A Distillation of Lessons Learned from Complex System of Systems Acquisitions

Richard Turner, Dinesh Verma Stevens Institute of Technology
Mark R. Weitekamp, ANSER
Ann Tedford, Federal Aviation Administration

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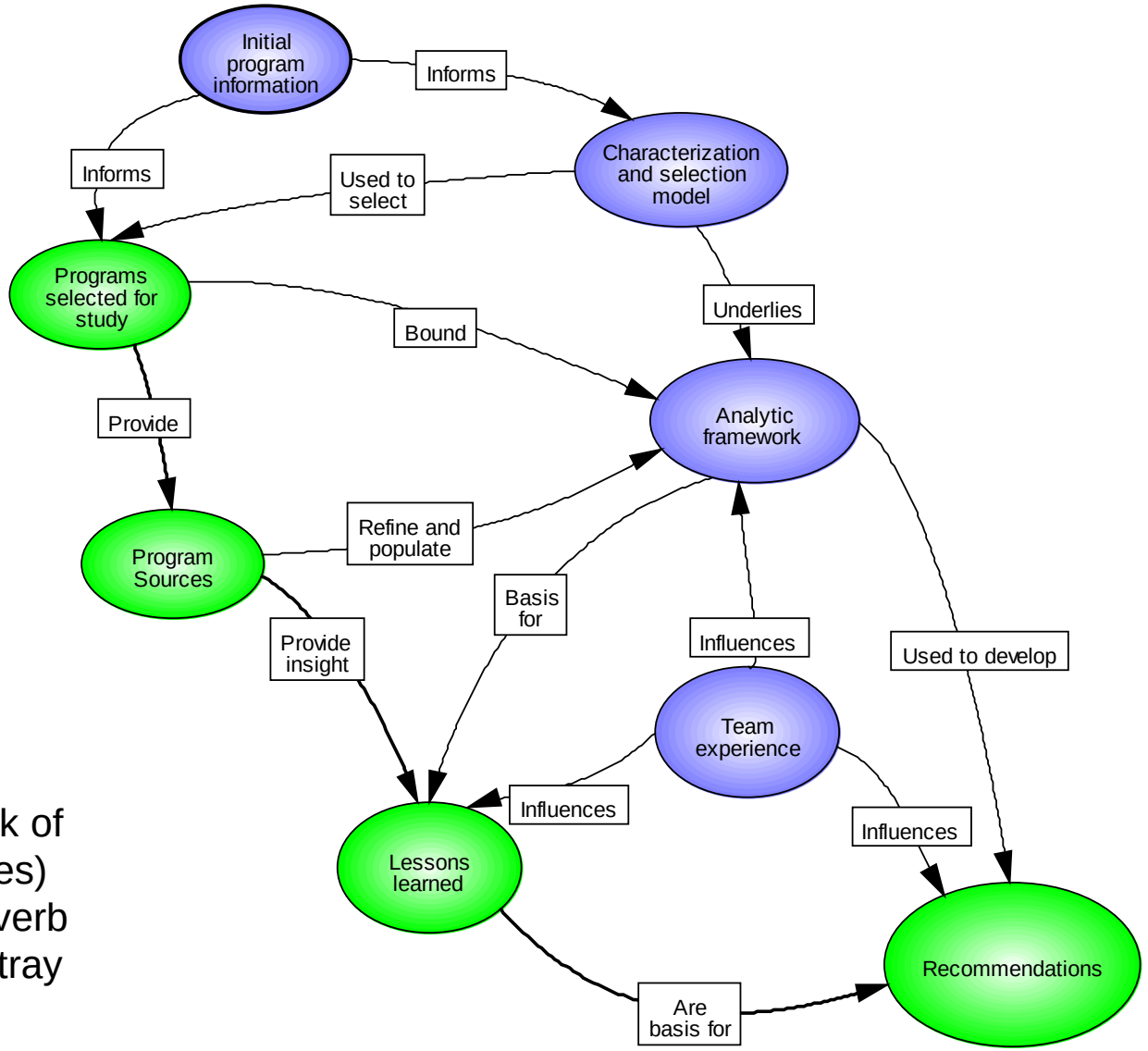
The Project

- To support FAA NextGen, Stevens tasked to
  - Study lessons learned from comparable large-scale, complex systems-integration projects
  - Make specific recommendations to FAA
- Study goals
  - Consider programs largely similar to NextGen.
  - Interview key decision-makers and leaders (e.g., program managers, chief engineers).
  - Identify lessons learned that are specifically applicable, rather than generic, to NextGen.
  - Place specific emphasis on governance approaches.
  - Provide clear, relevant, and implementable recommendations.

NextGen

- Broad in scope and significant in functionality
- Will change air traffic control by exploiting new technologies to enable
  - satellite-based navigation and surveillance
  - digitally communicated routine information
  - improved data accessibility
  - more effective air traffic “management”
  - weather forecasts embedded into air-traffic-control decisions
  - continued operation in lower visibility conditions
  - intelligent, prognostic safety functions.
- Multi-phase acquisition program spread over an extended time period.
- Unprecedented number, influence and diversity of critical stakeholders

Research Activities Systemigram



A systemigram™ is a network of nodes (nouns or noun phrases) and directed arcs, (verbs or verb phrases) that graphically portray the meaning of the prose.

http://www.boardmansauser.com/thoughts/systemigrams.html

Key Comparative Programs

- International Space Station (NASA)
- Future Combat Systems (United States Army)
- Deepwater (USCG)
- Ballistic Missile Defense System (MDA)
- Internet/World Wide Web (Commercial)

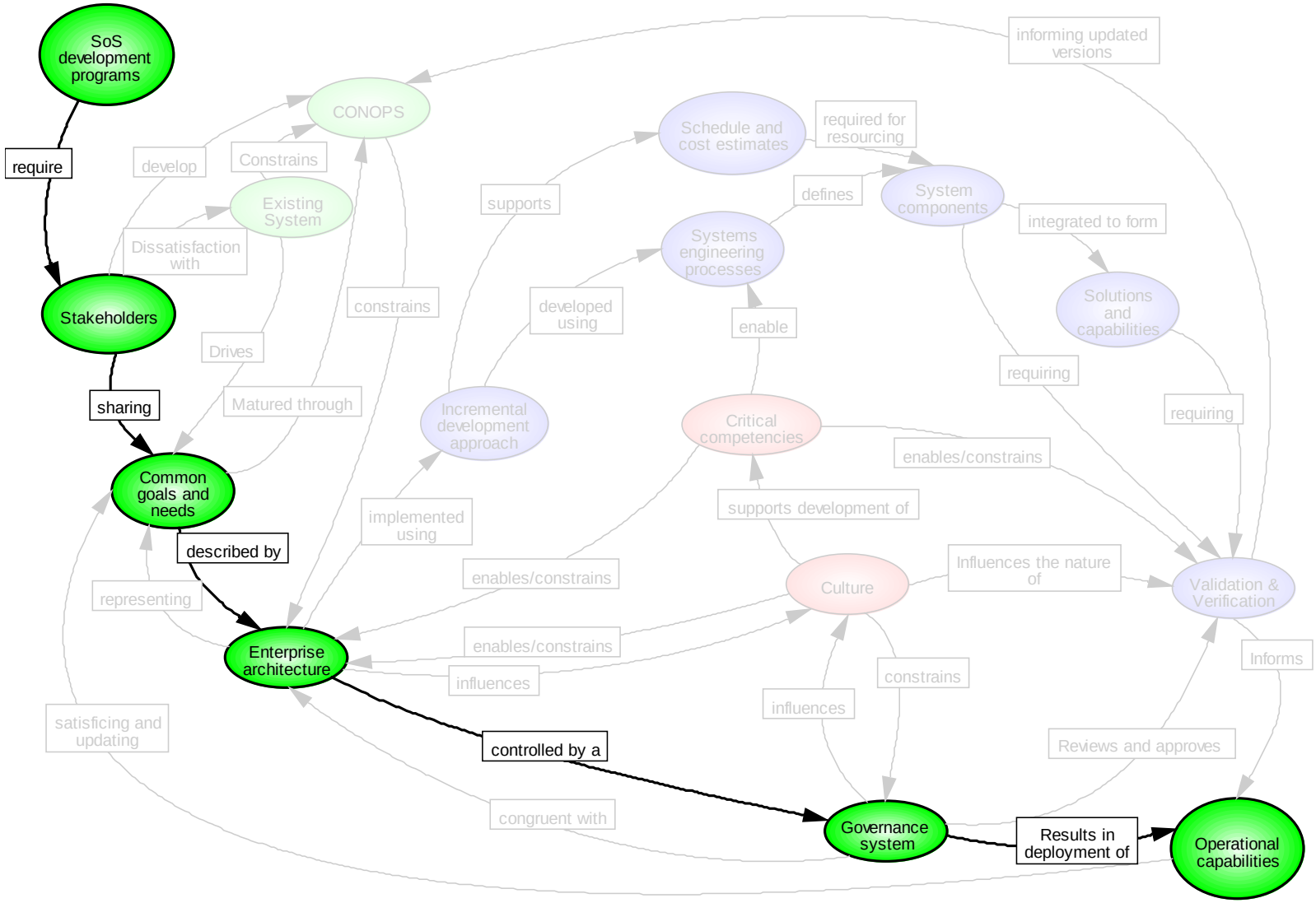
Key Observations

- CONOPS
- Enterprise Architecture
- Governance System
- Acquisition and Implementation Approach
- Critical Competencies
- Validation and Verification
- Cost and Schedule Estimates
- Organizational Culture

Analysis Framework

Development Environment	Knowledge Concerning System Developers
	System Stakeholder Diversity and Complexity
	Structural Complexity
	Program Uncertainty at Program Start
	Deadline Driven
	Significant Changes to Doctrine or Operational Policy Required for System Success
	Product Precedence
	Mission Predictability
	Technology Novelty
	Replace Existing System
	Number of Evolving and Interdependent System Developments within a SoS
	Type of SoS (Department of Defense definitions))
Development Approach	Approach to Requirements Development
	Concept of Operations (CONOPS) from inception
	Interface Maturity
	Validation and Verification (V&V)
	Governance system
Out-come	Success/Failure

Foundation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Constrains
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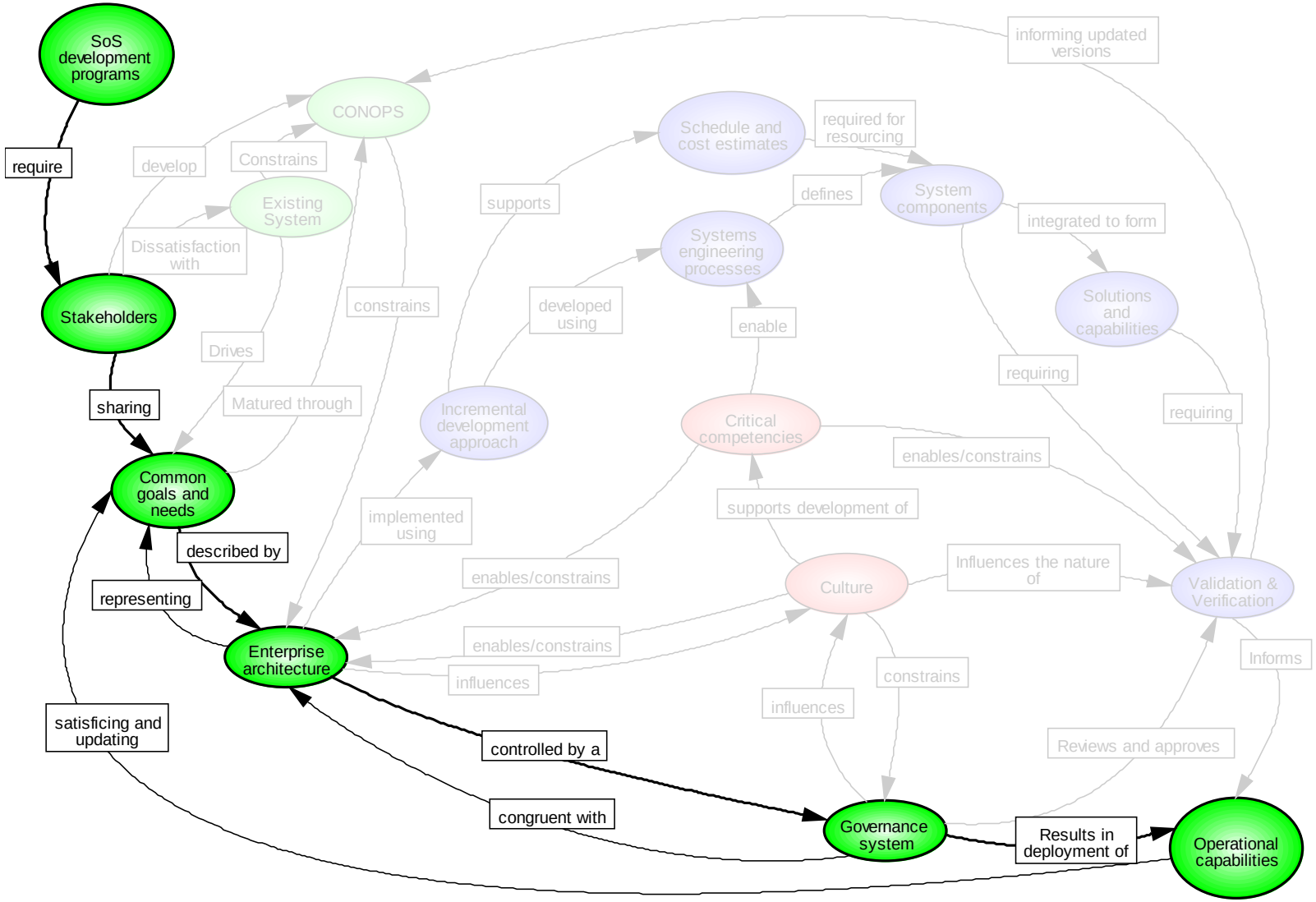
Alignment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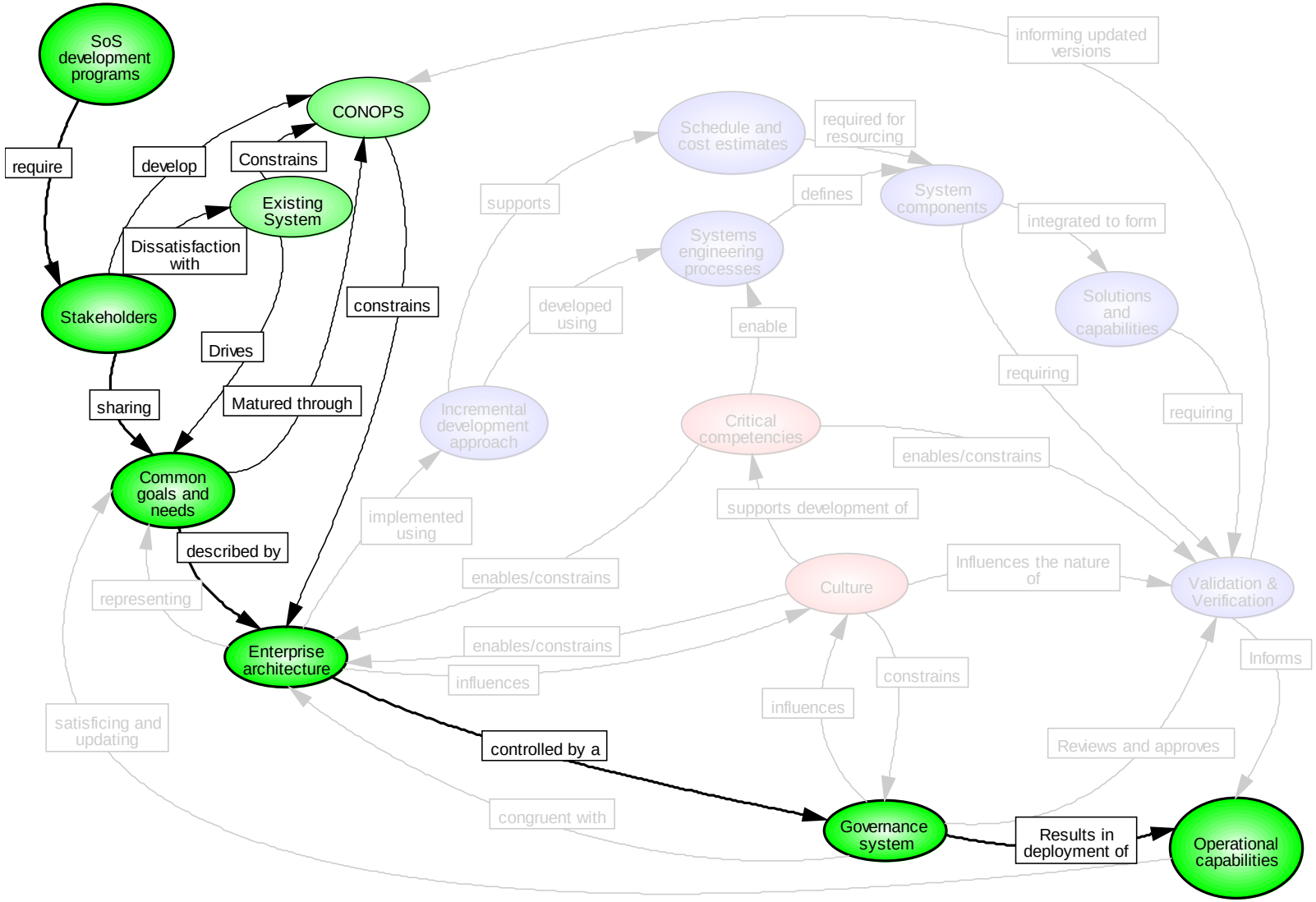
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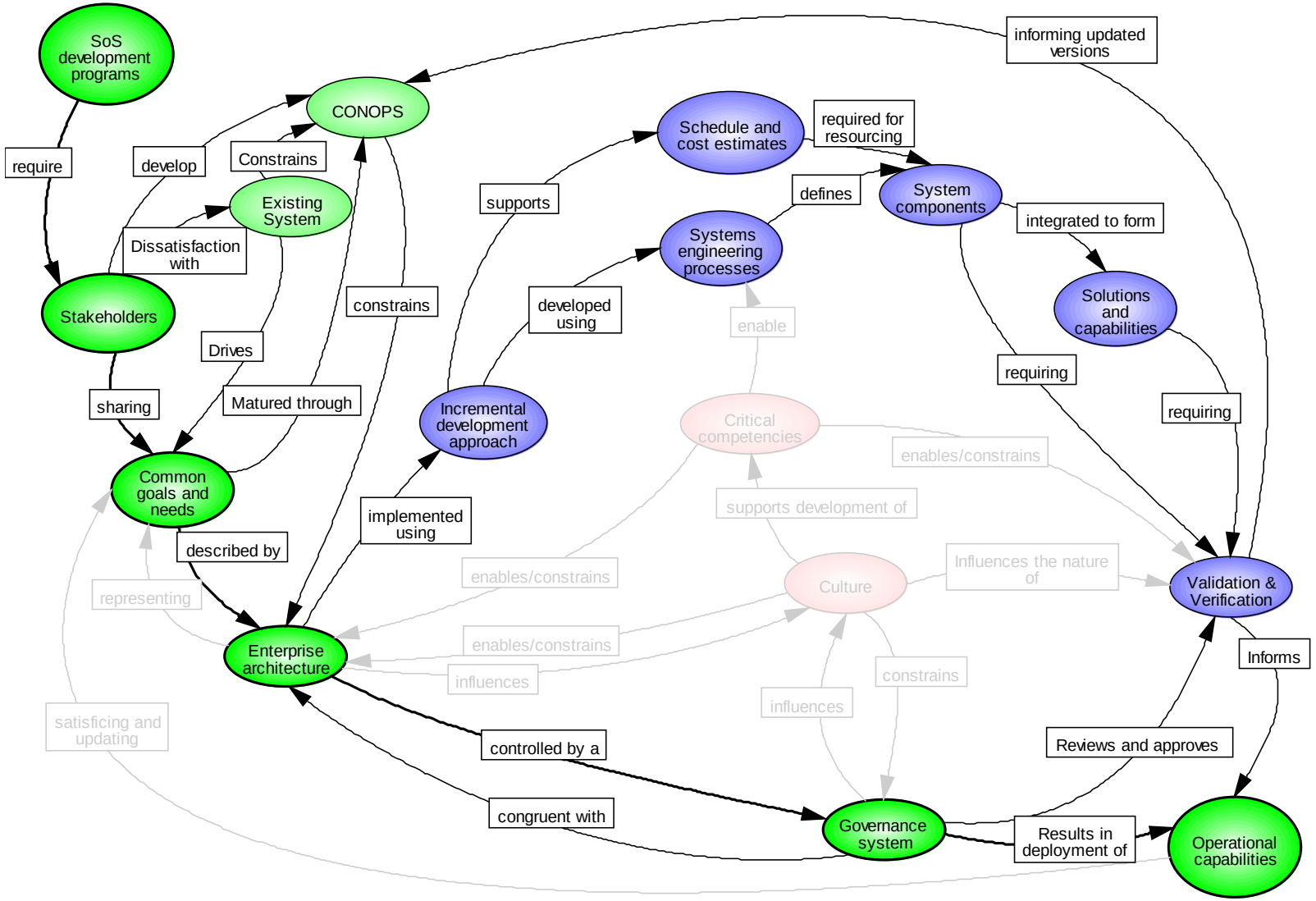
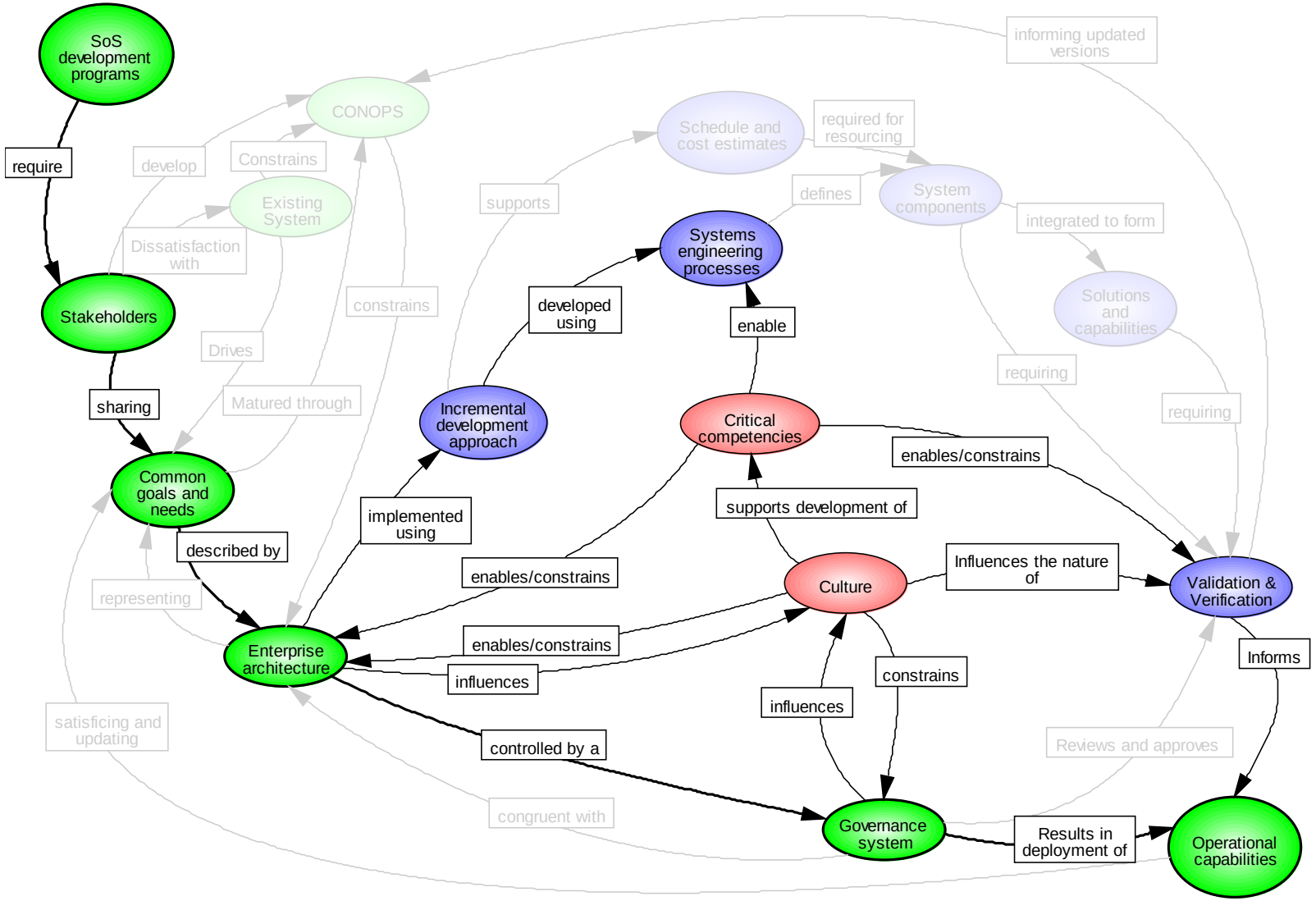
Second-Order Concerns



People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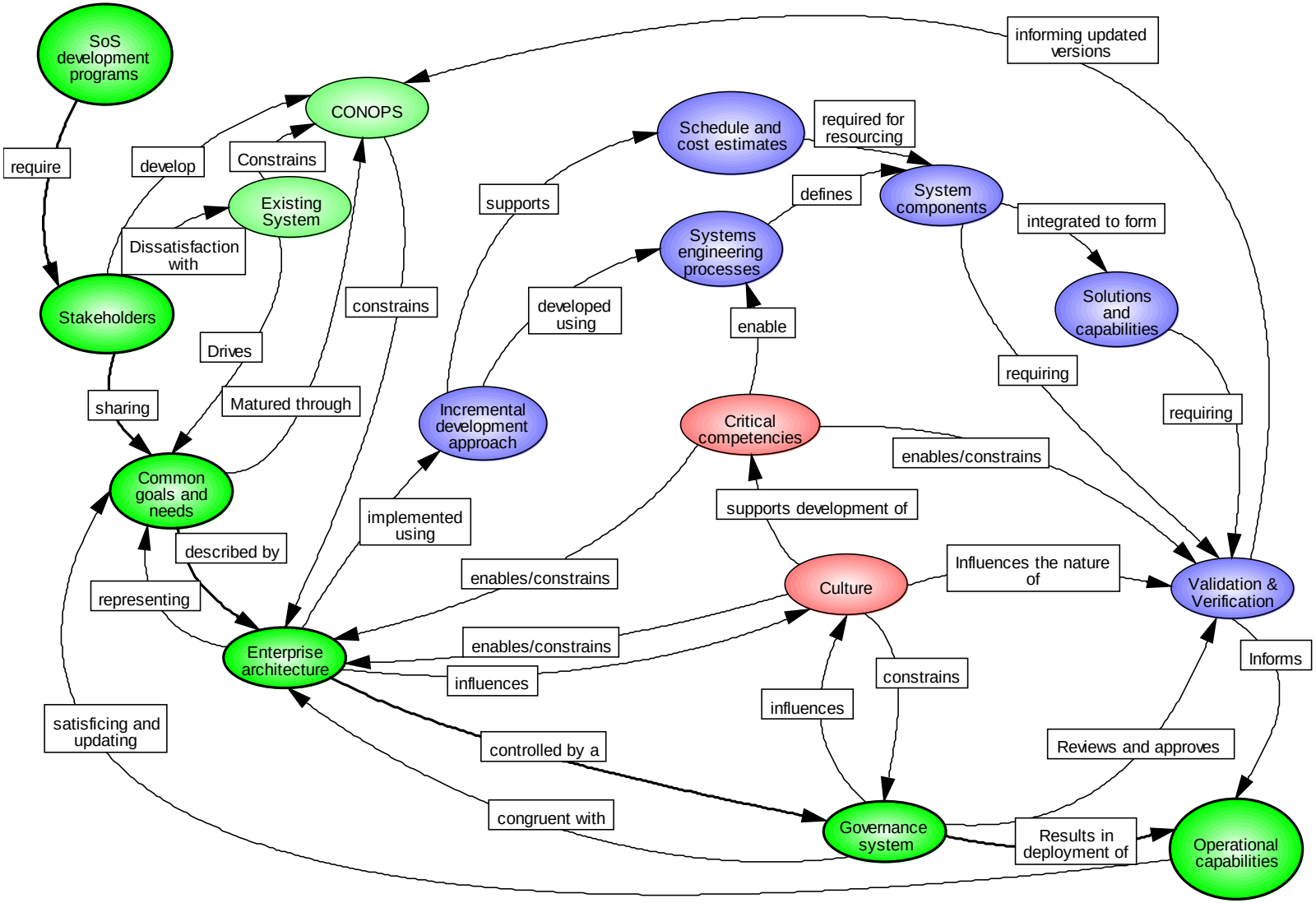
The Entirety



Recommendation 1

- The FAA should ensure that metrics are in place to assess the "goodness" and improve the value of the NextGen CONOPS. At a minimum, the metrics should measure:
  - degree to which NextGen stakeholders are identified and participate in the development of the CONOPS
  - degree to which the stakeholders share a common understanding of the problem, constraints, solution trade space, and potential solution concepts
  - determination of the most reasonable increment length(s)
  - ability of the CONOPS to be achieved through the existing EA structure

Recommendation 2

- The FAA should ensure that are in place to assess the capability of the EA to support the development and implementation of the solution system described in the CONOPS. Furthermore, the EA should be assessed from the following perspectives:
  - **Resiliency**
  - **Latency and Responsiveness**
  - **Scalability**
  - **Security**

Recommendations 3, 4 and 5

- The FAA should ensure that an explicit governance system is defined. This governance system should have the following characteristics:
  - be reflected in specific artifacts
  - be congruent with the EA
  - be congruent with the organizational culture
- The FAA should ensure that metrics are in place to assess the effectiveness of the governance system. The metrics should also provide insight into the alignment between the governance system, the EA, and the organizational culture.
- The FAA should ensure alignment between the evolving CONOPS, the EA, and the governance system in support of NextGen. This will also support the evolving V&V strategy and approach for NextGen. The alignment between the CONOPS, the EA, and the governance system should be periodically assessed, both qualitatively and quantitatively.

Recommendation 6

- The FAA should utilize an acquisition, development, and implementation approach that focuses on explicit increments.
  - Although the DoD recommends an increment's time span not exceed five years, the specifics of the NextGen problems, resource availability, and technology maturity may require varying and shorter cycle-times. For selected aspects of the NextGen enterprise, the increments may be significantly less than five years. Care should be taken to provide sufficient time to allow technologies to reach the maturity level required for increments in which they are to be used.
- In addition to determining the optimal time span for NextGen increments, the FAA should develop and implement governance mechanisms to ensure that each increment not only considers hardware, software, and policy components, but also identifies changes required in human–system components, such as staffing, skills, and training, required to field the desired incremental capability.

Recommendations 7, 8, and 9

- The FAA should identify, monitor, and manage critical workforce competencies required for the successful development and deployment of NextGen capabilities. Critical workforce competencies should include both technical and non-technical requirements.
- The FAA should include active and continuous V&V as an explicit component of the EA and that is supported by the governance system. Metrics assessing the EA and governance system should provide insight into their ability to support the desired level, tempo, and quality of V&V.
- The FAA should obtain independent cost and schedule estimates for each program increment. These estimates should be defined as probability curves and incorporated into program funding requests and schedule development. Over the long term, statistical analysis of the independent estimates, compared to the actual cost and schedule, should be used as an additional data input for the program development process.