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IMPACT THROUGH SYSTEMS ENGINEERING IN A RESEARCH ENVIRONMENT

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PROGRAM

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- What is Systems Engineering?
- The Scientific vs. the Systems Engineering Processes in R&D
- Applying systems engineering in a R&D environment
- Conclusion

WHAT IS SYSTEMS ENGINEERING?

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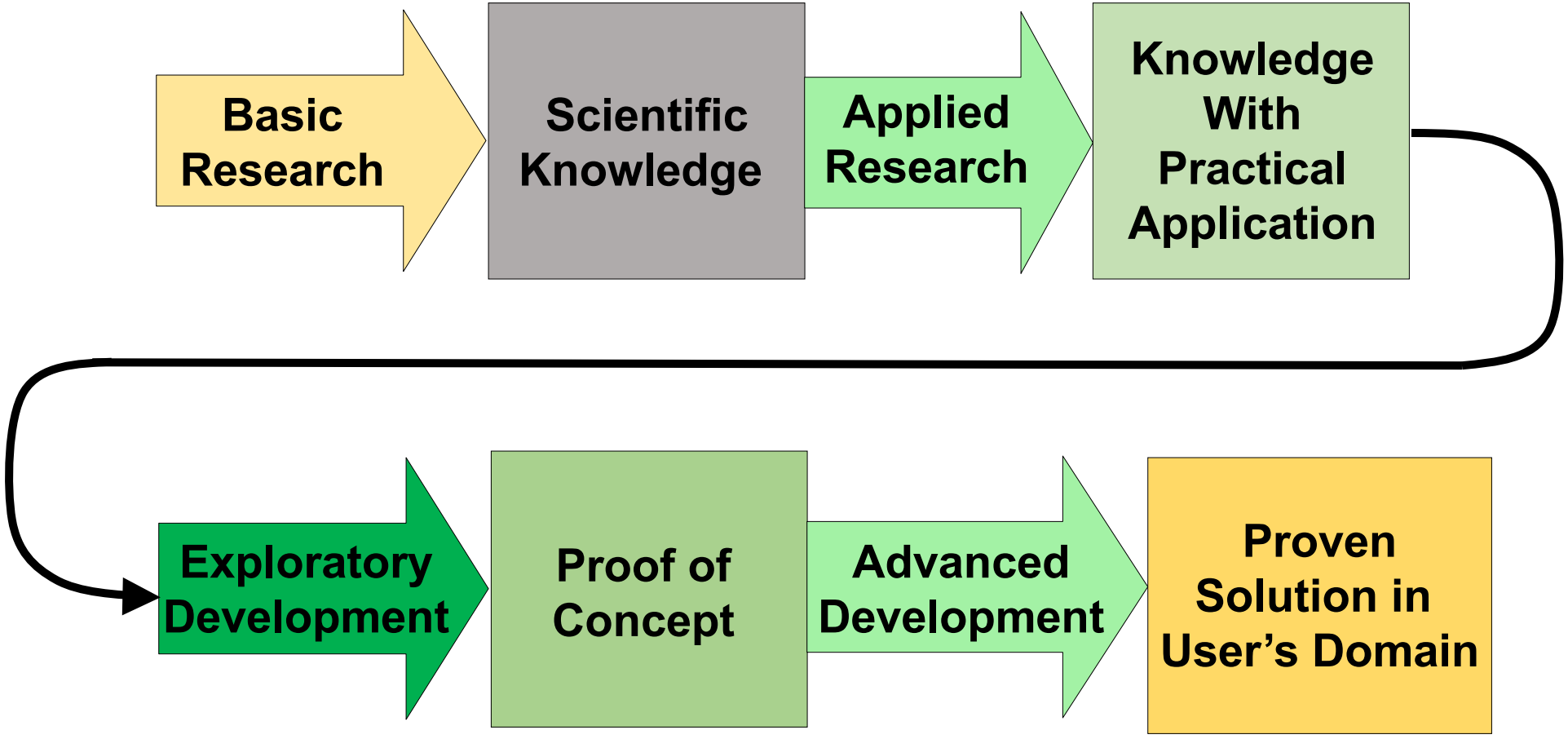
- “Systems Engineering is an interdisciplinary, collaborative approach to the engineering of systems (of any type) which aims to capture stakeholder needs and objectives and to transform these into a description of a holistic, life cycle balanced system solution which both satisfies the minimum requirements, and maximizes overall project and system effectiveness according to the values of these stakeholders. Systems engineering incorporates both technical and management processes.”

  (Halligan, 2003)

DEFINITION OF EVALUATION AND RESEARCH



DEFINITIONS: BASIC & APPLIED RESEARCH

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- Basic research
  - is considered long-range, non-focused inquiry that advances the state-of-the-art frontiers of fundamental knowledge. Basic research may never have a practical application and is directed toward solving the axiomatic problems of nature.

- Applied research
  - is differentiated from basic research in that it has a primary focus toward specific objectives, either as a final product or process. This objective may be to serve a commercial need or to satisfy a requirement in a much larger, more sophisticated system.

DEFINITIONS: EXPLORATORY & ADVANCED DEVELOPMENT

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- Exploratory development
  - the main goal of exploratory development is to bridge the gap between applied research knowledge (that intended for application) and the initial development of hardware or material for use in a bigger solution.

- Advanced development
  - incorporates the development of useable product for use in a bigger solution. It is structured to directly apply proven scientific and technological advances to community uses.

A SCIENTIFIC PROCESS

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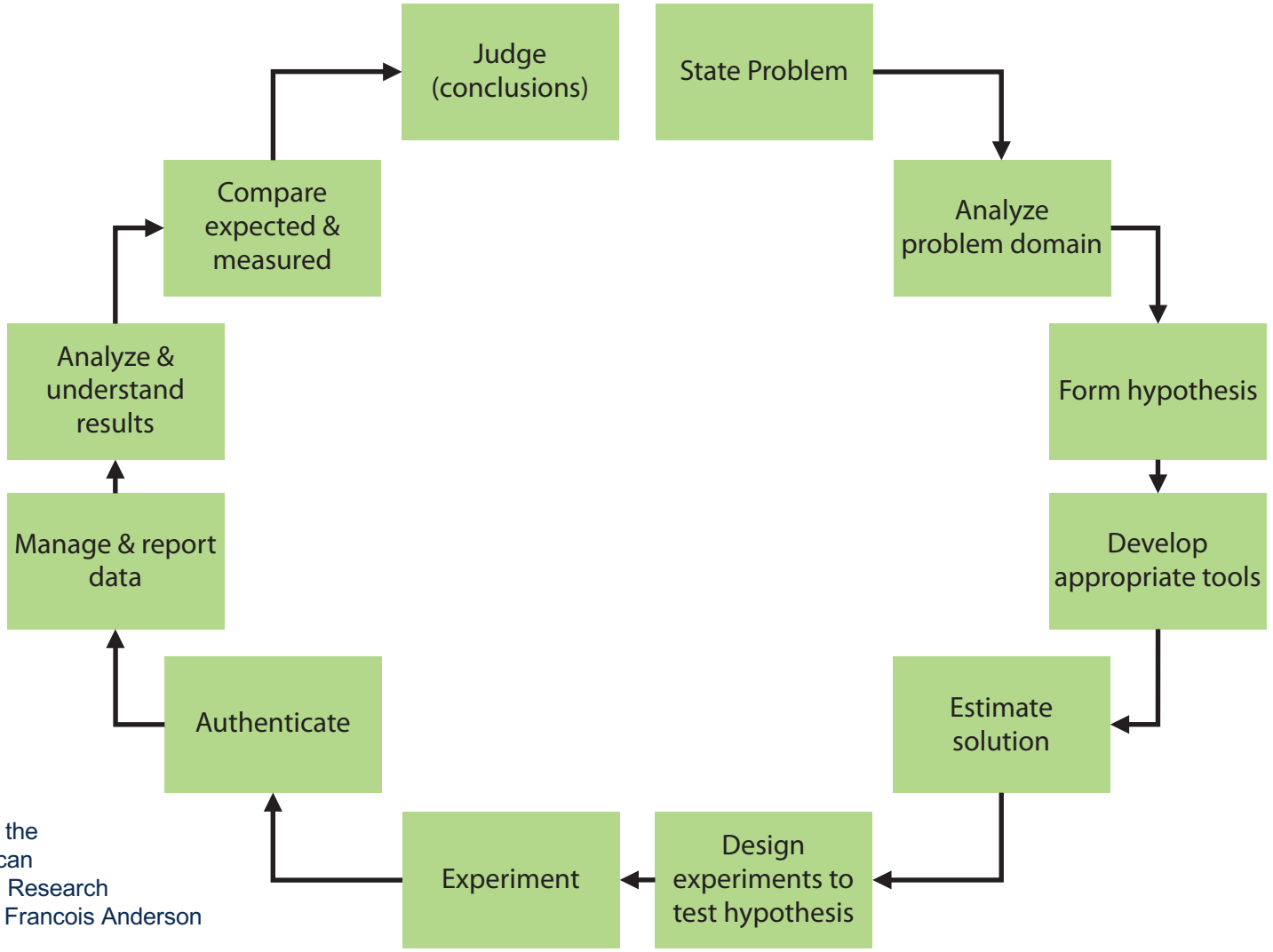

Source:
Systems Engineering in the Transformed South African Defence Evaluation and Research Institutes, Alwyn Smit & Francois Anderson
August, 2003

SYSTEMS ENGINEERING SUPPORT TO SCIENCE

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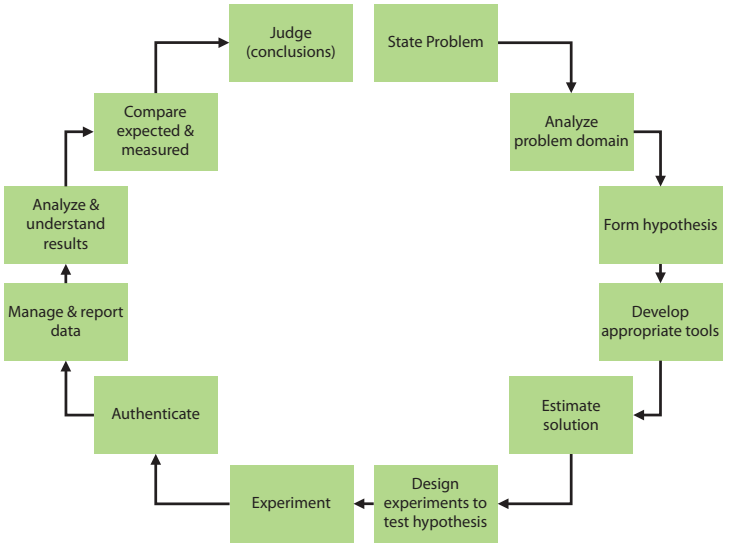
State Problem



- Ultimately, an applied research question has its origins in contributing value to society
- Hence the ROI from applied research is influenced by its relevance in contributing to solutions to societal problems, e.g.:

Societal problem: the depletion of oil

Research question: how can algae be turned into biofuel in commercial quantities at affordable cost and in a sustainable way?

A SE PROCESS VIEW

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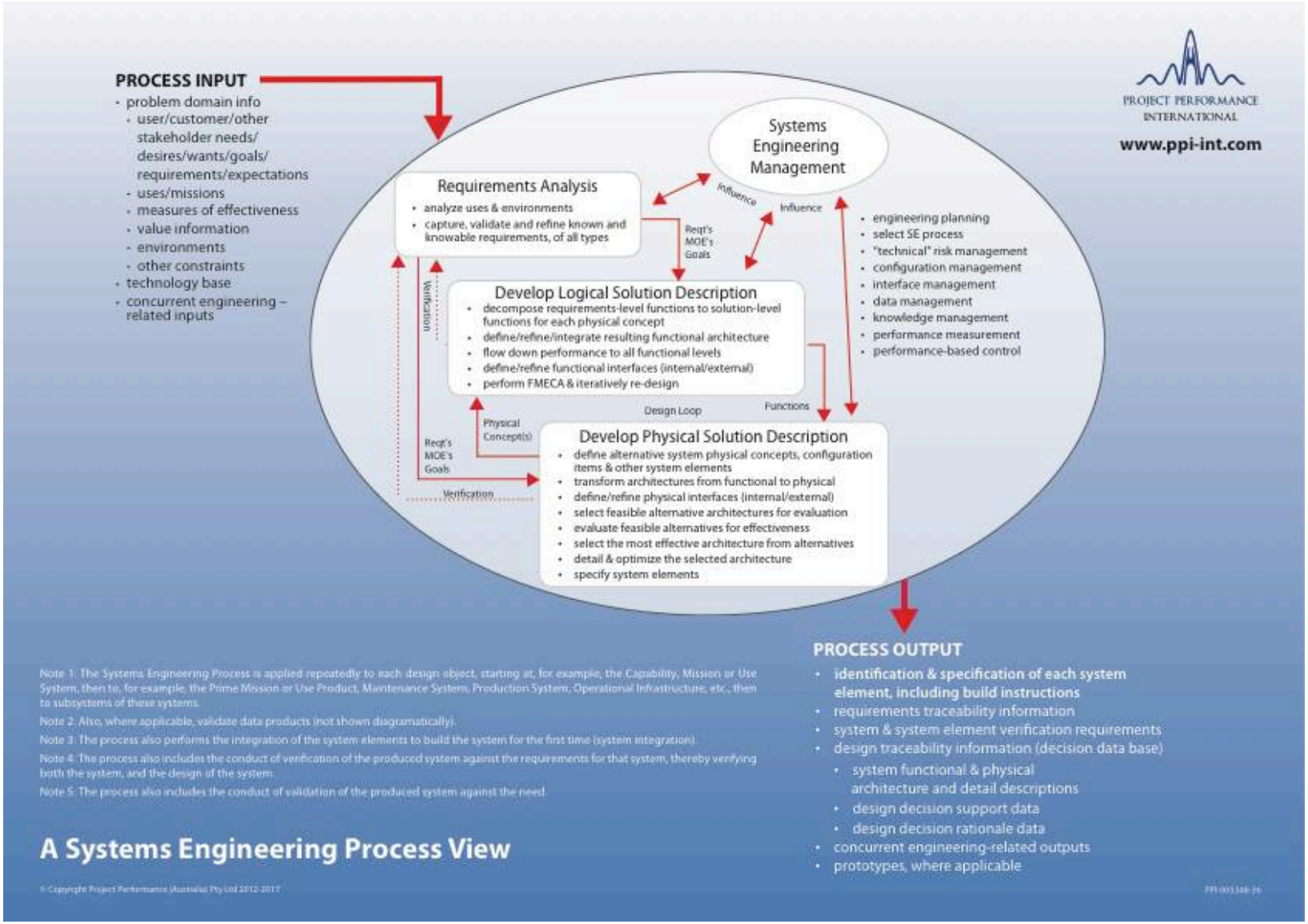

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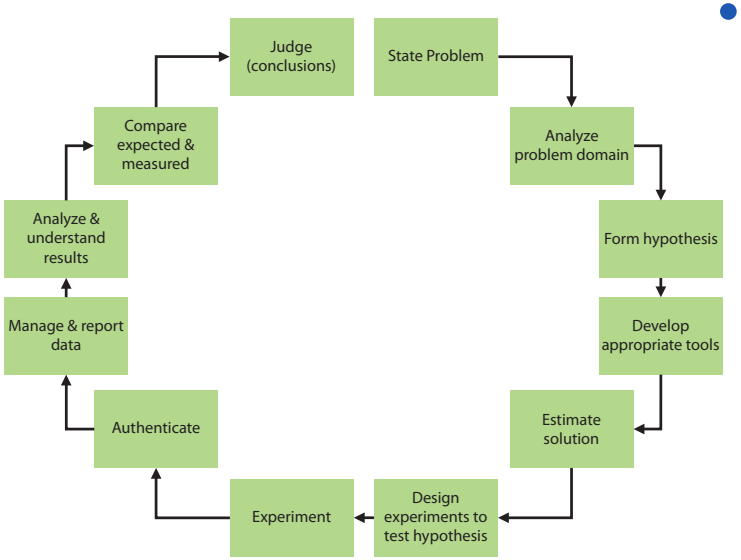

- Systems engineering provides the tools for:
  - defining the problem in terms of imperatives, together with stakeholder values in a suitable form
  - creating and evaluating solution alternatives
  - identifying technology readiness levels, related knowledge gaps, and levels of risk and opportunity
  - deriving related research questions
  - adequately expressing related research questions
  - eliminating research questions whose expected ROI (if answered) is low.

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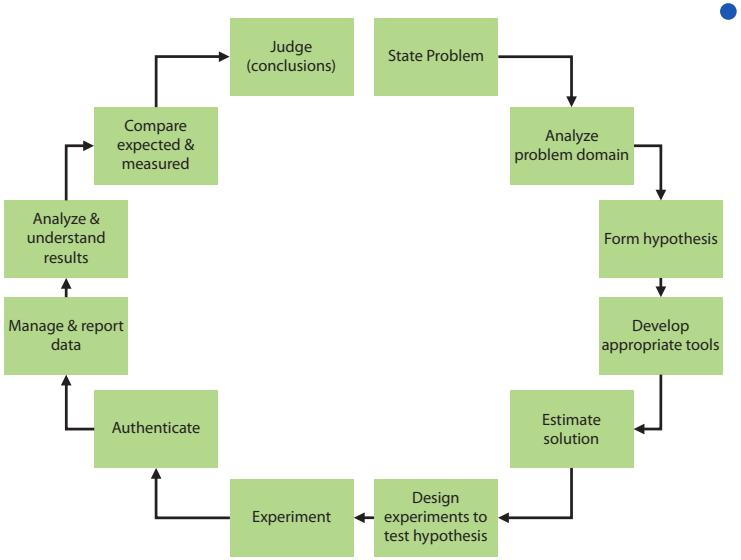
Analyze Problem Domain



- Via Requirements Analysis, systems engineering provides the tools for the recipient of a research question to:
  - establish the adequacy of definition of the research question
  - capture, validate and specify requirements to be satisfied by the research activity, e.g. cost limits, reporting, political imperatives
  - determine and record stakeholder values in a way which can drive decisions towards optimum outcomes from the research.

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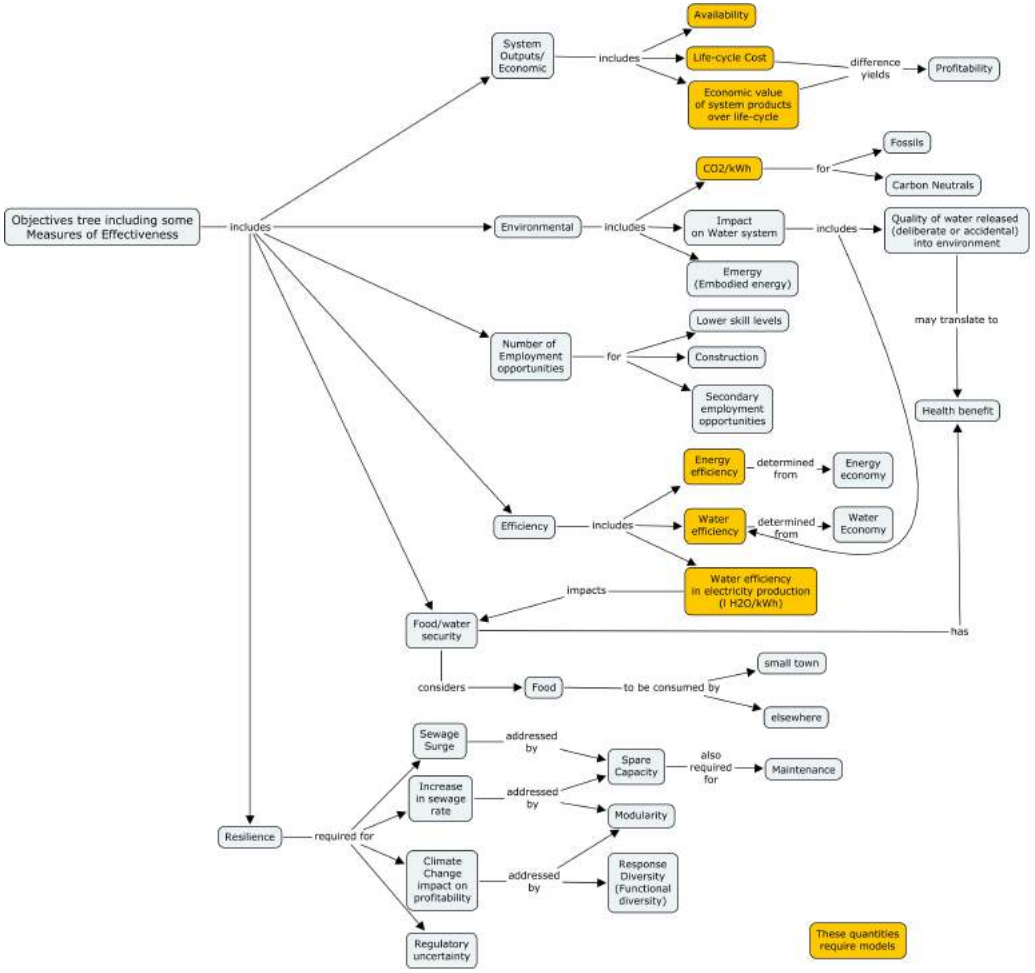
Analyze Problem Domain



AN EXAMPLE VALUE MODEL AND ITS APPLICATION

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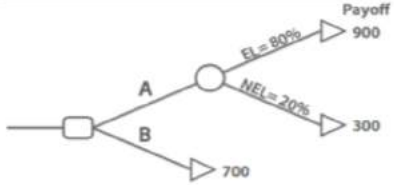
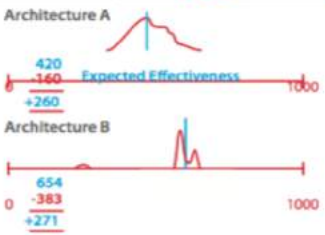
Value (System Effectiveness) Model

MOEs	Worst	Best	Pri	Pts	Weight %	UF	Architecture A Evaluation: Value of MOE	RVC	AVC (RVC x wt)	
Cost, $ks per unit	200	50	1	100	25		~~55k~~ 57	~~10~~	~~250~~	
Reliability, %	95	100	1	100	25		~~95.5%~~ 97.5	~~1~~ 5	~~25~~ 125	+100
Interoperability	0	17	7	14	4		0	0	0	0
Size(A/B/C)	C	A	8	3	1		~~C~~ B	~~0~~ 5	~~0~~ 5	+5
Schedule (Months)	12	6	3	40	10		~~7~~ 8	~~10~~ 9	~~100~~ 90	-10
Visible Optical Range, m	1000	5000	5	30	7		~~1200~~ 2500	~~2~~ 5	~~14~~ 35	+21
Duration of Transmission, hr	48	96	6	27	6		50	0.5	3	
Readiness, %	90	100	4	39	10		~~91~~ 95	~~1~~ 5	~~10~~ 50	+40
OS & D Cost, $k pu/10 years	300	10	2	50	12		~~200k~~ 106	~~4.5~~ 8	~~48~~ 96	+78
				403	100				Σ 420 (A)	
									Σ 654 (B)	



80% x 900 = 720
20% x 300 = 60
TOTAL 780

Payoff is the optimized outcome for A & B respectively, without consideration for A of the risk added by needing to obtain a Export License (EL).



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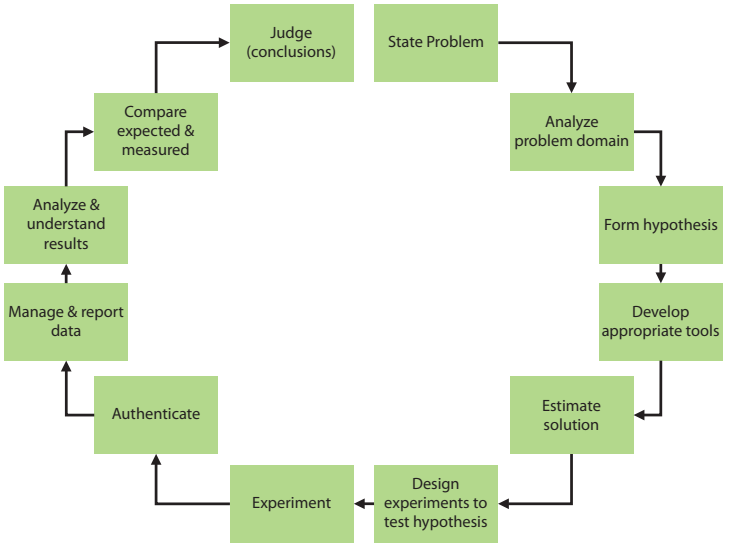
Develop Appropriate Tools



- Systems engineering, in all its facets, provides an approach for maximizing the value to the researcher of each tool developed, by:
  - ensuring that the definition of what is to be developed is adequate for the purpose of developing what is needed
  - developing the tool right – meeting the imperatives, and delivering maximum value to the researcher by optimizing the balance of, say, accuracy, ease of use, reusability, development cost, support cost, safety, etc .., as applicable.

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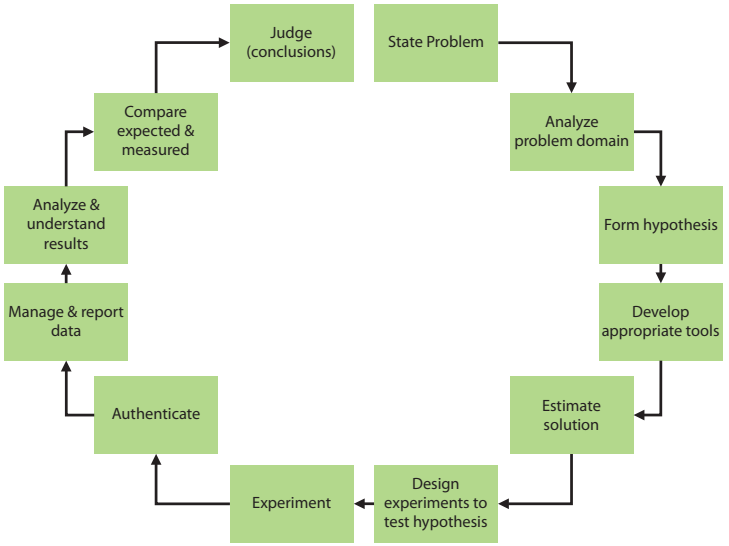
Design Experiments to Test Hypothesis



- Systems engineering, being a problem-solving approach which aims to do work only because the work adds value to the customer (here the researcher), and which aims to not do work for exactly the same reason, can contribute to any activity in which the application of existing knowledge to solve a problem is involved.

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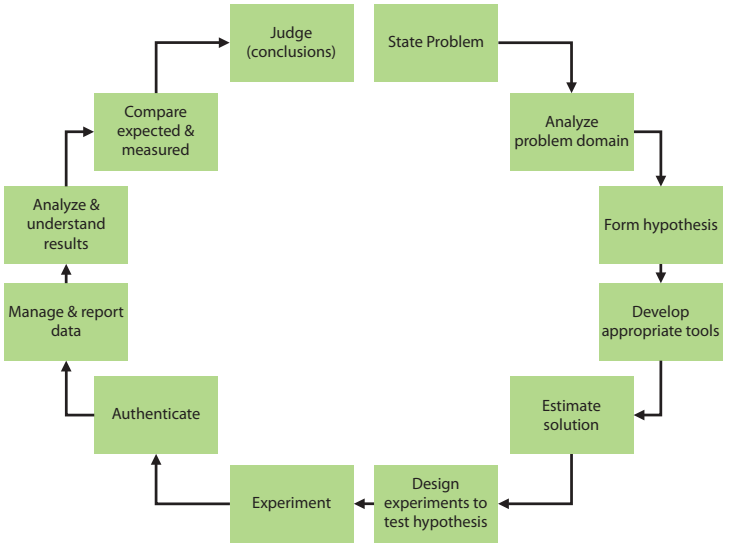
Experiment



- Systems engineering can contribute to achieving maximum value from experiments by developing tools that reflect the researcher's needs, as applicable, for reliability, adaptability, reusability, safety, etc. during experimentation, and being well prepared to respond to changing needs during experimentation.

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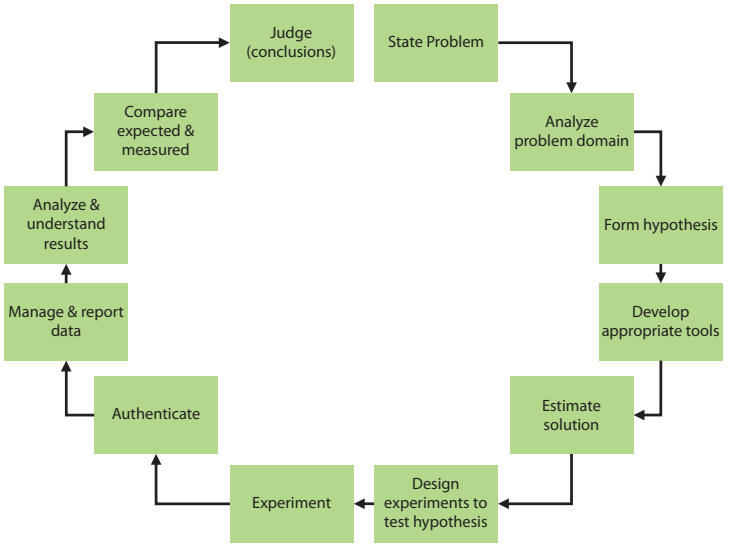
Business Models



- Systems engineering can contribute to achieving maximum value from science through applying the related technology and process knowledge of its practitioners to the identification and development of opportunities, and related means of exploitation. That is, practitioners are members of, and very well connected into, the application domain.

CONCLUSION

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- Both the scientific and systems engineering processes are applicable and mutually supportive in the modern research organization.

- Well-executed systems engineering approaches are self-limiting in their cost and time, doing only work that adds value on a balance-of-probabilities (expected value) basis, thereby, in a research context, maximizing the impact of research.

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QUESTIONS AND DISCUSSION

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MAY YOUR RESEARCH PROJECTS SUCCEED BEYOND YOUR WILDEST DREAMS.

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