How to Invent

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1926 - 1998

opportunities

Genrich Altshuller

a patent clerk in the Soviet Navy studied thousands of patents and extracted from them the principles of invention.

He codified, classified, synthesised, invention insights and used these to solve inventive problems systematically. To Innovate.

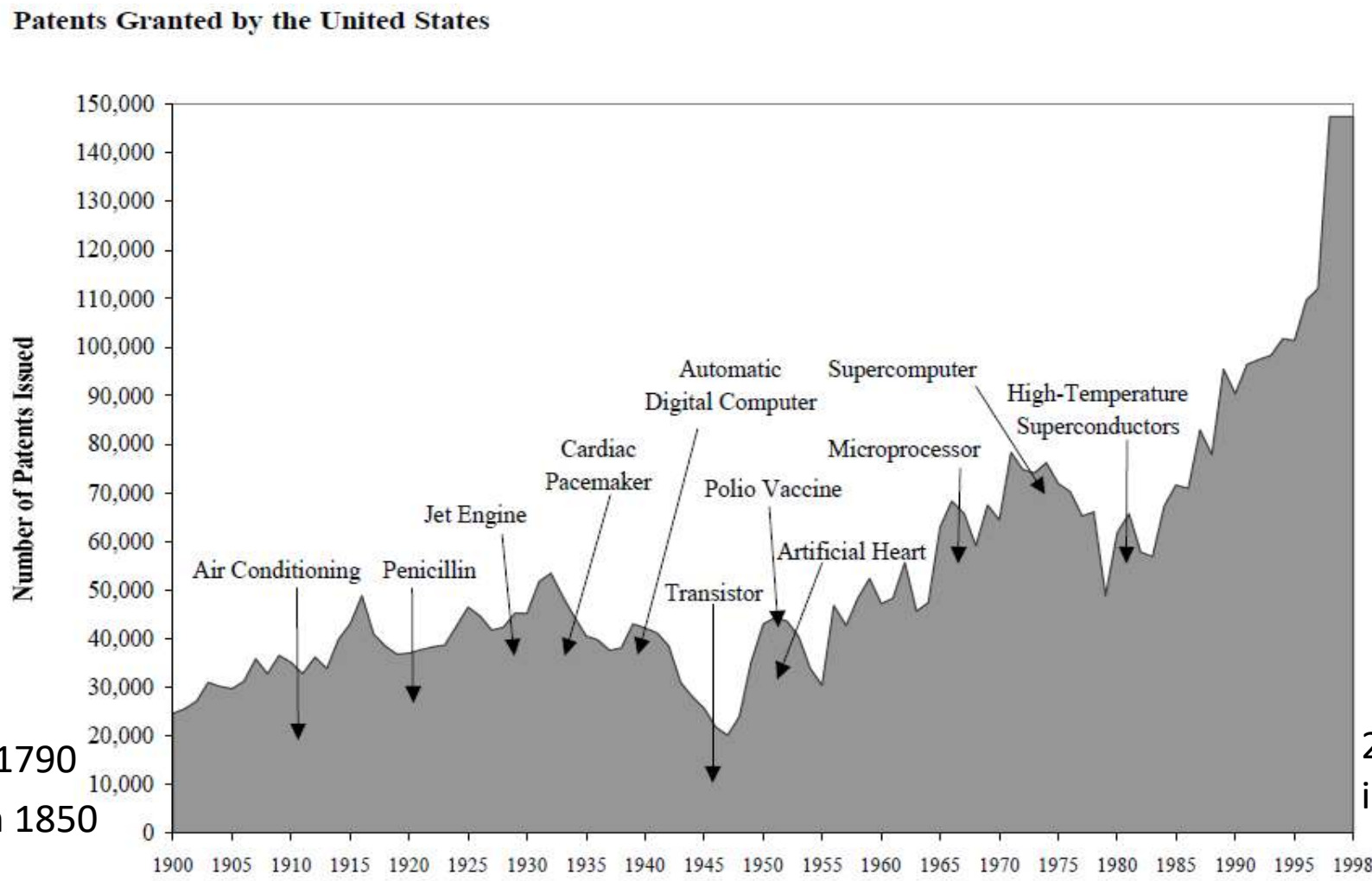
He is known as the father of TRIZ (Theory of Inventive Problem Solving)

This knowledge moved out of Russia as his students moved into Europe and America after 1989.

Altshuller and student S. Litvin

Photographs courtesy S. Litvin

(real-world) invention upon invention



3 in 1790

83 in 1850

277,835 in 2013

Stephen Moore and Julian L. Simon (1999) Policy Analysis - no. 364: *The Greatest Century That Ever Was, 25 Miraculous Trends of the Past 100 Years - accessed Internet 05 Feb 2015 - http://www.cato.org/sites/cato.org/files/pubs/pdf/pa364.pdf*

the importance of invention

Would being able to solve difficult problems or invent breakthrough product, service, process, and strategy improvements have importance for:

You?

Your organisation?

Your Industry?

Your community?

invention doesn't need to be expensive or complicated

The Pill Quality Challenge

A pharmaceutical manufacturer needs to reduce labour by three persons per shift who do visual inspection and removal of chipped tablets as they slide down an inclined plane.

- Tablets are either good or chipped.
- Chipped tablets make up about 15% or 15 000 of the 100 000 tablets inspected per shift. Each of 15 manufacturing stages damages about 1% of the tablets. I.E. each process is 99% good.
- Recommended engineering solutions
  - Visual inspection and separation computer system ~ 3.15 million rand.
  - Weighing and separation computer system ~ 3.15 million rand
- Management want a solution costing less than R15 000 rand

[Case adapted from Timothy Schweizer (2002) Integrating TRIZ into the Curriculum: An Educational Imperative]

invention results can be outrageously good – (and surprising)

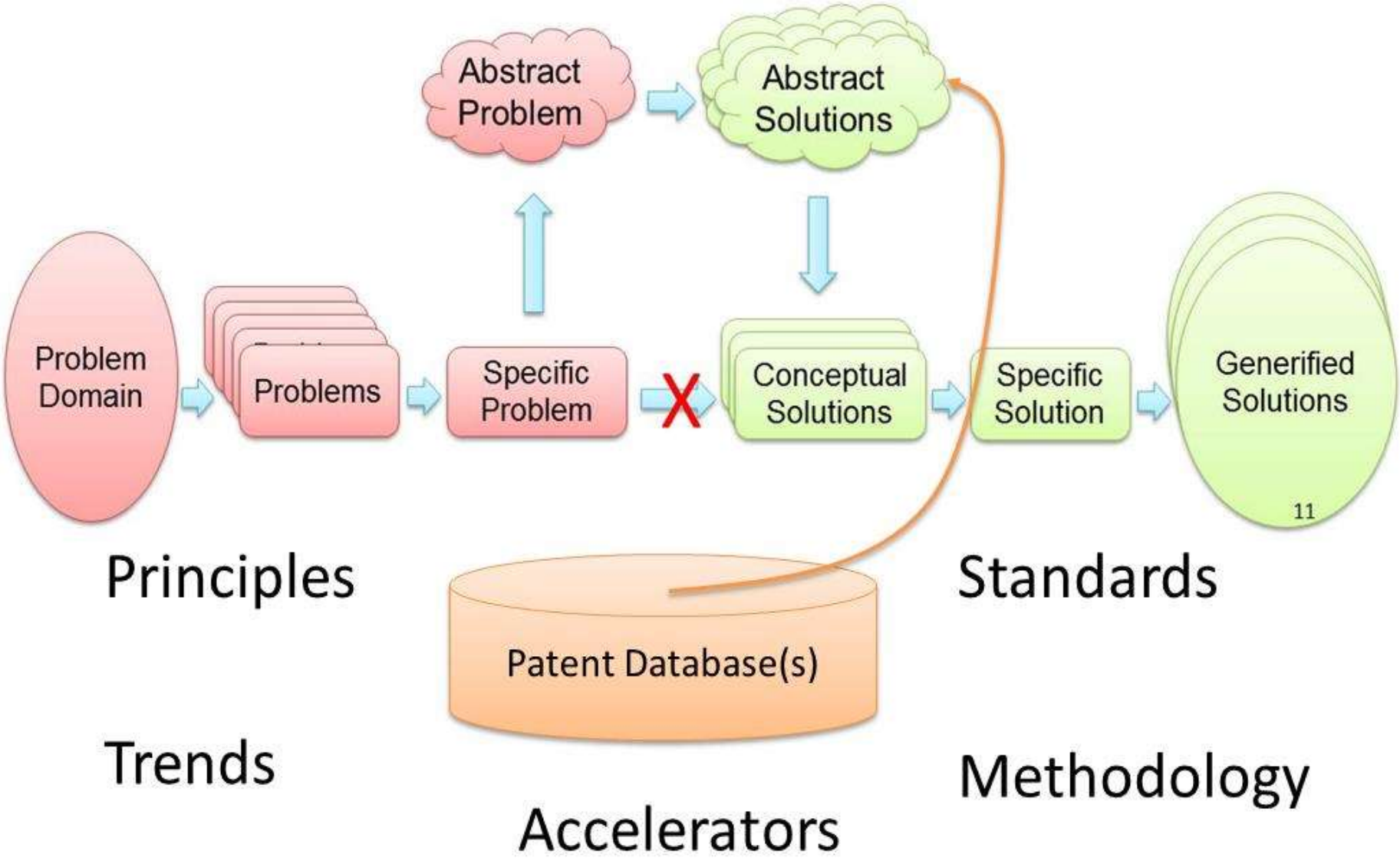
- **The Pill Quality Solution**

- Try to devise a solution for the problem on the previous slide that would cost around R15 000.00 or less.

- If you can't get to such a solution (simple, effective, robust, in budget) then proceed to the next step.

- The solution is breakthrough and surprising and so in an effort to maintain the surprise for other who may hear the talk repeated – for a plausible path to the solution contact wayne@novationnow.co.za

use abstraction and generalisation

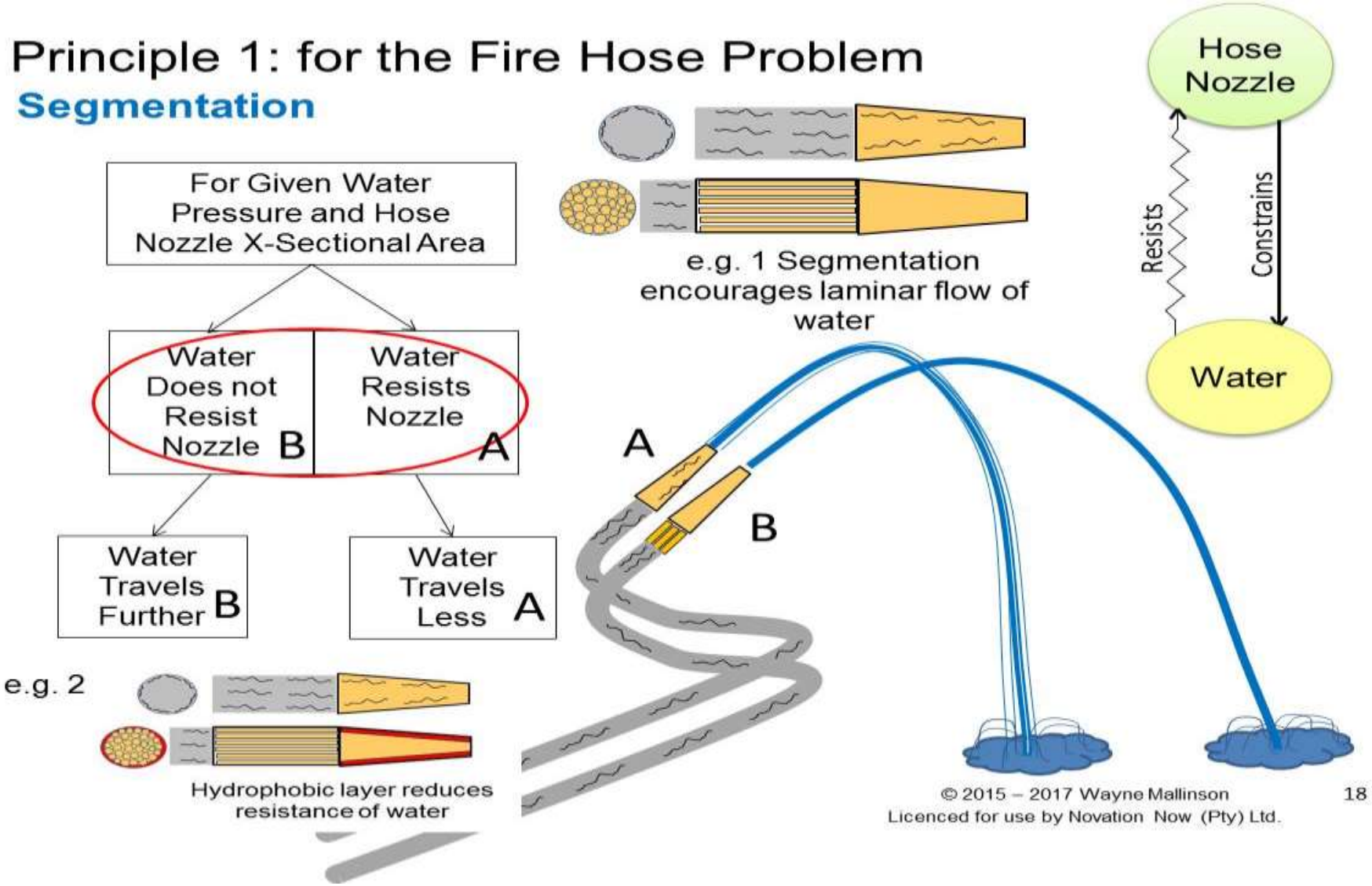


invention tools

Now to introduce you to some of the powerful invention tools of Altshuller.

- insights into principles of invention (from real-life)
- solving contradictions using matrix of physical properties
- trends of technological systems progress
- using Ideality to reduce constraints on thinking
- using the ‘triangle of invention’ functional analysis
- thinking past, present, and future, and at the same time picture, big picture, micro picture

example principles – slide 1 of 3



example principles – slide 2 of 3

Principle 1	Segmentation	
A. Divide an object or system into independent parts/persons - Mann		
Example: Replace a large truck by a truck and trailer.	Physical Object	**Source:** TRIZ40 by Solid Creativity http://www.triz40.com/aff_Principles_TRIZ.php
Example: Divide an organisation into different product centres.	Business Object	**Source:** Mann, D. and Domb, E. (1999) 40 Inventive (business) Principles http://www.metodolog.ru/triz-journal/archives/1999/09/a/index.htm
Example: Replace 'BUG' in software with root cause –> cause –> defect –> failure –> IR -> wsm - prevent future defects.	IT Object	**Source:** ISTQB Syllabus ISTQB Syllabus - [Book] Deming Out of the Crisis
B. Make an object or system easy to disassemble – wsm or assemble - ikea		
Example: Modular furniture (e.g. IKIA - wsm).	Physical Object	**Source:** TRIZ40 by Solid Creativity http://www.triz40.com/aff_Principles_TRIZ.php
Example: Modular independent processes or process steps.	Business Object	**Source:** Wayne Mallinson
Example: Modular units or components.	IT Object	**Source:** Wayne Mallinson
C. Increase the degree of fragmentation or segmentation		
Example: Replace solid shades with Venetian blinds.	Physical Object	**Source:** TRIZ40 by Solid Creativity http://www.triz40.com/aff_Principles_TRIZ.php
Example: 'Empowerment' – segmentation of decision making.	Business Object	**Source:** Mann, D. and Domb, E. (1999) 40 Inventive (business) principles with examples http://www.metodolog.ru/triz-journal/archives/1999/09/a/index.htm
Example: Replace requirements documents with Agile user stories.	IT Object	**Source:** Wayne Mallinson

Table M2-1: Principle 1 – Segmentation

example principles – slide 3 of 3

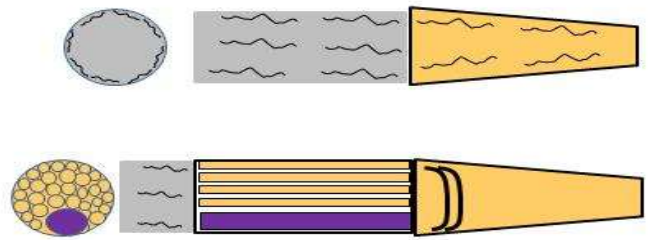
Principle 4: for the Fire Hose Problem

Asymmetry

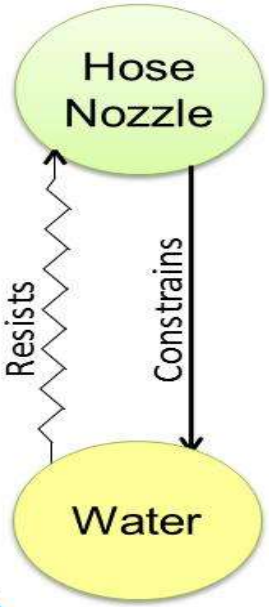
For Given Water Pressure and Hose Nozzle X-Sectional Area

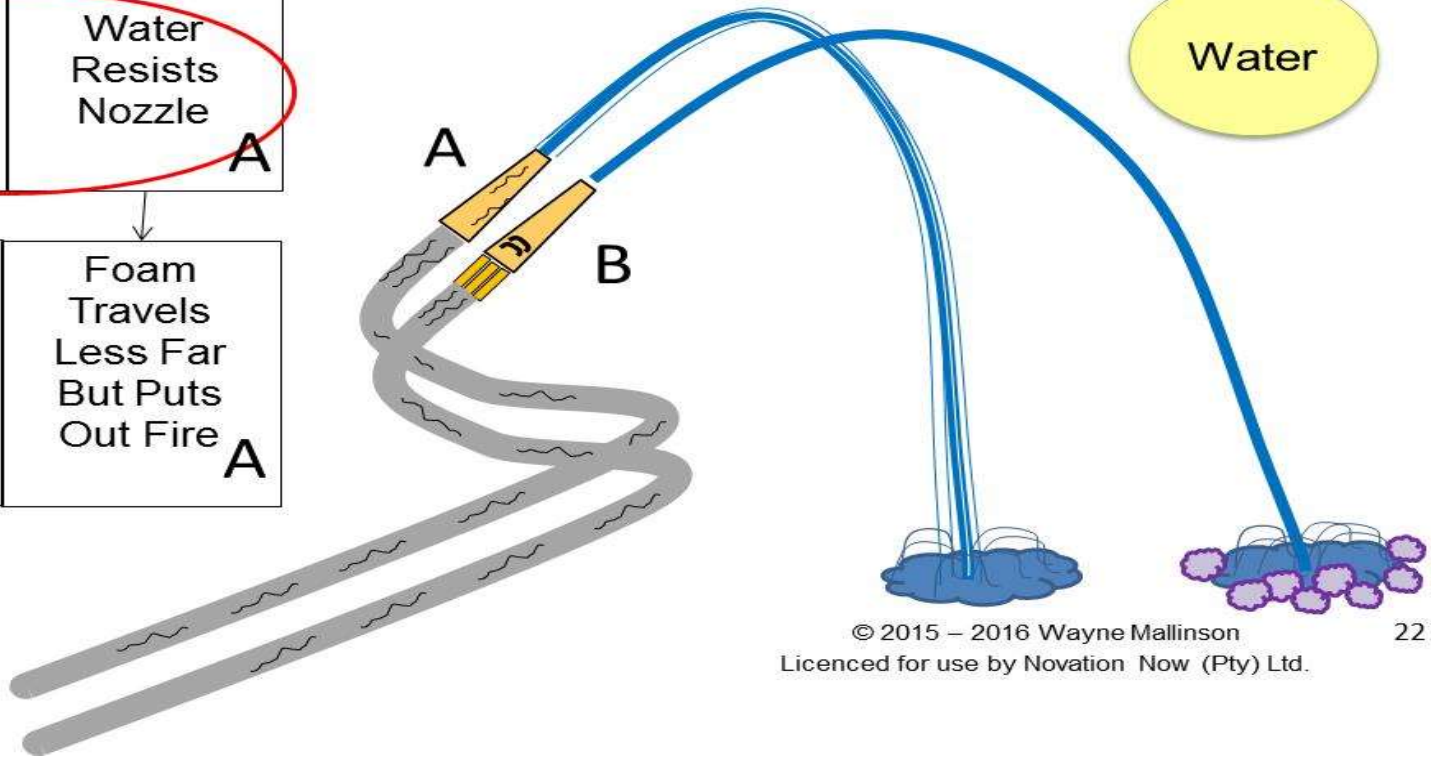
Water Does not Resist Nozzle B	Water Resists Nozzle A

Water Travels Further But Does Not Put Out Fire B	Foam Travels Less Far But Puts Out Fire A



Asymmetry – hose carries CO2 foam





1/9th Portion of Contradictions Table [Normally 39 x 39]

Characteristic that gets worse ⇐ / ⇒ Characteristic that improves		Weight of a mobile object	Weight of a stationary object	Length of a mobile object	Length of a stationary object	Area of a mobile object	Area of a stationary object	Volume of a mobile object	Volume of a stationary object	Speed	Force	Tension / Pressure	Shape	Stability of composition
		1	2	3	4	5	6	7	8	9	10	11	12	13
Weight of a mobile object	1		-	15, 8, 29, 34	-	29, 17, 38, 34	-	29, 2, 40, 28	-	2, 8, 15, 38	8, 10, 18, 37	10, 36, 37, 40	10, 14, 35, 40	1, 35, 19, 39
Weight of a stationary object	2	-		-	10, 1, 29, 35	-	35, 30, 13, 7	-	5, 35, 14, 2	-	8, 10, 19, 35	13, 29, 10, 18	13, 10, 29, 14	26, 39, 1, 40
Length of a mobile object	3	8, 15, 29, 34	-		-	15, 17, 4	-	7, 17, 4, 35	-	13, 4, 8	17, 10, 4	1, 8, 35	1, 8, 10, 29	1, 8, 15, 34
Length of a stationary object	4	-	35, 28, 40, 29	-		-	17, 7, 10, 40	-	35, 8, 2, 14	-	28, 10	1, 14, 35	13, 14, 15, 7	39, 37, 35
Area of a mobile object	5	2, 17, 29, 4	-	14, 15, 18, 4	-		-	7, 14, 17, 4	-	29, 30, 4, 34	19, 30, 35, 2	10, 15, 36, 28	5, 34, 29, 4	11, 2, 13, 39
Area of a stationary object	6	-	30, 2, 14, 18	-	26, 7, 9, 39	-		-	-	-	1, 18, 35, 36	10, 15, 36, 37	-	2, 38
Volume of a mobile object	7	2, 26, 29, 40	-	1, 7, 4, 35	-	1, 7, 4, 17	-		-	29, 4, 38, 34	15, 35, 36, 37	6, 35, 36, 37	1, 15, 29, 4	28, 10, 1, 39
Volume of a stationary object	8	-	35, 10, 19, 14	19, 14	35, 8, 2, 14	-	-	-		-	2, 18, 37	24, 35	7, 2, 35	34, 28, 35, 40
Speed	9	2, 28, 13, 38	-	13, 14, 8	-	29, 30, 34	-	7, 29, 34	-		13, 28, 15, 19	6, 18, 38, 40	35, 15, 18, 34	28, 33, 1, 18
Force	10	8, 1, 37, 18	18, 13, 1, 28	17, 19, 9, 36	28, 10	19, 10, 15	1, 18, 36, 37	15, 9, 12, 37	2, 36, 18, 37	13, 28, 15, 12		18, 21, 11	10, 35, 40, 34	35, 10, 21
Tension / Pressure	11	10, 36, 37, 40	13, 29, 10, 18	35, 10, 36	35, 1, 14, 16	10, 15, 36, 28	10, 15, 36, 37	6, 35, 10	35, 24	6, 35, 36	36, 35, 21		35, 4, 15, 10	35, 33, 2, 40
Shape	12	8, 10, 29, 40	15, 10, 26, 3	29, 34, 5, 4	13, 14, 10, 7	5, 34, 4, 10	-	14, 4, 15, 22	7, 2, 35	35, 15, 34, 18	35, 10, 37, 40	34, 15, 10, 14		33, 1, 18, 4
Stability of composition	13	21, 35, 2, 39	26, 39, 1, 40	13, 15, 1, 28	37	2, 11, 13	39	28, 10, 19, 39	34, 28, 35, 40	33, 15, 28, 18	10, 35, 21, 16	2, 35, 40	22, 1, 18, 4	

problem statement, ideality, principles

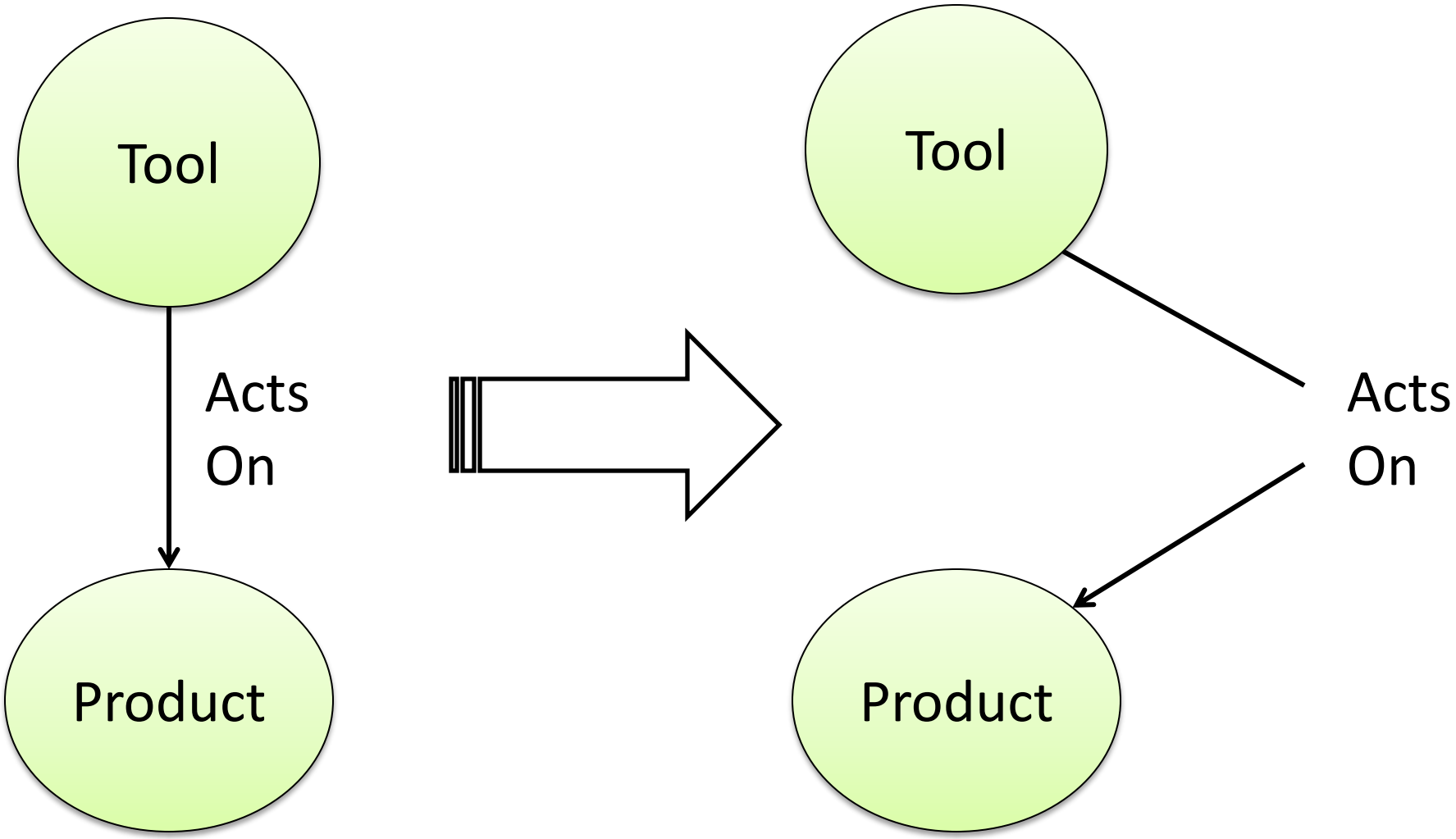
EXERCISE
Part A

- Get into groups of three. Each person think of a challenge to solve
- Now pick **one** challenge to solve
- Develop a problem statement. Make sure you are treating cause not symptom.
- Describe "**Ideality"** solution requirements
- Use the given principles to get solution insights

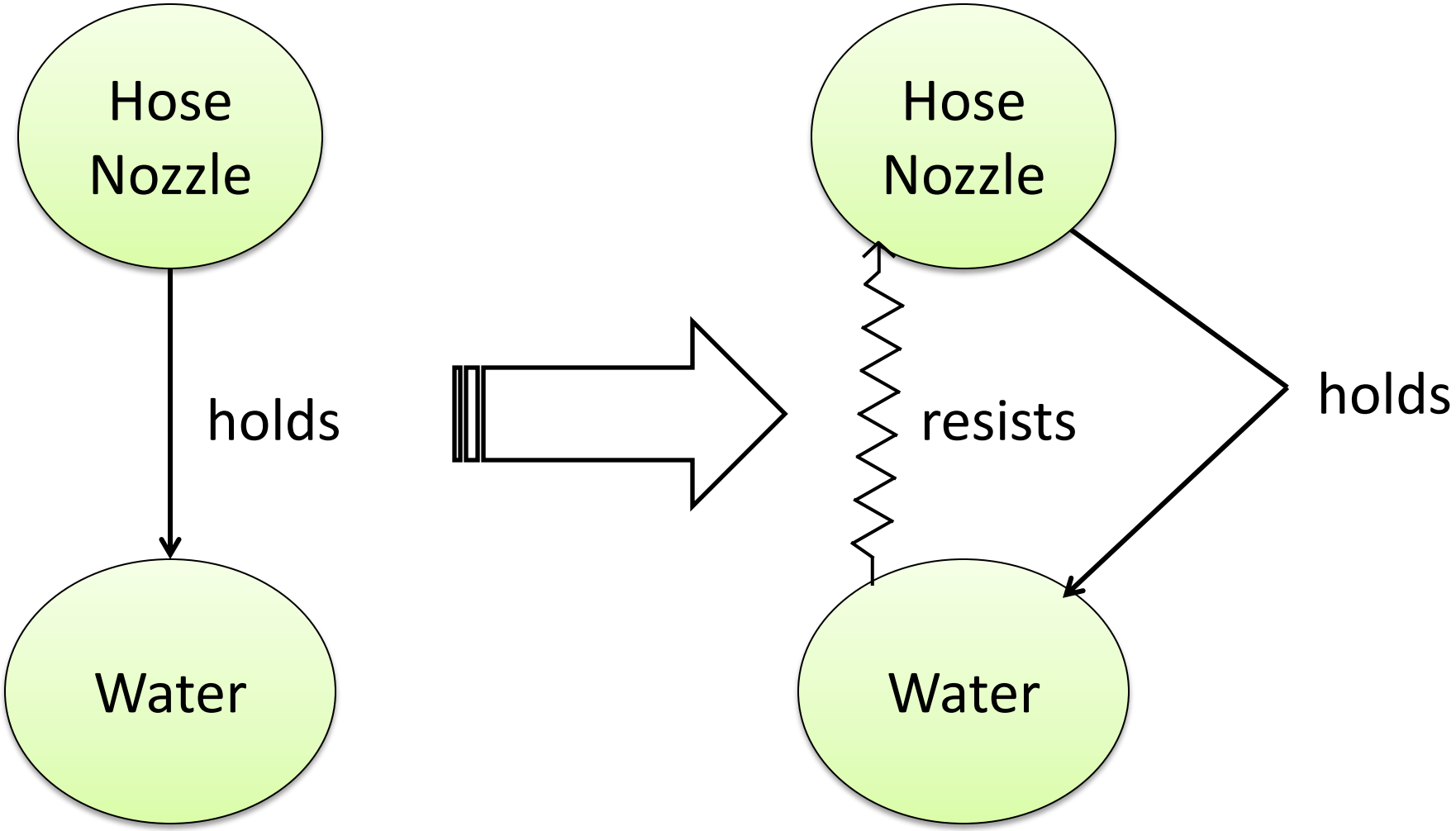
$$\text{Ideality} = \frac{\Sigma \text{ Benefits}}{\Sigma \text{ Costs} + \Sigma \text{ Harms}} \Rightarrow \text{Ideal Final Result}$$

"All of the benefits and none of the harms or costs"

the triangle of invention



the triangle of invention



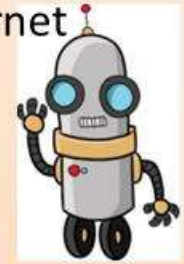
subset of principles for insights

Segmentation: Objects into independent parts; People into independent groups; Easy to assemble or disassemble; Increase the degree of fragmentation or segmentation
Take Out: Offending part or property; Leave only necessary part or property
Local Quality: Change object or system or environment from uniform to non-uniform or vice versa; Make each object, part, or person function in conditions most suitable for its/their operation; make each part, system or person fulfill a different and useful function.
Asymmetry: Change the shape of an object from symmetrical to asymmetrical; Increase an objects degree of symmetry or asymmetry
Merging: Bring closer together identical or similar objects, groups or systems; Assemble identical or similar parts to perform parallel operations.
Universality (multi-purpose): Make a part, system or structure perform multiple functions; Eliminate the need for other parts.
Nested doll: Place one object inside another; Place each object in turn, inside another; Make one part pass through the cavity in another.

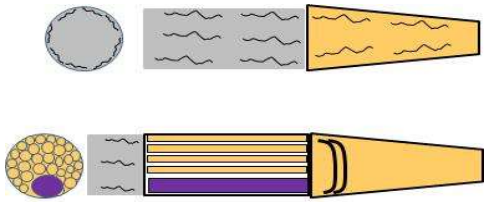
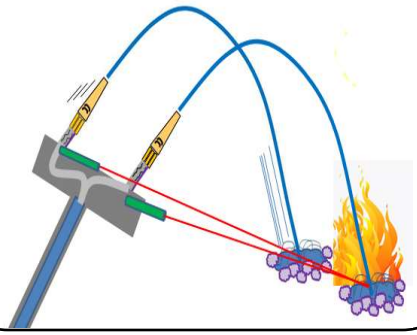
contextual thinking for insights

EXERCISE Part B

9 Windows Tool

	Past	Present	Future
Super-system	Industrial manufacturing 	combustion engine electric engine 	Fast software logic. Internet tiny smart sensors ecological culture 
System			 Eco Mower Jason Force
Sub-System	wheels handles blades back roller	wheels casing handles blades catch basket engine	wheels handles blades engine grass catch basket Internet GPS/RFID/ magnetic/ optical sw program

contextual thinking for fire insights

	PAST	PRESENT	FUTURE
SUPER - SYSTEM	*River or dam, people, water wagon if available*	*firemen, fire trucks ladders, fire hydrants, city water infrastructure, electro-mechanical systems*	*Hydraulics, mechanics, infrared, lasers, ladders, electronic, sensor based sensors, Artificial Intelligence*
SYSTEM		 Asymmetry – hose carries CO2 foam	
SUB-SYSTEM	*Buckets or hand pumps*	*foam, flat roll out hoses, nozzles, turbulence reducing pipes*	*Hoses, booms, display screens, remote control, motors, automated operation, computers, software, Infra-red sensors*

trends of technological evolution for insights

EXERCISE
Part C

	Evolutionary Trends of Technical Systems
1	A life cycle of birth, growth, maturity, and decline
2	Ideality
3	Uneven development of subsystems leading to contradictions
4	Increasing dynamism and controllability
5	Increasing complexity, then simplicity through integration
6	Matching and mismatching parts - increasing coordination of rhythms
7	Transition from macro to micro systems using fields for better performance & control
8	Less manual work and more automation

- Write down further solution ideas from the contextual thinking and from the trends above

share your experiences

1. Any better understanding of the problem?
2. State your problem statement
3. State your best two solution concepts
4. Did you get a sense that invention/innovation might be possible to systematise?
5. Any other thoughts?

Agri-breakthrough - tech-greenhouses 1

	Principles	Technical Greenhouse e.g. Growing Tomatoes My Insights from Videos and TRIZ
1	**Segmentation**	Clustered individual (segmented) greenhouses combine for food volumes while isolating biosecurity risks from the other greenhouses. This allows the running controlled experiments in a chosen greenhouse. For the greenhouse teams, segment experts and expertise.
2	**Take Out**	**Soil** as substrate for hydroponics, **old plants**, **business risk** by starting with multi-year supply contracts and piloting the concepts at smaller scale, **Guesswork** by hiring experts
3	**Local Quality**	Green houses control local environment quality parameters: temperature, water, minerals, pests, wind, pollination, light, to optimise for tomato growth and quality.
4	**Asymmetry**	Pilot new techniques, parameters in one of the cluster of greenhouses.
5	**Merging**	Merge all greenhouse outputs for total food volume, access to water, heat, electricity and expertise. Merge light reflected from mirrors on to the boiler for electricity and heat. Merge experts and expertise.
6	**Universality (multi-purpose)**	Could also be used for education (public tours) or as a reference site. Future use - could be used to grow other crops, train staff for new projects. Grow other vegetables.
7	**Nested doll**	Probability of heat containers being nested for/with thermal insulation.

Agri-breakthrough - tech-greenhouses 2

	Evolutionary Trends of Technical Systems	My Insights from Videos and TRIZ
1	**A life cycle of birth, growth, maturity, and decline**	Farming in fields, farming in greenhouses, farming in greenhouses in technological complex. Concept – pilot – first scale production plant - national - global business e.g. **Shouguang Vegetable Cluster, China**
2	**Ideality**	Water sourced from ocean and 'clean' solar energy, biosecurity from greenhouses, optimal nutrition from hydroponic feeds, off-take agreement, profits, food security
3	**Uneven development of subsystems leading to contradictions**	Beta prototype often less efficient and not to market scale and efficiencies
4	**Increasing dynamism and controllability**	Controlled power, temperature, irrigation, atmosphere, sunlight, market, biosecurity

Agri-breakthrough: tech-greenhouses 3

	Evolutionary Trends of Technical Systems	My Insights Videos and TRIZ
5	**Increasing complexity, then simplicity through integration**	Each greenhouse in the cluster meets all own needs. Power, light, water, (nutrients, profits, logistics)
6	**Matching and mismatching parts - increasing coordination of rhythms**	Synchronisation - daily rituals, changes from beta implementation
7	**Transition from macro to micro systems using fields for better performance & control**	Rain, sprinklers, hydroponic feeds, Macro-system - nature e.g. Sunlight, warmth, to mirror concentration of sunlight for energy via data and operational commands, temp regulation, etc.
8	**Less manual work and more automation**	Automated energy, environmental parameters, water, tomato growth - design reuse for other ventures.

contextual thinking farm insights

	PAST	PRESENT	FUTURE
SUPER - SYSTEM	*Nature, Fields,* ***rain, hail temperature and water fluctuations****, variable nutrition.* ***Pests, diseases****.*	***Irrigated*** *outdoor farming,* ***rain, hail, ice, nutrients*** *supplied,* ***weeds, diseases and pests semi-controlled***	***Technical green houses****. Automated environmental controls.* ***Optimum nutrition, water, temperature, light****.* ***Bio-secure.***
SYSTEM			
SUB-SYSTEM	***Fields****, wild tomatoes, limited intentional care. Given water, nutrients, temperature and bio-conditions*	***Autonomated irrigation, irrigation pipes, water source – river, dam****.* ***Nutrients, weeding, pest-control****.*	***Heat and cooling supplies, Water supply*** *and monitoring,* ***nutrient supply*** *and monitoring,* ***bio-secure****.* ***Autonomated tending***


//www.youtube.com/watch?v=SIl2CUF1TIc

ICT and construction breakthrough – BIM 1

Construction and IT Principles	BIM - Largely Enabled Through IT.
1. Segmentation	Each entity is modelled in 3D and in 3D space wrt other elements. Persons can work remotely and simultaneously
2. Take Out	**Guesswork** of the 3D interactions eliminated. Layouts can be explored in virtual reality. **Defects** and most **manual calculations** are eliminated (taken out). **Life cycle costs** are taken out. **Paper work** is replaced by site electronic models **Disagreements** are taken out as signed and distributed agreements occur in real time. **Beforehand preparation of parts** is easily done (taken out before construction site) Logistical considerations completed early.
3. Local Quality	The buildings fire-proofing, maintenance, acoustic properties can all be tested before construction, allowing best chance for optimal design and suitability in environment. Best planning for gas, lights, plugs, water and other utilities or fittings.

ICT and construction breakthrough – BIM 2

Construction and IT Principles	BIM - Largely Enabled Through IT.
4. Asymmetry	There is a **steep learning** curve, change management curve rather than comfortable **status quo**. **Different roles** can manage the project. Construction manager; civil engineer, quantity surveyor, architect etc.
5. Merging	The feedback and BIM models cause **tighter technical integration** and if accompanied by **tighter team integration** reduces costs, build time and supports building management and maintenance and even recycling. Merging and accurate visual and data feedback gives the tight integration.
6. Universality (multi-purpose)	The BIM tools can model **all types** of building, but also handle **landscaping**, **product development** and **simulation assessments**.
Nested doll	The buildings are nestings of the modelled parts; furniture and fittings can also be placed (nested) in room layouts and interior design aspects. Utilities are nested in the structures.

ICT and construction breakthrough – BIM 3

Evolutionary Trends of Technical Systems	BIM - Largely Enabled Through IT.
1. A life cycle of birth, growth, maturity, and decline	Old 2D inked or digital plans have met their match and can't deliver accuracy, speed, convenience of BIM modelling for construction.
2. Ideality	Benefits: 3D, visualisation, accuracy, information and schedule and bill of quantities information. Visual feedback, tight integration, remote working accuracy etc. Costs and Harms. Steep learning curve, data and material codes and standards not yet fully in place. Large change initiatives required, may put non-changers, and lower skills in jeopardy. Further harms may come from automated building robots in terms of job losses.
3. Uneven development of subsystems leading to contradictions	BIM ready - standards and codes lagging; BIM ready - people not all on board, construction culture not going to easily take the necessary changes.
4. Increasing dynamism and controllability	Absolutely able to create accurate representations of buildings before they are constructed - and update them in line with any changes or maintenance requirements. These together with automated reminders and calculations gives good control and speed.

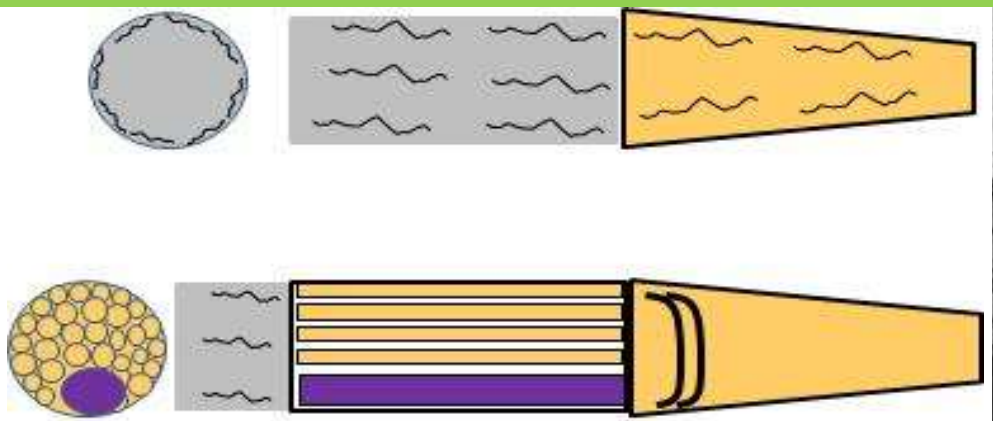
ICT and construction breakthrough – BIM 4

Evolutionary Trends of Technical Systems	BIM - Largely Enabled Through IT.
4. Increasing complexity, then simplicity through integration	Once learning curves, change management, culture, industry standards aligned absolute simplicity for total building life cycle control. What you see is what you get and reminders cycle through necessary inspections, paintings, replacements and maintenance. Adding new parts is made easy because of accurate and complete information concerning the current status of buildings.
5. Matching and mismatching parts - increasing coordination of rhythms	Decisions, discussions, coordinated planning, design, logistics all ultimately made easy and should be easy for team to keep the rhythm.
6. Transition from macro to micro systems using fields for better performance & control	The BIM model is a digital double of the planned and then constructed reality. The models can probably fit on USB sticks in terms of micro-level. The software will facilitate detailed needs for inspection, tasks etc. - micro-management better known as support in every detail, than interference.
7. Less manual work and more automation	Automated bill of quantities, simulations, planning, logistics, calculations, reminders, access and adherence to standards, backups etc.

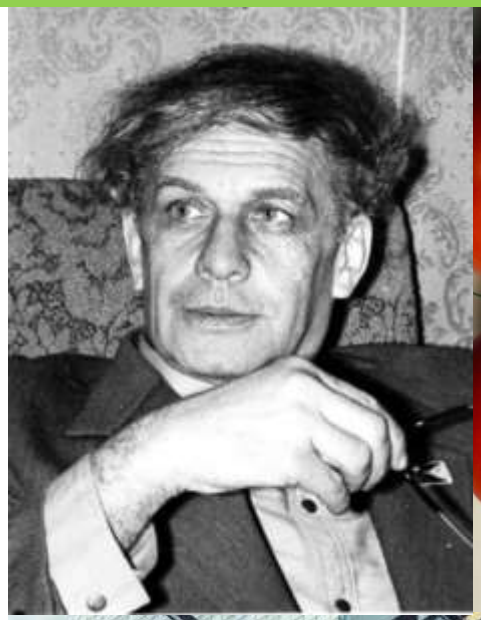
contextual thinking for BIM insights

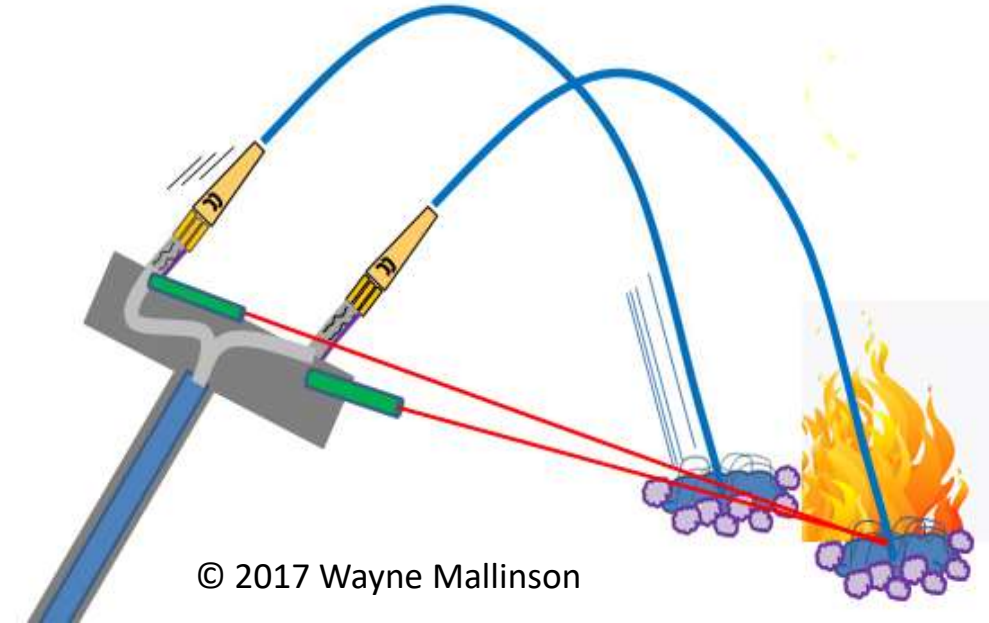
	PAST	PRESENT	FUTURE
SUPER - SYSTEM	*Office, drawing table, Set square, scale rulers, inking pens, chair, filing cabinet, specifications. Eraser.*	*Office, air conditioners, table, cutting knife, paint brushes, glue gun, concept photo, ruler.*	*Workspace, Internet connectivity, tablet or computer, BIM software, work spec. Websites.*
SYSTEM			
SUB-SYSTEM	*Paper, inked designs, legend, plan id number.*	*Balsa wood, sand paper, sponge, paint, model people and cars, trees, cellulose, crushed stone*	*Digital shapes, materials, objects, components, simulations, calculations, lists, documentation sharing. Printers 2D, 3D.*

thank you! and q & a



Asymmetry – hose carries CO2 foam





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Novation Now Facebook page: https://web.facebook.com/NovNowSA/
Novation Now website – for some innovation and other book reviews: www.novationnow.co.za

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Wayne has written Posts concerning systematic innovation and invention: These may be found at the following links:

https://www.linkedin.com/pulse/want-competitive-innovation-advantage-wayne-mallinson

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