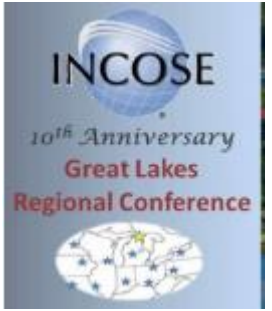


Comprehensive Approach to Systems Engineering Capability Development in GE Healthcare

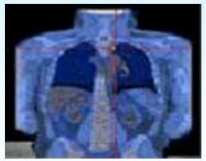
Chris Unger
Chief Systems Engineer, GE Healthcare

Based on work presented at Is2016

GE Healthcare

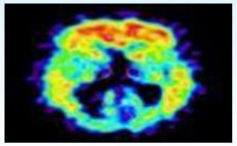
Broad Based Diagnostics

Diagnostic Imaging



- CT, PET/CT
- MR

Medical Diagnostics



- Contrast agents
- Molecular diagnostics

Clinical Systems

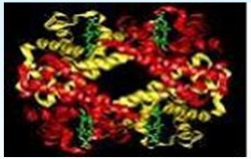
- Ultrasound
- Critical care systems

Information Technology & Services

- Electronic medical records
- Revenue cycle

- Performance solutions
- Multi-vendor services

Life Sciences



- Discovery systems
- Protein separations

Professional Development
Problem Statement – GE Healthcare

~20 businesses

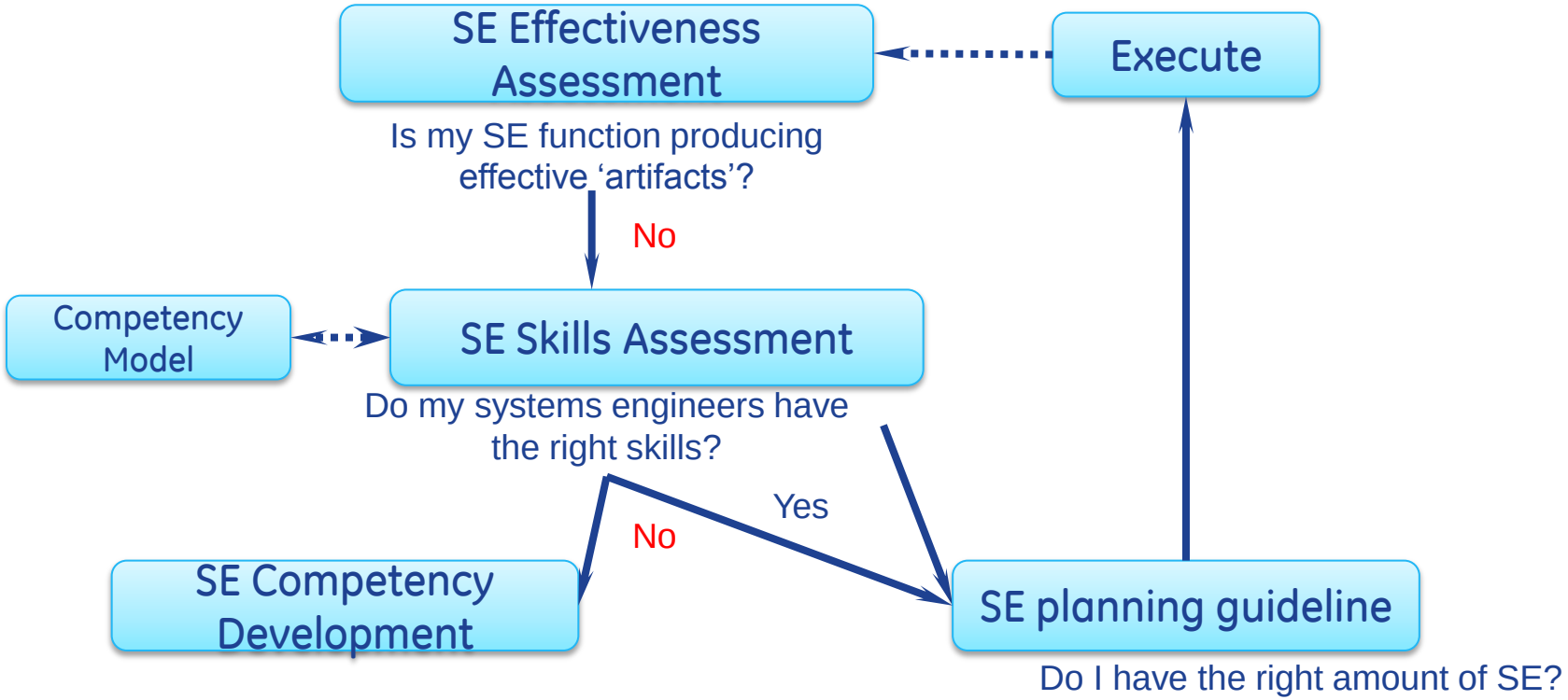
Many countries

Systems Engineering teams ranging in size from >100 to <10 engineers

No consistent way to assess and develop engineers

SE Handbook – Professional Development

Figure 2.9



Professional Development Response

SE Effectiveness Assessment

- Short assessment of SE program implementation – based on SEI survey

SE Skills Assessment:

- Competency model: four levels; 9 technical excellence, 6 leadership skills.

SE Competency Development

- A set of development strategies were defined for each competency area
- Mix of self-study, classroom, on-the-job, experiential, and intact team training.

SE Estimation Guideline

- Simple guides to estimating based on the work of Eric Honour (2013).

Execution Monitoring

- Reusing the criteria for SE effectiveness…with a bias toward actions

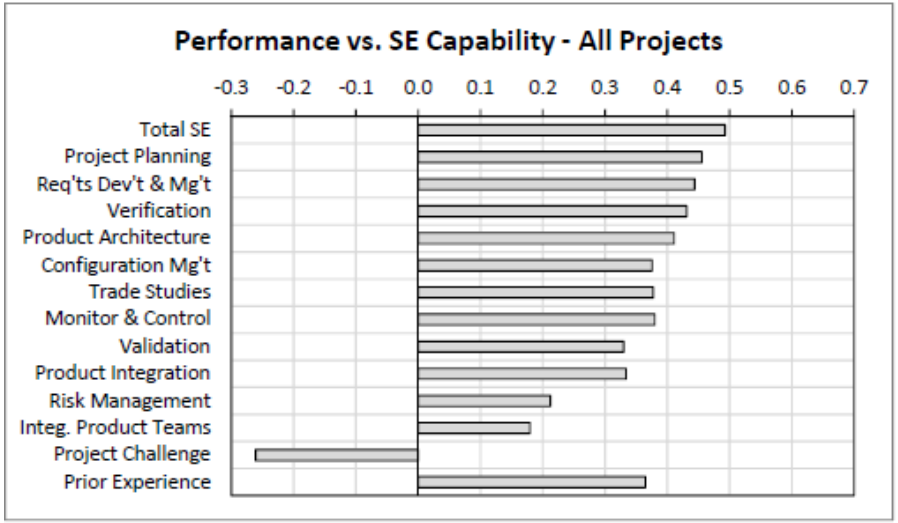
SE Effectiveness Assessment

Elm and Goldenson showed a simple assessment with four levels can differentiate performance

We combined their 83 systems capability questions into 30 questions

We included more extensive questions on topics related to "Design for …"

- Usability
- Reliability
- Six Sigma
- Manufacturability
- Serviceability



The Business Case for Systems Engineering Study: Results of the Systems Engineering Effectiveness Survey Elm and Goldenson, 2012

SE Skills Assessment - Competency Model

Different locations were assessing their engineers on a 'local' scale ("the tallest skyscraper in Kansas")

Needed a consistent assessment scale (functional or competency maturity model)

Needed something simple (~10 criteria)

Needed to balance technical and leadership skills

Had to be consistent with existing leadership models (I.B.)

SE Skills Assessment - Competency Model

GE Corporate Systems Council agreed to a technical competency model based on the NASA model

- It was simple
- The two level hierarchy made it scalable
- NASA was close to GE Oil and Gas headquarters, and they could 'outsource' their SE handbook development
- It mapped well to Elm and Goldenson ("don't optimize the subsystems")

GE Healthcare then further simplified the technical model and integrated our leadership model

SE Skills Assessment - Competency Model

Technical Excellence Competencies
SE 1.0 System Design
SE 1.1 Scope and Requirements Management
SE 1.2 Architecture and Design Optimization
SE 2.0 Product Realization
SE 2.1 Application, Product, and Technology Knowledge
SE 2.2 Product Integration, Verification , and Validation
SE 2.3 Product Lifecycle/ DFx Management
SE 3.0 Technical Management
SE 3.1 Systems Engineering Management
SE 3.1.1 Technical Design Reviews
SE 3.2 Technical Risk Management (and Safety)
SE 4.0 Critical Thinking

SE 5.0 Technical Leadership Competencies
SE 5.1 Communication and Conflict Resolution
SE 5.2 Takes Risks Courageously
SE 5.3 Adapts and Leads Change
SE 6.0 Business Acumen
SE 6.1 Customer, Clinical and External Acumen
SE 7.0 Personal Attributes
SE 7.1 Execution and Accountability
SE 7.2 Teamwork and Collaboration

Balancing simplicity with effectiveness

- ✓ 4 Technical, 3 Leadership Competency Areas
- ✓ 15 Competency sub-areas
- ✓ 51 Behavioral anchors

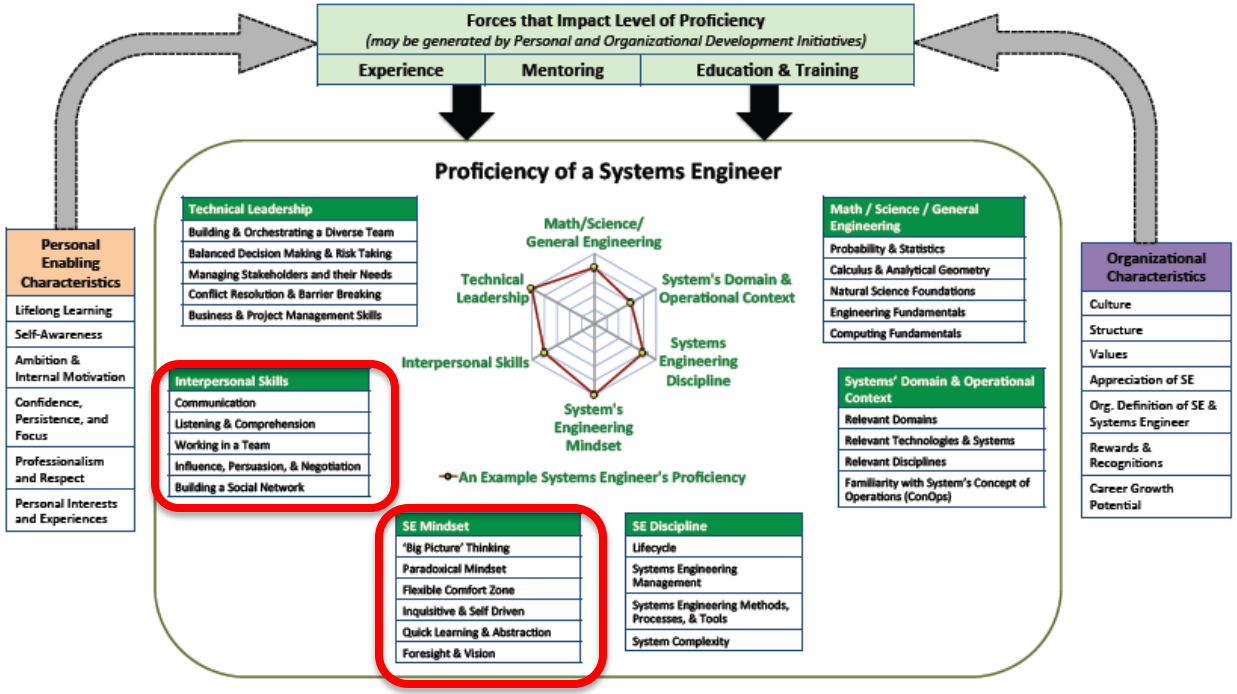
Behavioral Anchors

SE 4.0 Critical Thinking: Competencies and Behaviors

4.1 Frames Problems and Decision Making – Accurately frames complex and ambiguous problems, including key issues and critical stakeholder input. Uses creative approaches to synthesize separate pieces of data from multiple sources, to make sound and rational decisions in complex situations.

	Aware	Skilled	Expert	Strategist
Frames Problem	• Identifies and relates key issues to customer, market and business value.	• Identifies key issues, utilizing a systematic and methodical approach to prioritize problems.	• Accurately frames a complex problem, using foresight to sort out essential from detail.	• Accurately and confidently frames a complex system problem, appropriately engaging and challenging experts and advocates.
Trade Offs	• Recognizes that a problem exists tradeoffs between similar design criteria.	• Avoids jumping into problem solving before actually framing the problem and brainstorming scenarios and solutions.	• Balances traditional project management concerns of cost and schedules, with technical requirements, sound evidence and sources.	• Utilizes innovative approaches and relevant evidence to remove bias and identify predispositions.
Decisions	• Identifies correct data needed to make a decisions.	• Collaborates to logically examine facts and situations to arrive at a decision.	• Accepts decision making responsibility, balancing analysis and intuition, while considering program implications.	• Comfortable with uncertainty; experiments with innovative solutions, using logic , intuition and past experience to make system life-cycle decisions.

Helix Model of Competencies



How to assess some of the softer skills on the left?

- "Paradoxical mindset"
- "Flexible comfort zone"
- …

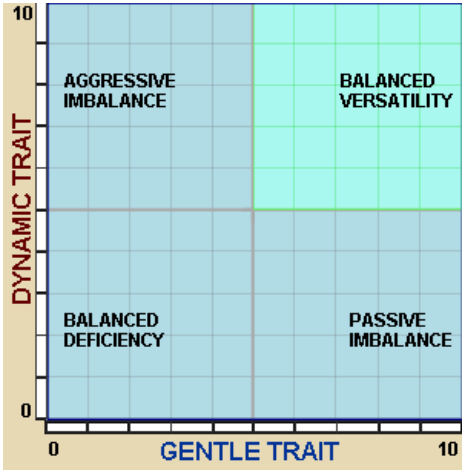
Harrison Assessment

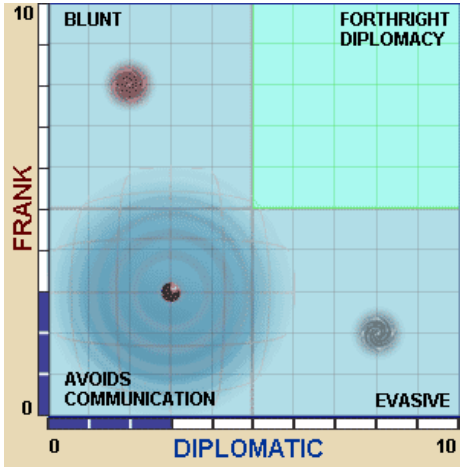
We used the managers assessment of the employee's technical skills (mixed with senior technical people's inputs)

For leadership skills we complemented that with a 'work preference tool' (Harrison Assessment)

- Measures 175 independent critical traits
- Summarizes 12 "Paradoxes"…well mapped to the Helix study critical skills

Example “Paradox” - Communication

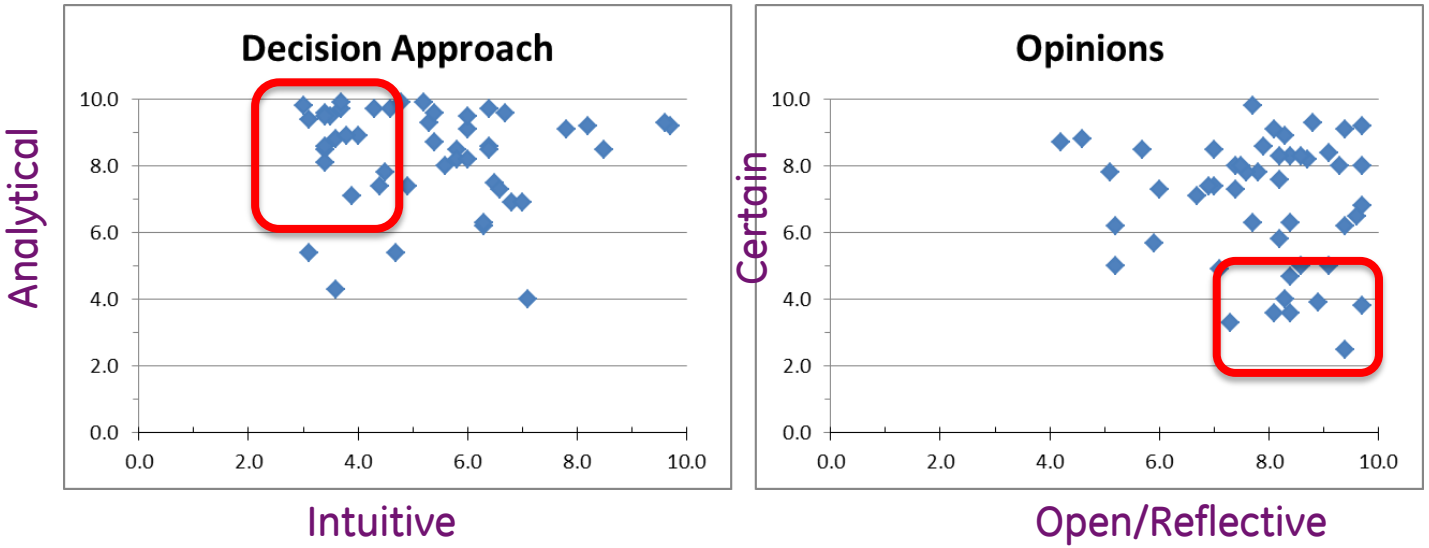




Paradoxical traits are complementary, not contradictory

Possible to be strong in both…and both are useful

Example GE Healthcare Skill Portfolio



Employees are individuals

Our SE leaders **tend** to be "laser logical" and "inconclusive"

Execution Monitoring

Why do we monitor execution?

- To improve design quality, market impact and engineering productivity

What is an SE "Dashboard"?

- A dashboard should include early (leading) indicators of quality, which are easily translatable directly to actions.
- The dashboard helps you adjust real-time during program execution…
- A scorecard displays event based performance vs. goals to you and stakeholders

Elements of a "Dashboard"?

Dashboard vs. Scorecard

Dashboard

Consider the difference in an auto race between an odometer/speedometer and the standings.

On the car's dashboard, the speedometer & odometer allow the driver to take actions to best 'finish the race safety and in first place'.

Or for the SE lead to deliver high quality differentiated features on time leading to satisfied customers.

Scorecard

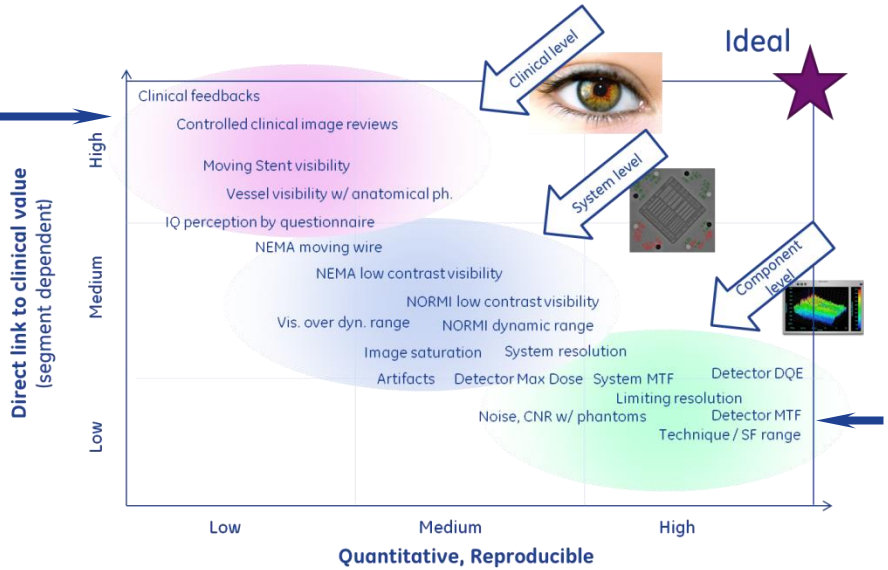
Both are Important!

Dashboard vs. Scorecard

As engineers, we understand this…when it is purely technical

Scorecards

- "Goals"
- Customer based



Dashboards

- Controllable 'techniques'
- Internal/team focused

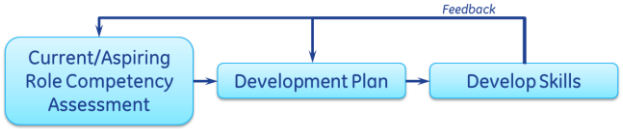
Example: DFSS Dashboard

Elements of a dashboard for 'variability' – Design for Six Sigma

Questions	Good/Poor Attributes	Actions
Are the critical performance criteria (CTQs) defined which capture the key market differentiation and enable the elevator speech?	System CTQs quantify all key competitive differentiation at M3. 10-15 CTQs at system level, 50-100 total). System CTQs do not don't cover all key parts of the marketing 9 block, don't have targets, or don't have competitive data	Trace CTQs from the marketing 9 block (not simply reuse from prior programs) Perform competitive analysis, and extrapolate to likely performance at M3 with Chief Engineer (don't assume no market evolution)
Are they flowed down to key subsystems with quality targets defined	Z-value quality targets; (typically Z>3-4.5) CTQs lack targets (limits, quality and confidence levels) System CTQs are not flowed down at least 1 level to subsystem	Set and flow down targets. Ensure the targets are realistic and customized to each CTQ.

- Not only do you get better program control…**we are trying to get people to "think",** not just go on autopilot
- Increase the organizational learning 'speed'

Next Steps



Individual Development View

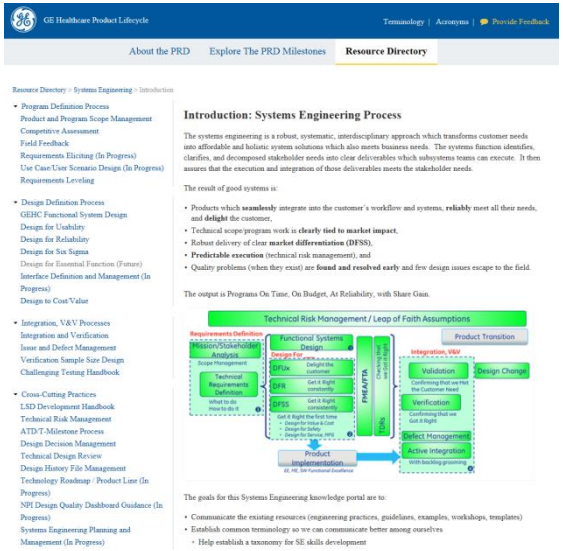
Job Skill Profiles

Systems Roles	1.1 Scope & Requirements Management	1.2 Architecture & Design Optimization	2.1 Application, Product, & Technology Knowledge	2.2 Product Integration, Verification, Validation	2.3 Product Lifecycle / DFx Management	3.1 Systems Engineering Management	3.2 Technical Risk Management & Safety
Lead System Designer							
Lead	Expert	Skilled	Skilled	Skilled	Skilled	Expert	Expert
Senior	Strategist	Expert	Expert	Expert	Expert	Expert	Strategist
Verification Leader							
Lead	Skilled	-	Skilled	Expert	Aware	Aware	Skilled
Senior	Skilled	-	Expert	Strategist	Aware	Skilled	Expert
Systems Engineer							
Entry	-	-	-	-	-	-	-
Lead	Aware	Skilled	Skilled	Aware	Aware	Aware	Aware
Senior	Skilled	Expert	Expert	Skilled	Skilled	Aware	Skilled
Systems Architecture							
Architect	Skilled	Expert	Expert	Skilled	Skilled	Skilled	Expert
Senior Architect	Expert	Strategist	Expert	Skilled	Skilled	Skilled	Expert
Principal	Expert	Strategist	Strategist	Expert	Expert	Expert	Strategist
Reliability Engineer							
Entry	Aware	Aware	Aware	Aware	Skilled	Aware	Aware
Lead	Aware	Skilled	Skilled	Skilled	Expert	Skilled	Skilled
Senior	Aware	Skilled	Skilled	Expert	Expert	Skilled	Skilled
Architect +	Skilled	Expert	Expert	Expert	Strategist	Expert	Expert
Service Designer							
Lead	Skilled	Skilled	Skilled	Skilled	Expert	Skilled	Skilled
Senior	Skilled	Expert	Expert	Expert	Strategist	Skilled	Expert
Risk Management							
Senior	Skilled	Skilled	Skilled	Skilled	-	Skilled	Expert
Architect	Skilled	Skilled	Expert	Skilled	Aware	Skilled	Expert
Senior Architect	Skilled	Skilled	Expert	Skilled	Aware	Expert	Strategist
Principal	Expert	Skilled	Expert	Skilled	Skilled	Expert	Strategist

Learning Tools

Area	Class Title	DOC	Skill Level
Requirements			
	Requirements Writing	DOC0433817	Aware
	Requirement Management	DOC1109277	Skilled
Architecture			
	System Thinking	Gap	Skilled
	System Modeling	DOC1509391	Expert
Reliability			
	Reli Basics/DFR	5250084GSP	Skilled
	DFSS Basics/Tools Intro		Expert
Integration V&V			
	Verification Guidance	DOC1256103, DOC1200592	Skilled
	Integration Planning	Gap	Skilled
	Issue and Defect Mgt	Gap	Aware
	Challenging Verif Handbook	DOC1256106	Expert
	Sampling and Design Verif	DOC1256103	Expert

SE Knowledge Portal

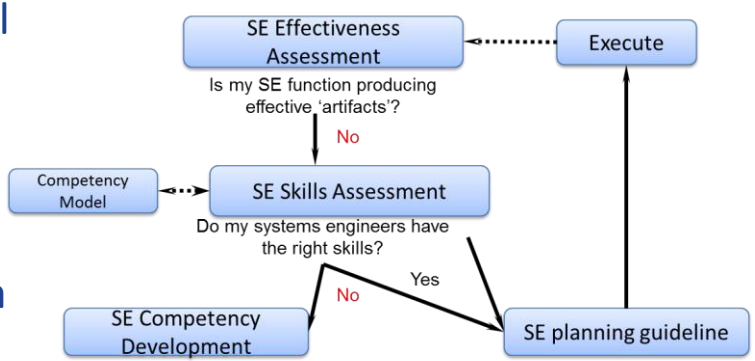


Building Out the Tools To Support the Development Loop

Conclusion

We implemented Professional Development as a 'system'

- Did not try to optimize the components of the model
- Tried to optimize the overall model
- Tried to manage the interfaces (consistency)



Focused on the competency model

- Formed the basis for the 'terminology' of the system
- Simplified to fit the 'capability' of our global team
- Used "Harrison Assessment" to measure some paradoxical thinking identified as critical in the Helix/Atlas model of SE professional development and effectiveness

On execution monitoring, distinguished Scorecards from Dashboards

- Reinforces thinking and learning in on the job assignments