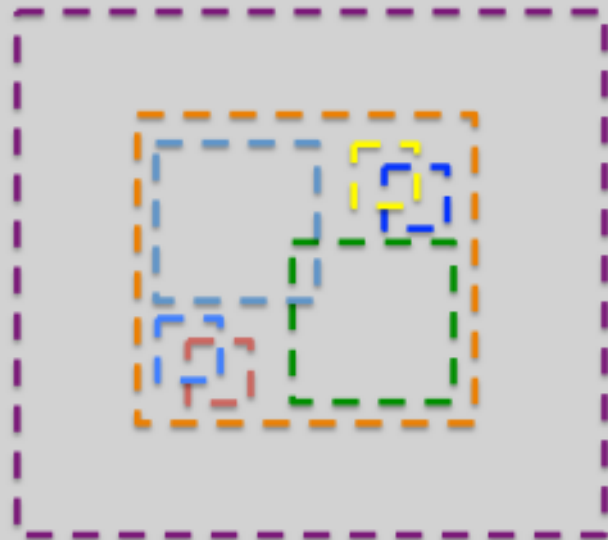# SYSTEMS ENGINEERING, INNOVATION & LEADERSHIP

Dr-Ing Dietmar Winzker
www.winzker.com
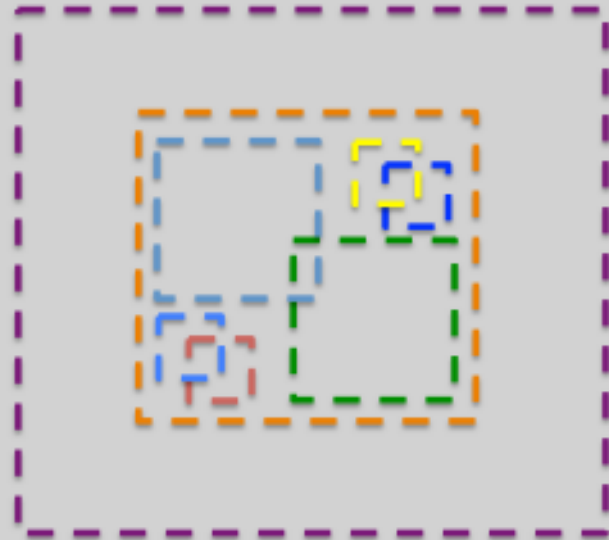
Linked in

PROLOGUE

Why is Dietmar talking to us about this topic?

PROLOGUE

Systems Eng

Why is Dietmar talking to us about this topic?
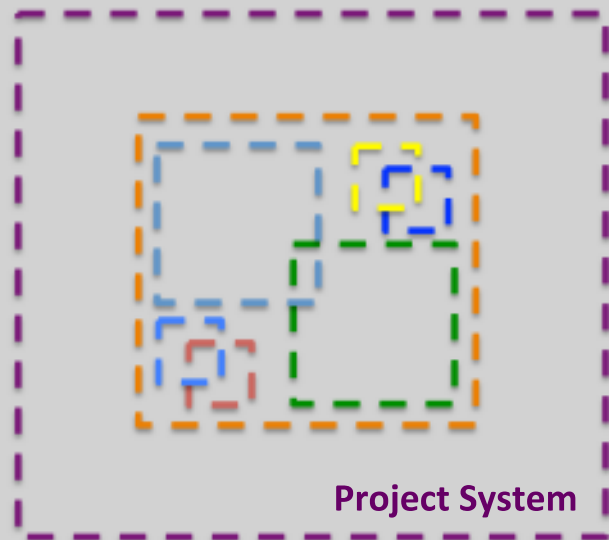
What is so special about Systems Engineering?

PROLOGUE

The Functions that make a difference for competitiveness in a global context

Innovation

Leadership

Systems Eng

Contextual System

Project System

Why is Dietmar talking to us about this topic?

What is so special about Systems Engineering?

Why the combination of SE with Leadership and Innovation?

Get The Bigger Picture

SE1 Basics – Systems and the SE Process

SE 2 Systems Engineering & Program Management

A 1 Art of Creative Thinking: Fit for the Current challenges

A 2 Art of Innovation: Ensuring 'Fit for the Future'

L 1 Leadership. Leadership? Leadership!

L 2 Types of SE contextual Innovative Leadership: Leonardo da Vinci, Steve Jobs, Elon Musk.

SE1 Basics – Systems and the SE Process

1. *Can SE be perfectly, uniquely, unambiguously described for every parameter, characteristic, interface or situation?*

SE1 Basics – Systems and the SE Process

A System is defined by the integration of Subsystems such that,

$$\text{SUM f(System)} \neq \text{SUM f(Subsystems)}$$

Work must be done to satisfy the inequality

If there is no inequality, subsystems can exist independently

Systems are defined in specific control volumes. Inputs and Outputs across the control volumes constitute Interface Definitions.
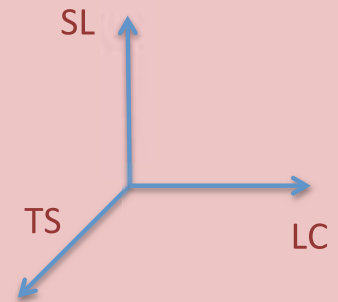
SE1 Basics – Systems and the SE Process

Systems must be managed in terms of,

Level in the System Hierarchy

Type of System

Phase of the Life Cycle

SL

TS

LC

SE Methodologies

- System Levels à la Dr WJ Barnard (SE, Armscor)
- US Military Specs:
  o A - Specs: Highest System
  o B – Specs: Subsystem
  o C/F – Specs: Product, Assembly, Process, Materials etc
- RSA Mil Specs

SE Methodologies

- CLAAS Agricultural Machinery (In-house developed SE process)
- Integrated collaboration (Krauss-Maffei-Wegmann, MBB & Dornier)
- Skunk Works (Lockheed) and Silicon Valley CA, Start-ups (PayPal)
- Tinkerer (Experimental – where is SE?)

SE Methodologies

As good as it gets.........

and still get failures!

- Examples:
  - SST Challenger Accident
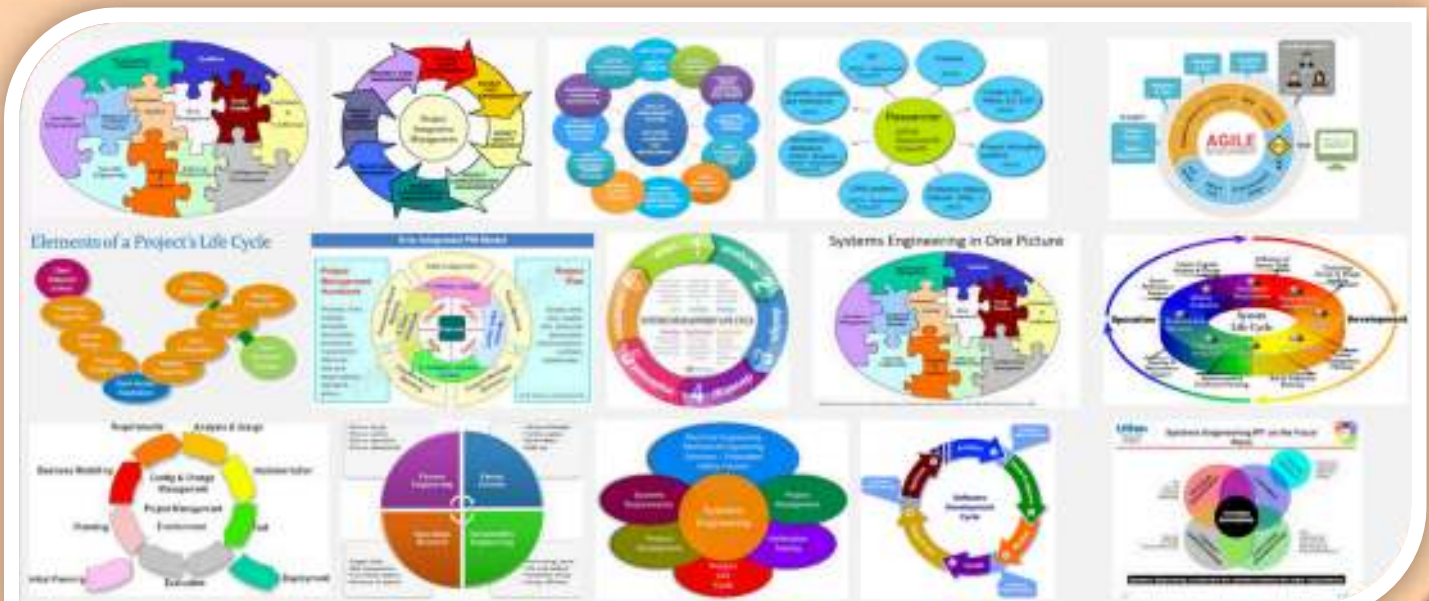 - G5 Electronic Fuze
  - Anti-Tank Weapon
  - A-Class Mercedes

SE1 Basics – Systems and the SE Process

Can SE be done solely by means of models, processes, Mind-maps?
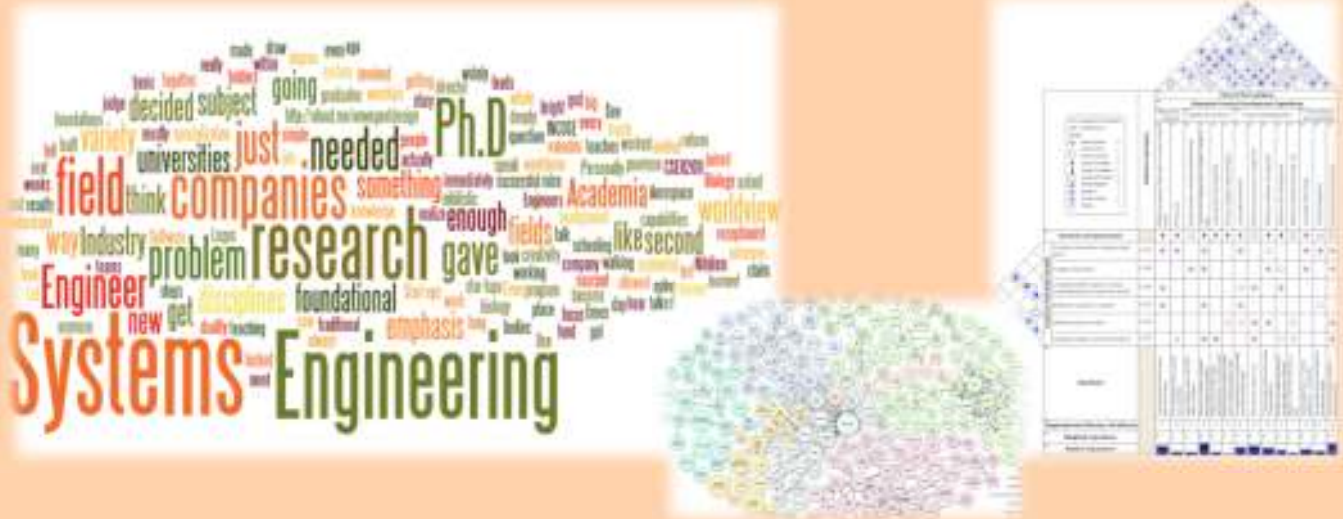
Dozens of Models.....

SE1 Basics – Systems and the SE Process

Why MAPS generally don't work in today's world.

SE methodologies are like recipes. It requires more than the ingredients to be a great cook.

A Map is a flat depiction of the surface of a sphere. Hence,

- Maps are not impartial
- Maps are inaccurate
- Maps are not current
- Maps will not get you THERE

Maps* are not impartial

What is the project?
What is the desired outcome?
What cultural context?
What does the Leader see?

as in SE Methodologies

Maps are not impartial

Maps are not impartial

What is the project?
What is the desired outcome?
What cultural context?
What does the Leader see?

By analogy: The SE Process is not impartial!

Maps are not accurate

- ## The only TRUE representation of a particular geography can only exist on a scale of 1:1

From Lewis Carroll' *Alice in Wonderland*:

" We actually made a map of the country on the scale of a mile for a mile!"

"Have you used it much?" I enquired.

"It has never been spread out yet", said Mein Herr. "The farmers objected: They said it would cover the whole country and shut out the sunlight! So now we use the country itself, as its own map and I assure you it does nearly as well"

By analogy: The SE Process is not always accurate

Maps are not current
and No Map will get you THERE

Maps are notoriously difficult when it comes to application

" in Theory there is no difference between theory and practice.
In practice however there is"   - ascribed to Albert Einstein

A new laptop comes with a 1-year warranty but is already outdated within 120 days!

By analogy: The SE Process will not get you where you want to be.

Our SE models cannot tell us everything!

"In a steady state world, descriptions such as maps are partially useful but not in todays ultra-fast unpredictable environment. Here maps are of limited to no value. Sometimes they are a serious detraction"

One Exception! Maybe.

Mathematics.

$$\frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0$$

$$u \frac{\partial u}{\partial x} + v \frac{\partial u}{\partial y} + \frac{1}{\rho} \frac{\partial p}{\partial x} = \nu \left(\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} \right)$$

$$u \frac{\partial v}{\partial x} + v \frac{\partial v}{\partial y} + \frac{1}{\rho} \frac{\partial p}{\partial y} = \nu \left(\frac{\partial^2 v}{\partial x^2} + \frac{\partial^2 v}{\partial y^2} \right)$$

Mathematics models real life physics extremely well.

Almost one to one, depending on the degree of knowledge and insight AT ALL LEVELS, ALL PHASES.

$$F = ma$$
N   kg   m/s²

Examples: *Boeing 777, Landing on a rotating Comet, Rendez-vous with Pluto at 50 000km/h and a couple of billion miles away!*
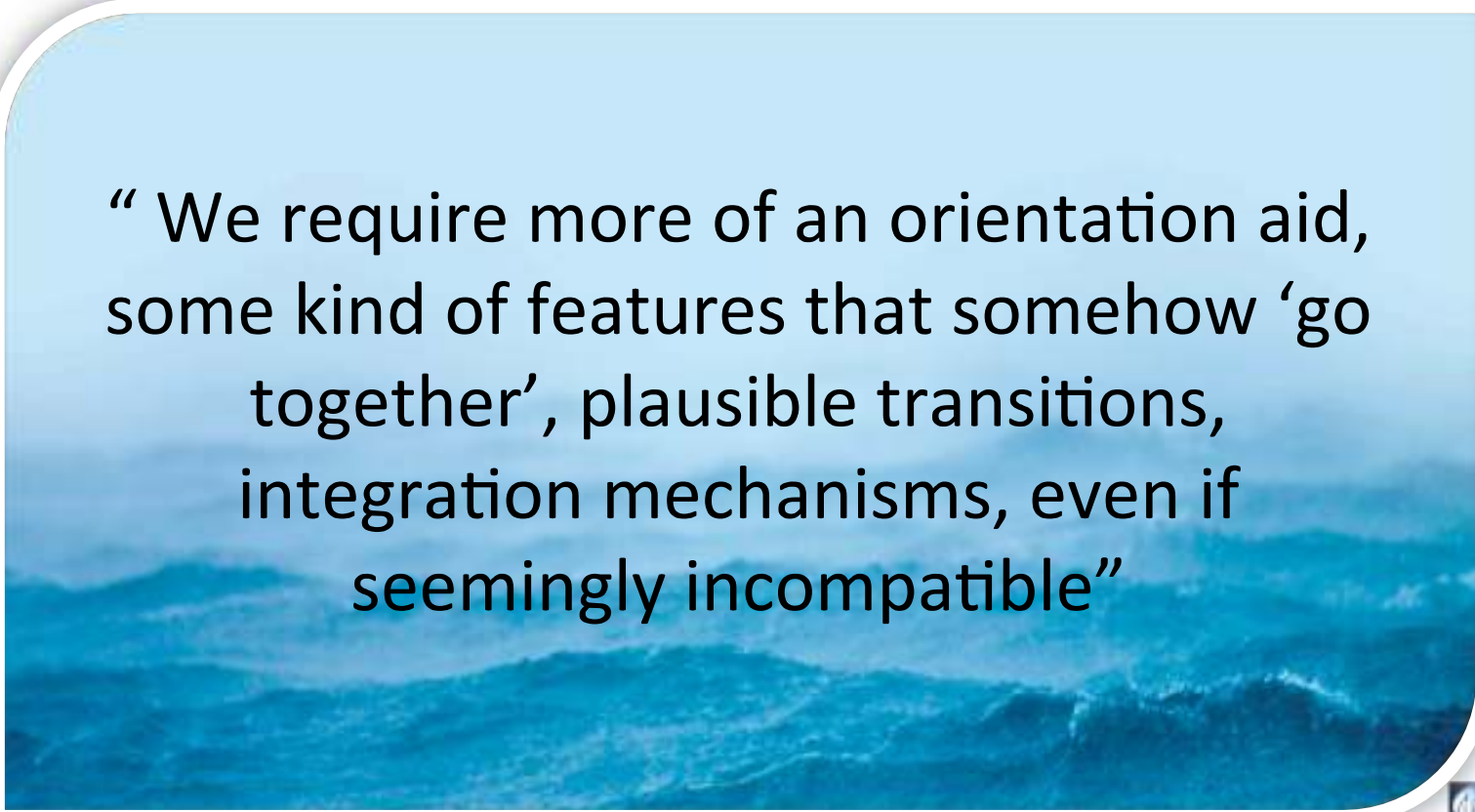
Sail it!

You cannot create a map of *terra incognita.*
Especially when *terra* is no longer *firma.*

We need navigational skills for getting from the real problem to a plausible solution.

To seek simple formulas/ processes / maps for complex missions is to incubate mediocrity.

" We require more of an orientation aid, some kind of features that somehow 'go together', plausible transitions, integration mechanisms, even if seemingly incompatible"

" Todays SE involves traveling in largely unchartered territory, navigating the unfamiliar terrain of new projects for which no pathway exists"

e.g. Tesla Automotive, MeerKAT, Space-X
but also On-demand industries Uber, airbnb,
Transportation, cash-less payments, Nature of WORK

1. Proof: Re-engineering & re-structuring, "ticking the boxes" does not work.
2. Signposts maybe..........Open SE Design Platforms possible?
3. Make use of a compass!
4. Pull yourself forward by means of an anchor

Metaphorically speaking

Let's switch gears

Part 2: Innovation

WHAT IS INNOVATION?

"The ability to see connections, spot opportunities and to take advantage"

It is not always clear if innovation describes the process, is inside a product or provides a method.

Innovation can be a cause or an effect. Mostly it is a question of perspective.

What is Innovation?

- A new **idea**; original, more effective, categorically different
- Asking the right **questions** and suggesting answers
- A **radically** better solution, radically more effective process
- Creative **destruction** of the current situation
- An **Entrepreneurial** way of looking at processes, products, service delivery
- Opening previously unthinkable paths to new **possibilities**

Innovation is difficult to pin down

- Innovation does not equal invention
- Innovation is not just new products, materials and processes
- Technology is very often a trigger for innovation
- Co-operation across disciplines often aids innovation
  - Hand-gun development at Gluck
  - SE at Barclays Bank
  - Starnode B2B development

- Breakthroughs often come from unexpected corners by means of Paradigm Shifts:
  For example,
  - Alfred Wiegener, Tectonic plates
  - Prof Ignaz Semmelweis, Hand washing
  - Albert Einstein, $E=mc^2$

innovation

INNOVATION IS MAINLY ABOUT THINKING, EVALUATING AND DOING AND EVALUATING AND DOING…….

is not only about utilizing technical knowledge…….

innovation

Innovation is an INTEGRATED PART OF A DESIGN in terms of technology, economy, politics, education, community, company and national culture and others involving many different stakeholders at different levels and in diverse contexts.

Innovation has many different dimensions

Different context
Different levels
Different disciplines
Different cultures
Different systems
Different Paradigms

Understand the contextual interaction, the content and the application of its different disparate pieces.

Innovation may take place on many different interconnected layers in a bigger system in a kind of neural network.

Examples: KWV from co-op to Int Companies; KWV Benchmarking;
SKA - Engineers & Scientists; Armscor - Engineers & The Military
DMD Talk: From indication-based to process-based medical thinking!

Fundamental requirements for Innovation

Thinking !
Asking the right questions
Vision / Perspective
Passion
Persistence
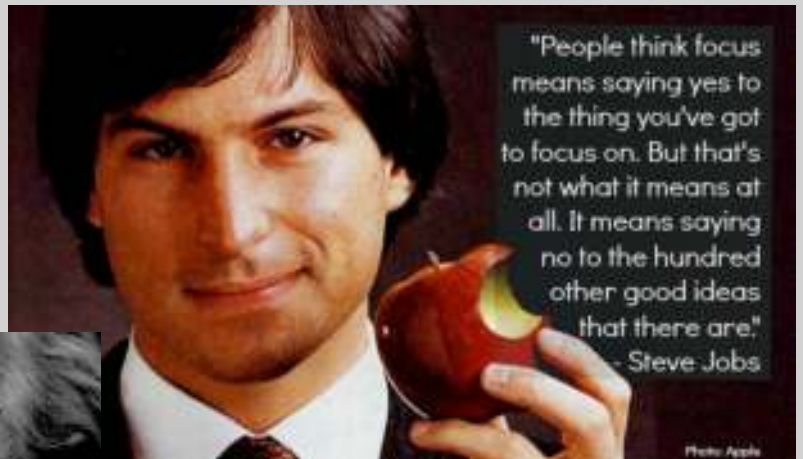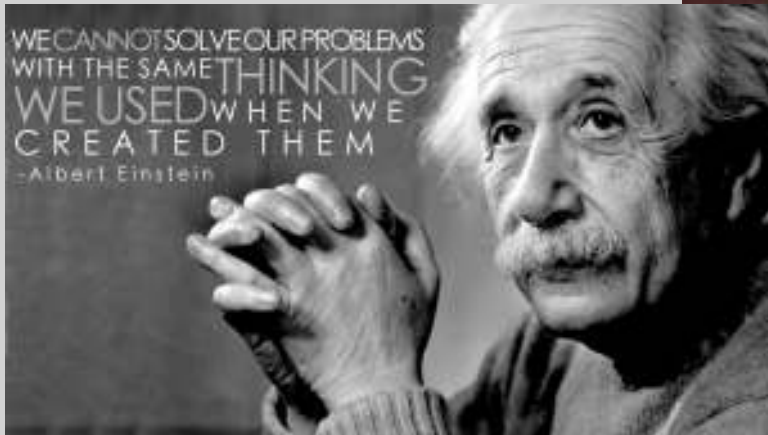Leadership
Execution (ie shipping)

"Unless there is utility and sales possibility an innovation is useless" - Thomas Edison
Examples: Domestic electric light, Einstein's theories wrt gravity waves, Digital Everything

"People think focus means saying yes to the thing you've got to focus on. But that's not what it means at all. It means saying no to the hundred other good ideas that there are."
- Steve Jobs

WE CANNOT SOLVE OUR PROBLEMS WITH THE SAME THINKING WE USED WHEN WE CREATED THEM
-Albert Einstein

"To turn really interesting ideas and fledgling technologies into a profitable company that can continue to innovate for years, requires a lot of discipline."

– Steve Jobs, CEO Apple Inc

"Innovation distinguishes between a leader and a follower."

~ Steve Jobs

www.jobsdrwas.com

Innovative System Thinkers:
LEONARDO, Copernicus, Newton

- 500 years ago Leonardo da Vinci (1452 – 1519) invents the future by asking questions

- Leonardo had no formal education

- But he was inquisitive, had great Ideas and keen observation

- Although the technology for his innovative thinking was not yet available, he was a genial *innovative Engineering Scientist*.

- ***Architect of the Possible (& Impossible)***

Innovative System Thinkers:
Leonardo, **COPERNICUS,** Newton

- Copernicus (1473 – 1543) hypothesized that the sun "was the center of the universe" and not the earth.

- Copernicus started a new cosmology

- *The innovation was a completely new system perspective* which opened the door to many new innovations due to a new paradigm.

- ***He caused a Weltbild Revolution***

Innovative System Thinkers: **NEWTON** - the dawn of a new understanding

- Isaac Newton (1643 – 1727)
- Keen Observation
- *Newton proposes that Nature is a system of knowledge, ordered and structured*
- The utility of Mathematics
- Genius – Greatest Scientist of all times
- ***Fundamentals upon which to build for centuries***

LESSONS? - Leonardo, Copernicus, Newton

- Looked at the Possible & the Impossible
- Clean sheet observation; Leonardo had no "education" bias!
- Detailed, meticulous observation genius-level education (Newton)
- Challenged assumptions, looked a a bigger picture for explanations
- Produced Paradigm shifts in their time
- Disseminated Ideas widely with the technology available
- Absolutely passionate about what they were doing

Modern Innovative System Thinkers:
Steve Jobs, Elon Musk

- Steve Jobs (1955 – 2011)
- "A Computer in every home"
- The digital connection of TV, Music, Entertainment, Computers, Mobile comms.
- Innovative Designs, unique products, complimentary systems, raving fans, profitable

Modern Innovative System Thinkers:
Steve Jobs, **Elon Musk**

- Elon Musk (1971 wants to die on Mars, but not on impact!)
- Re-thinking FINANCIAL TRANSACTIONS (PayPal)
- Re-thinking MOBILITY (Tesla)
- Re-thinking ENERGY (SolarCity)
- Re-thinking SPACE (SpaceX)
- Re-thinking TRANSPORTATION (Hyperloop)

SE, Innovation, Leadership – 3 in 1

LESSONS? – Steve Jobs and Elon Musk

For both Individuals:

- Asked the right questions at high systems level
- Thinking at higher level than simply products and subsystems
- Relentless, Persistent, Diligent, Passionate, Ferocious, DRIVEN!

- Big picture perspective and attention to detail to an extreme degree.
- Mobilized Teams of inspired, knowledgeable individuals to "impossible" levels of performance and achievement.

They change(d) the world through innovative system thinking & Leadership

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Scope of Innovation: Big Picture
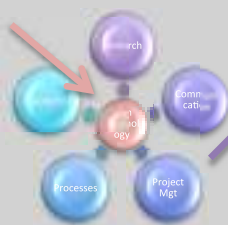Disciplines / Context / Culture / Level / Content /

Content:
Big Picture
Strategy
Vision
Leadership
Asking the right Q
Knowledge management
Nurturing of creativity
Prepared for Paradigm shift

Employees / Coworkers
Enabled / empowered

Etc etc

Disciplines:

Politics
High-Technology
Finances
Trade
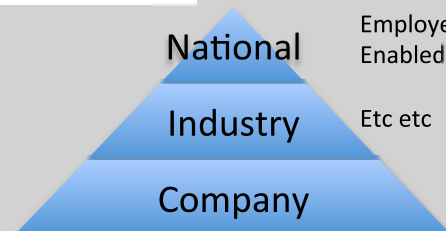Environment
Energy
Economics
Construction
etc

High-Tech:
Research, Communication, Project Mgt, Processes, Systems

Culture:
Culture of
Learning
Mentoring
Coaching
Facilitating

Democracy
Socialist
Dictatorship

National

Industry

Company

But there is more….

Boeing Dreamliner, TESLA car….

…incorporate thousands of innovations in terms of systems, products, assemblies, processes, materials, design……..

Classifications of Innovations

Innovations

- E.g. Morse Code
- E.g. Valves and transistors
- E.g. Steel making
- E.g. Newton's Laws

- E.g. Hand-washing (Semmelweis)

Influence in space and over time

- ✓ Wide app / time ltd
- ✓ Electronic app / time ltd
- ✓ Industry specific / time unltd
- ✓ Widest application / time unltd

- ✓ Medical – Hygiene app / time unltd

Innovation Systems Levels

- **PARADIGM INNOVATION** – changes of mental models
- **POSITION INNOVATION** – changes in context
- **PRODUCT INNOVATION** – changes in things
- **PROCESS INNOVATION** – changes in creation and delivery

Towards practical application

Innovation can arise out of untested opinion or detailed research

Fundamentals to "release" Innovation

- Ask Questions

- Apply in-sight and whole-sight

- Apply Systems Thinking

- Apply an open, collaborative company culture

- Awareness of developments in space and time

- Adaptability and flexibility

- Authentic Leadership

- "Artful": Artful IN TERMS OF DESIGN, MARKETING, and creating RAVING FANS

awareness FRAMEWORK (no recipe!)

- **Time:** The moment of time and its contemporariness. *"Zeitgeist"*

- **Business Space:** a three-dimensional space in which the three spatial axes define the business environment

- **A System Framework:** the broad challenges – or literacies - which every business has to be able to handle effectively
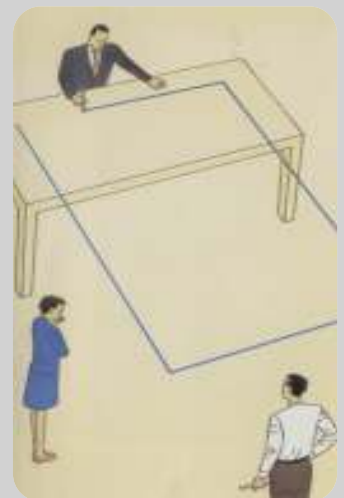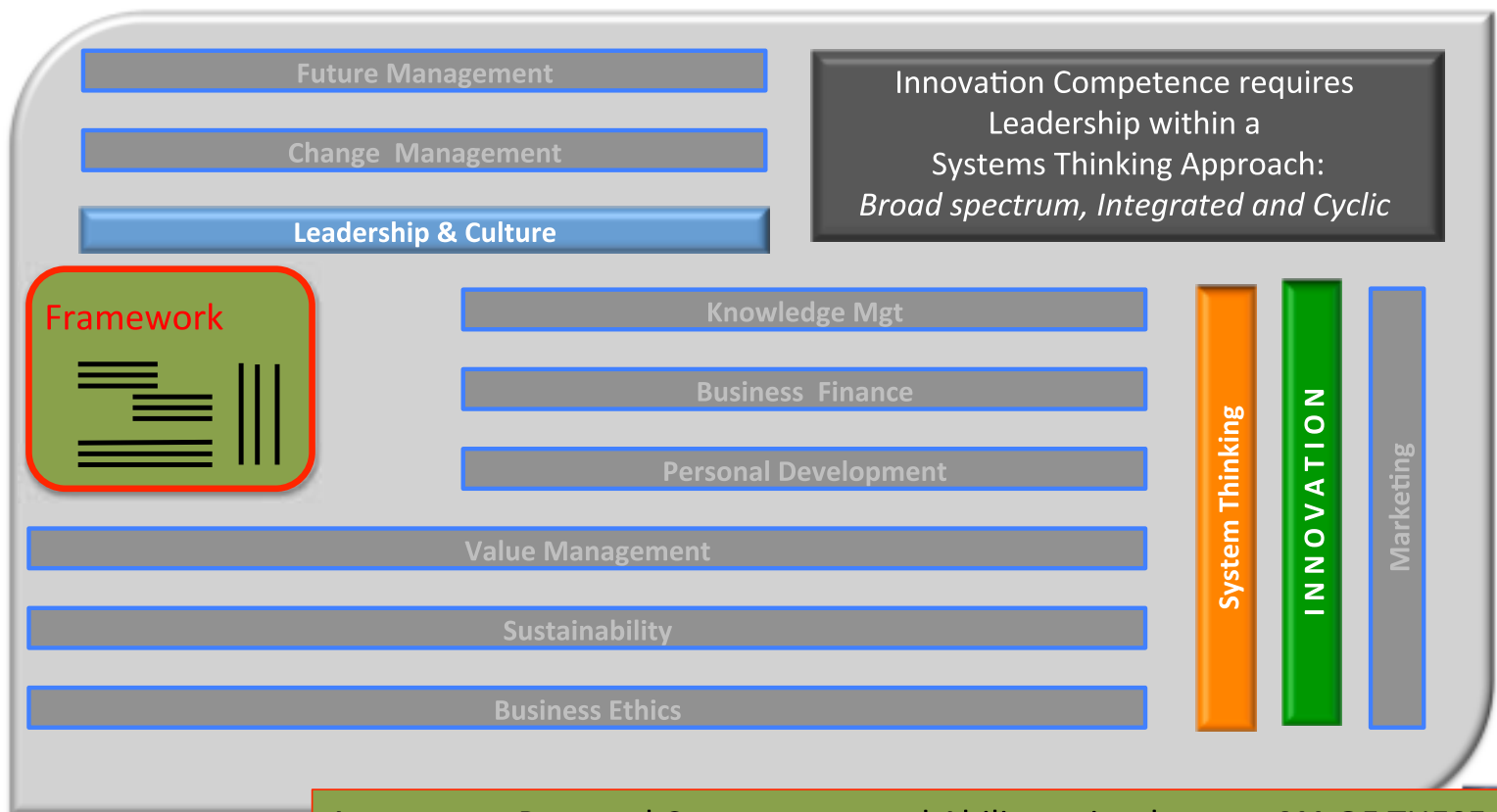
- **A Process:** the four-step process **Imagine-Shape-Deliver-Support**

- **An Integrator:** Integrating all concepts and sub-models on a continuous basis

- **Systems Thinking:** The overall integration of multi-disciplinary complex systems over time in cultural ctxt

Future Management

Change Management

Leadership & Culture

Framework

Innovation Competence requires
Leadership within a
Systems Thinking Approach:
Broad spectrum, Integrated and Cyclic

Knowledge Mgt

Business Finance

Personal Development

Value Management

Sustainability

Business Ethics

System Thinking

INNOVATION

Marketing

Awareness, Personal Competence and Ability to implement *ALL* OF THESE

Let's switch gears again

Part 3: Leaders

- They don't make plans, they "manage paradox".
- They don't even organise people.
- They monitor, mentor and coach, rather than control.
- ***They prepare the organisation or the Team for change and they help them cope as they struggle through it.***
- Followers want stability and solutions from their leaders. But that's babysitting! Don't "coerce" your Leader into babysitting you!
- Real leaders ask hard questions and knock people out of their comfort zones.

  THEN THEY MANAGE THE RESULTING STRESS!

Example from the South African Defence Industry

- The Systems Engineering approach was "applicable" and contextualized
- Tailored for SA conditions
- Extremely young SE team with little experience but also no "baggage"
- Asked the right questions and were asked the right questions
- Excellent educational background & knowledge base (but little insight, little wisdom)
- **Team diversity, committed leadership / mentorship**
- **Culture of openness, professional integrity and freedom of decision making (good or bad)**
- Strategic Priority due to perceived external pressure/circumstances

  Within 10 years from zero to battle-proven 43/100.

TRANSFORMATIONAL LEADERSHIP WAS / IS KEY

Fresh, original, no "baggage"
(also much cheaper!!!)

Thinking in a team,

including the customer.

Communication

Mutual respect

Frequent Interaction
*(in fact all the time!!!
Spontaneous, Open)*

Diversity in the team

"Thinking" as a culture.

Tolerance for failure.
Encouragement, commitment, fun
*(Control –this ugly word - through respect
for/and by Leadership,
not ruled by "politics"*

or punishment)

"Thinking" as a culture.
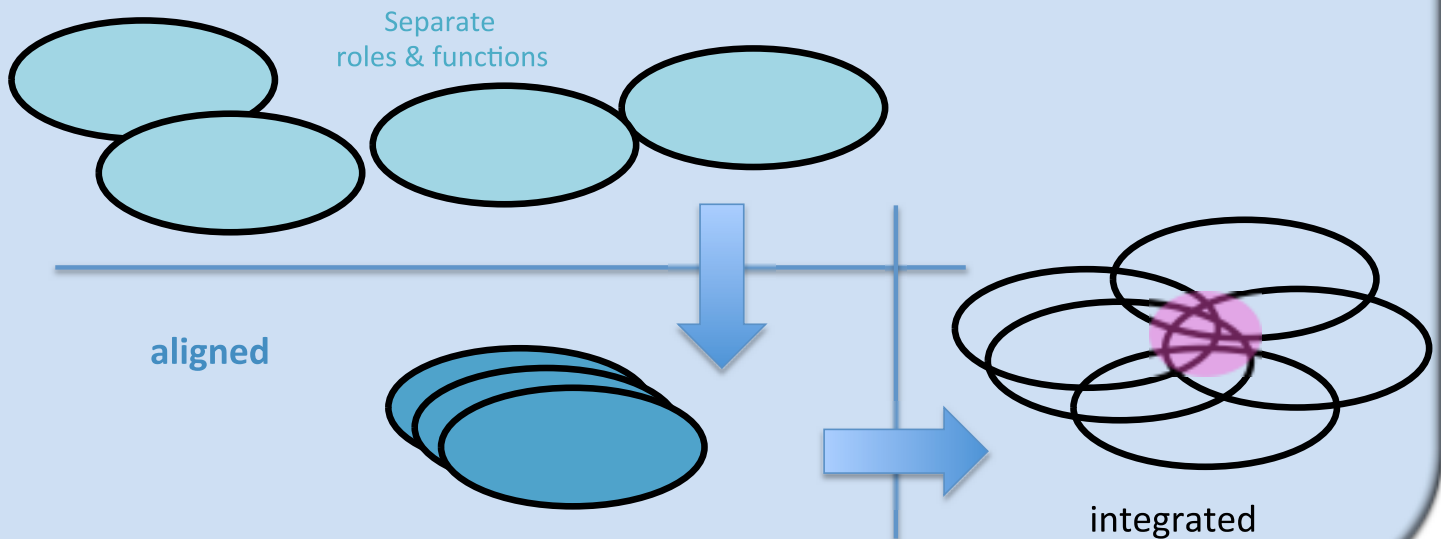

Thinking in levels.
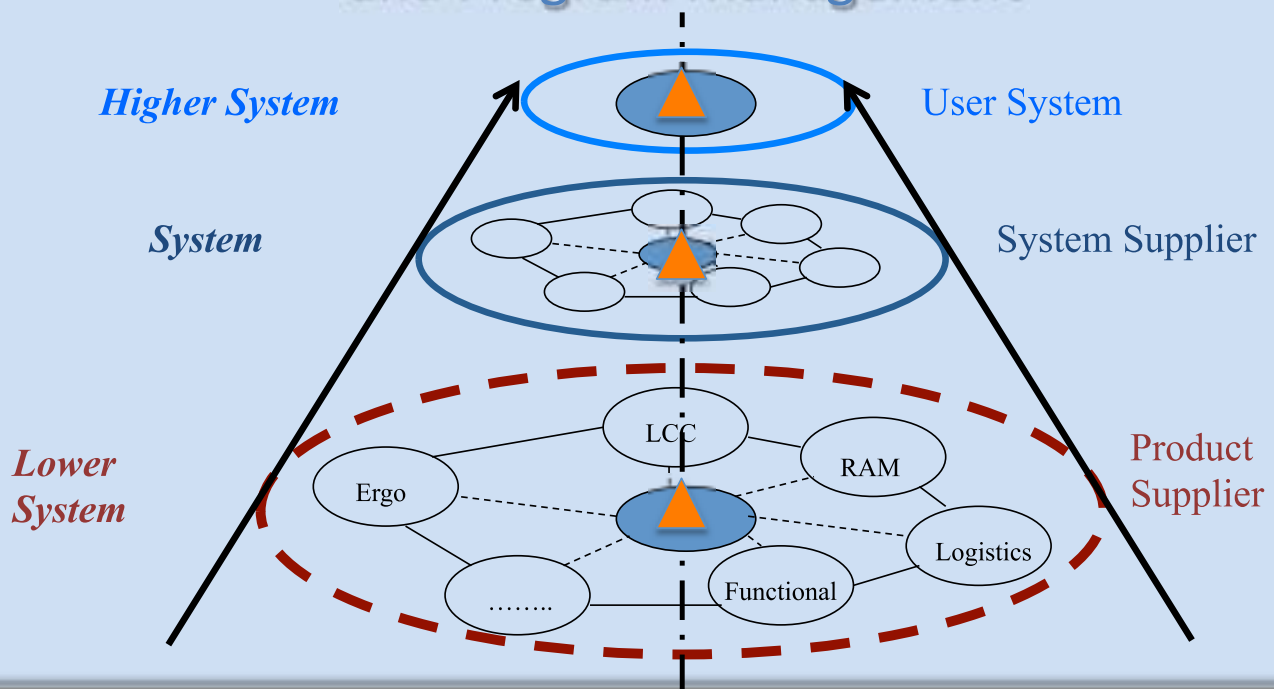

F(g) ? F(z) ? F(q) ?

$y = f(x)$

$a + b = c$

$1 + 1 = 2$

Thinking in particular roles & functions.
in an integrated manner.

Separate
roles & functions

aligned

integrated

Synergy between Customer, Systems Engineering and Program Management

Higher System

User System

System

System Supplier

Lower System

Product Supplier

LCC

Ergo

RAM

Logistics

Functional

....

Inspired Leadership: Culture, added value, professionalism, mind-set.

- A Culture Of Learning, Innovation, Experimentation
- Enablement & Empowerment - Openness
- Professionalism:
  - Formal/Informal, Discipline/"Freewheeling"
  - Responsibility & Authority clearly allocated and respected
  - Personal Integrity & Technical Integrity
- Mind-set: External Threat, Sense Of Achievement, Sense Of Can Do,
    Sense Of Contribution

Young, dynamic, professional team under external pressure

- Pioneer Spirit and external pressure (UN Sanctions)

- Average age and years of experience relatively low

- Very dynamic, multi-disciplinary teams

- High exposure rate to different projects (sometimes simultaneously)

- High iteration rate; i.e. rapid prototyping

- Flexibility of mind, very adjustable to new ideas, situations etc
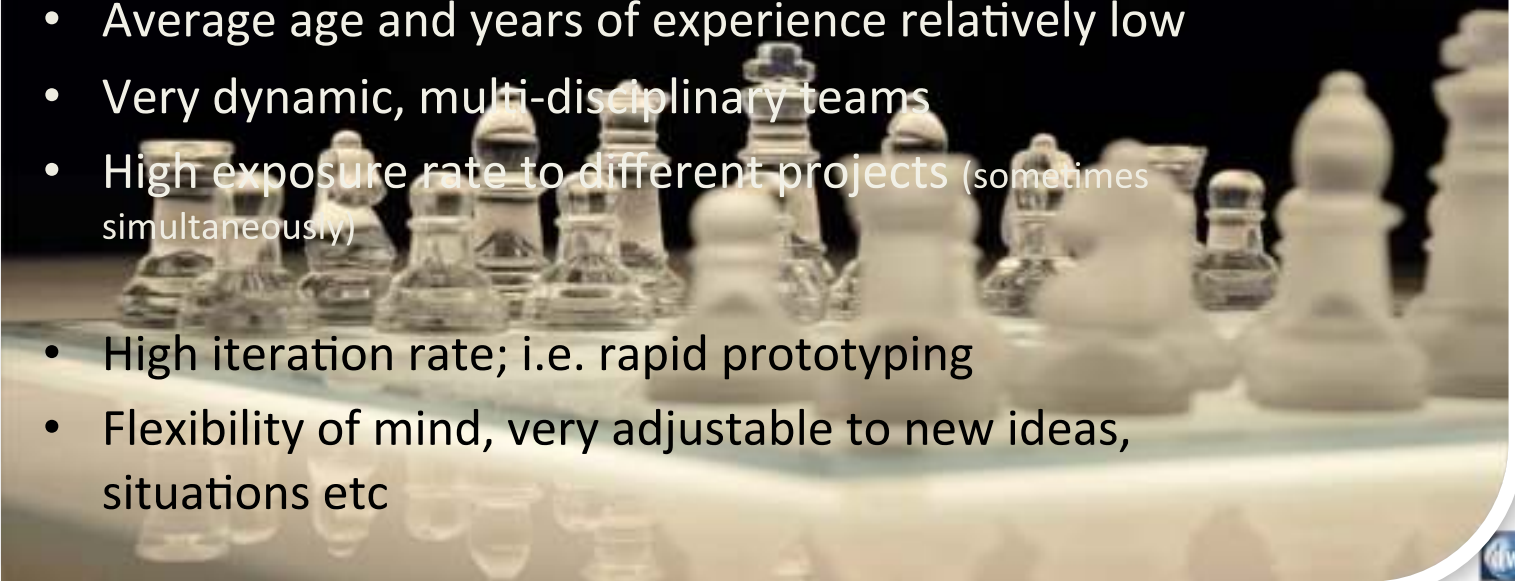
Why transformational leadership does matter in Design & Development

- If you haven't been there before, it is a continuous journey of discovery, you have to keep focus. What's YOUR anchor?
- The Leader keeps the vision alive, keeps the Team aligned, keeps the Team nimble and "encourages exploration". Failure resulting in new insights & learning is tolerated.

Why transformational leadership does matter in Design & Development

- Leadership is not only resident in the top leader but care was taken in the institutional development of leadership for all team members.
- There must be Leadership in form of mentorship and coaching. And a lot of trust! In a common culture.

Great SE implies: Expertise. Experience. Excellence. Experimentation. Errors. Exhilaration. These are constantly leveraged and integrated.

- **People development** and opportunity
- **Experience** is wide _and_ deep (specialist & generalist)
- **Commitment** to excellence, operationally driven
- **Encouragement** to prototype, experiment, error tolerance and quick learning
- **Culture** of openness, trust, flexibility professionalism and listening to the client.

...and Enormous Energy.

Think SYSTEM

Be INNOVATIVE

Be an inspiring LEADER

THANK YOU

INCOSE
International Council on Systems Engineering
South Africa