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Systems Engineering Program

# Systems Engineering Analysis to Improve Concept Development of Complex Defense Systems


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**Improving operational effectiveness through C4ISR common integrated solutions**

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# Purpose

Define the framework for an investigation to improve concept development of new-start and reengineering of complex defense systems and systems of systems.

Formulate Systems Engineering approaches through systemic analyses to provide feedback into future policy, guidance, education, and training updates for Concept Development environment, methodology, tools and skills to increasing effectiveness of SE in Concept Development.

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# Current Environment

Increasing System Complexity (SoS)

- Network centric and extension of system applications are driving more integration
- Functional and physical interfaces expanding in number and complexity
- New approaches to testing balanced with modeling and simulation must match new system of systems requirements

Experienced but Aging Work Force

Not sufficient Systems Engineering education, research and training resources to meet needs

| Issue | Single System | System of System |
|---|---|---|
| Constituents | All known and visible | Changing, potentially unknown<br>May not know is part of SoS |
| Purpose | Predetermined by system owner and conveyed to constituents | Continuously evolving, cooperatively determined, may or may not be known by systems participating in SoS |
| Control | Hierarchically structured | No control in SoS |
| Requirements | Defined and managed by System Owner | Often required to anticipate how system will be used |
| Ownership | Pieces developed are owned, maintained, and evolved by owner | Independently owned, developed, maintained, and evolved |
| Boundaries | Closed with clearly defined boundaries | In general, unbounded and part of a larger SoS |
| Visibility | All aspects seen, understood and controlled | Components and process aspects beyond control and visibility of developers, users, and owners |

Smith, et al. SEI, 2006

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# Objective

Develop a framework for identification of overlap, gaps and needs based on current and evolving DoD program acquisition policies and regulations

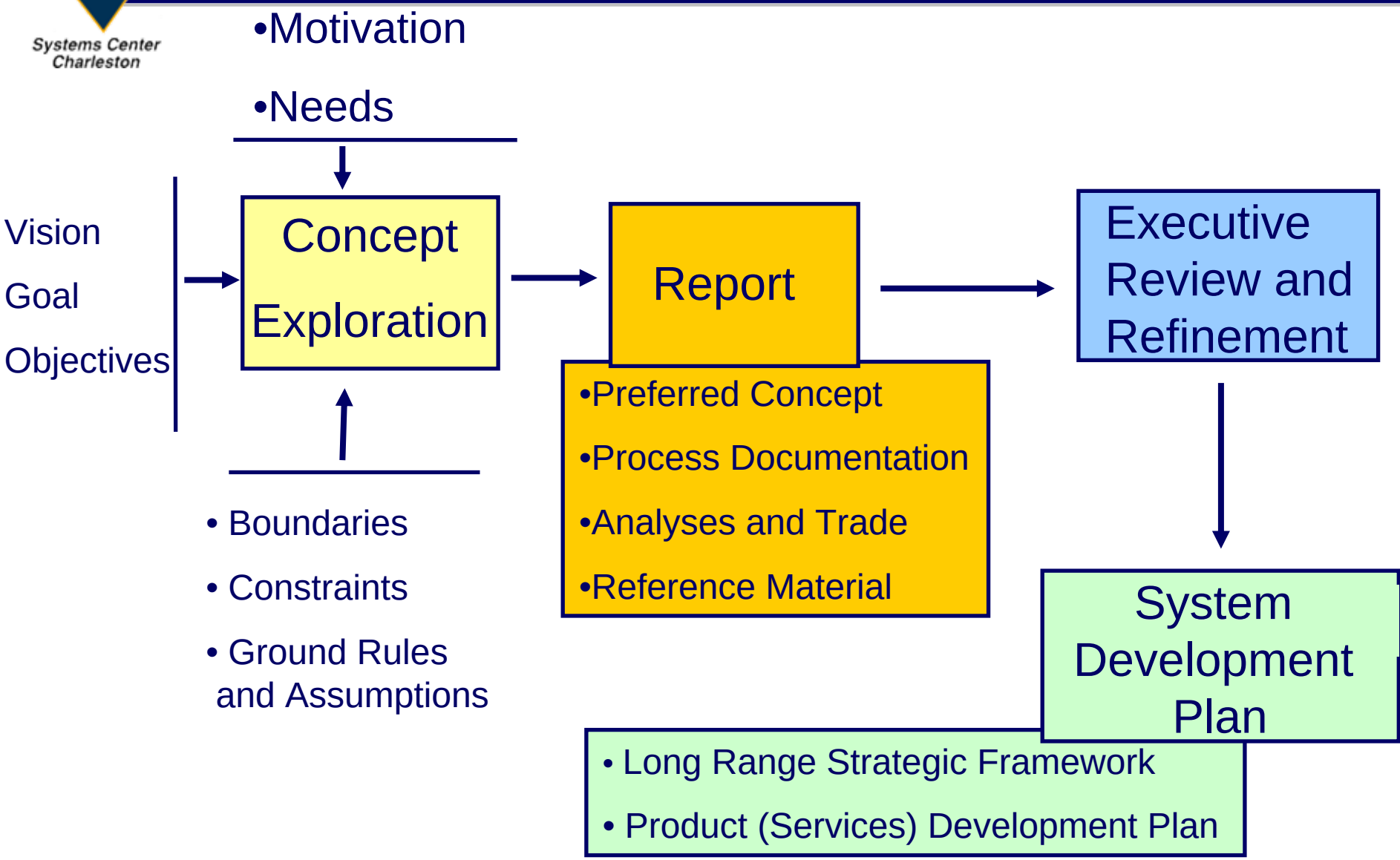
- **Identified to determine improvement candidates**

Specific focus directed at earlier “real” consideration of critical elements

- **Reliability, Availability, Logistics (sustainment), Security and Disaster Tolerance**

Directed at Aerospace / Defense / Security sectors

# Research Framework



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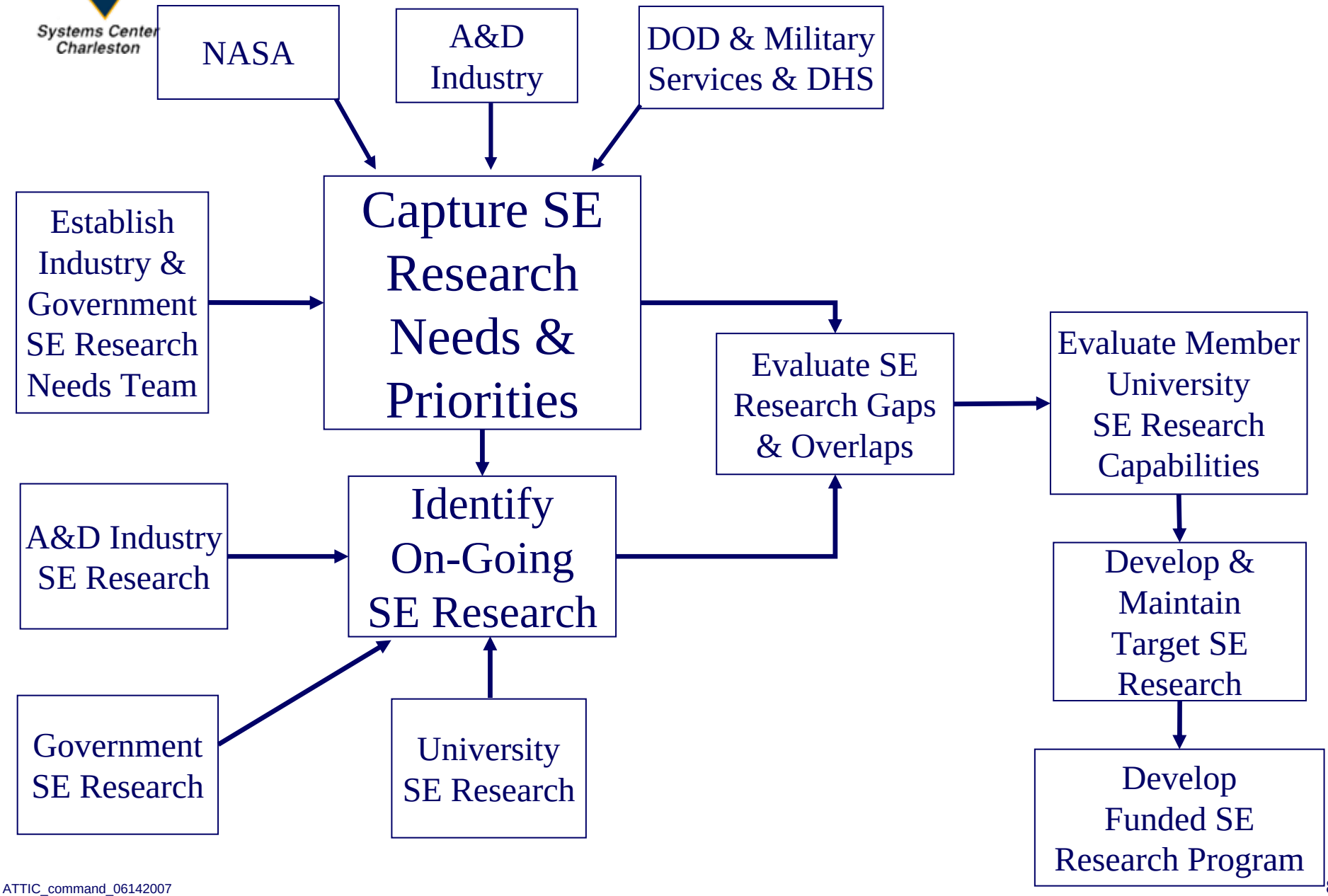
# Methodology

Specific tasks necessary to evolve the framework

- Industry and government needs capture and assessment
- Identification and analysis of capabilities
- Analysis for gaps and overlaps with respect to needs
- Explore and define alternatives for needs response
- Evaluate and refine alternates to evolve preferred concept
- Strawman research framework development plan

# A&D SE Research Process Concept



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# Critical Elements of Defense Engineering of Complex Systems

Critical elements identified for engineering of complex defense systems

- SoS Critical Element Reliability and Availability
- SoS Disaster Tolerance
- SoS Security
- Culture and Infrastructure

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# Critical Element
## SoS Reliability and Availability

Metrics

- Mean Time between SoS maintenance and support
- Expected Failure free SoS operation time: MTBF
- SoS Mission Success Probability
- Probability of SoS being ready for use

Features that determine SoS

- Likelihood of being ready for use / mission success probability
- Life cycle cost in terms of product and customer support

Consequences not considering R&A as critical SoS elements

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# Critical Element SoS Disaster Tolerance

## SoS Disaster

- Catastrophic Failure in System A can Result due to Missing Requirement in System B
- Disaster Tolerant Driven Requirements Definition MUST OCCUR at SoS Level

## Enormous SoS Complexity Necessitates

- High-level, Manageable SoS Model with “What-if” Analysis Capability (SysML?)
- Simple, Robust Injection of Failure Models in Component SoS Systems
- Capability to Ensure DT in Presence of Failure Model

# Critical Element SoS Security

- Ensuring access and functional security difficult for single component
- Exponentially more difficult for SoS
  - Internet-based access architecture
  - Shortened development and deployment cycles
  - Integration complexity
  - Costly and time-consuming
- Model-Based Security Testing
- SysML models for security testing
  - Attack models
  - Verification vs. validation
  - Integration security?

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# Critical Element
# Culture and Infrastructure

## Characteristics of DoD and Corporate Culture

- Identify cultural norms of enterprises (DoD and contractors)
- Understanding cultural norms wrt senior management decision making
- Influencing the growth of enterprise cultures

## Leveraging DoD/ Contractor Infrastructures and IP

- Understanding competing DoD & contractor needs
- Leveraging/reuse of prior design to shorten development timelines (set-based concurrent engineering)

## Role of Systems Engineering in Enterprise

- Identification of SE role with respect to PM and senior management

## Role of Initiatives

- CMMI (Effects on Corporate Culture)
- Lean, Six Sigma and Collective System Design

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# Implementation

Advancing SE Technology

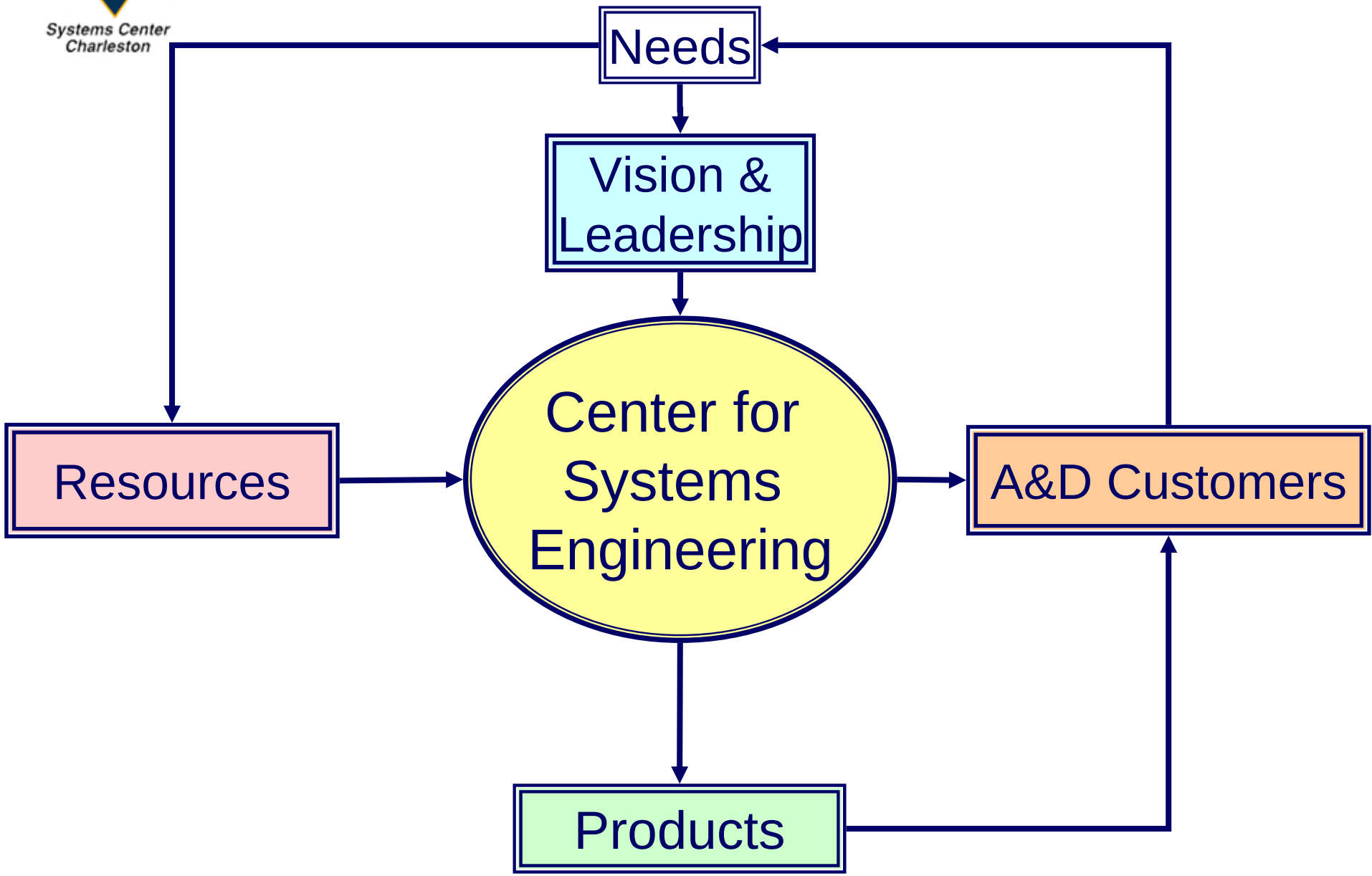
SE Think Tank

Center for Systems Engineering

Engineering Work Force Advancement

An Industry-Government-University Partnership to Improve Development of Complex A&D Systems

# Functional Concept



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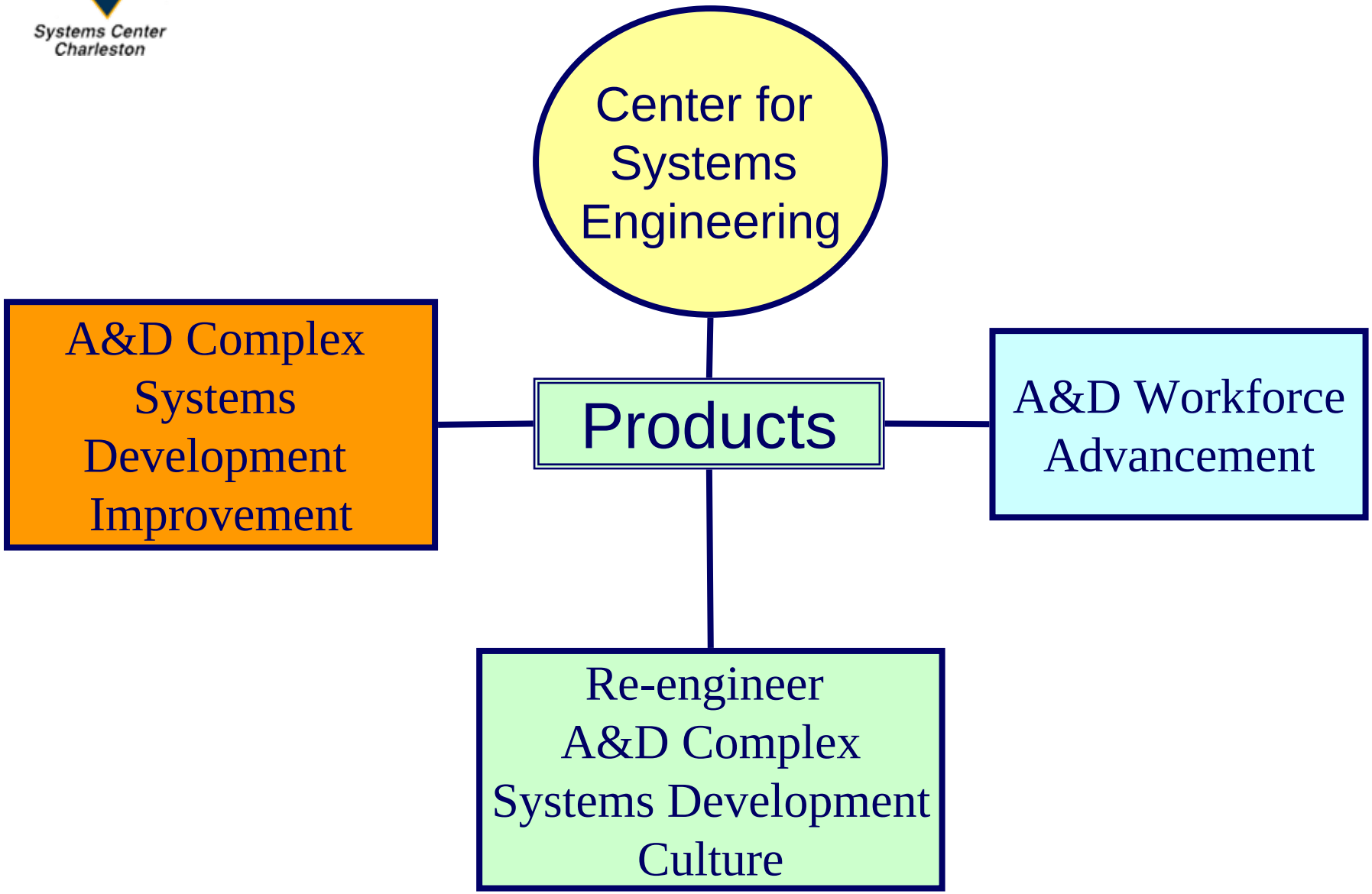

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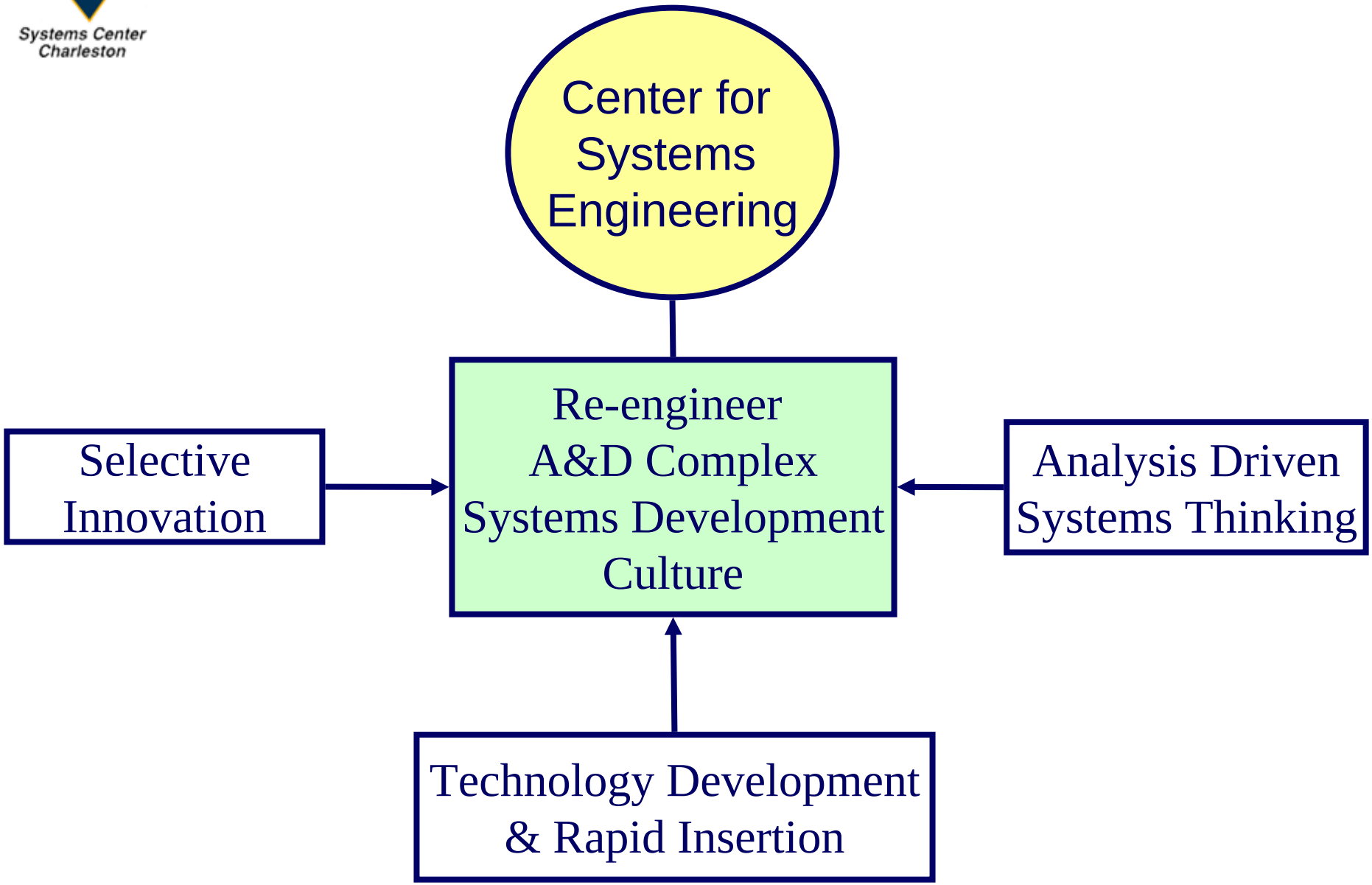

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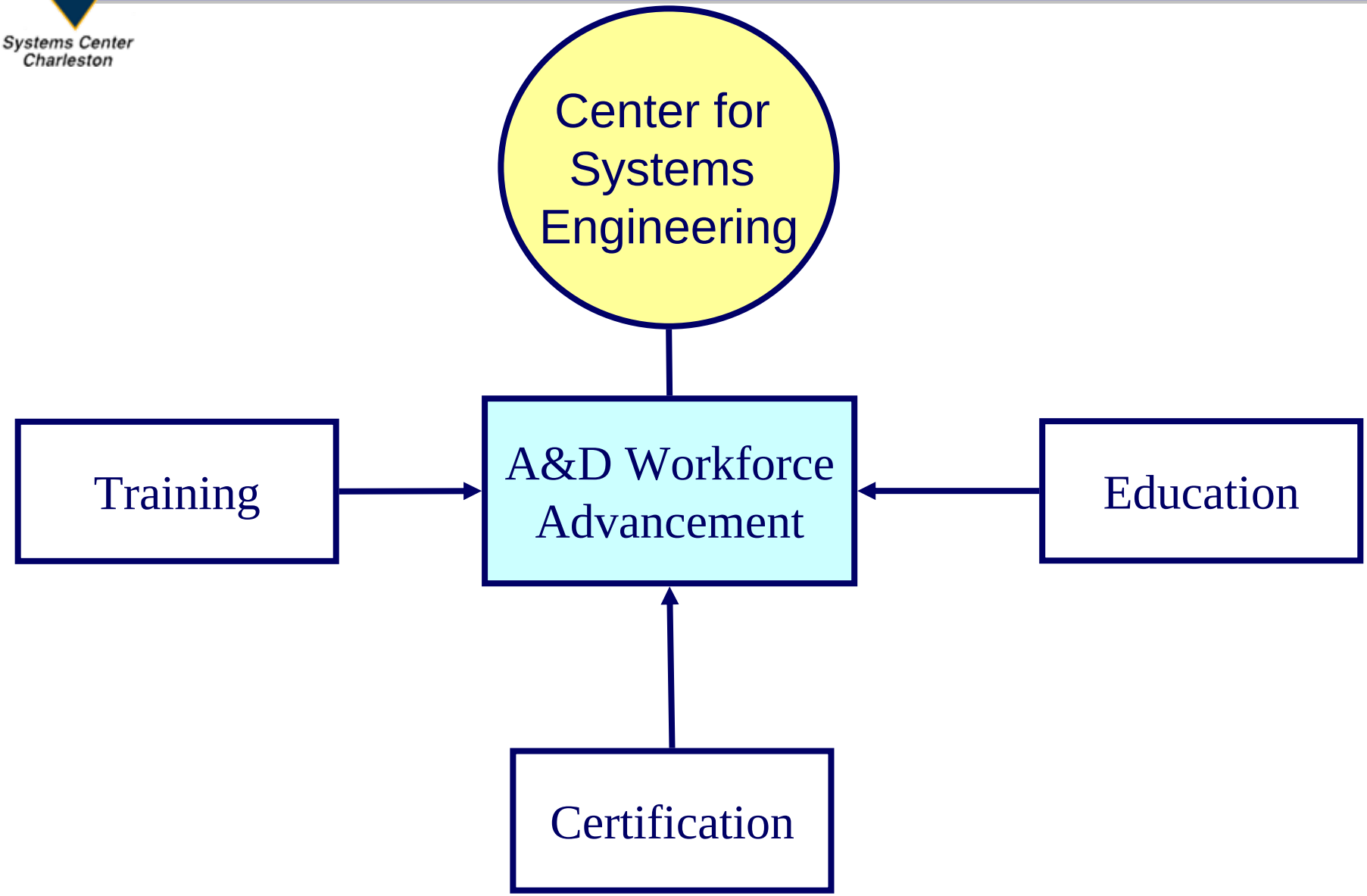
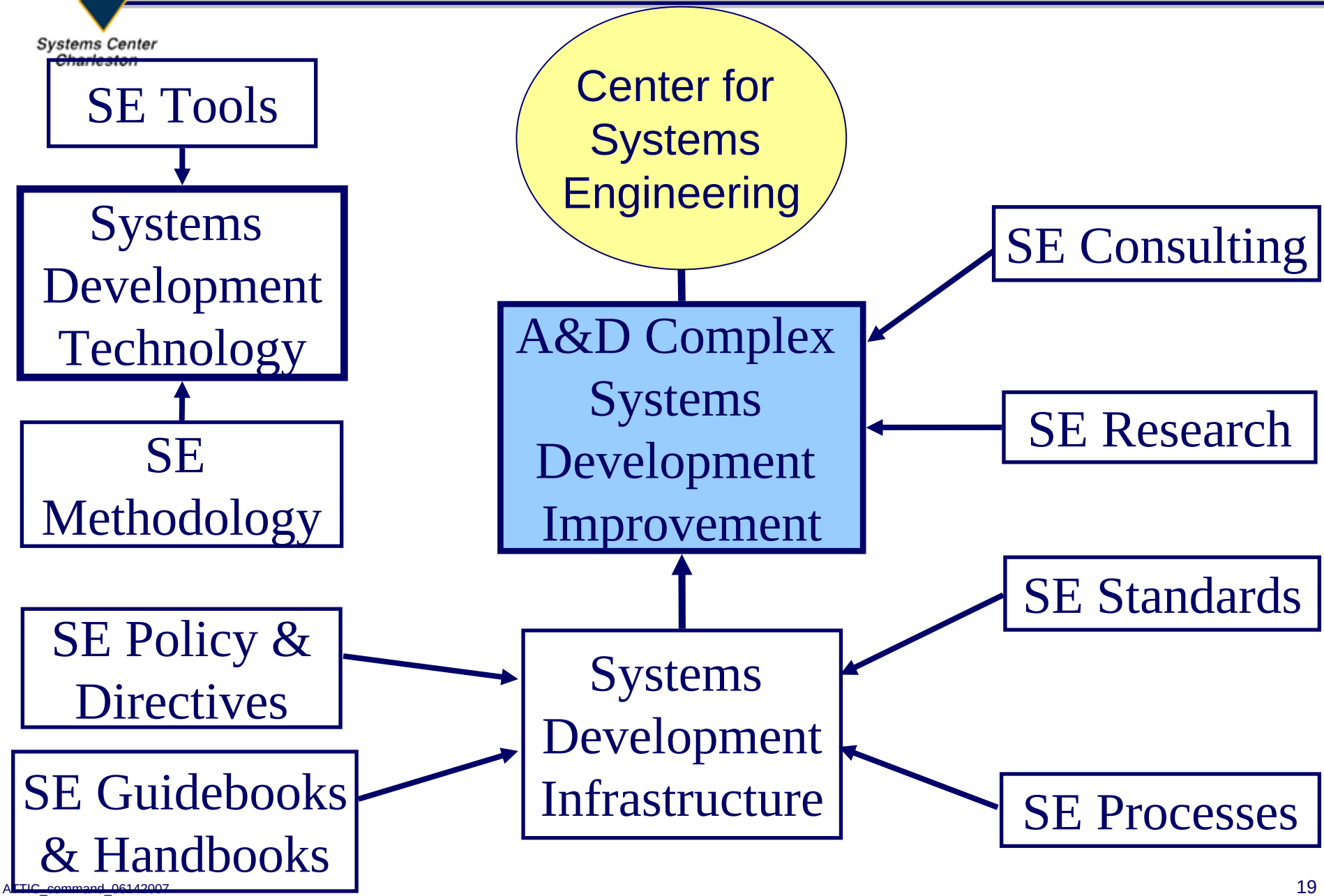


# Complex Systems Development



# Center for SE – Overview Concept

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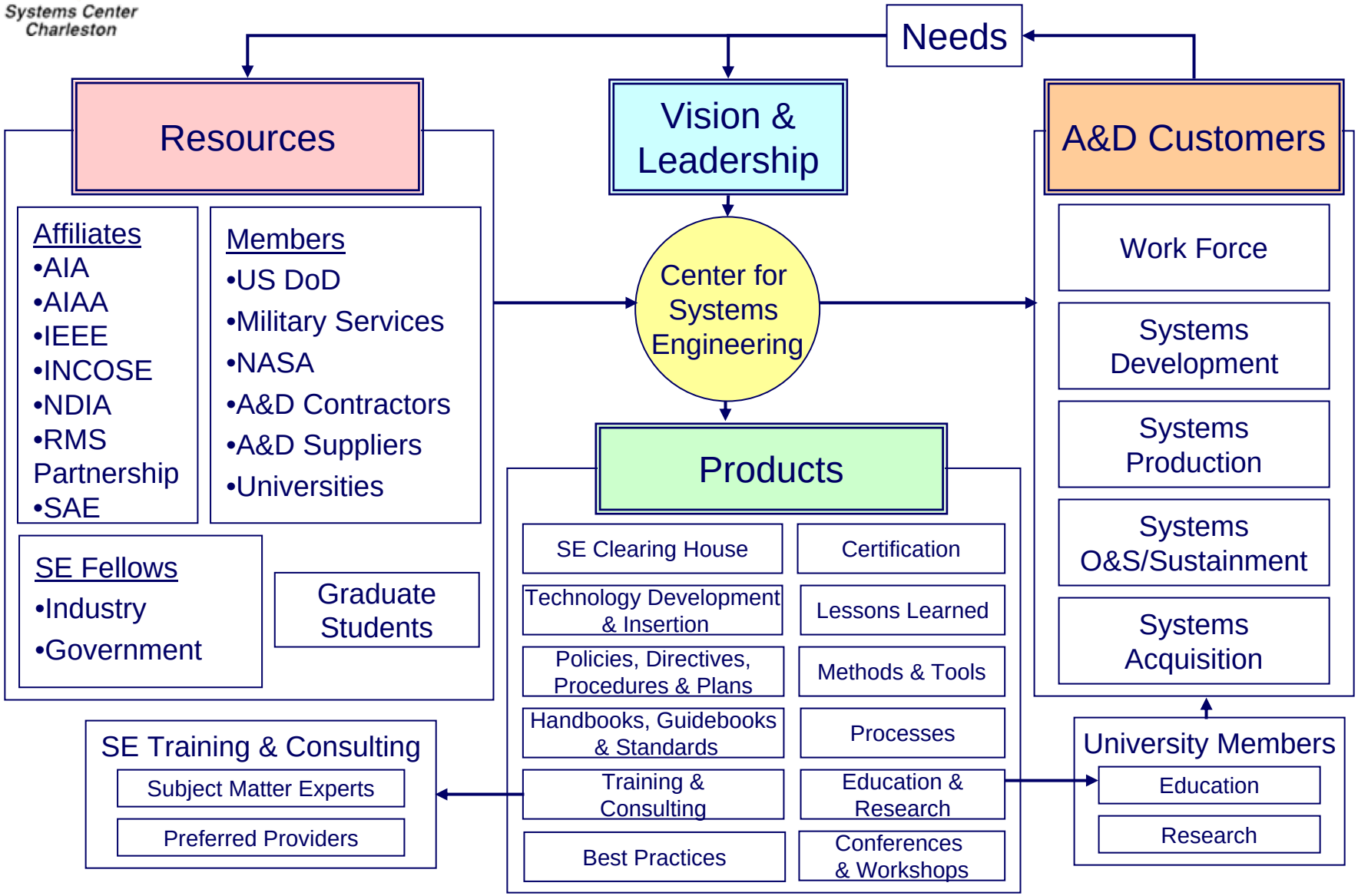

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# Summary

- Vision, Goal and Plan Formulated
- Research Initiatives Evolving
- Key Meetings Planned
- Team being Expanded – Task Driven

Challenge is to focus resources on Concept Exploration & Definition – Not Detailed Design

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# Thank you!

## Questions?