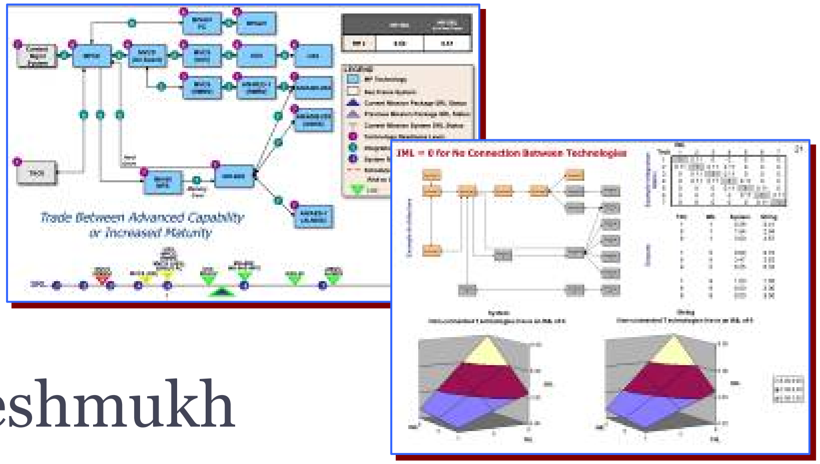
SYSTEMS Development & Maturity Laboratory

System Capability Satisficing in Defense Acquisition via Component Importance Measures

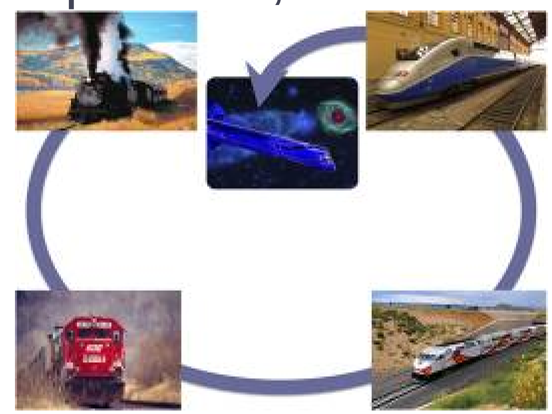


Dr. Brian Sauser
Dr. Jose Ramirez-Marquez
Weiping Tan, Romulo Magnaye
Dr. David Nowicki and Dr. Abhijit Deshmukh

STEVENS Institute of Technology

SSE School of Systems & Enterprises

With ever-increasing environmental and technical complexities, three challenges persist and continue to propagate…

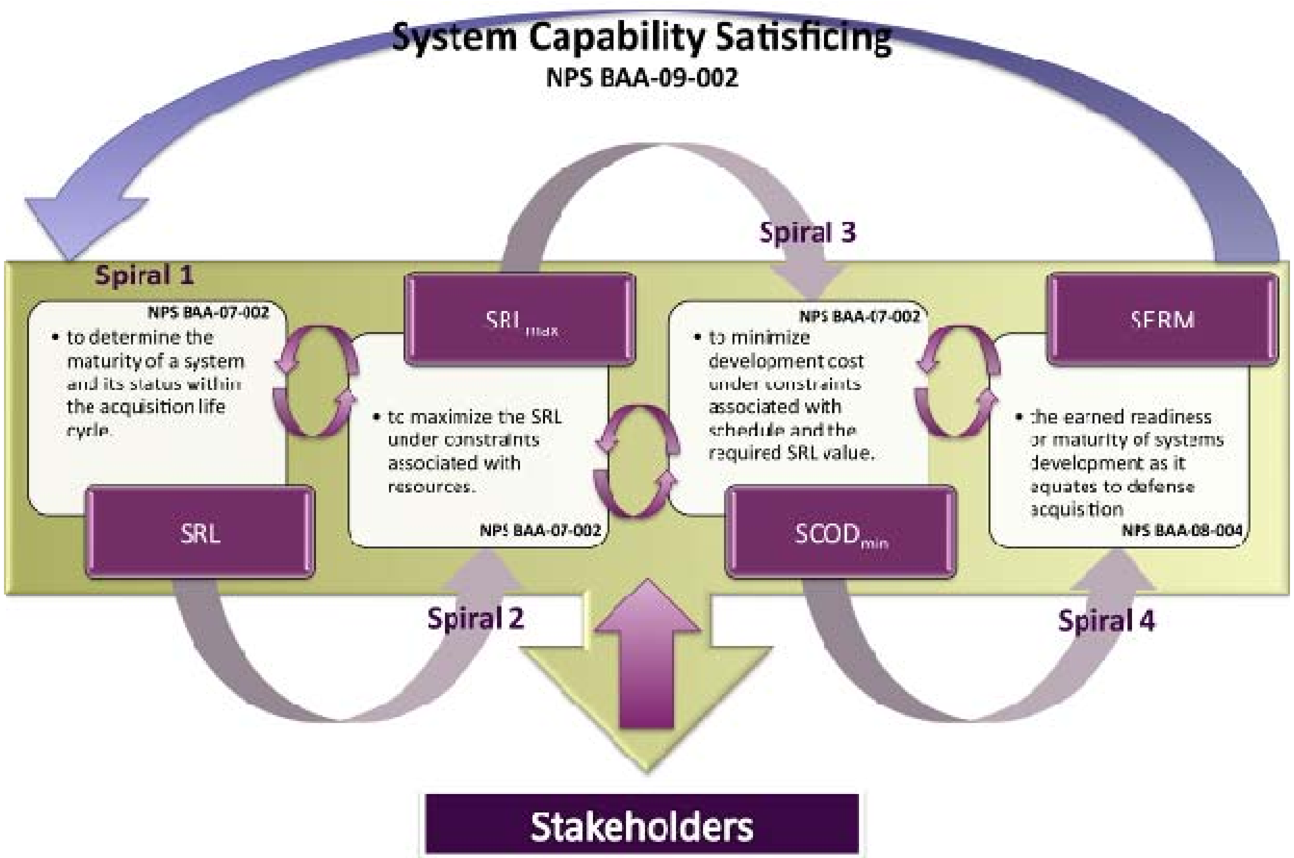


- **Lifecycles**: System's lifecycles from conception to sustainment are comprised of interrelated clockspeeds linked by legacy, change, and unpredictable demand.

- **Decisions**: Our ability to understand, monitor, measure, and govern a system's lifecycle is not keeping pace with the rate of systems' change.

- **Solutions**: Our understanding of how systems can be integrated to provide a "good enough" solution to meet a capability in an agile environment is insufficient.

System Capability Satisficing



“What technologies and integrations are important or critical to each architectural view to achieve a functionality or capability?”

“What functionalities or capabilities are sufficient, critical, or important to achieving a level of system maturity that can satisfy a warfighter’s needs?”

“What impact does this have on system maturity and ultimately the acquisition of a deployable system?”

Key Performance Parameter

- The U.S. government mandates that Key Performance Parameters (KPP) must be specified in the Capability Development Document (CDD) and Capability Production Document (CPD), and be verified by testing and evaluation or analysis.

- Key Performance Parameters (KPP) are “those attributes or characteristics of a system that are considered critical or essential to the development of an effective military capability and those attributes that make a significant contribution to the characteristics of the future joint force as defined in the Capstone Concept for Joint Operations (CCJO)” - DAU 2009

- Volkert's methodology (2009) to predict the achieved capability of satisfying KPP

$$T = SRL * \alpha$$

  - α: the maximum level of performance capability of satisfying a KPP.
  - SRL: the proportional level of performance expected at a specific maturity stage.

$$SRL = f(TRL, IRL)$$

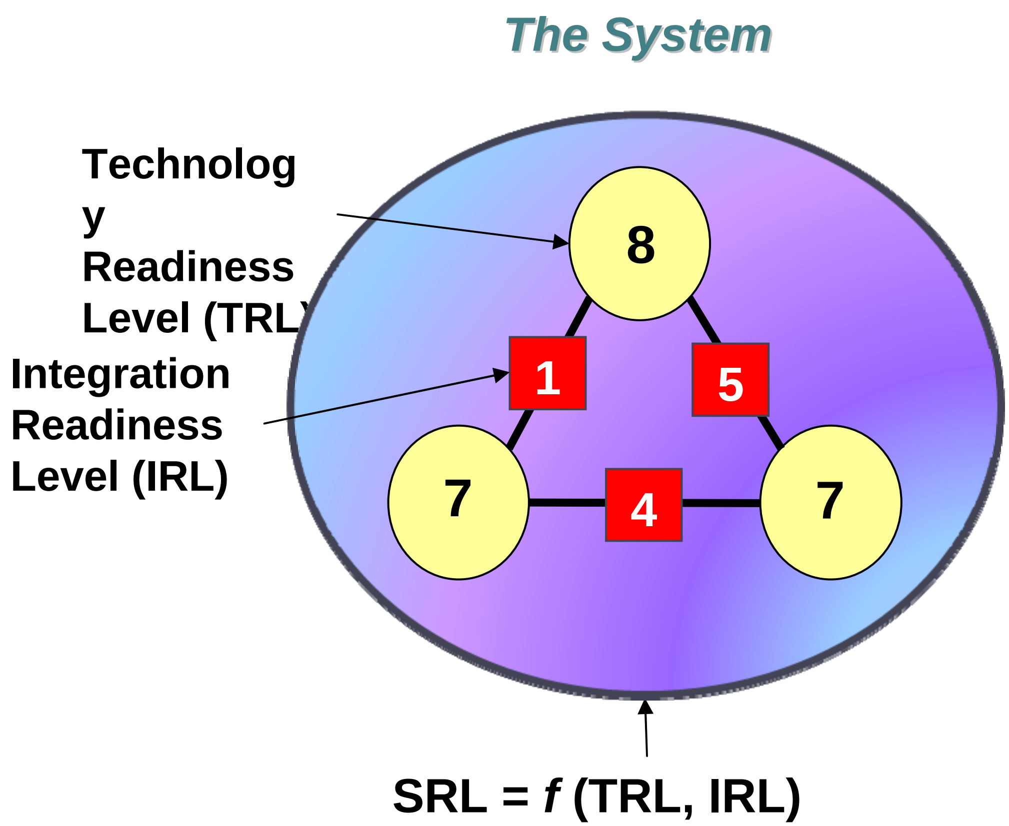
  - T: the achieved performance level of the capability which satisfies the corresponding KPP.

- Volkert's approach
  - Can-do
    - Track the development progress with respect to achieved capability performance.
    - Identify development problems in terms of actual progress against that is planned.
  - Cannot-do
    - Prescribe resources allocation to fix development problems

Then...

- Component importance analysis with measures

Component Importance Measure 1 - System Capability Satisficing with Respect to TRL/IRL (I^P)



- What's the impact of component readiness level on SRL?
- Which component(s) should be improved to a target readiness level?

Component Importance Measure 1

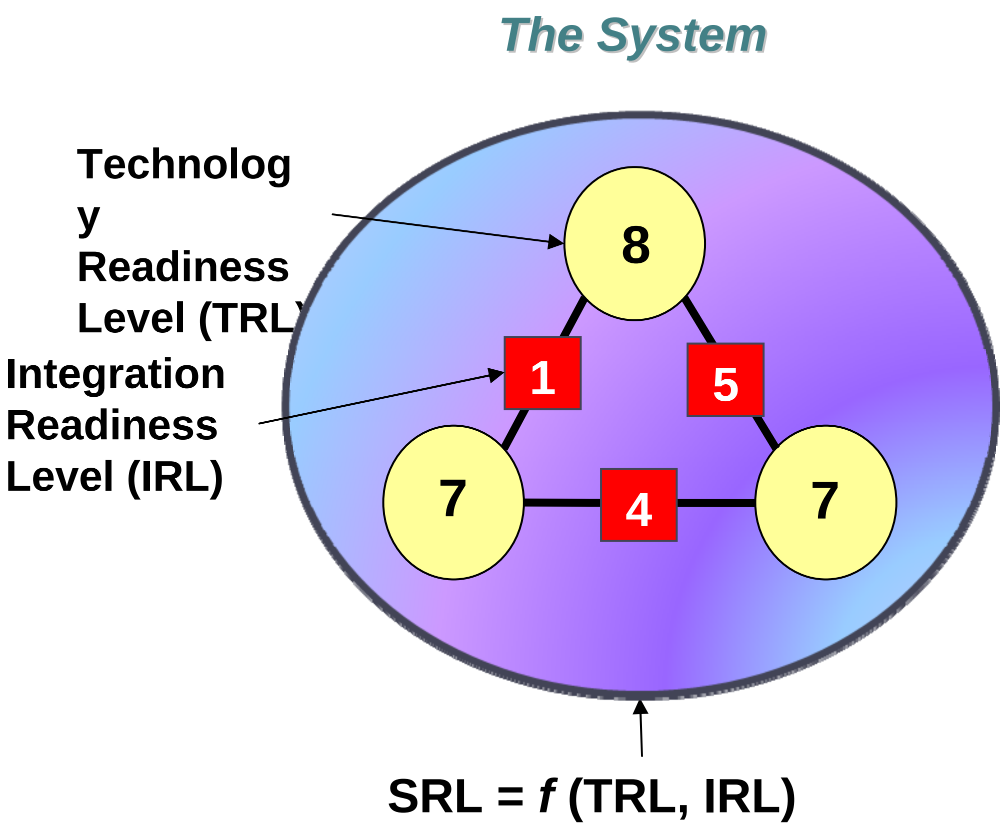
- System capability satisficing with respect to TRL/IRL (I^P)

$$For\ TRL, I_i^P = \frac{SRL(TRL, IRL \mid TRL_i = \overline{TRL_i})}{SRL(TRL, IRL)}$$

$$For\ IRL, I_{ij}^P = \frac{SRL(TRL, IRL \mid IRL_{ij} = \overline{IRL_{ij}})}{SRL(TRL, IRL)}$$

- SRL(TRL, IRL): Current system SRL
- $SRL(TRL, IRL \mid TRL_i = \overline{TRL_i})$: the resultant SRL when TRL_i changes to a target maturity level and all other $TRLs/IRLs$ stay on current maturity values (the same for IRL_{ij}) .

Component Importance Measure 2 - System Capability Satisficing with Respect to Cost (I^{CT})



- Certain amount of

- Where to put the available money to achieve more system maturity?

Component Importance Measure 2

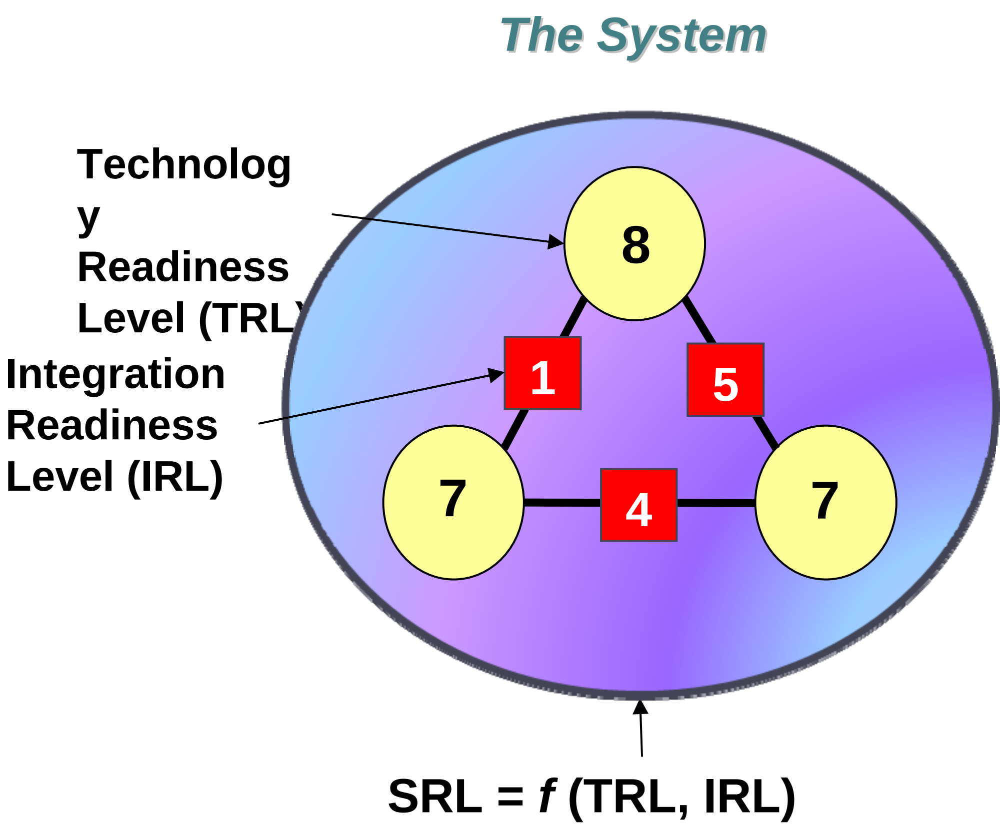
- System capability satisficing with respect to cost (I^{CT})

$$For\ TRL, I_i^{CT} = \frac{\Delta SRL}{CT_i} = \frac{SRL(TRL, IRL \mid TRL_i = \overline{TRL_i}) - SRL(TRL, IRL)}{CT_{\overline{TRL_i}} - CT_{TRL_i}}$$

$$For\ IRL, I_{ij}^{CT} = \frac{\Delta SRL}{CT_{ij}} = \frac{SRL(TRL, IRL \mid IRL_{ij} = \overline{IRL_{ij}}) - SRL(TRL, IRL)}{CT_{\overline{IRL_{ij}}} - CT_{IRL_{ij}}}$$

- $CT_i = CT_{\overline{TRL_i}} - CT_{TRL_i}$: the cost for maturing TRL_i from its current readiness level to a target level $\overline{TRL_i}$ (the same for IRL_{ij}) .

Component Importance Measure 1 - System Capability Satisficing with Respect to Effort (I^{LH})



- Certain amount of

- Where to put the available Labor-Hours to achieve more system maturity?

Component Importance Measure 3

- System capability satisficing with respect to labor-hours (I^{LH})

$$For\ TRL, I_i^{LH} = \frac{\Delta SRL}{LH_i} = \frac{SRL(TRL, IRL \mid TRL_i = \overline{TRL_i}) - SRL(TRL, IRL)}{LH_{\overline{TRL_i}} - LH_{TRL_i}}$$

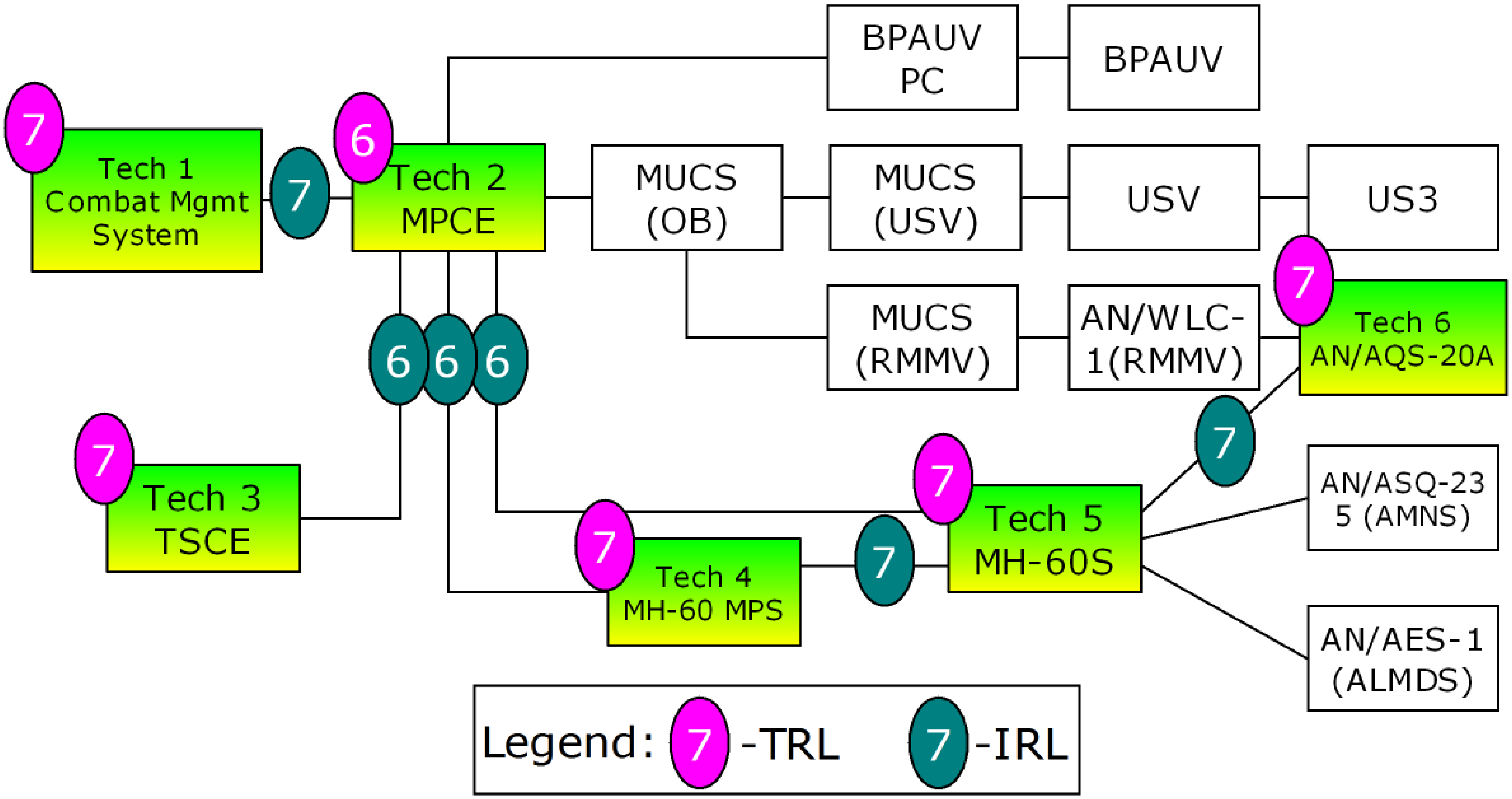
$$For\ IRL, I_{ij}^{LH} = \frac{\Delta SRL}{LH_{ij}} = \frac{SRL(TRL, IRL \mid IRL_{ij} = \overline{IRL_{ij}}) - SRL(TRL, IRL)}{LH_{\overline{IRL_{ij}}} - LH_{IRL_{ij}}}$$

- $LH_i = LH_{\overline{TRL_i}} - LH_{TRL_i}$: the labor-hours for maturing TRL_i from its current readiness level to a target level $\overline{TRL_i}$ (the same for IRL_{ij}) .

Meaning of the Value of Measures

- I^{P} implies the effect of change in the readiness level of a given component on SRL.
- I^{CT} implies the effect of change in the cost to mature a given component on SRL.
- I^{LH} implies the effect of change in the labor-hours (i.e., effort) to mature a given component on SRL.
- The larger the measure value, the more important is the corresponding component.

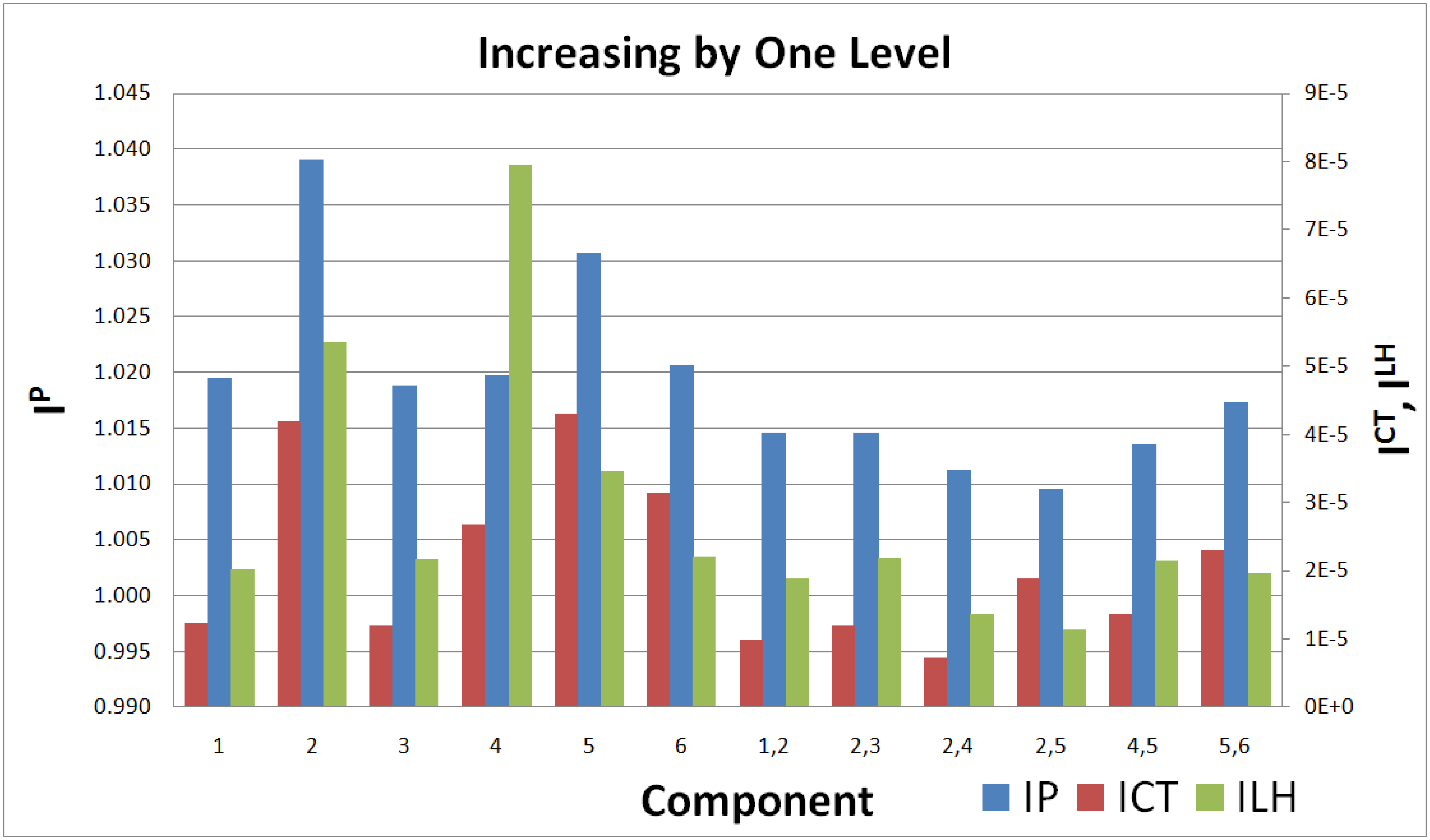
System Diagram of A Notional Example



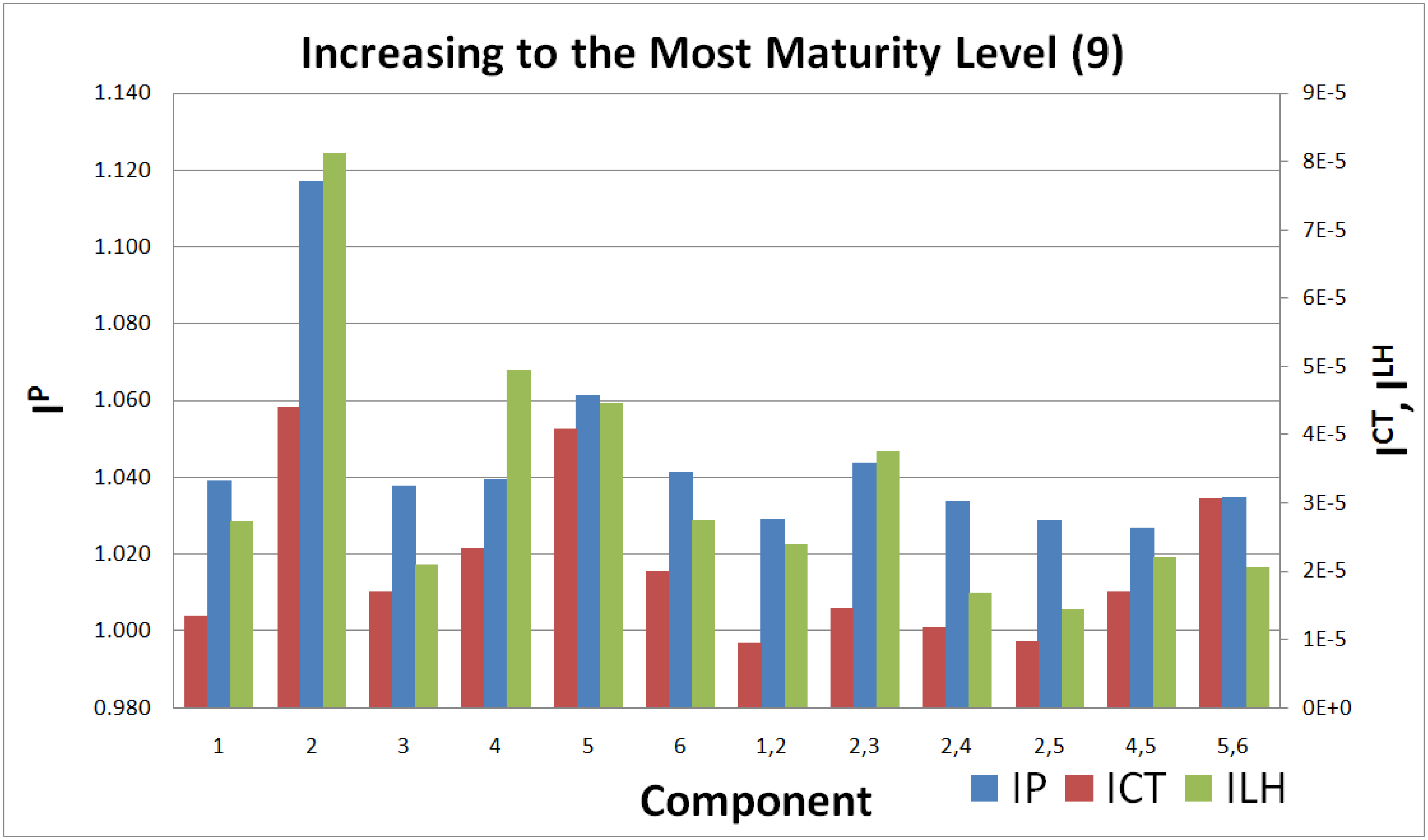
Assuming the Mine-Detection capability enabled by the combination of shaded components is the KPP of interest

Scenario 1 - Increasing Component Readiness by One Level

$$\overline{TRL_i} = TRL_i + 1$$



Scenario 2 – Fully Maturing Components $\overline{TRL_i} = 9$



Conclusion

- Technology components are generally more important than integration components
  - How to coordinate the parallel development of these two kinds of components?
- Component importance is ranked based on the current development maturity status
  - Will importance rank change if the components are further matured?
  - Will a spiral methodology be needed to address component importance for the long system development life cycle?

Future Work

- SRL enhancement for multi-function multi-capability (MFMC) systems development
- Earned readiness management
- SRL calculator plug-in to enterprise architecture

Special Thanks

- Office of Naval Research
- Naval Postgraduate School
- NAVSEA PMS 420
- Northrop Grumman