



From Artisans to Mass Production

Systems Engineering
in the Enterprise

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Introduction



How to introduce and implement Systems Engineering in an Enterprise ?

- A recurring theme in enterprises whose business models are challenged or in crises
 - Usually, objections against change follow a not-invented-here narrative characterising systems engineering as something alien and incompatible with ...
 - All too often, promoters of systems engineering fall into the trap claiming systems engineering as an unprecedented novelty
 - Please, remind:
 - At the emergence of civilisations, human communities around the world started to invent, to construct, to build, to maintain, and to improve irrigation systems to feed a growing population
- H. Parzinger: Die Kinder des Prometheus. 2014.*
- Wasn't that systems engineering, too?

A new approach to substantiate the need for Systems Engineering in Enterprises

- Systems thinking and systems engineering are deeply rooted in human cognitive capabilities
- Systems engineering practices in enterprises may be defined by five enterprise categories
- Several typical transition paths between the five enterprise categories exist
- As a common denominator, all enterprises should consider to integrate systems engineering in their business planning at least

The Cognitive Foundations of Systems Thinking and Systems Engineering



Systems Thinking

- Systems Thinking means thinking in Scenarios

Systems Engineering

- Systems Engineering comprises the intended innovative manipulation of scenarios by applying existing or newly developed tools



Implicit Systems Engineering

- A Caledonian Crow understands the scenario: A caterpillar is unreachable in a crack of a wooden trunk
- The crow is motivated to get this protein-rich food
- Due to an act of insight it invents and manufactures a hook for leveraging the caterpillar out of the crack
- Other crows learn by imitation to manufacture hooks as well, and they may improve the design by their own intuition occasionally



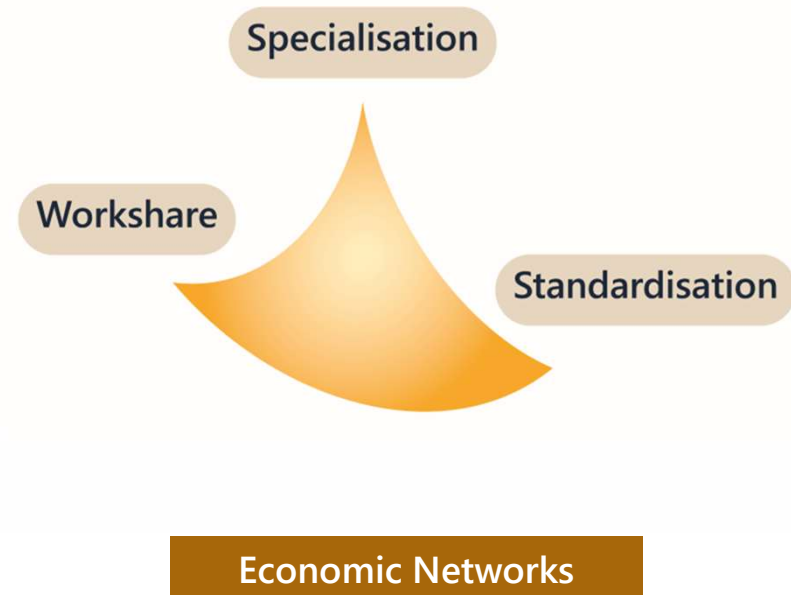
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Argumentative Language



Argumentative Language

- Today, leading anthropologists have identified the human capability for using argumentative language as the unique reason for the human dominance on Earth
- Argumentative language supports the advance and progression of knowledge and technologies by learning from explanations and theories in addition to imitation
- Argumentative language provides humans with a high variability of human interaction leading to sophisticated and powerful social relationships



M. Tomasello: A Natural History of Human Thinking. 2014.

Enterprise Categories



Single
Artisan
Workshop

Artisans in
Manufacturing

Mass
Production

Mass
Production
in Saturated
Markets

Enterprises in
the Context of
Changing
Architectures

The Single Artisan Workshop



Systems Engineering Considerations

- The artisan knows about the scenarios in which his hammers are applied

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The Hammer Business – Example

- The hammer artisan produces hammer body and hammer shaft based on traditional knowledge and designs
- He assembles hammer body and hammer shaft and reworks both parts to achieve a perfect match, most likely by using appropriate wedges

- He is able to validate his product designs and products regarding fitness for purpose and reliability
- Continuous improvement is directed to the hammers in their usage context exploiting own intellectual capabilities and capacities for optimising body, shaft, and the match

Artisans in Manufacturing



The Hammer Business – Example

- Due to increasing demand, production capacity is increased by increasing the manpower

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- Specialisation leads to hammer body artisans, hammer shaft artisans, and assembly artisans
- Assembly artisans need the complete skillset to rework hammer body and hammer shaft for ensuring perfect matches

Systems Engineering Considerations

- Assembly artisans keep the knowledge about the scenarios in which the hammers are applied

- Assembly artisans are able to validate product designs and products regarding fitness for purpose
- Assembly artisans are still committed to improve the hammers in their usage context
- The other artisans address their cognitive capabilities to the improvement of hammer bodies and hammer shafts
- Due to increased intellectual capabilities and capacities overall improvement cycles may accelerate

Mass Production



The Hammer Business – Example

- Due to advances in standardisation the effort for assembling hammer body and hammer shaft is reduced
- Production capacity increases and production costs decrease
- Assembly artisans do not require the full hammer artisan skillset anymore and may be rated down to unskilled assembly workers as in the theory of the American style of mass production

General Remarks

- Economic networks develop as standardisation allows deeply staggered supply chains
- Contributors within supply chains are not fully aware anymore about all the final usages of their products and services

R. Schwartz Cowan: A Social History of American Technology. 1997.

Systems Engineering Considerations

- Initial designs are replicated in high numbers

Mass
Production

Mass
Production
in Saturated
Markets

Enterprises in
the Context of
Changing
Architectures

- Continuous improvement is directed to specialty disciplines regarding product parts, and effectiveness and efficiency of assembly lines
- Continuous improvement of the overall design demanding changes of product architectures vanishes due to the power of the production organisation fearing cost increases and profit decreases in case of disturbances
- Overall, systems engineering awareness and systems engineering practices are reduced

Mass Production in Saturated Markets



The Hammer Business – Example

- In saturated markets, opportunities for growth become sparse
- To avoid a downward spiral in prices and profits, design variations are introduced to achieve a competitive edge in particular market niches for specific applications with increasing granularity
- To minimise additional costs, production is organised around platform strategies with unified architectures for all product variants

General Remarks

- Production organization and production technologies are optimized to achieve at maximum a single item batch capability

T. Ohno: Toyota Production System – Beyond Large-Scale Production. 1988.

Systems Engineering Considerations

- Product development departments with an overall design responsibility emerge

Mass
Production

Mass
Production
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Markets

Enterprises in
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Changing
Architectures

- Product development is driven from production generating the income hampering principal design improvements, especially if architectural changes would imply far reaching changes to the assembly line

Enterprises in the Context of Changing Societal, Economic, and Technological Architectures



The Hammer Business – Example

- Automation and new technologies challenge the business, e.g. pneumatic hammering, small high-capacity electrical batteries, etc.
- The existing product architecture – hammer body and hammer shaft – needs to be altered essentially to cope with the challenges successfully
- Alternatively, the business may be reverted to premium quality niches with high-priced products ensuring a sustainable business

Systems Engineering Considerations

- Systems engineering becomes an essential part of business planning

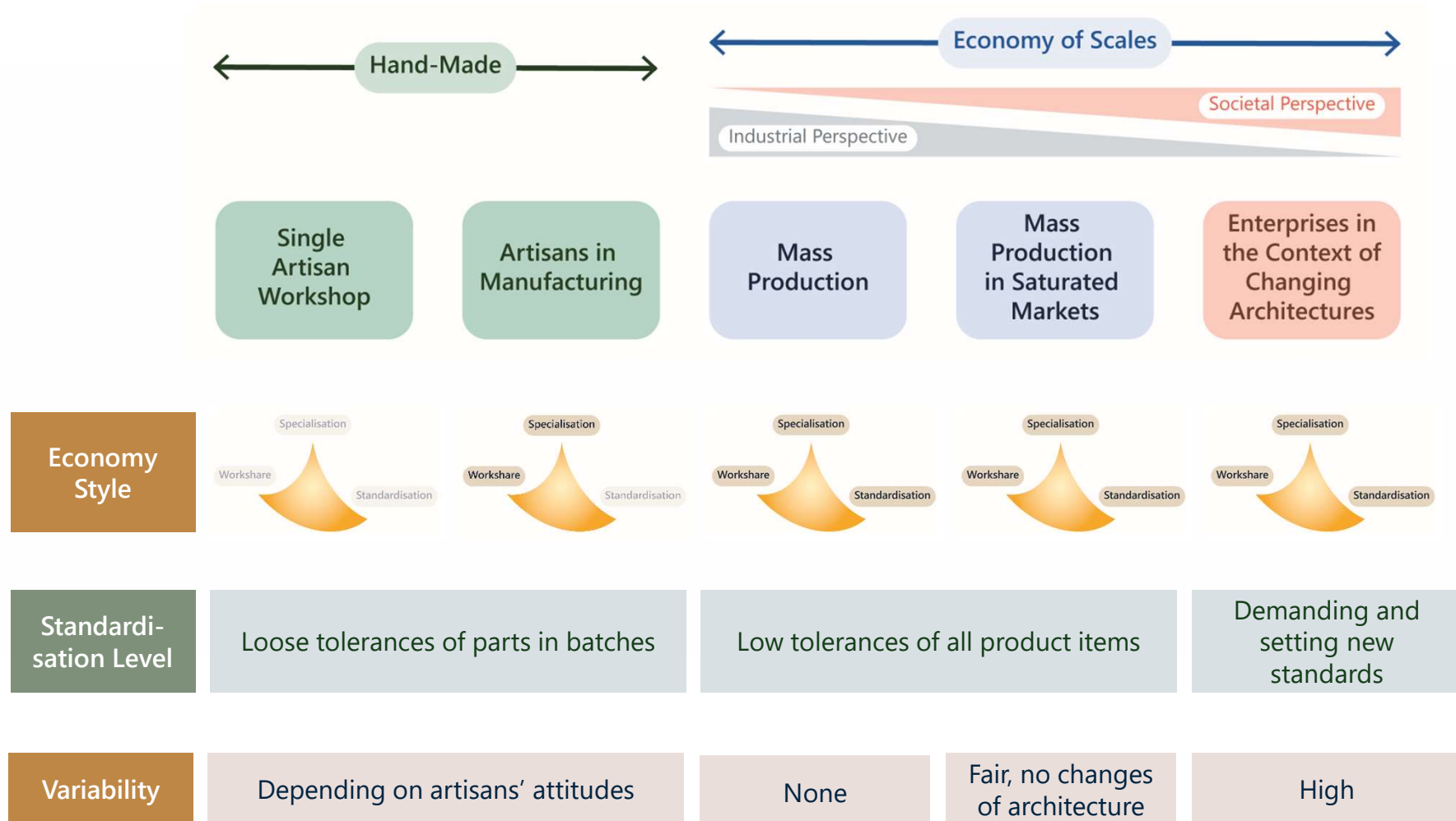
Mass
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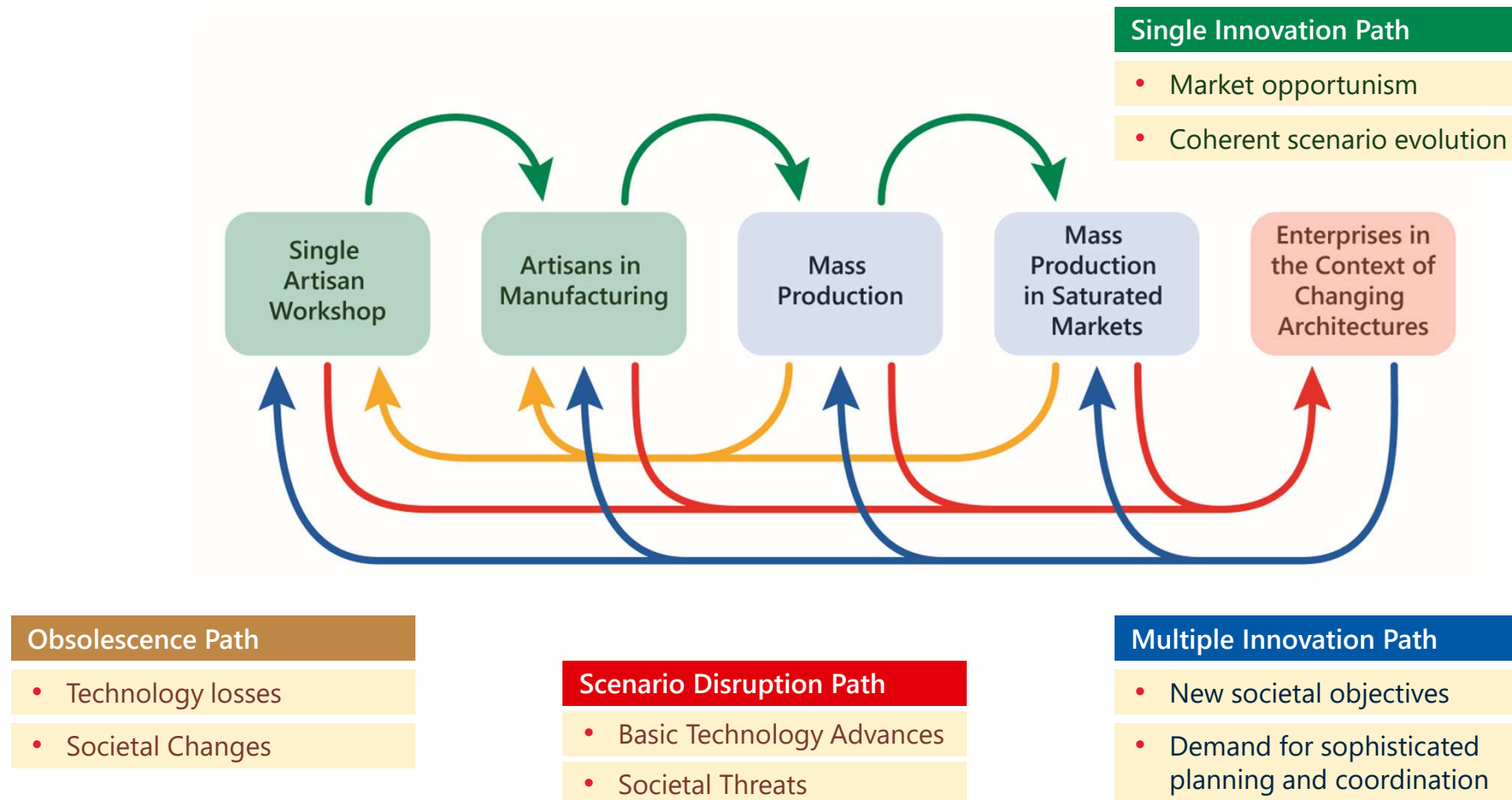
Enterprises in
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- The production organisation is faced with decreasing power and production management may struggle with the new situation
- Systems engineering can only succeed as a multidisciplinary endeavour involving all enterprise-internal stakeholders in open-societal structures
- Systems engineering capabilities become existential for sustainability and organisational survival, especially in case of approaching global resource limits

Enterprise Category Summary



Enterprise Evolution Paths

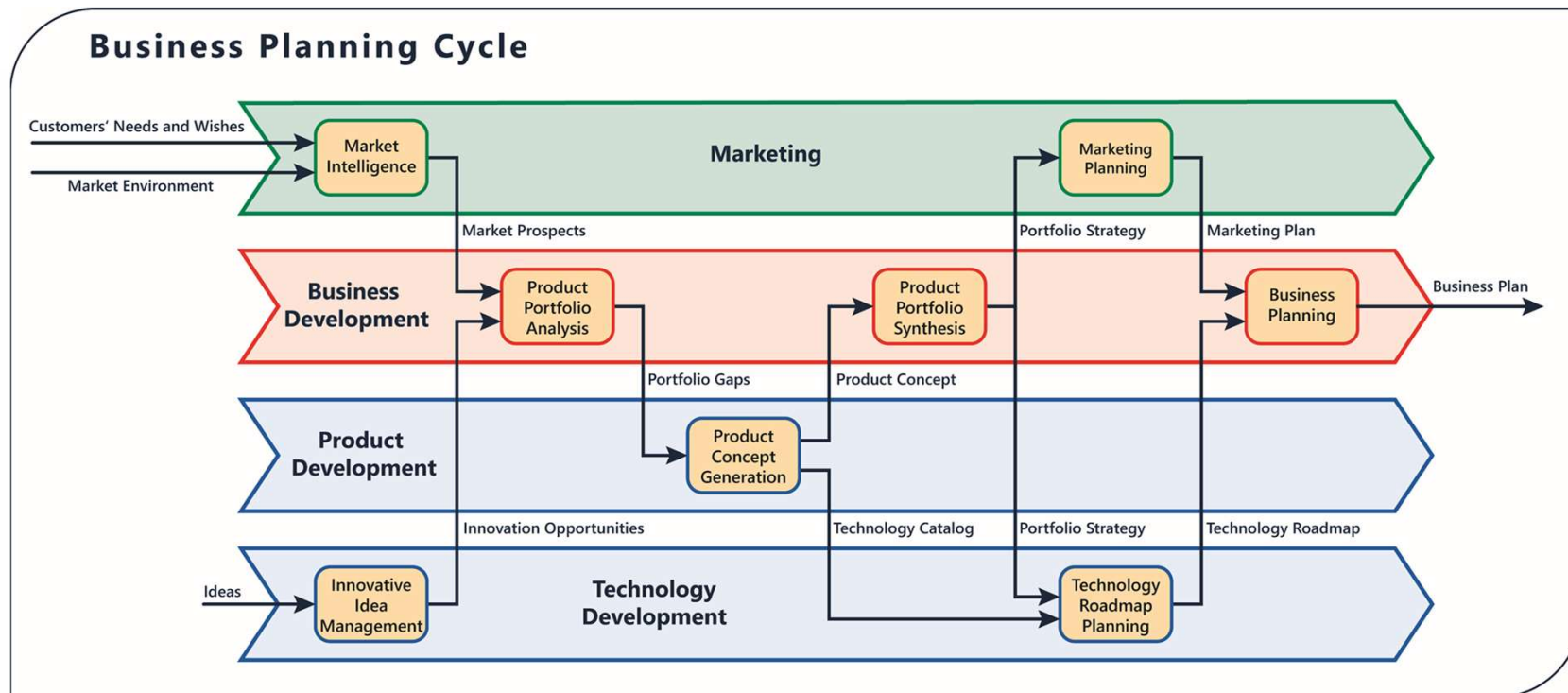


Concluding Remarks



- As legal entities, most enterprises follow the model of a single enterprise category
- Without enhanced systems engineering capabilities enterprises may turn into essential crises in case of disruptive scenario changes
- From a societal perspective, systems engineering is a must to survive essential threats like resource constraints of all types including natural resources and global compensation of human activities
- From history, various hints exist that the decline of civilisations comes along with a lack of responding to disruptive scenarios successfully
- All enterprises are best advised to introduce and to practice continuous business planning early for being prepared to cope with more or less smooth or disruptive transitions in their business environments successfully

Business Planning Cycle



- Business Planning is an enterprise activity using general budgets
- A Business Planning Cycle may run at least once per year
- Product Concepts may be matured over longer time periods



Thank You
for your attention

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H·I·T·S Engineering

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