27th annual INCOSE international symposium

Adelaide, Australia

July 15 - 20, 2017

Future Proofing Process

Dr. Obaid Ur Rehman

A/Prof. Michael J. Ryan

Dr. Mahmoud Efatmaneshnik

Capability Systems Centre, UNSW Canberra.

Outline

- Research theme
- Ontology of future-proofing
- System Life-Cycle Value
- Capability gap
- Future Proofing process

Research Theme

- Future-proofing (FP) is one of the ways to obtain a system design which deters obsolescence and extends the system's service life.
- FP concepts have been explored in various forms in several industries. However none of this work present a solid definition of FP in systems engineering context.
- Our main research theme is to mature a generic semantic and process for FP which is useful for SE community. Towards this goal we
  - Explore some of the working definitions of FP widely used in the literature and try to create an ontology for FP, that is useful to SE.
  - Develop a system engineering framework for future proofing concept with well-defined processes.

Expectation from System

- FP concepts are essential for large and complex systems such as defense systems which are required to last long and have enduring warfighting capabilities.
- In general a defense capability should have the following attributes (Ross et al., 2007)
  - capable of adapting to changes in mission and requirements;
  - expandable/scalable, and designed to accommodate growth in capability;
  - able to reliably function given changes in threats and environment;
  - effectively/affordably sustainable over their lifecycle;
  - developed using products designed for use in various platforms/systems; and
  - easily modified to leverage new technologies.

- These expectations cannot be addressed purely as a matter of system robustness.

Ross et al., 2007 Defining system changeability: Reconciling flexibility, adaptability, scalability, and robustness for maintaining system lifecycle value', INCOSE International Symposium, 17(1):1579–1593

- In order to fulfil all the system attributes described in previous slide, a system is required to be flexible, maintainable, agile, upgradable, modular, resilient, and adaptable.
- Since FP deals with almost all these attributes, the notion of future-proofing has the potential to address these challenges.

Future-proofing Various Definitions

- According to the Cambridge dictionary the word future-proof (*verb*) means “to design software, a computer, etc. so that it can still be used in the future, even when technology changes”.
- The Collins English dictionary defines future-proof as (*adjective*) “guaranteed not to be superseded by future versions, developments”
- The Oxford dictionary defines it as “unlikely to become obsolete”.
- The theme of FP can be inferred which is; future-proofing makes system “resilient” and “long lasting”.

Definition “Proof” and “Obsolescence”

- The Cambridge dictionary defines proof as “to protect against something”.
- Oxford dictionary defines it as “able to withstand something damaging” or “resist”.
- So “resist” or “protect” against what?
- In the case of future-proofing it is the future for which an object able to withstand or resist.
- The word obsolescence defined as “the condition of no longer being used or useful” and hence this plays a vital role in future-proofing concept.
- The consequence of the resistance against future would make the object long lasting and the way it is achieved is by defying obsolescence.

Future-Proofing

- The main objective of the future proofing is to resist obsolescence of a system by adjusting the present situation so that future emerging opportunities can be utilized.
- The most logical definition of Future-Proofing can be derived by considering the base meanings of two separate words “future” and “proof”, as well as the involved process when these two words combined together

  “Future-proofing is the process of anticipating the future and developing methods of minimizing the effect of shocks and stresses of future events”.

- The definition actually addresses the two-word term “future” and “proof” very effectively. The process of anticipation deals with the word “future” and developing mitigating strategies (to avoid obsolescence) addresses the word “proof”.

Lifecycle Value (LCV)

- The life-cycle value of a system is a concept in economics where long-term implications of a system are considered.
- LCV is obtained by asking users/stakeholders if the system meets the user need.

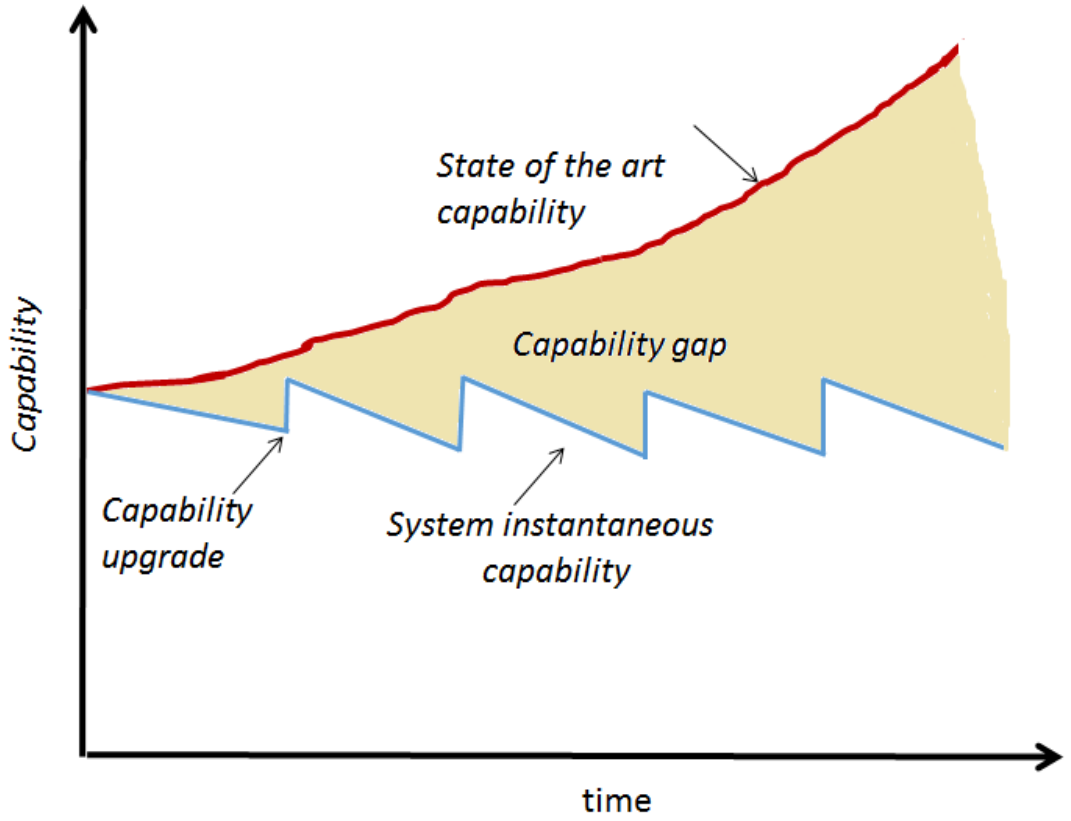
> *"The value provided by a system, let alone its LCV, is difficult to quantify. Value is largely subjective, and individuals have difficulty articulating exactly what makes a complex system valuable".*

*(*Browning, T. R. and Honour, E. C., 2008, 'Measuring the life-cycle value of enduring systems'. System Engineeirng, 11(3):187–202*)*

- LCV provides different value to different stakeholders, with each obtaining value largely based on personal preferences.

Future-proofing Concept

- We propose to use a measure of the capability gap to obtain the loss in the system capability over the years.
- The capability gap is measured by comparing the state-of-the-art solution exists at any particular time with the system's present capability.
- It provides an absolute measure rather than a subjective value.
- Thus helps initiate mitigating strategy which resist obsolescence

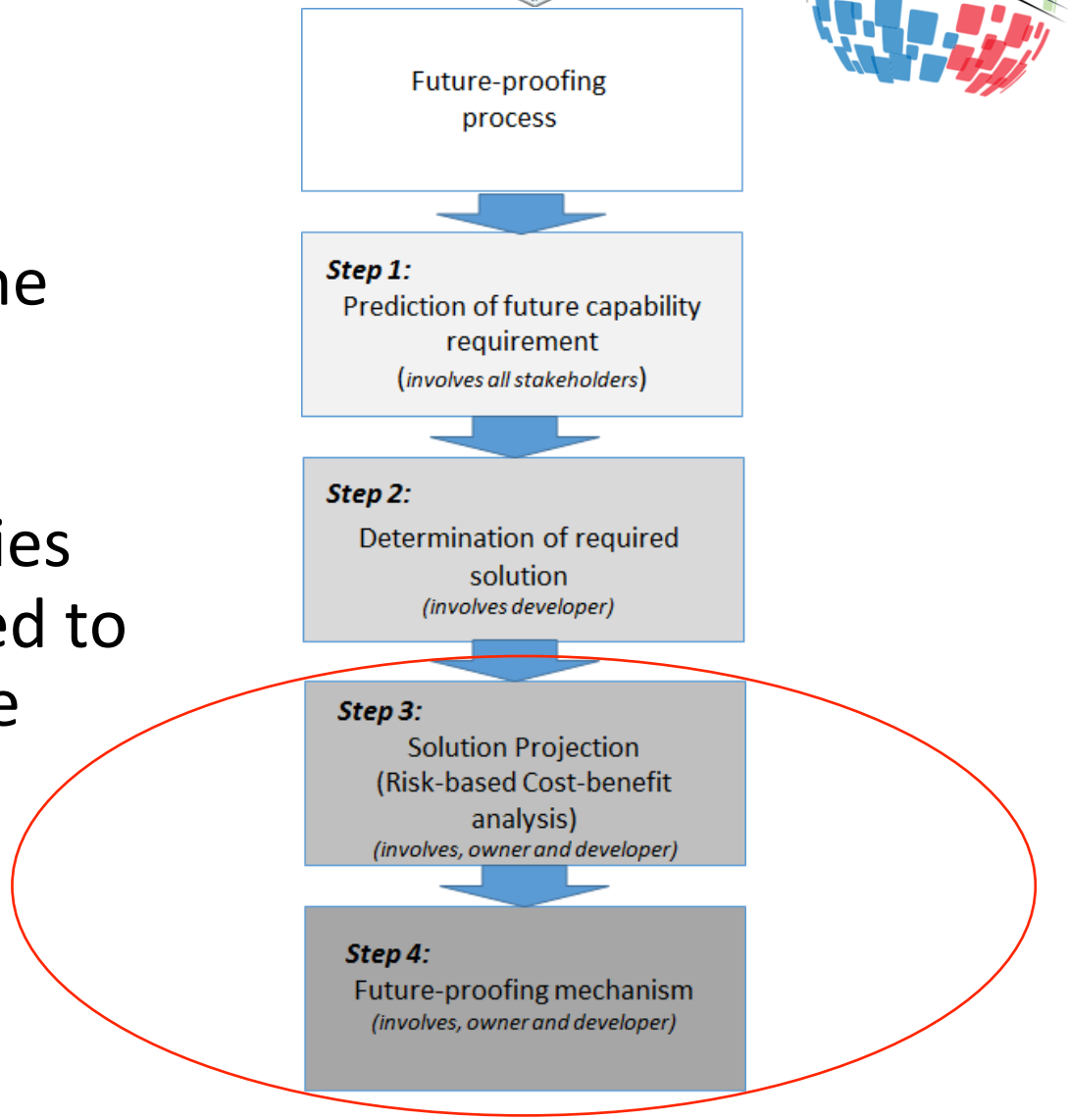


Example- Capability gap

Future-proofing Process

- The FP process starts at the conceptual design stage and continue throughout the system life-cycle.

- FP requirements are additional capabilities for which the system may not be required to provide the solution until the future date arrives.
- In the FP process, identification of stakeholders is necessary.
- We propose four step FP process.



Prediction of Future Capability Requirements

- As previously said, future-proofing means securing or protecting the unknown future.
- Take some action now (in present) to secure future.
- There are various methods available for prediction or forecasting which use historical data, trend analysis, and statistical and mathematical tools for estimation.

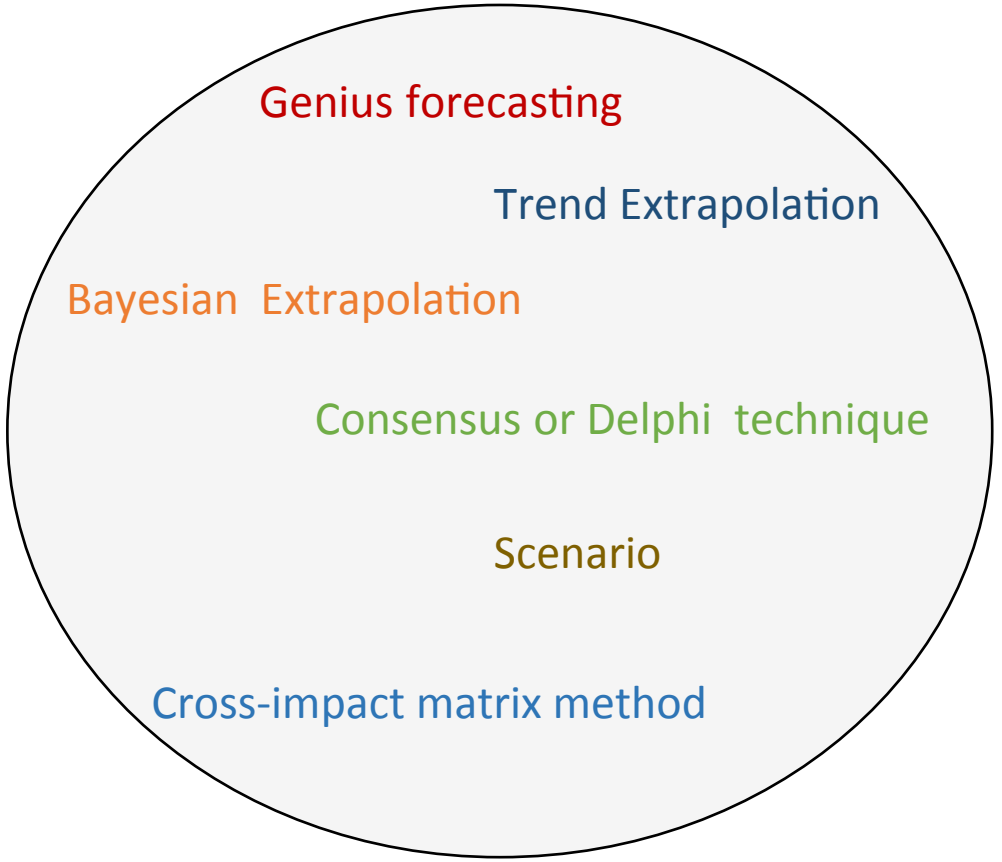


Figure. Various estimation and forecasting methods.

Solution Determination

- The next step is to identify candidate solutions for estimated requirements.
- The solution should be estimated and analysed by considering the complete lifecycle.
- There could be various future solution projection through which system can be made future-proof.

Solution No.	Projection of future solution	Solution details
1.	0 %	Buy a three bedroom house.
2.	44 %	Buy a three bedroom house with a large piece of land for future built.
3.	50 %	Solution 2 plus foundation for fourth bedroom.
4.	66 %	Solution 3 plus frame and roof work construction.
5.	77 %	Solution 4 plus wiring and plaster for fourth room.
6.	100 %	Buy a four bedroom house now.

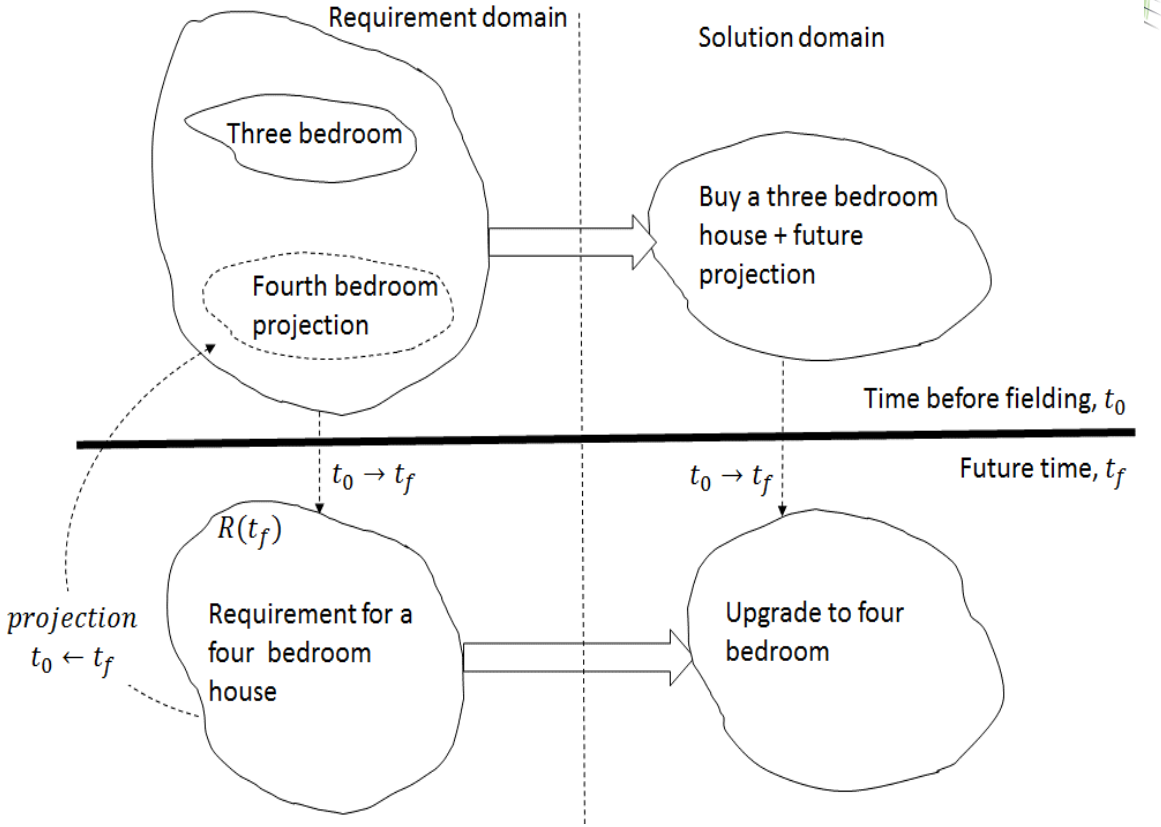


Figure. Requirement and solution domain.

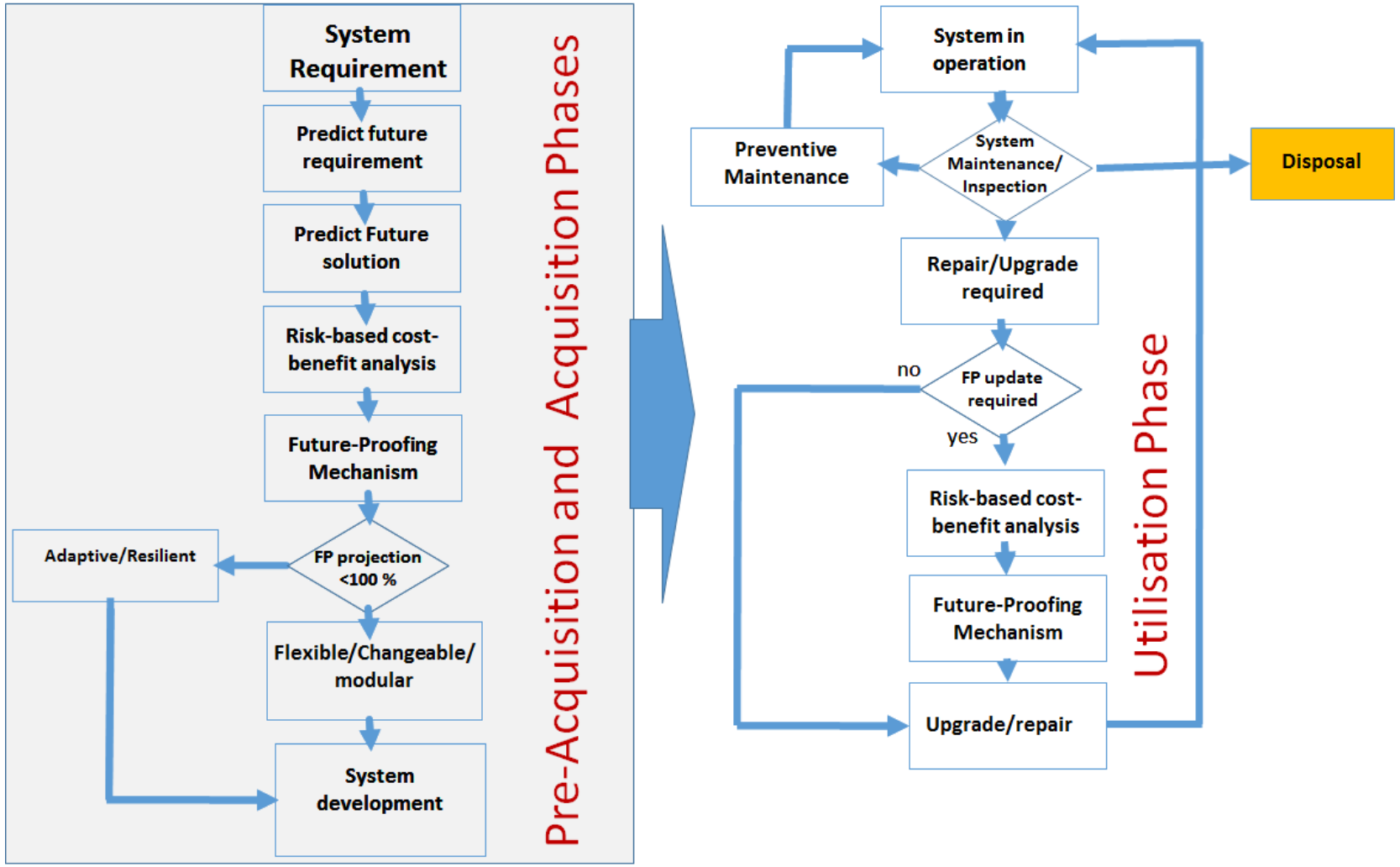
Future-Proofing projection Selection

- The third step in the FP process is to analyse prospective solutions (future projections) for their suitability.
- The risk-based cost-benefit analysis using multiple criteria such as cost, utility etc may be used to select an optimal solution.
- This analysis will help to determine a mechanism of future proofing to meet the FP requirements.

Future-Proofing Mechanism

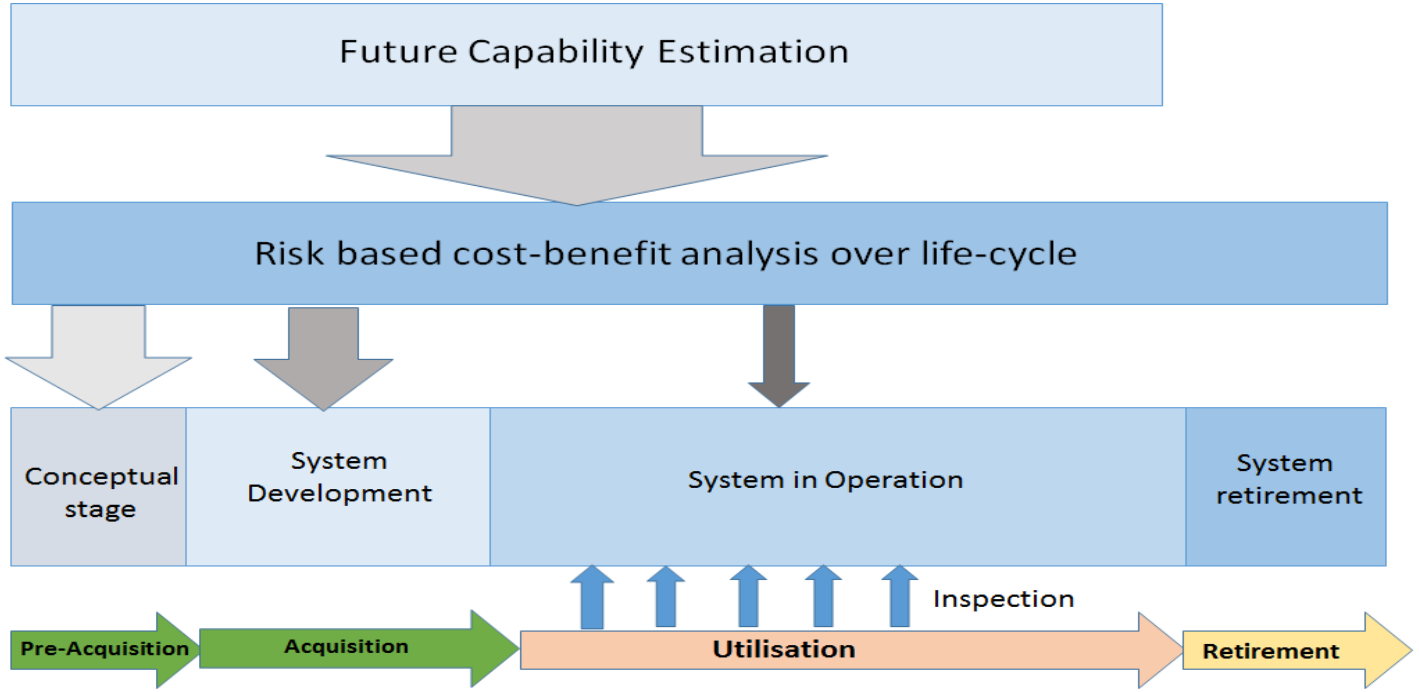
- A system can be made future-proof using various mechanisms.
- For FP mechanism, we propose three system categories based on system's future-proofing capability requirements i.e. purpose, goal or mission:
  - **System type I:** complete future solution is needed to be incorporated in the design at the time of the system's fielding. *resilient or adaptive design*.
  - **System type II.** systems where only a partial solution (some projection of FP solution) is provided by considering the estimated future capability requirement at the time of system development. *flexible, upgradable or agile design.*
  - **System type III.** We put System of Systems (SoS) in this category as systems can evolve independently of each other and hence can be made future proof by considering modularity in the design.

Overview of FP Process



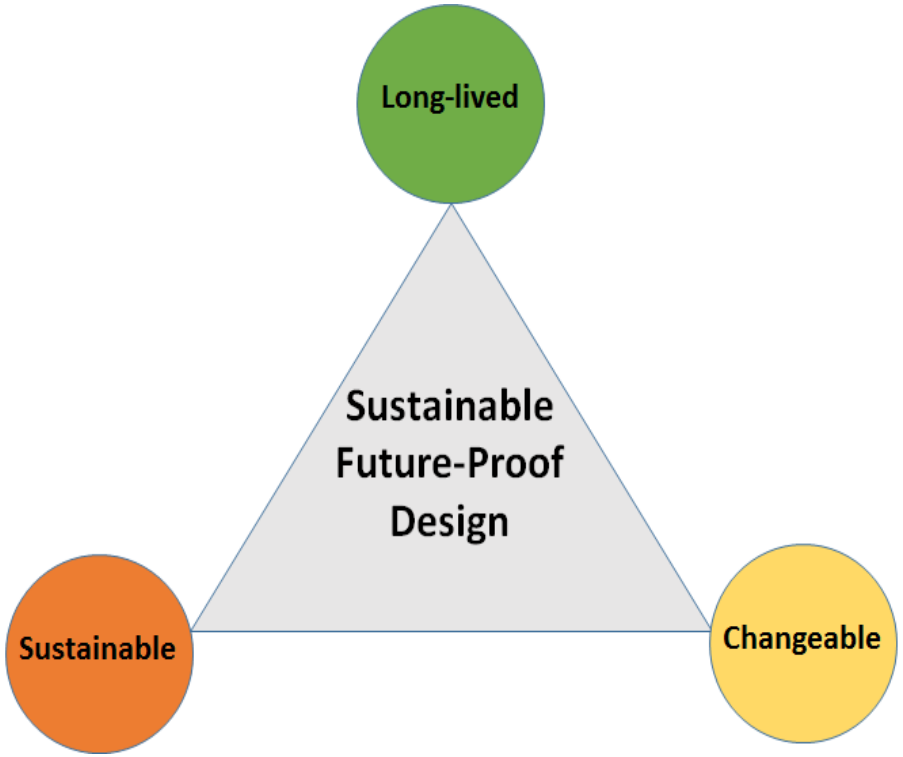
Recommendation

- It is important that prediction of future capability requirements continue in the development and utilisation phases and the FP process is updated regularly whenever possible.



Conclusion

- The word future-proof is investigated using several definitions available in the literature and a definition is presented to help develop FP process.
- Future proofing process is proposed to systematically approach the future-proofing problem through a four-step process.
- Three system categories are proposed to select future-proofing mechanism.
- The conflict of focusing on future-proof design with economic growth and sustainability is an important subject and requires a study of design trade-off.
- Future research is directed towards developing methods which systematically address this conflict.


Long-lived
Sustainable Future-Proof Design
Sustainable
Changeable

27th annual INCOSE international symposium

Adelaide, Australia

July 15 - 20, 2017

ENGINEERS AUSTRALIA

SESA

www.incose.org/symp2017