ENTERPRISE CYBER SECURITY

# SYSTEM THINKING

University of Glasgow

# OVERVIEW

- anything becomes manageable when you decompose it into smaller chunks, but must remember the system **holistically**.

- systems can be decomposed into **elements**, **interconnections** and **purpose** as well as **hierarchies** of **subsystems**.

- **insecure subsystems** do not form the basis of a **secure system**.

- consider the **system(s)** that seek to **attack** and **undermine** enterprises.

# TARGET APT

# WHAT IS A SYSTEM?

"A system is a set of things people, cells, molecules, or whatever interconnected in such a way that they produce their own pattern of behaviour over time."

– DONELLA MEADOWS

# SYSTEM THINKING

- systems can be constrained and controlled, but the response of a system is a product of its nature.

- system responses are not necessarily simple or easy to predict.

- consider the United Kingdom, an oil-exporting nation, it is not impacted just by other oil-importing nations.

- considering systems as a whole, slight changes can have unforeseen consequences.

# OPERATION CAT DROP

# EXAMPLE: OPERATION CAT DROP

- malaria is an infection disease that kills many individuals every day.
- mosquito-borne, it is harmful to humans
- nations where mosquitos thrive will perceive this as serious threat to national health.
- assumption is that controlling malaria, requires controlling mosquitos.

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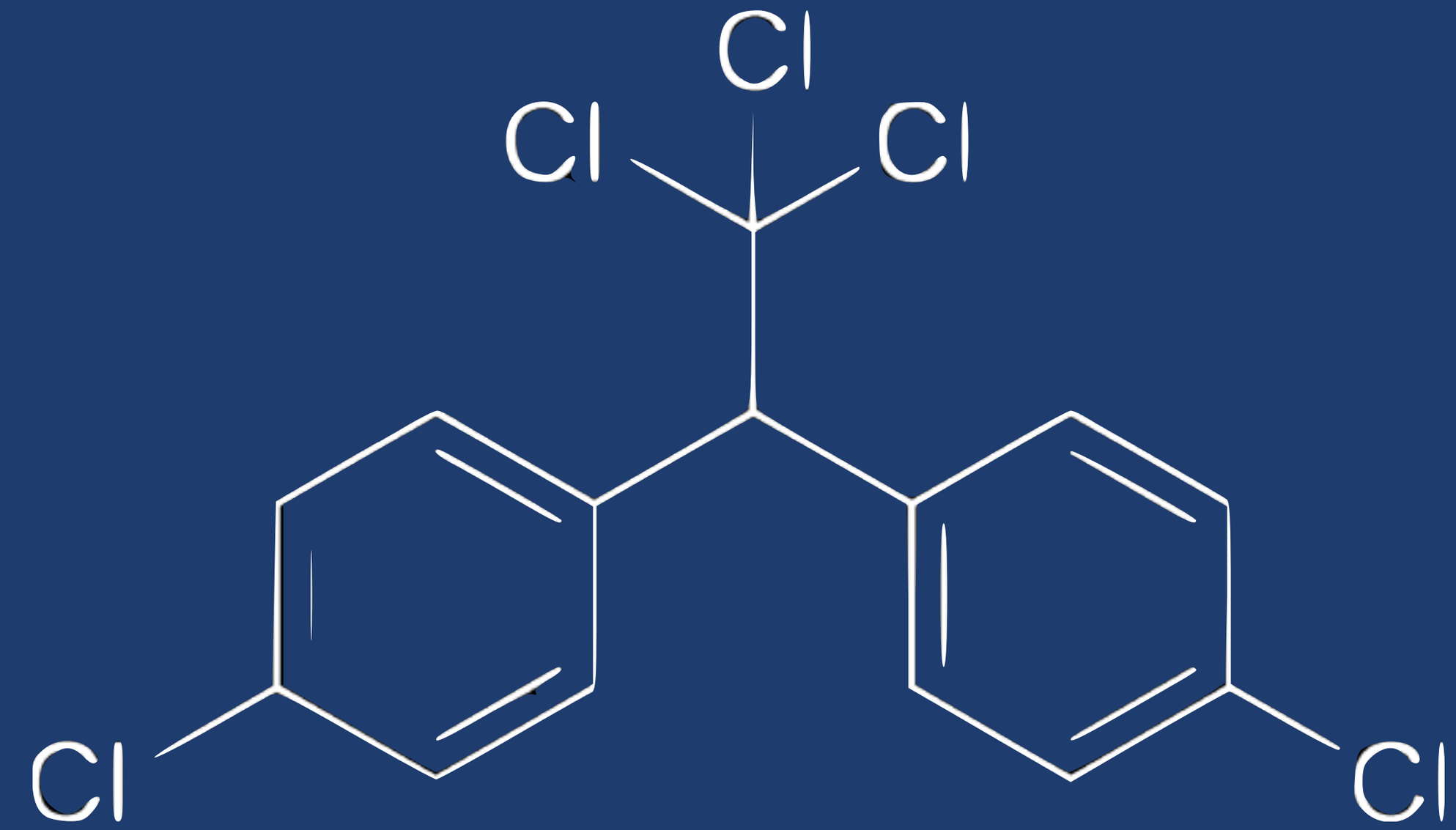
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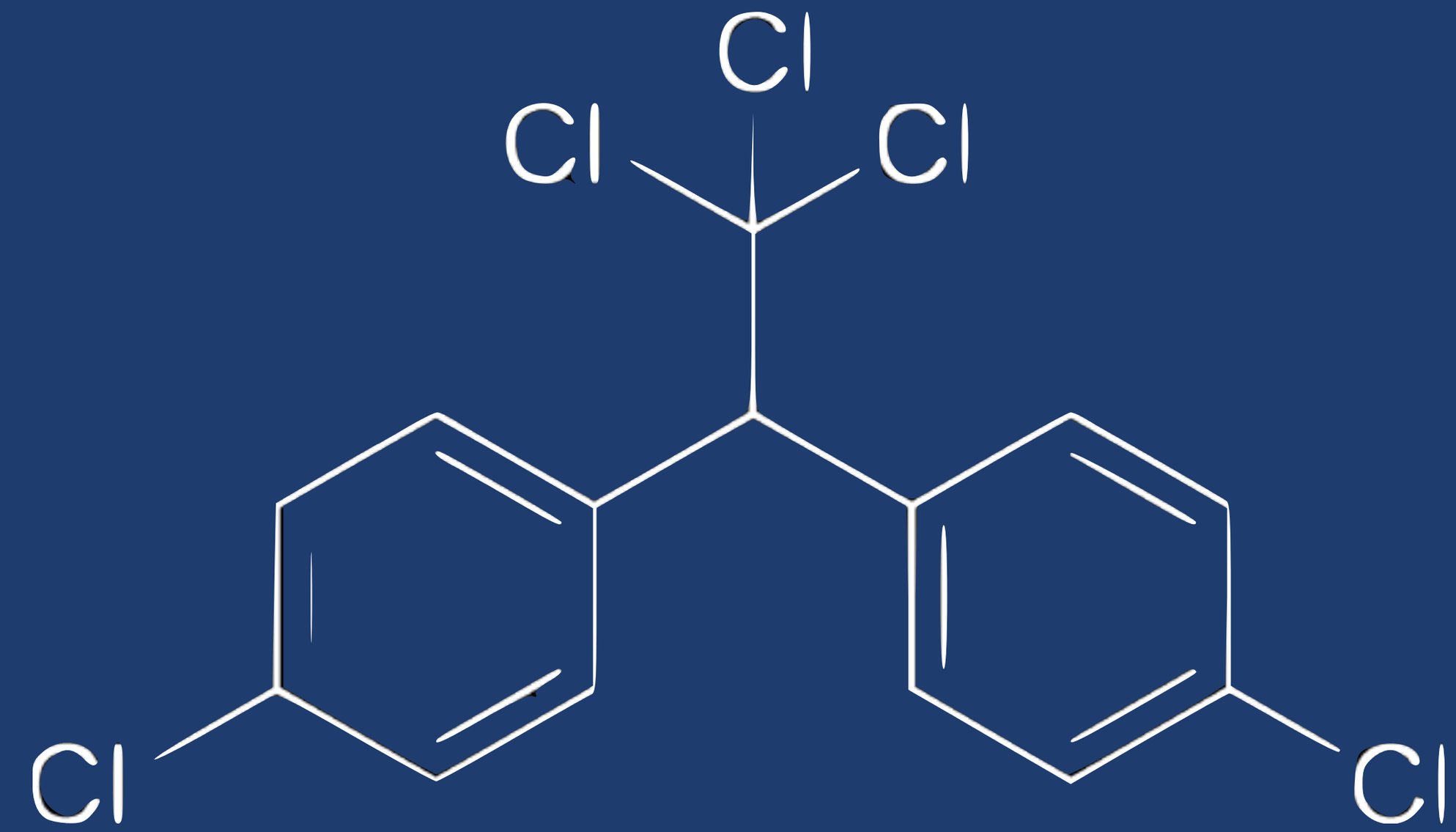



Dichlorodiphenyltrichloroethane (DDT)

World Health Organisation (WHO)

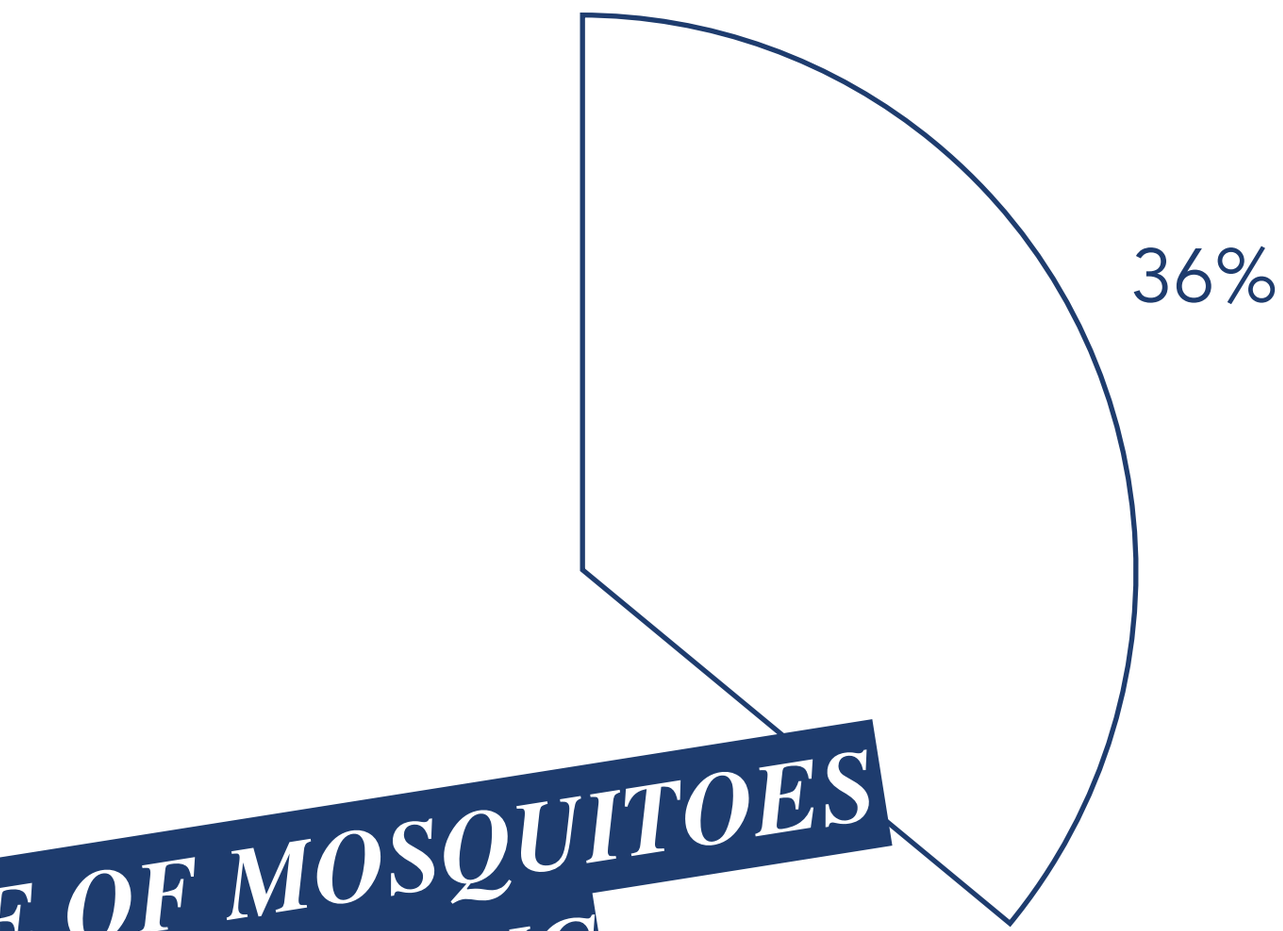
# OPERATION CAT DROP

- World Health Organisation concerned about the impact of malaria, supported malaria control.

- DDT was invented for use in World War One, but was perceived as useful for controlling malaria.

- sprayed DDT in the homes of people in Borneo, long-houses that could contain up to 100 families.

- the expectation was that this secured homes from mosquitos and protected families from infection.




# PERCENTAGE OF MOSQUITOES WITH MALARIA CAUSING PARASITE

American Journal of Public Health

1953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American Journal of Public Health

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**FALL IN DEATH RATE IS REPORTED BY UN**

New York Times

**1954**

# SUCCESS

- 1945 there were 2.5 million cases of malaria, by 1963 that had dropped to around 100 in Ceylon.

- 1953 the percentage was 35.6%, then down to 1.6% by 1955 in Sarawak, Borneo.

- the approach was clearly effective at reducing mosquitoes carrying malaria.

- World Health Organisation claimed success, but program was not rolled out because of cost.

# CONSEQUENCES

- indigenous people invaded WHO conference on malaria control and declared their homes had collapsed.

- caterpillars were able to distinguish between areas containing DDT or not and subsequently consumed parts of the roof.

- wasps, that kept caterpillars population under controlled, were impacted by the DDT, other insects like cockroaches were consumed by geckos.

- cats eat the geckos and died off, leaving rats, that began to bite and infect humans.

# SOLUTION

# ACCURACY

- biomagnification is unlikely explanation for the death of cats, better explanation would cats cleaned paws and ingested DDT.

- dieldrin is an alternative insecticide that would have been toxic enough to impact mosquitos, wasps and caterpillars.

- also arguments cats could be protected with some simple precautions.

# ANOTHER EXAMPLE

aquasalis

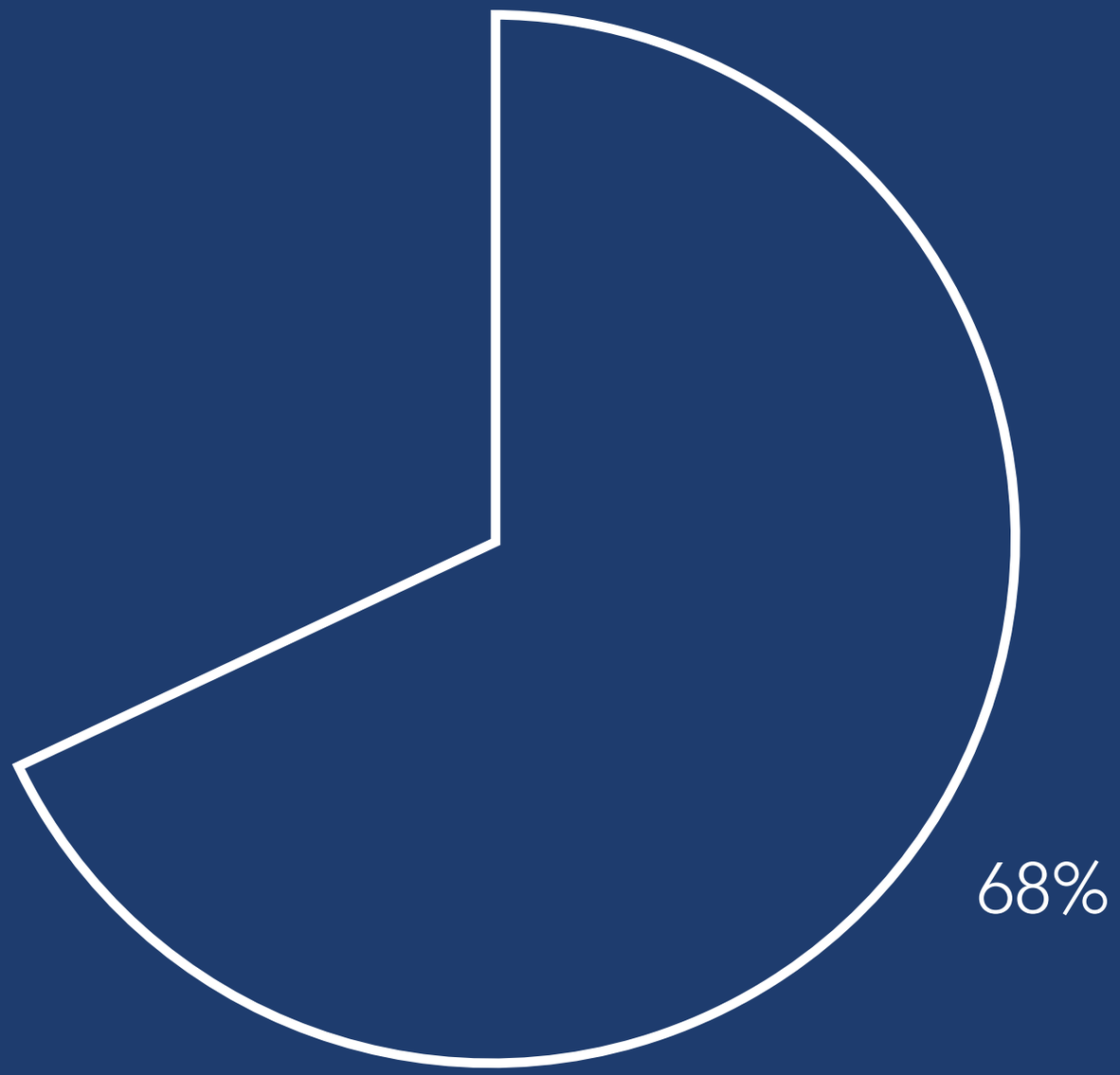
albitarsis

# MALARIA CONTROL

- another example of arguably unsuccessful malaria control is in Brazil.

- two types of mosquito, one that relied on humans as a food source, another that relied on cattle.

- malaria control focused on reducing the population of the mosquito that relied on humans as a food source.




increase in human population

# MALARIA CONTROL

- the increase in human population put more pressure on food sources.

- space spent on expensive cattle was repurposed for grain to feed the increasing human population.

- displaced mosquitos that relied on cattle as a food source, switched to the human population.

# MALARIA CONTROL CONCLUSIONS

- important not to lose sight of that fact this was about sparing human life, a serious national security issue.

- problems were not resolved properly in the longer term because the system was not considered as a whole.

- in the case of Borneo, homes collapsed and people died of illnesses from rat bites.

- in the case of Brazil, mosques turned to humans as a new food source to replace previous dependency on cattle.

# SYSTEM THINKING

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- important to understand the bigger picture and how various subsystems interact.

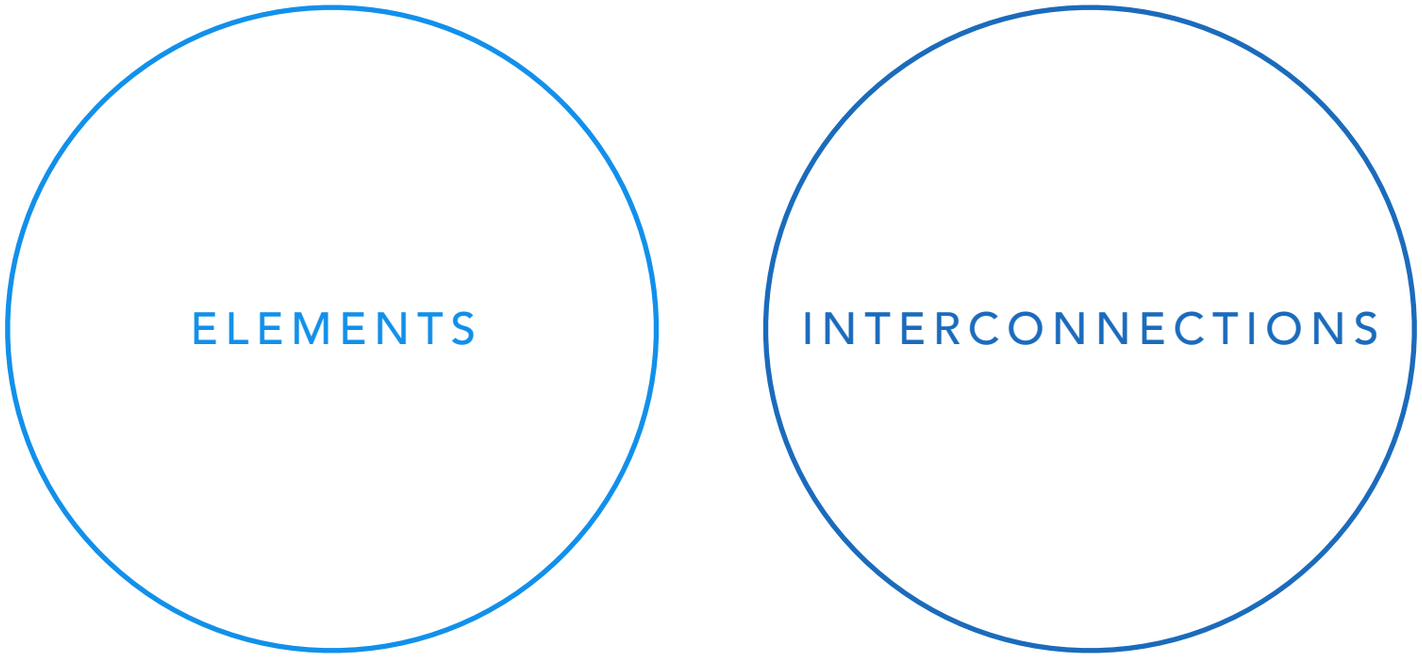
- systems can be reduced down and considered to comprise of tangible and intangible **elements**.

- elements are interrelated and connected, these **interconnections** are difficult to identify.

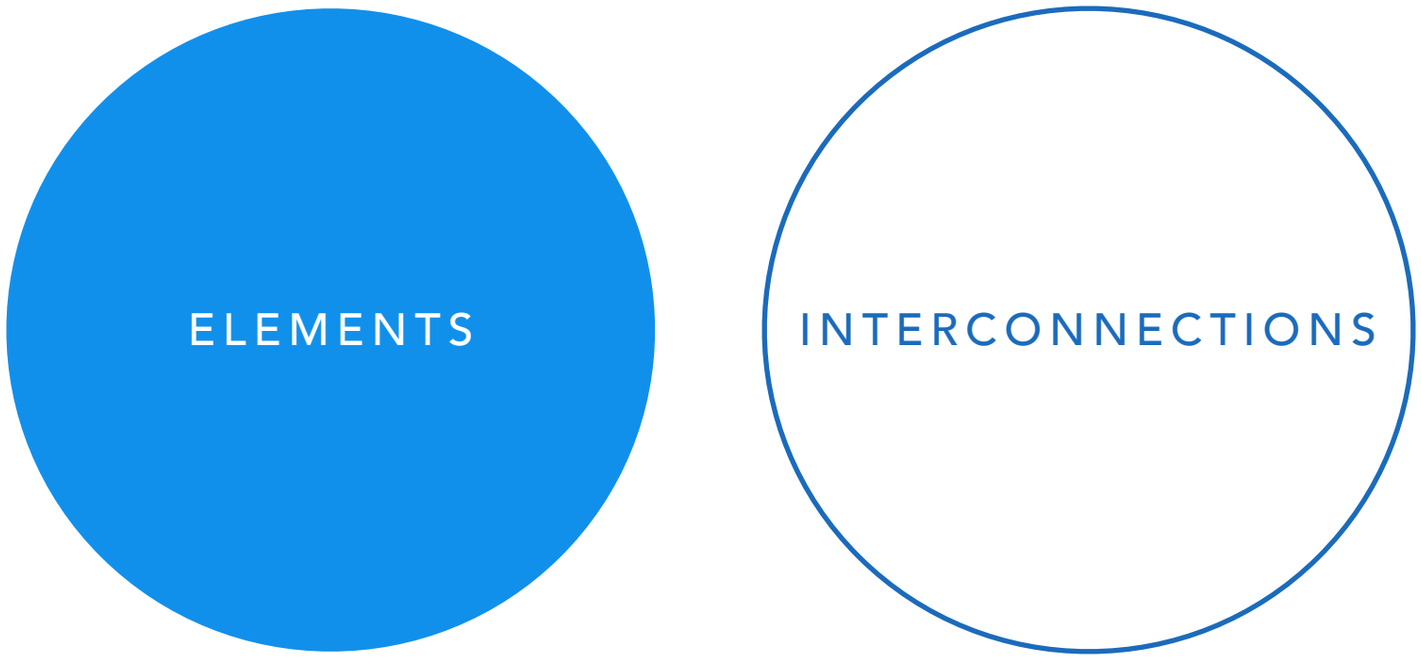
- interconnected elements serve a **purpose**, the hardest aspect of a system to determine.

ELEMENTS

INTERCONNECTIONS




HUMAN DIGESTIVE SYSTEM

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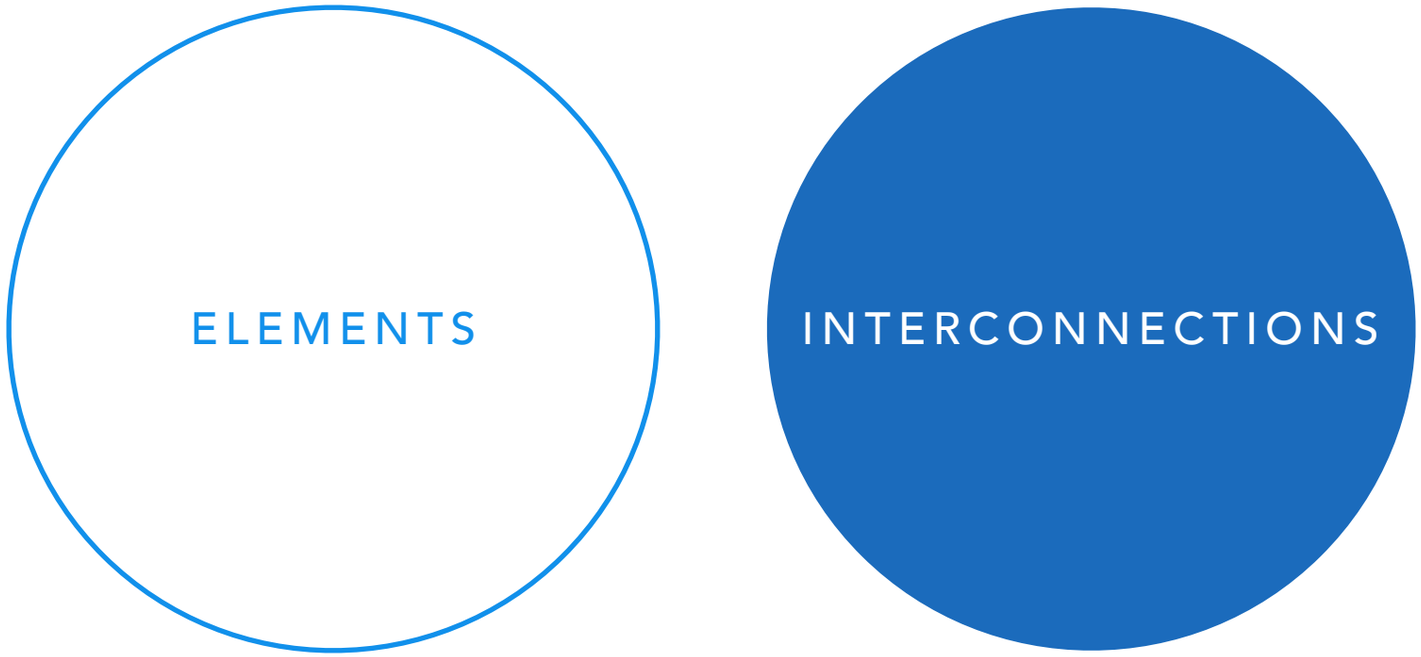


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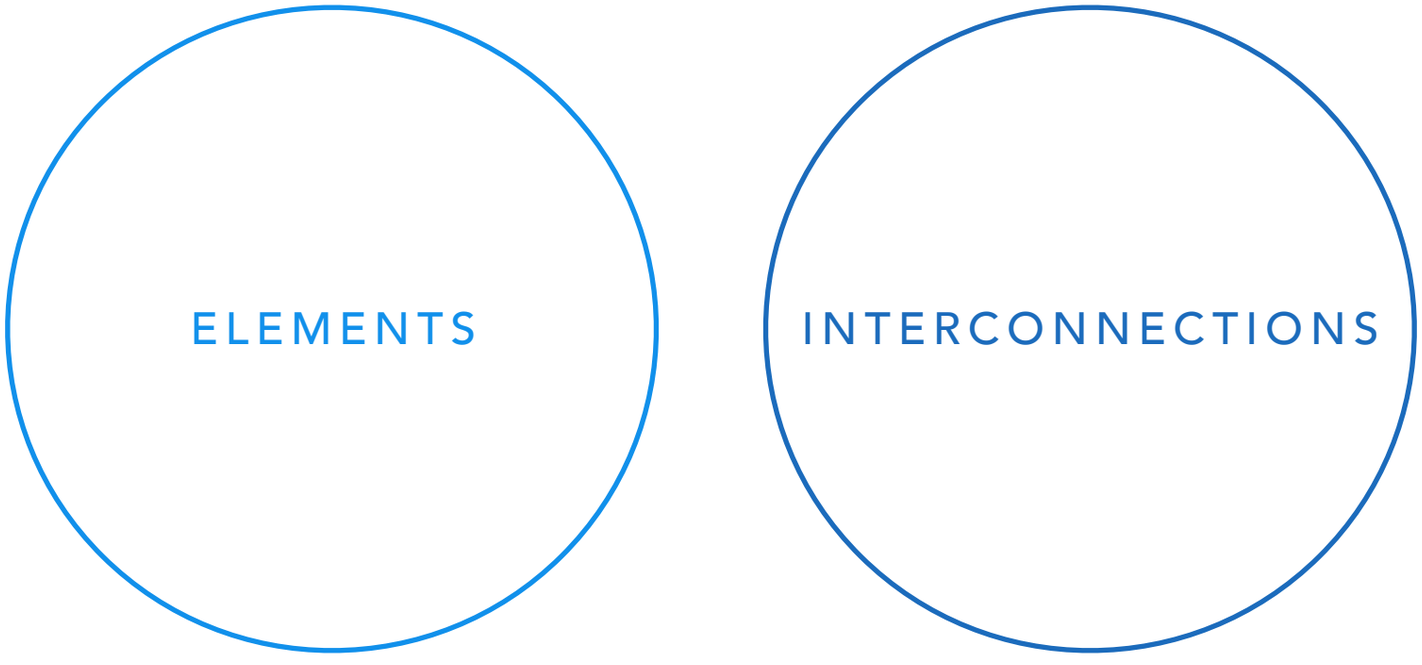


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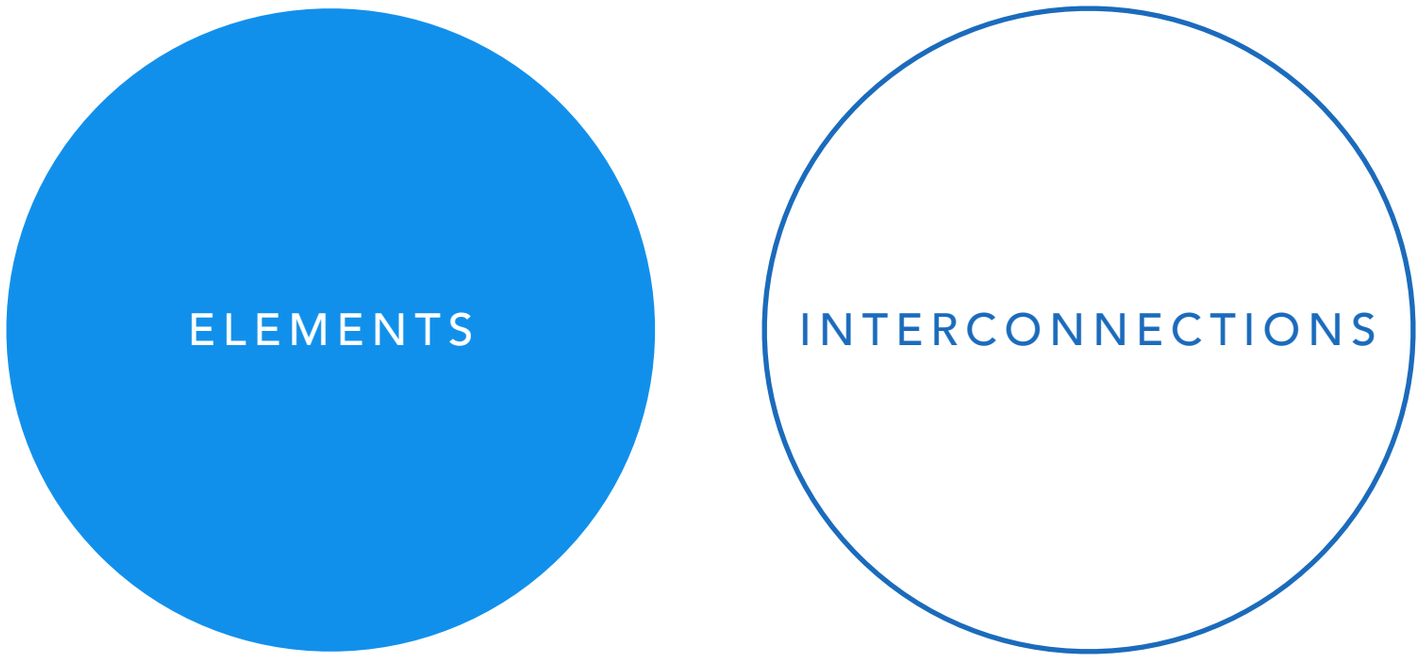


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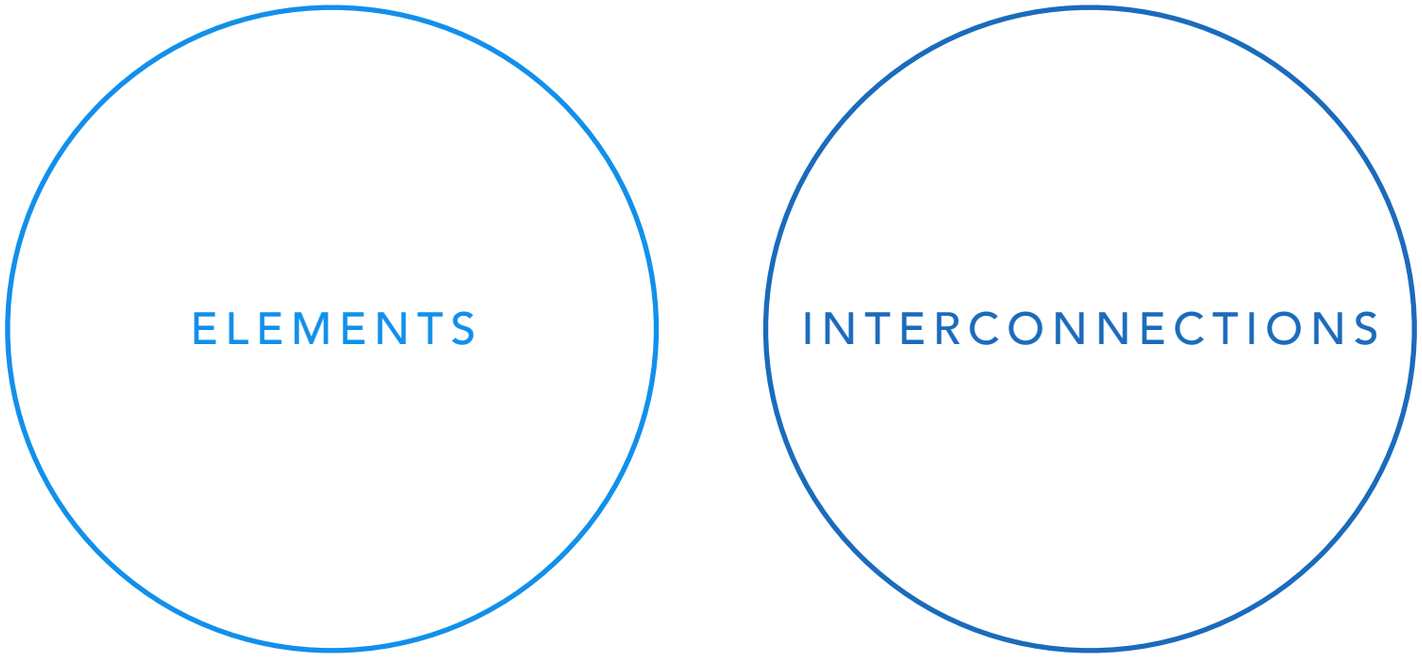
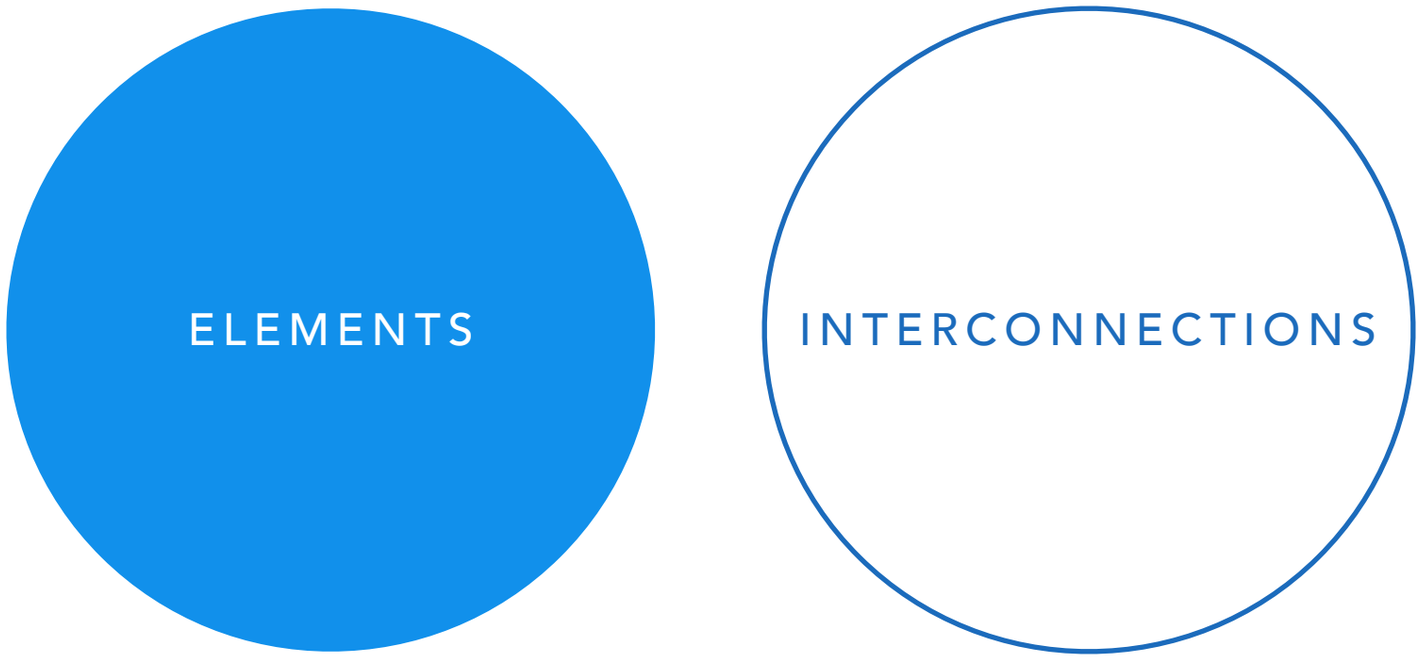



FOOTBALL TEAM




FOOTBALL TEAM

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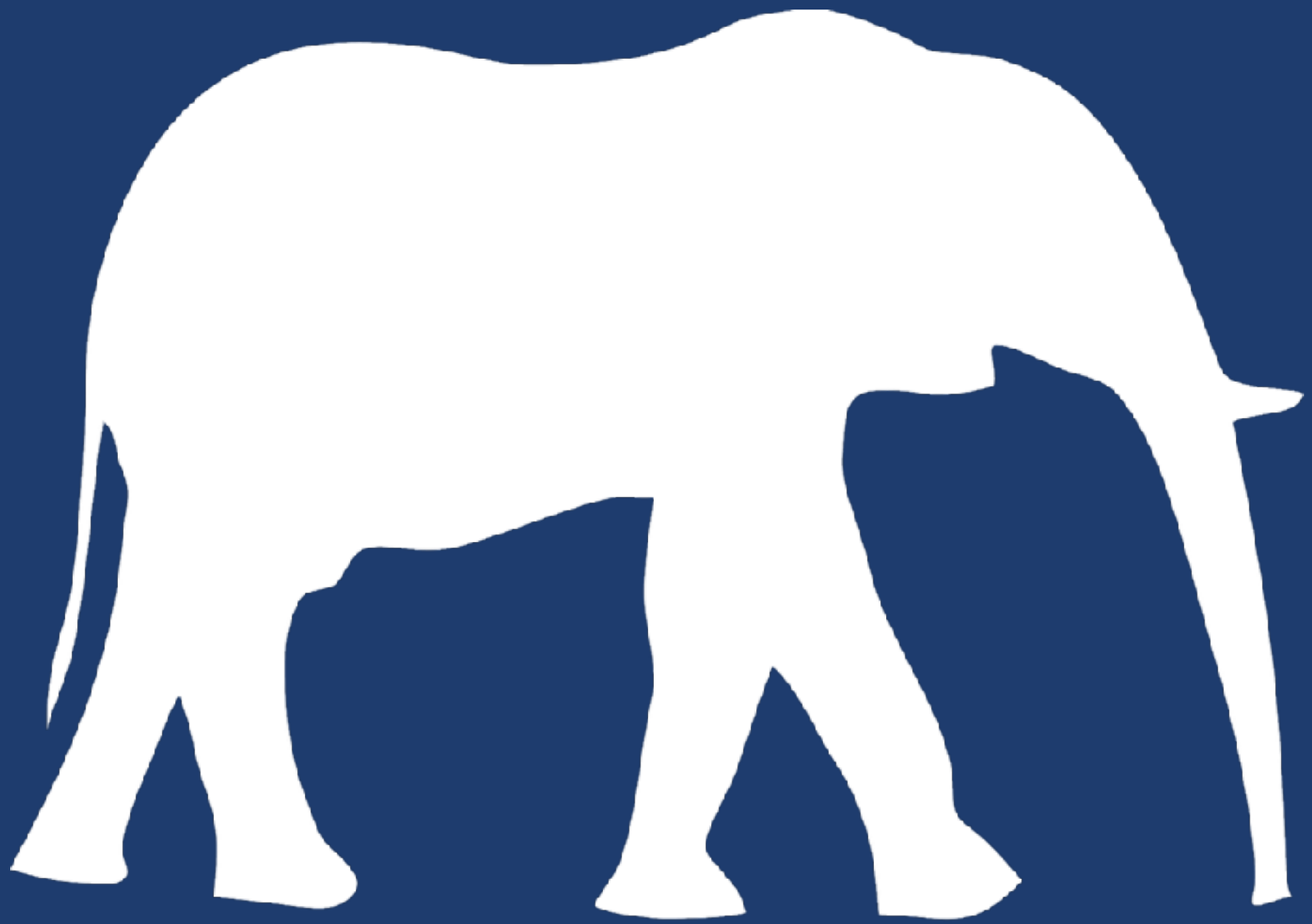
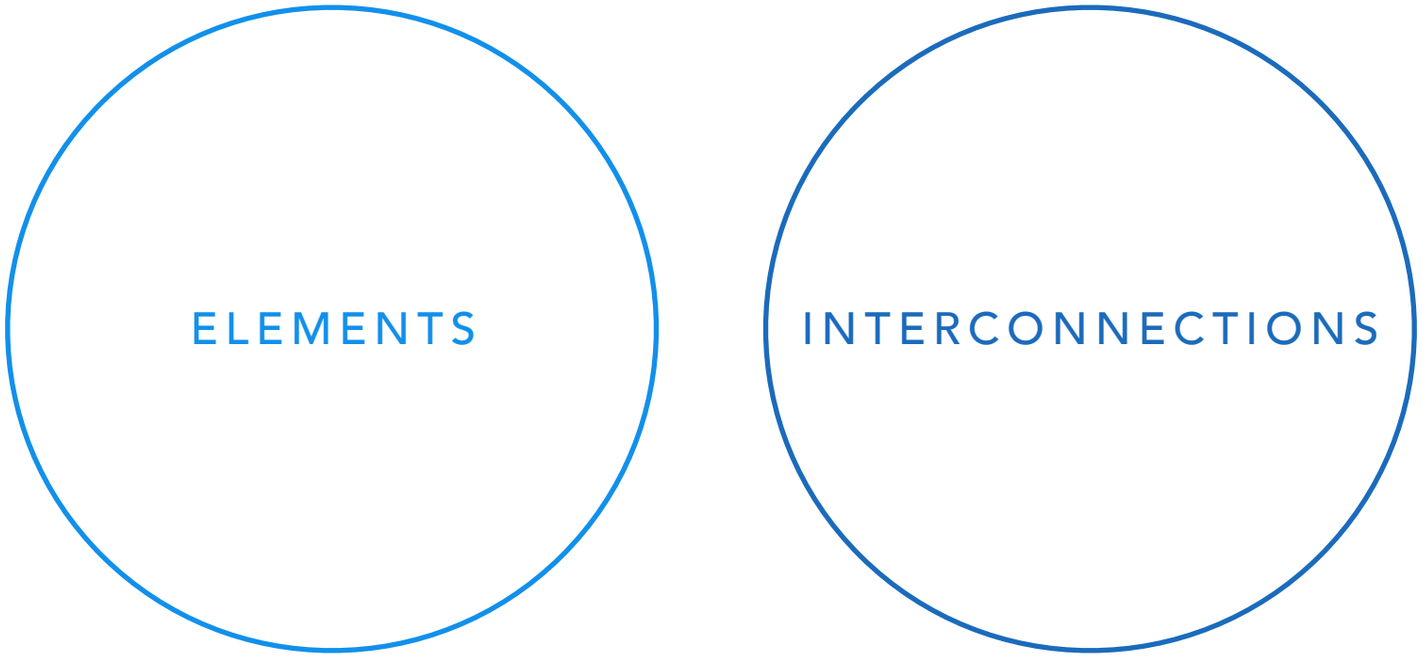
INTERCONNECTIONS

# FOOTBALL TEAM

# PURPOSE

- system purpose is difficult to determine for any given system.
- importantly, system purpose should not be inferred from simply what an individual states or what is documented.
- depending on perspective, system purpose could different on what individual is consulted.
- system purpose must be identified by observing and monitoring the system itself.



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# SUCCESS VS FAILURE

- individuals may claim a system is failing, but the system could be succeeding.
- perceptions of failure could come from false expectation of system purpose.
- systems could be designed to achieve an expected purpose and fail, but succeed in many other ways.
- consider various examples, such as the education system or European Union.

# FEEDBACK LOOPS

- system behaviour that persists over a period time suggests the presence of a feedback loop.

- **stabilising feedback loops** are goal-seeking loops, resistant to change, that seek to balance elements.

- **reinforcing feedback loops** emphasise the direction of change.

- reinforcing feedback can result in growth or collapse, depending on the direction.

# SELF-PRESERVATION

- systems may be wide and varied but all share the nature of **self-preservation**.

- systems are resilient and potentially evolutionary, adapting to changing situations.

- interfering with systems does not necessarily result in desired outcomes.

- individuals may introduce new elements, but workarounds allow the system to achieve it’s purpose.

# HIERARCHY

- systems can compromise of hierarchies of subsystems, that have developed from the bottom-up.

- autonomous, resilient sub-systems can operate effectively within a larger system.

- systems will disintegrate and collapse if the higher-level systems do not serve the lower levels of systems.

# CYBER SECURITY

- insecure subsystems do not form the basis of a strong system.
- securing complex systems such as enterprises is far more challenging than small businesses.
- decomposing and considering large systems as sub-systems allow you to consider and focus on aspects.
- countermeasures introduced with any subsystem need to consider the impact to the wider hierarchy of systems.

# CYBER SECURITY

- enterprises need to have an understanding of system purpose.
- enterprises need to understand what are the elements they control and what elements they do not control.
- enterprises also need to understand what elements they influence, if they do not control them.

# SYSTEM THINKING LIMITATIONS

- people intensive systems are hard to decompose and understand.
- human elements are incredibly difficult to model and fully understand.
- we may think a system is failing, but is succeeding in ways we do not perceive or understand

# SUMMARY

- anything becomes manageable when you decompose it into smaller chunks, but must remember the system **holistically**.

- systems can be decomposed into **elements**, **interconnections** and **purpose** as well as **hierarchies** of **subsystems**.

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