



Australian Government

Department of Defence

Defence Science and Technology Group

A SoS Approach for Engineering Capability Programs

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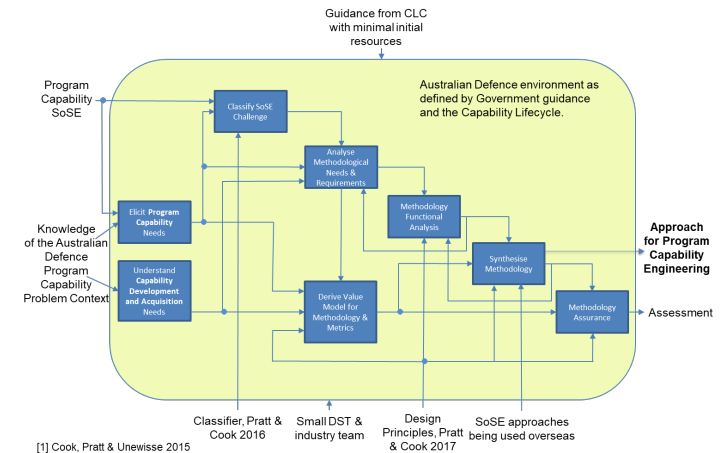
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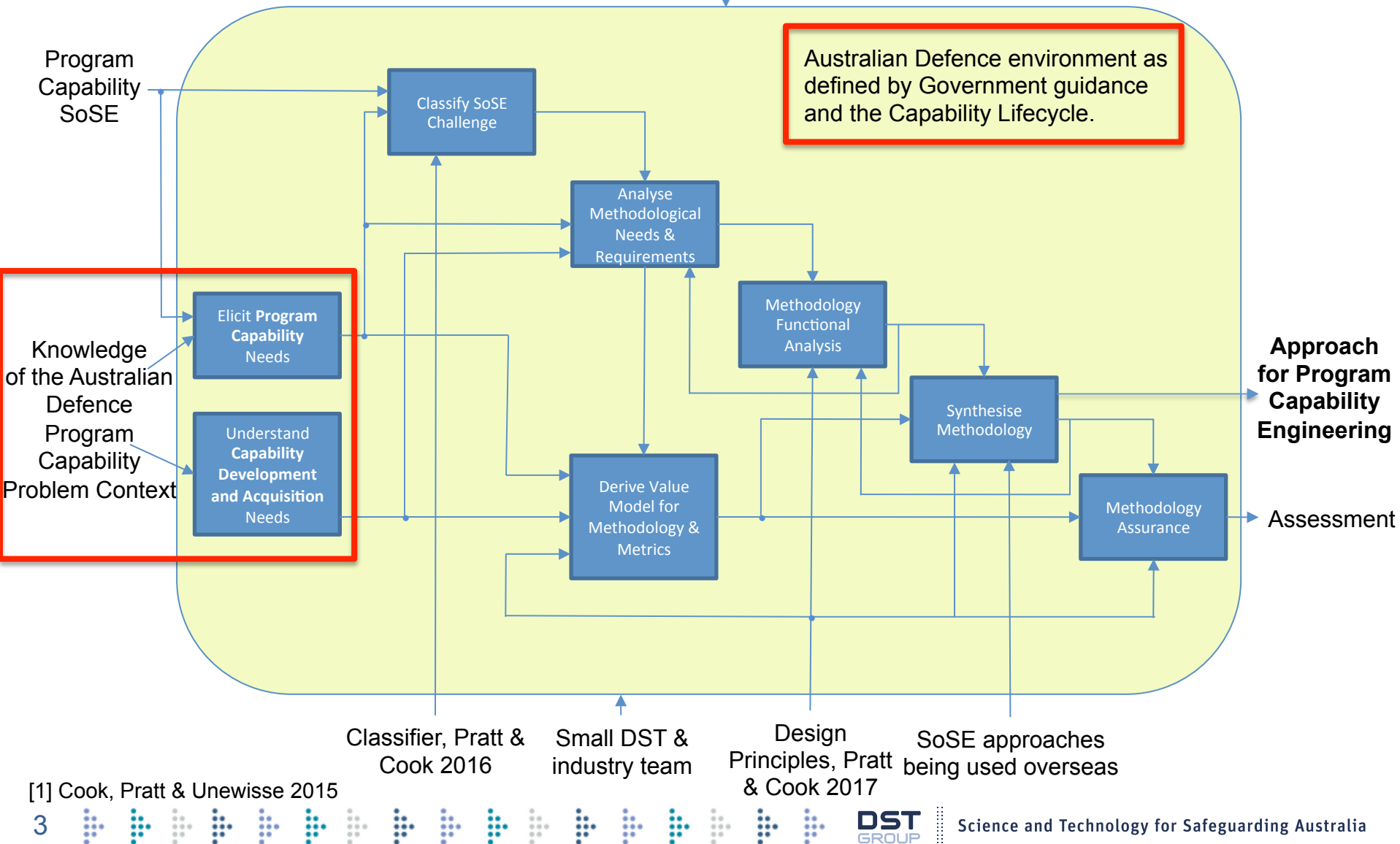
Overview

- Design Approach
- Problem Context
- SoS Challenge and Classification
- Functional Analysis
- Identification of the Needs
- Review Existing SoSE Approaches
- Generation of a Hybrid SoSE Approach
 - Needs
 - Key Recommendations
- Initial Applications and Assurance
- Conclusion



Application of SoSE Methodology Design Process [1]

Guidance from CLC
with minimal initial
resources



Impacts of Changes in Australian Defence

- First Principles Review (2015)
 - Recommended and initiated a range of reforms
 - One Defence Business Model
 - Capability Managers leading development
 - CJC, CA, CN, CAF, DEPSEC SPI
 - Created the Integrated Investment Plan
 - 10 year expenditure plan
 - Approved annually by Government
 - Managed through the Investment Committee
 - Chaired by Vice Chief of the Defence Force (VCDF)
 - Increased Focus at the Portfolio and Program Level
 - Establish effective, arms-length contestability
 - Establishment of VCDF as the Joint Force Authority



Pre-Existing Defence Enterprise Characteristics

Current Characteristics	SoSE Implications
Modest Size force in 3 services, but operates as a joint force	Need for joint SoSE and Integration
Project-centric capability development and acquisition	SoSE must support project-centric acquisition
Complex capability development organisations, processes and cultures	Work within and to each culture Support Project-centric organisation
~ Off-the-shelf acquisition	Focus on system and SoS integration Defence as the SoS integrator
National SoSE capability is embryonic	Start by aiming at “Level 1”
Significant Processes Flexibility	Supports a tailorable approach to SoSE
Resource challenges & limitations for joint force design and realisation	Need to keep SoSE team(s) small, with lean processes and overheads

New More Flexible Capability Lifecycle (CLC)

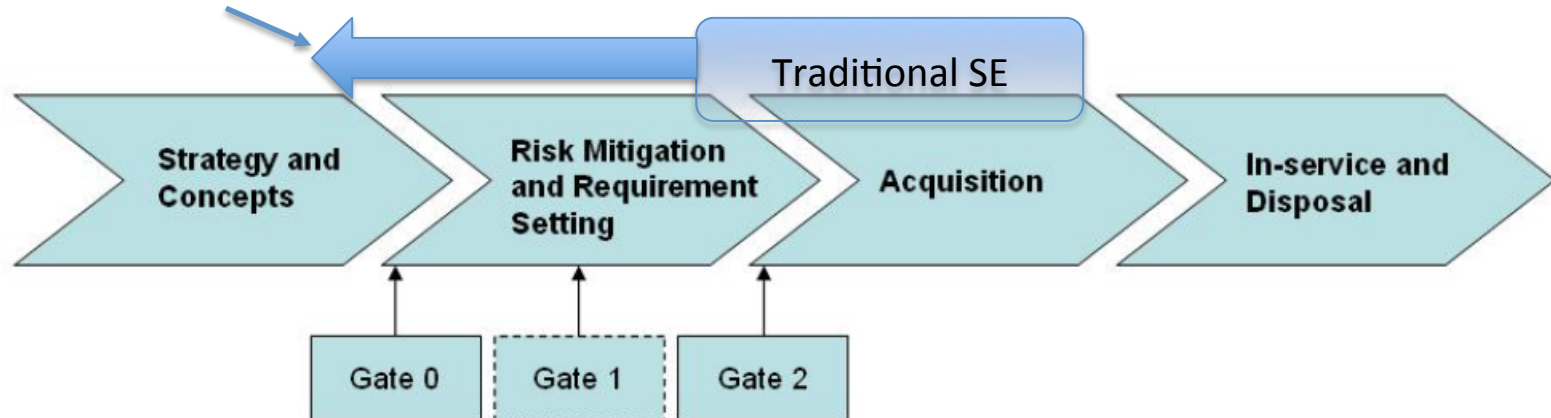
■ Four Stage CLC

1. Strategy and Concepts
2. Risk Mitigation and Requirement Setting
 - Gate 0, [1], 2
3. Acquisition
4. In-Service and Disposal

■ Three Management Levels

1. **Portfolio:** Whole-of-Defence capability consideration
2. **Programs:** Collections of Projects and Products to deliver capability outcomes
3. **Projects:** Development and acquisition on new Products

Extend SE to SoSE early in the CLC



Portfolio and Program Management

- CM Domains
 - Joint, Maritime, Land, Air & Space, Intelligence & Cyber
 - Deliver capabilities

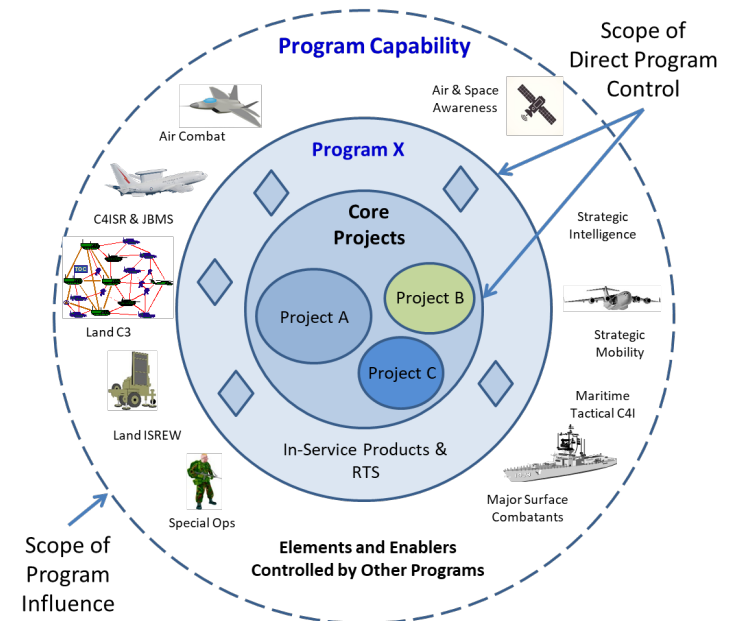
- Capability Streams:
 - Guidance from Government
 - Reporting to Government

- 40 Programs
 - Across the CM Domains and Capability Streams
 - Introduced to improve decision-making & management

Capability Streams: Prioritisation						
	ISREW, Space and Cyber	Air & Sea Lift	Land Combat & Amphib Warfare	Strike & Air Combat	Maritime & Anti-Sub Warfare	Key Enablers
	Vice Chief Defence Force	Chief of Air Force	Chief of Army	Chief of Air Force	Chief of Navy	Vice Chief Defence Associate Secretary
Capability Manager Domains	Joint Integration C4I and Joint Battle Management Systems Joint ISR and EW Warfighting Innovation (Inc Cyber) Asymmetric Response Vice Chief Defence Force					Health Services Fuel Explosive Ordnance Training Support and Simulation
	Maritime Maritime Tactical C4I Chief of Navy	Sea Lift	Amphibious Combat		Major Surface Combatants Submarines Naval Aviation Maritime Logistics Minor Combatants Maritime Military Geospatial Information	Maritime Infrastructure and Ranges
	Land Land ISREW Land C3 Chief of Army	Battlefield Aviation	Combat Vehicles Soldier Systems Non-combat Vehicles Combat Support Special Operations			Combat Service Support Systems
	Air & Space Air and Space Awareness Chief of Air Force	Air Mobility		Airborne Electronic Attack Integrated Air and Missile Defence Air Combat	Maritime Patrol and Response	Base Operations Aircrew Training
	Intelligence & Cyber Strategic Intelligence Strategic Cyber Deputy Secretary Strategic Policy and Intelligence					

Program Capabilities

- Some of the 40 Programs can be considered as the core of broader Program Capabilities
 - Amphibious Combat, IAMD ...
- Components within the Program
 - Core Projects delivering new Products
 - In-Service Products
- Components within other Programs
 - Need to shape and influence
- The Program Capabilities are SoSs

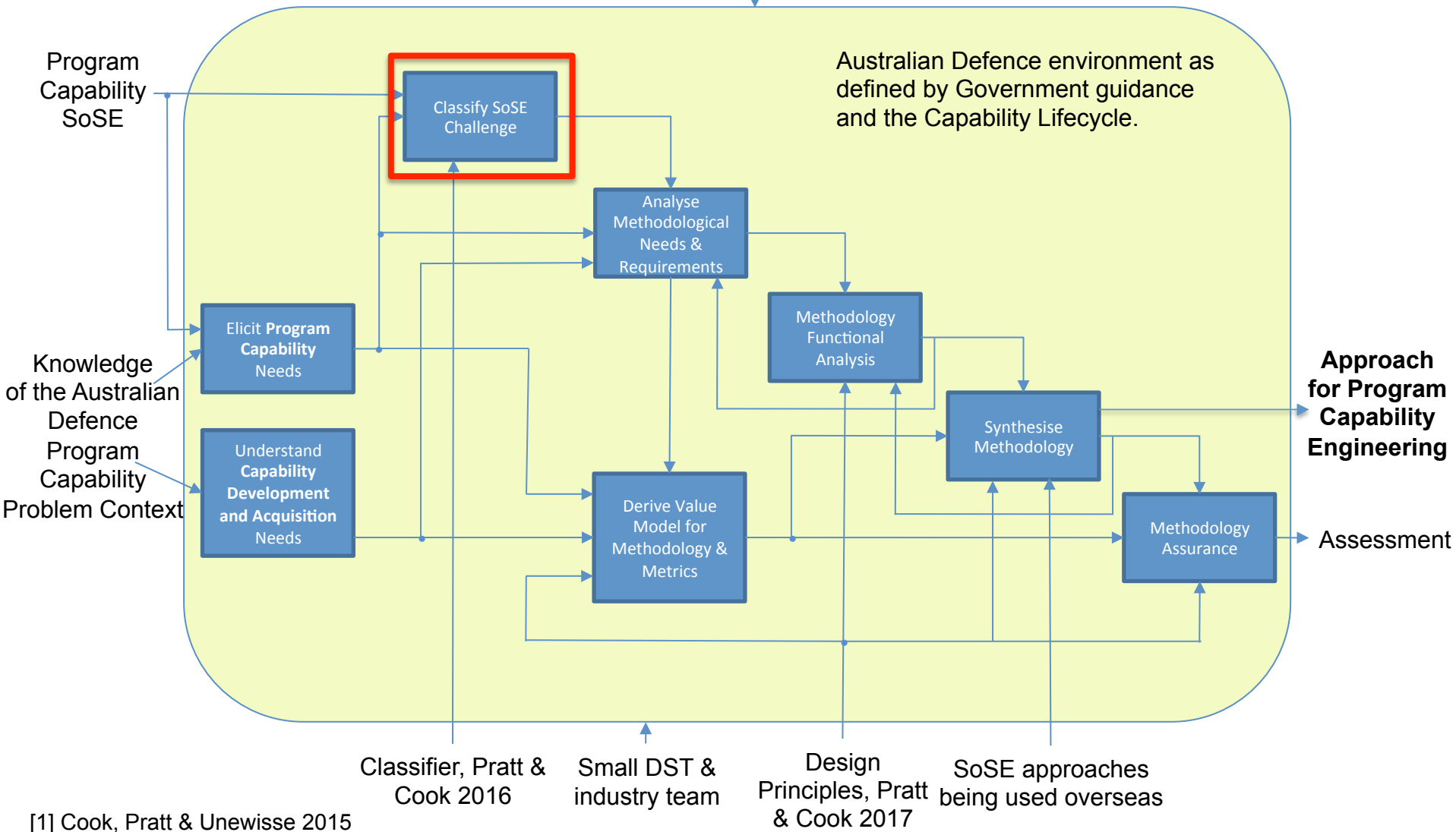


Joint Force Authority

- VCDF Identified as the JFA Responsible for:
 - Force Design:
 - Ensuring gaps, risks and issues in capability (military, enabling & enterprise) and future force structure are considered, joint, and developed upfront to allow informed, prioritised, balanced investment decisions
 - Joint Integration:
 - Shape Programs to deliver capabilities that are integrated and joint by design
 - Ensure Projects are designed to deliver required joint integration & interoperability
 - C4ISR Design:
 - Direction setting and assurance for all capability options under development to ensure they comply with the C4ISR Design Concept
 - Joint T&E:
 - Policy and direction setting with ongoing governance and direct involvement with Capability Manager Test & Evaluation organisations to ensure capability being delivered meets the required joint needs
- Shape via Programs and deliver by Projects

Application of SoSE Methodology Design Process [1]

Guidance from CLC
with minimal initial
resources



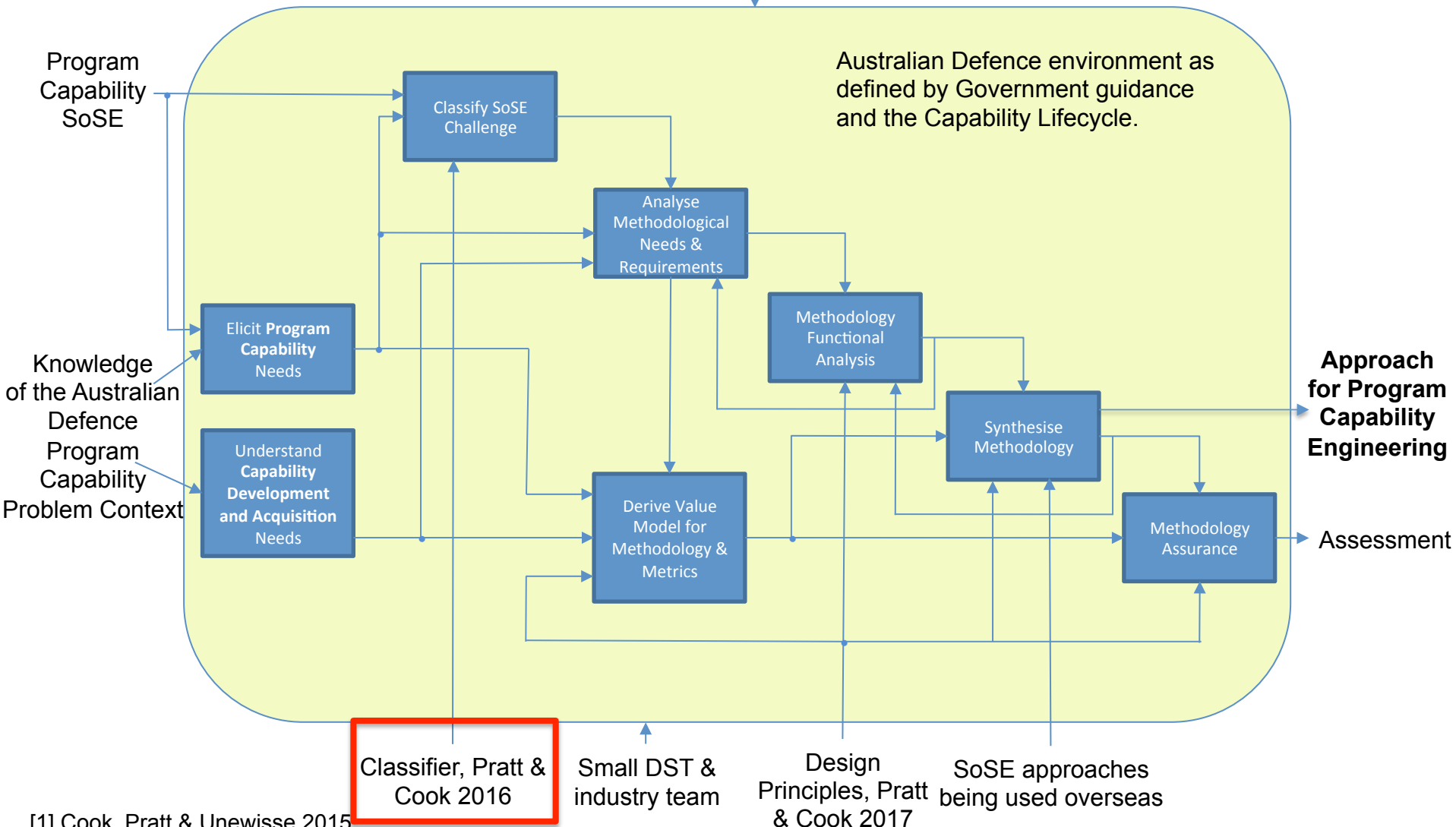
[1] Cook, Pratt & Unewisse 2015

SoSE Challenge

- Develop a SoSE approach that can support Program capability Design, Realisation and Management
 - Underpin delivering Joint Force by Design
 - Able to evolve and be tailored as required
 - Work with austere resources
 - Build on emerging SoS and SoSE awareness
 - Shape the relevant Projects and Products

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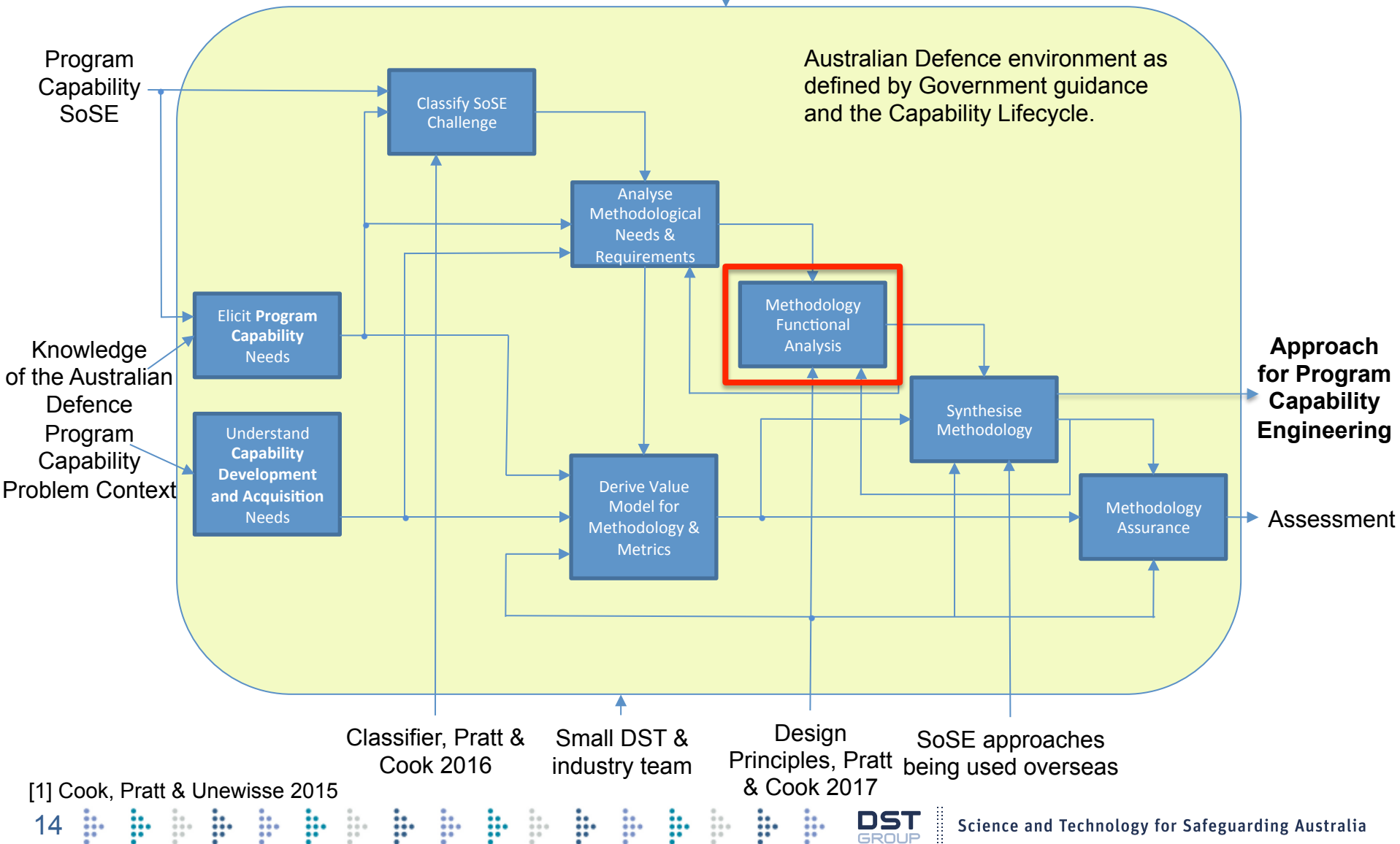
[1] Cook, Pratt & Unewisse 2015

SoS Classification

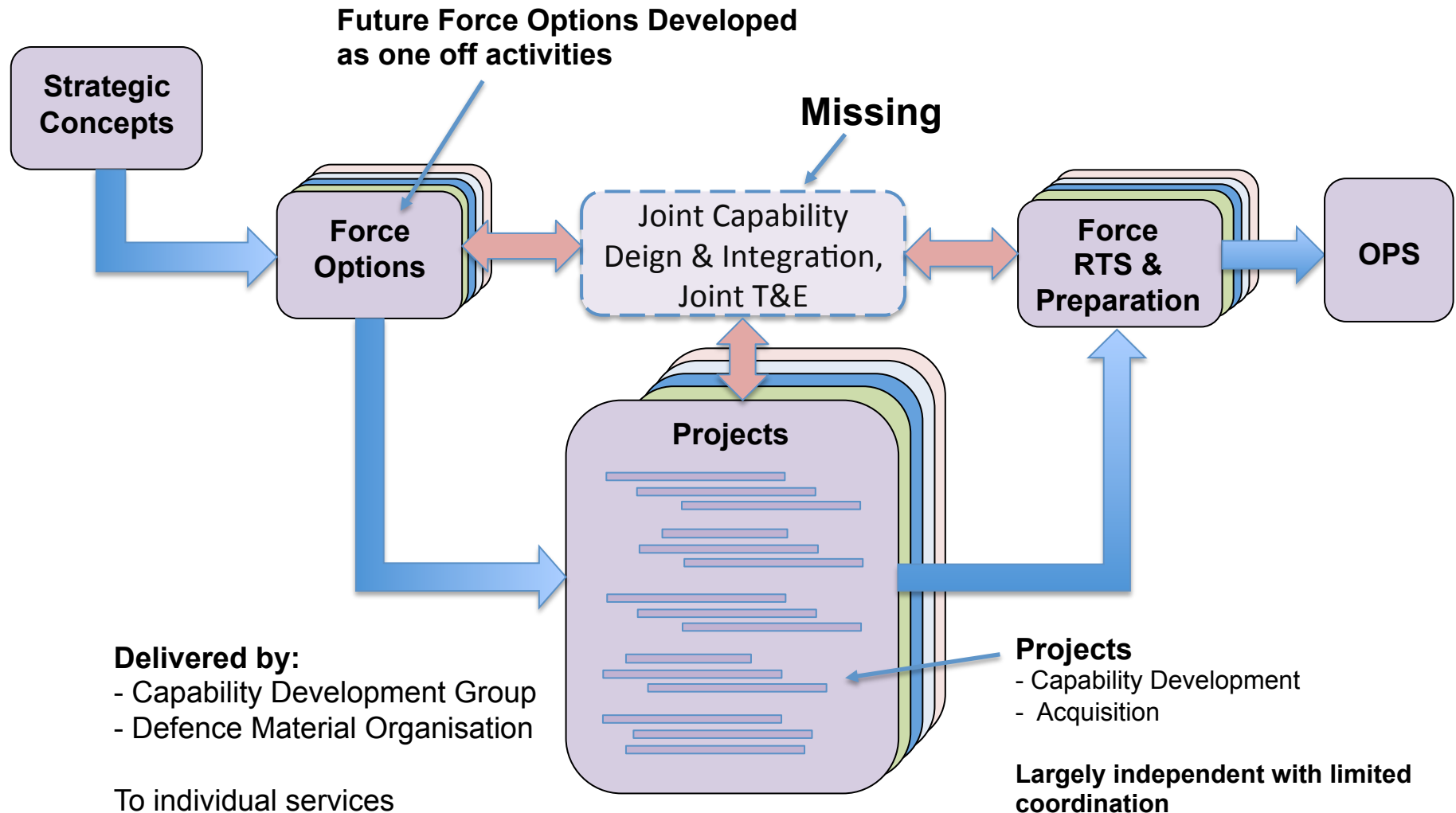
■ Domain	Defence
■ Governance	Collaborative to Acknowledged
■ Complexity	High (technical and social)
■ Stakeholder Agreement	Pluralist - Can be convinced
■ Rate of change	Systems – Moderate Environment – Rapid
■ Level	Major Defence Capabilities
■ SoS Lifetime	Enduring > component systems
■ SoS Connectivity	High
■ Sociotechnical Nature	Highly complex and varied

Application of SoSE Methodology Design Process [1]

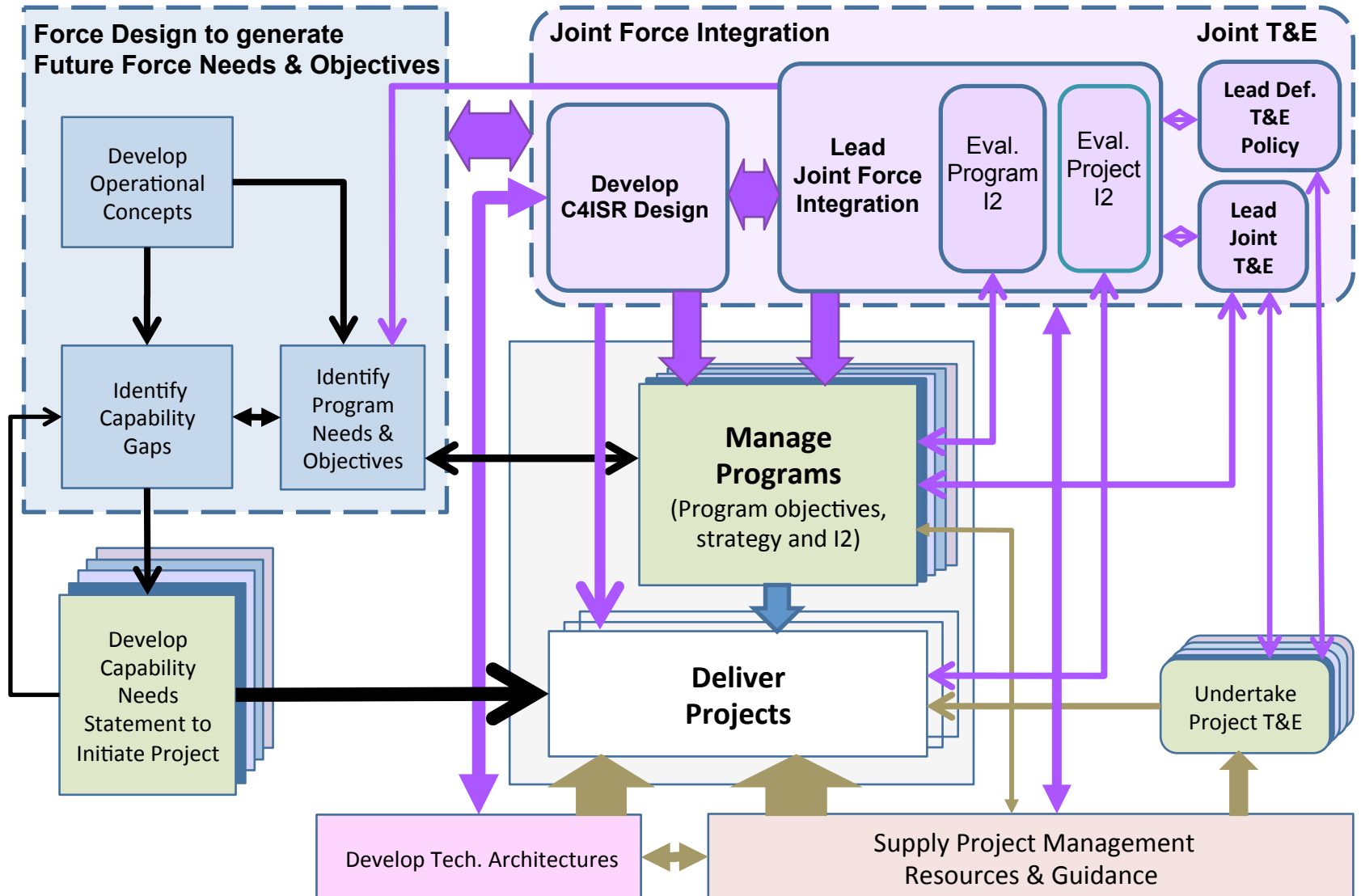
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Functional Flow of Previous CLC

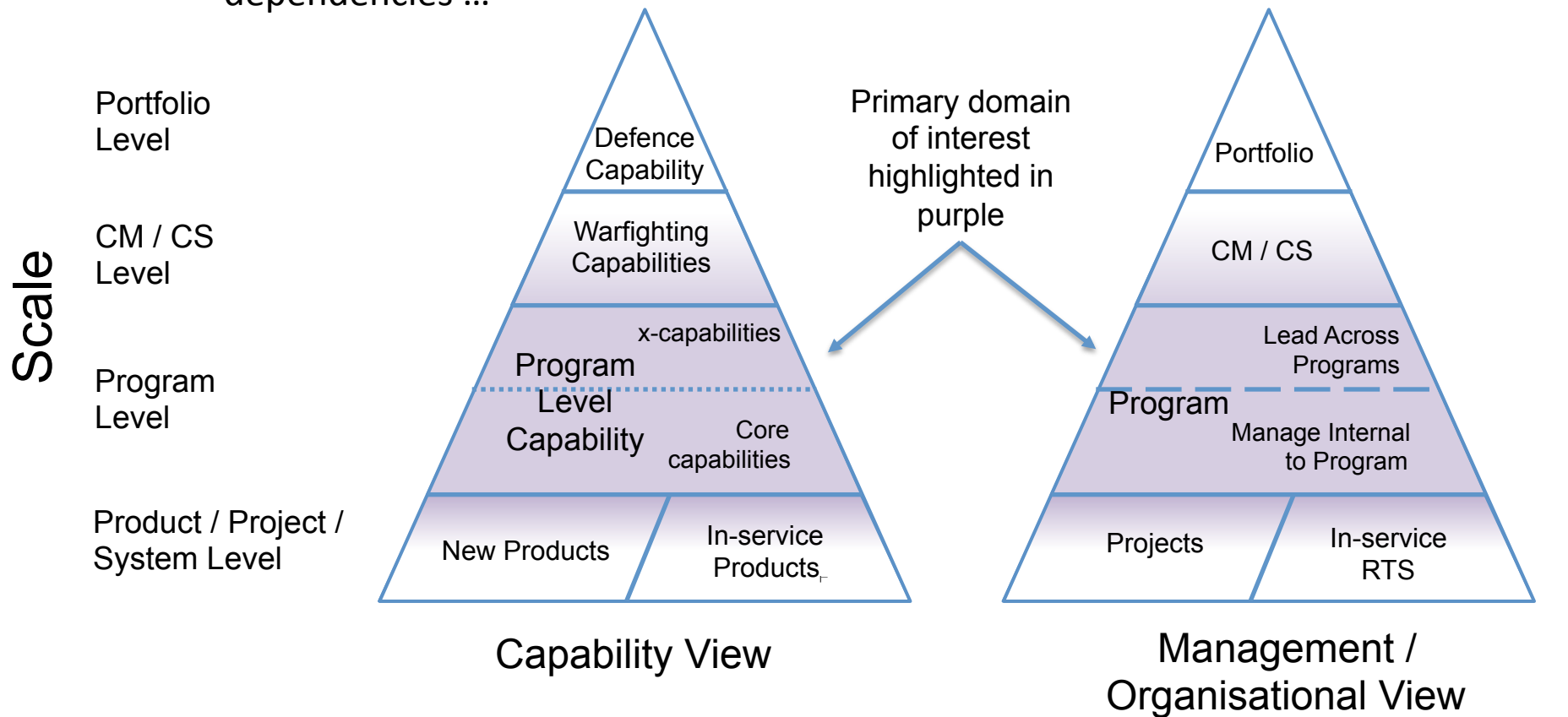


New CLC : More Detailed Functional View



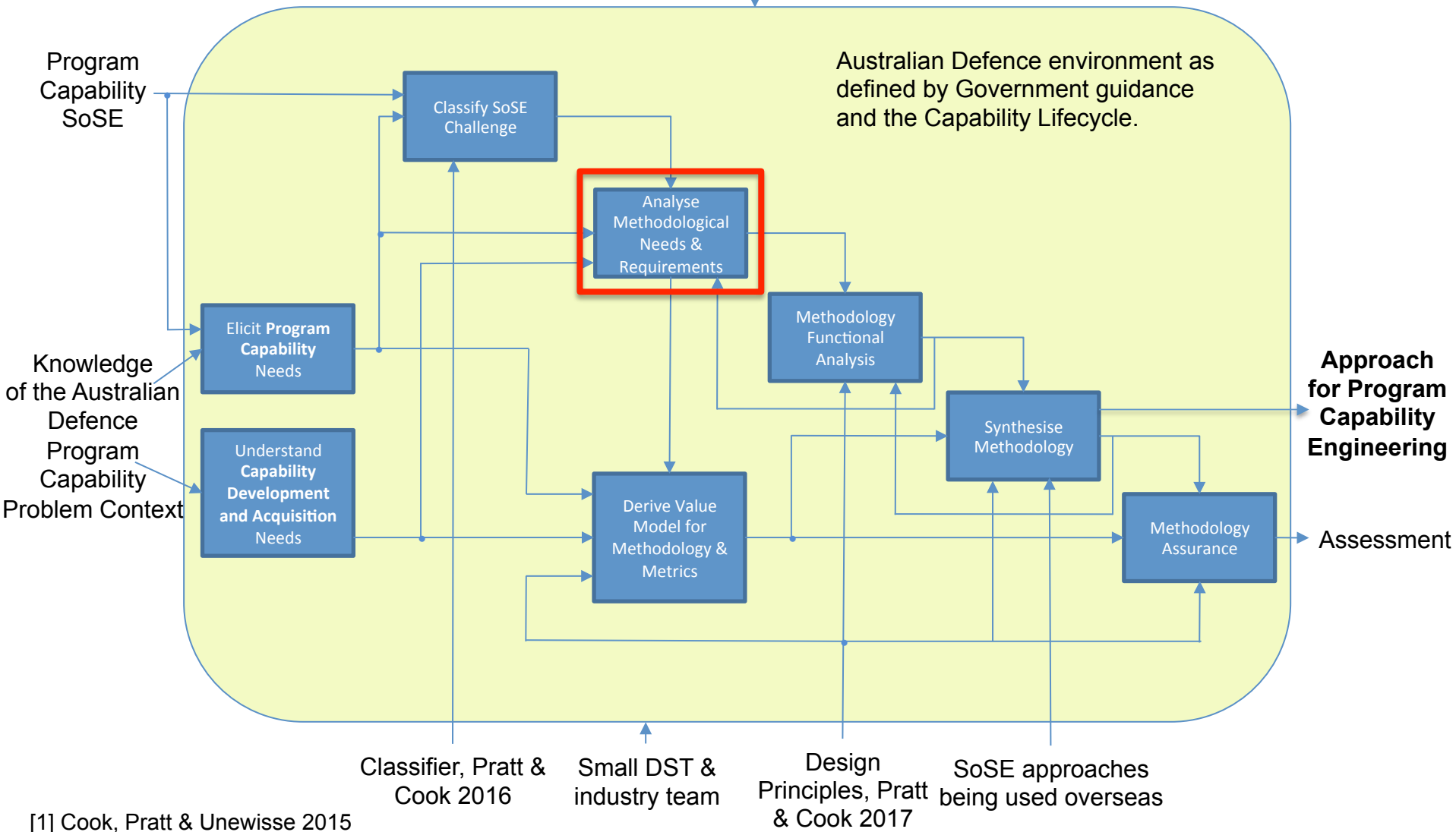
Capability and Management Views

- Need to address both:
 - 12 capability challenges – architectures, systems dependencies ...
 - Management / organisational challenges – implementation, management dependencies ...



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[1] Cook, Pratt & Unewisse 2015

Analysis and Solution Space Using SoSE Elements

- Use a simple decomposition to capture Australian Defence SoSE

- SoSE Elements:

1. Governance
2. People
3. Processes (Design)
4. Tools
5. Information
6. Culture
7. Evidence Based Approach



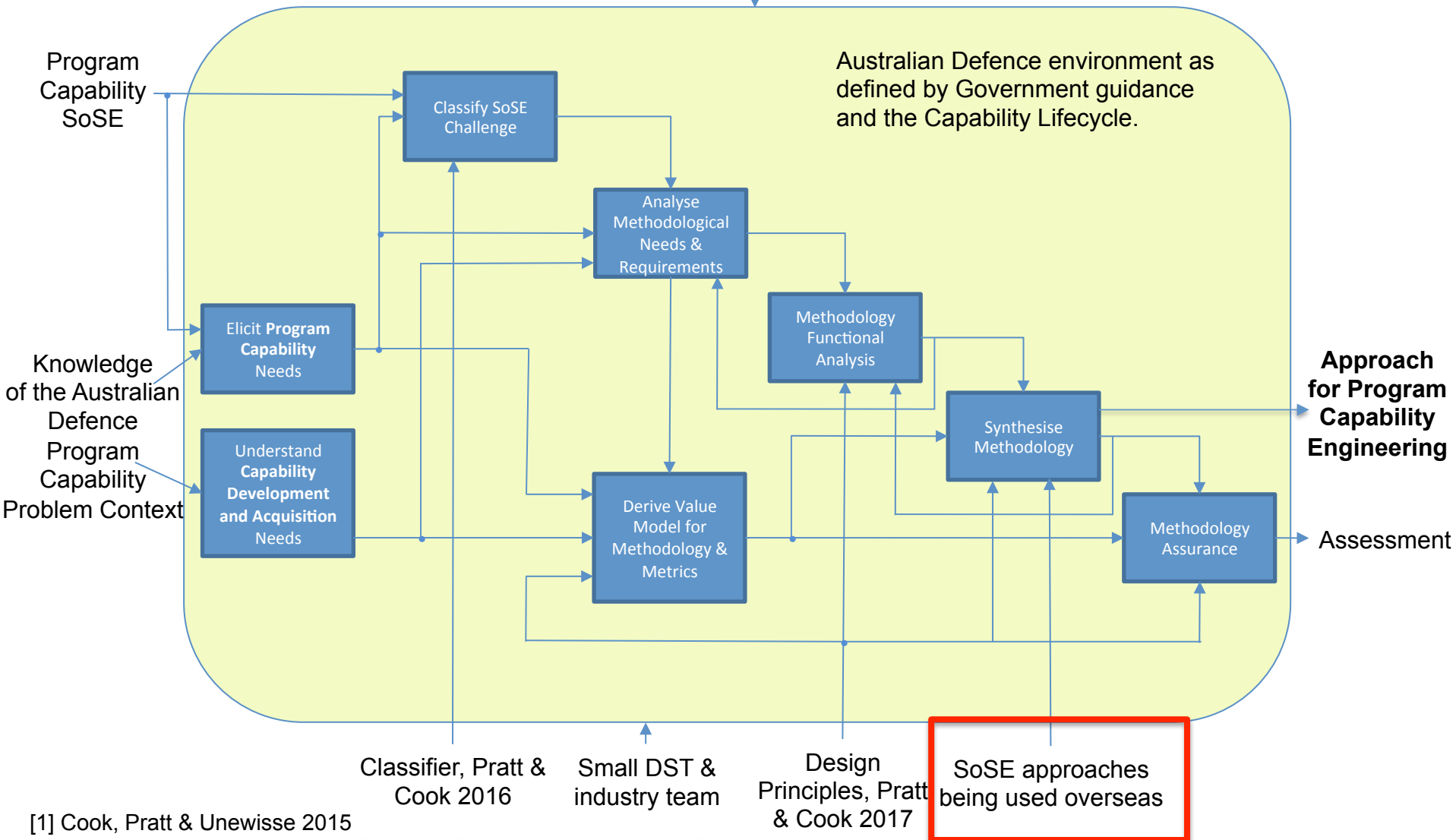
- Total of 35 Needs Identified across the 7 elements

Capture of Needs – e.g. Governance

	Governance Needs
G1	Implement high-level governance recommendations from FPR, including: <ul style="list-style-type: none">- government to focus on activities that either only government can do- eliminate complicated and unnecessary structures & systems- enable arm-length contestability- enable responsibilities and facilitate accountabilities- default to fastest and simplest decision making processes
G2	Need to clearly identify Program scope and associated lines of authority and responsibility.
G3	Must ensure that organizational and management elements are working together.
G4	Resources (people, funding and facilities) and governance structures must be agile, collaborative, flexible and innovative and address the challenges of implementing SoS capabilities.
G5	Senior decision-makers should consider making decisions at the Program level rather than on disconnected individual Project proposals.
G6	Need to ensure that there is a common understanding of the nature and scope of the SoS capability.

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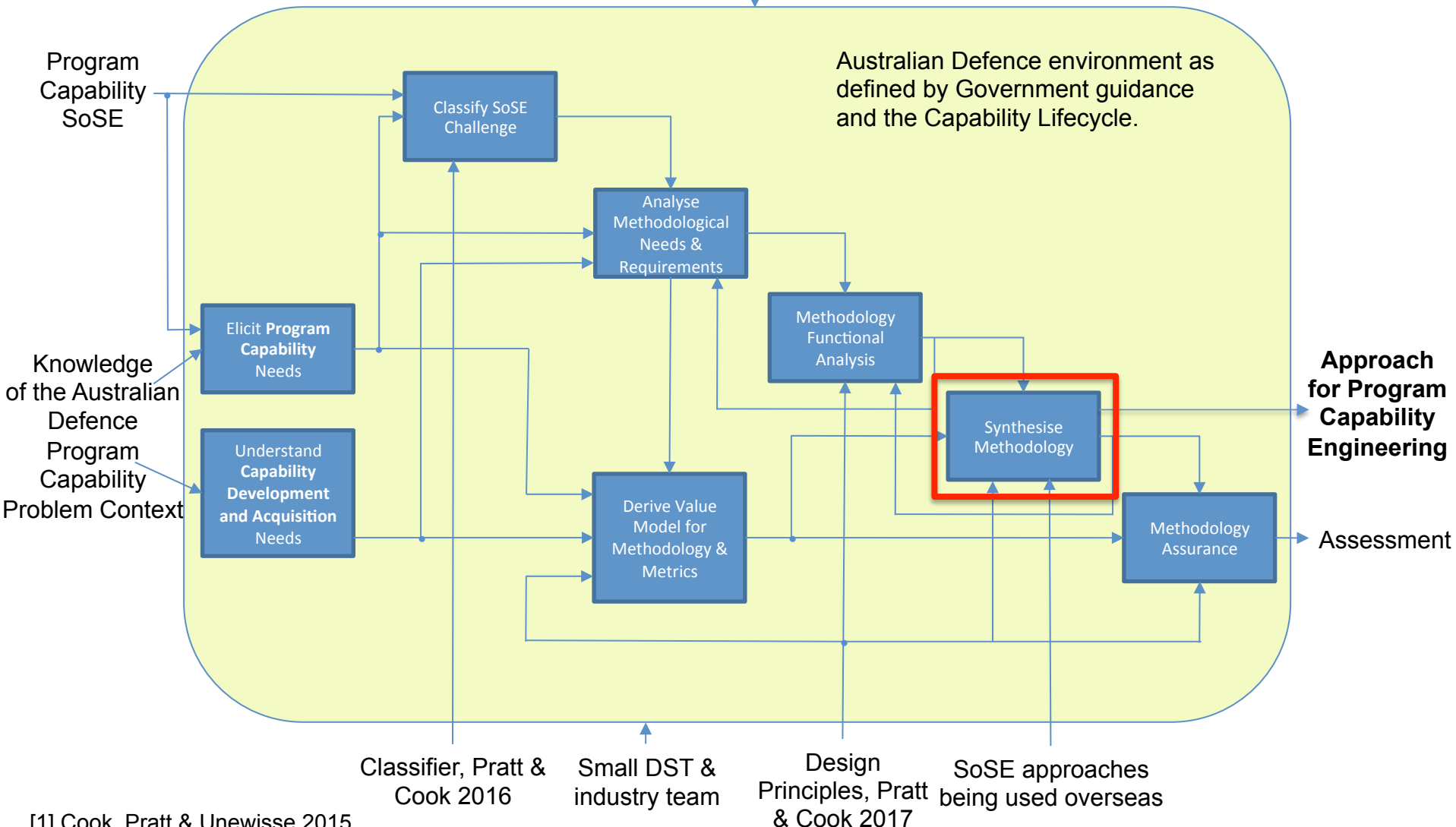
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Review of Current SoSE Approaches

- Reviewed a range of SoSE approaches that have been successfully applied:
 - Enhanced Traditional Systems Engineering (ETSE)
 - Complex Systems Engineering (CSE)
 - Dynamic Optimization of SoS using Value Measurement (DOSVM)
 - SoS Governance (SoSG)
 - US Department of Defence SE for SoS: The Wave Model
 - US Navy Mission Engineering Approach
 - The British Systems Thinking Approach (BSTA)
 - Systemic Strategic Planning and Execution (SSPE)
 - The United Kingdom Ministry of Defence (MOD) System of Systems Approach (SOSA)
- All have strengths and weaknesses
- None by themselves are suitable for Australian Defence

Application of SoSE Methodology Design Process [1]

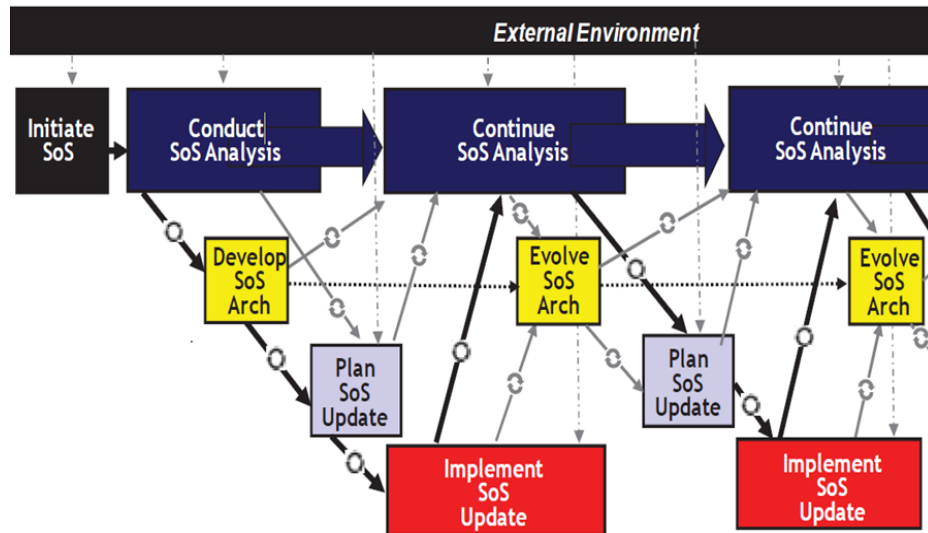
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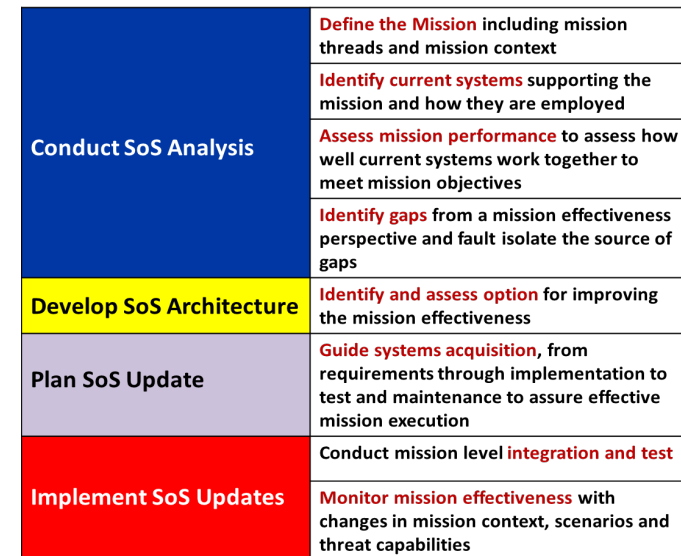
[1] Cook, Pratt & Unewisse 2015

Proposed Hybrid SoSE Approach

- Hybrid SoSE Approach for Program Capabilities
 - Broadly based on US Wave-Model
 - Cyclic model for enduring Program capabilities
 - Drawing on CSE, ESTA, DOSVM and ME approaches
 - Significant elements of US Mission Engineering approach
 - Plus drawing elements from most of the SoSE approach reviewed



Wave Model



Wave Model Mission Engineering

Features of the Hybrid Approach

- Austere hybrid with elements from most of the approached reviewed
- Designed for enduring Program Capabilities
 - Delivered in defined development stages
- Use Wave-Model steps modified for hybrid approach
 - Initial SoS
 - Conduct SoS Analysis
 - Develop and Evolve SoS Architecture
 - Plan SoS Update
- Tailorable to address diverse Program Capabilities
- Use methodology guidance rather than prescription
- Incorporates Program-level T&E
- Able to address a mix of collaborative and acknowledged SoS
- Use a minimal set of artefacts

Recommendations to Implement Approach

- Total of 48 recommendation
- General - 5
- Governance – 8
- Personnel – 4
- Processes – 10
- Tools – 5
- Information – 5
- Culture – 4
- Evidence-Based - 6

GLR1		Select an information-centric Program as the initial test case of Program SoSE.
GLR2		Apply a modified wave model as the basis for the overall approach and for the initial test case. The modification should encompass the ideas from mission engineering and complexity theory (as used in CSF, DOSVM and BSTA) to allow the approach to span both acknowledged and collaborative SoS.
GLR3	GR1	Governance Establish a set of agreements to underpin delivery of the Program capability, between the:
GLR4		- Program and its constituent System Project Offices
GLR5		- System Project Offices within the Program
		- Program and other Programs delivering Products and services required for the overall capability
GR2	PR1	Personnel Establish a small initial SoSE Team to address the initial test case.
GR3	PR2	Establish a cadre of experienced SoSE personnel that can both support the initial test case and form the core of an enduring SoSE Team that can support Programs as required.
GR4	PR3	Build a strong partnership model for the provision of SoSE expertise between government and industry
GR5	PCR1	Processes Program SoSE should be implemented as an incremental, evolutionary approach with long-term goal(s) and phased, implementable milestones that mark clear capability augmentation.
GR6	PCR2	Leverage existing SoSE processes and artefacts, while developing more systemic solutions for later iterations.
GR7	PCR3	Tools Obtain consensus on which tools to utilize. Initially, this should build on existing tools. However, it should migrate as soon as practical to tools utilizing open standard that employ databases that support direct access by application program interfaces.
GR8	PCR4	Tools should be simple to use with sufficient comprehensiveness to support Program SoSE at multiple levels.
	PCR5	Information Ensure that SoS engineering and programmatic information, as well as SE information of the constituent elements, is kept up to date and conforms (or is migrated) to an agreed ontology, including: key Project artefacts, Program artefacts, capability development databases, and architectures.
	PCR6	Culture Establish training and education to build cultural acceptance of SoSE as a key enabler in the delivery of Program-level capabilities across the CLC.
	PCR7	Establish incentives to reward and instil good SoSE behavior across key stakeholders groups.
	PCR8	Evidence-based Establish and use appropriate SoSE key performance indicators (KPIs) that:
		- can assess the effectiveness of the evolving Program capability
		- can assess the effectiveness of constituent systems options
		- provide appropriate SoSE assessment of both the capability and associated management processes
		- provide leading indicators to enable timely intervention
		- provide leading indicator feedback to the SoSE team, Program and Projects to enable timely actions in delivering effective SoSE outcomes
		- inform the Program level decision-makers of the progress against Program goals
		- inform senior decision makers of the status and progress against the high-level Program goals
		- reinforce positive SoSE behaviors and culture
		EVR1 Assess the maturity of SoSE in and across Programs to track the evolution of overall SoSE capability.
		EVR2 Implement targeted mission engineering assessment of key SoS components and plan to evolve towards an end-to-end mission engineering approach to inform evidence based decision-making for Program SoSE.
		EVR3 Establish a learn-by-doing approach supported by appropriate lessons-learned capture and dissemination.
		EVR4 Establish Program-level Operational T&E to validate capabilities delivered by the Program.
		EVR5
		EVR6

Recommendations – e.g. Governance

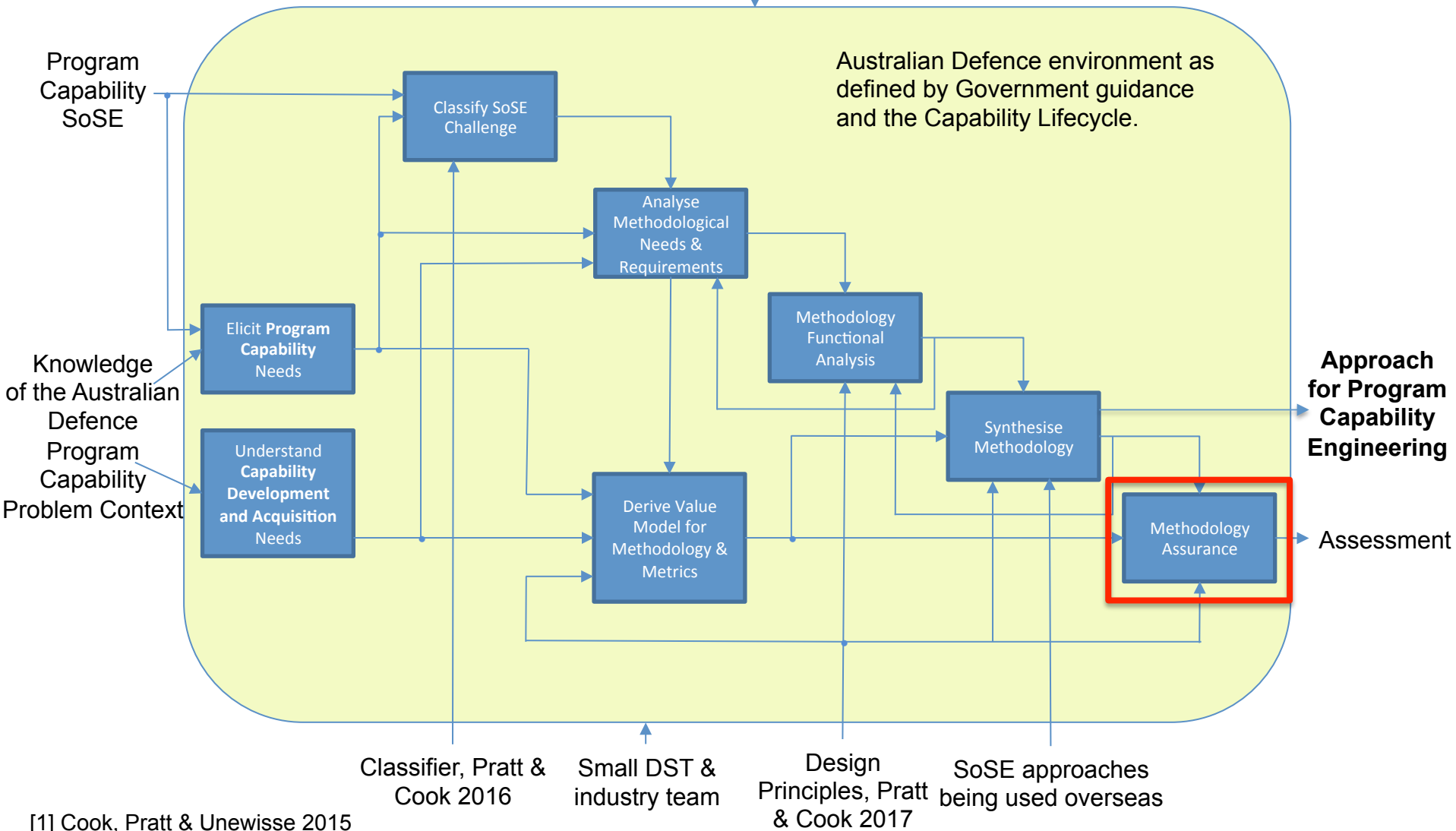
	Governance	Need
GR1	Establish a set of agreements to underpin delivery of the Program capability, between: <ul style="list-style-type: none"> - Program and its constituent System Project Offices - System Project Offices within the Program - Program & other Programs delivering Products to the Program capability 	
GR2	Distil SoSE artefacts and insights to inform senior decision-makers	G1
GR3	Clarify Program-level roles and responsibilities through the implementation of the initial test case, including the lines of authority and influence over and between the constituent Projects.	G1, G2
GR4	Facilitate collaboration between key Program stakeholders.	G3
GR5	Inform senior decision-makers of the value delivered by SoSE.	
GR6	Plan to deliver much of the SoSE mission through the agency of the constituent System Project Offices.	G4
GR7	Encourage the use of collaborative, flexible and innovative governance and approaches to support Program implementation.	G4
GR8	Encourage senior decision-makers to make decisions at the Program level, placing individual Projects within the Program context.	G5
GR8	Identify operational contexts for the SoS capability and key capability instantiations to shape the capability goals and assessment criteria for each development stage.	G6

Additional Research & Development Required

- Some of the recommendations require additional research and development, including:
 - Development of a clear SoSE value proposition
 - High-level artefacts to support senior decision-making
 - Design and Implement of a SoSE Team
 - How to migrate to a more Mission Engineering approach within the austere resources available?
 - Build and evolve Program Capability SoSE tools – model-based
 - Integration with existing databases
 - Information configuration control across multiple Programs
 - Design and implementation of incentives for good SoSE behaviours
 - Identification of key leading indicators
 - Establishment of Program-level OT&E

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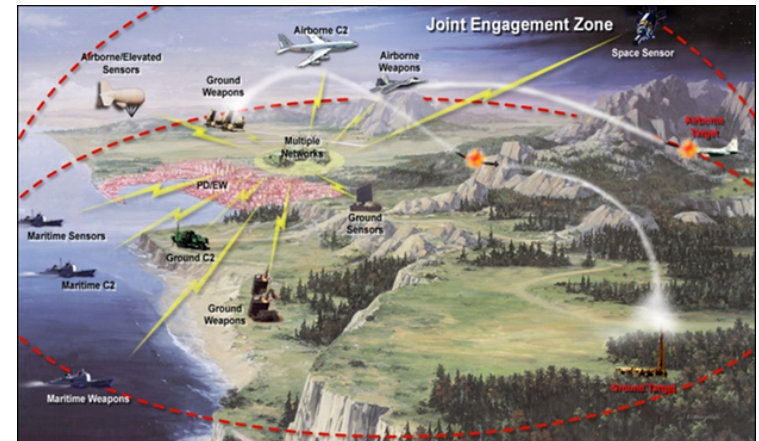
[1] Cook, Pratt & Unewisse 2015

Methodology Assessment via Initial Applications

1. Used as the basis for a SoSE review of current Program Capability Design, Realisation and Management
 - Successfully used to gain insight into and provide recommendations on Program Capability Design, Realisation and Management
2. Used as the basis of a Program Capability Integration and Interoperability (I2A) Methodology
3. Applied Program I2A Methodology to IAMD
 - Successfully applied to IAMD
 - At 'Initiate SoS' point of development
 - Provided feedback on the development of Program-level tools

Use IAMD Program Capability as a Test-Case

- Apply proposed approach to a major information centric SoS
- Integrated Air and Missile Defence as Test- Case
 - Protect from Air Threats
 - Joint/Coalition
 - Distributed Capability
 - Enhanced ISR and C2 capabilities
- IAMD Program
 - A few core Projects
 - Currently collaborative
 - Migrating towards acknowledged
- Elements from multiple other Program



Conclusion

- Australian Defence is Implementing a New CLC
- Program-level a key innovation
 - Programs of a better way to manage elements of Portfolio
 - Deliver via Project
 - Shape and deliver Program-level Capabilities
- A hybrid SoSE approach developed for Program Capabilities
 - Broadly based on the 'Wave-Model'
 - Drawing an many other existing approaches
 - Austere and tailorable approach
- A range of recommendations to implement proposed approach
- Successfully being used as the basis for SoSE developments in Australian Defence

QUESTIONS