SE Simulation Experience Design: Infrastructure, Process, and Application

Richard Turner, Douglas Bodner, **Duncan Kemp**,
Yvette Rodriguez, **Jon Wade**, Peizhu Zhang

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Outline

- Experience Accelerator Overview

- Development Process & Tools

- Case Study: UK MoD In-Service Safety

- Demonstration

- Results and Future Work

# Experience Accelerator Overview

Experience Accelerator: Program Overview

- **What:** SERC Multi-year Phased Research Program

- **Sponsor:** Defense Acquisition University, SERC

- **Collaboration:** Stevens, Georgia Tech, Purdue, USC (year 1)

- **Problem Statement:**
  adequate to meet the emerging challenges posed by ever increasing Systems and Societal demands, the workforce called upon to meet them and the timeframe in which these challenges need to be addressed.

- **Program Goal:** *Transform the education of SE by creating a new paradigm capable of accelerating the time to mature a senior SE while providing the skills necessary to address emerging system's challenges.*

Workforce Demographics

Workforce Breakdown by Generation

Legend:
- National Workforce
- DoD Workforce
- Civilian ATL Workforce
- NASA Engineers Workforce

Y-axis: 0.0%, 10.0%, 20.0%, 30.0%, 40.0%, 50.0%, 60.0%, 70.0%, 80.0%

X-axis categories:
- Millenium (1990-present)
- Generation Y (1977-1989)
- Generation X (1965-1976)
- Baby Boomers (1946-1964)
- Silent Generation (born before 1946)

GAP!
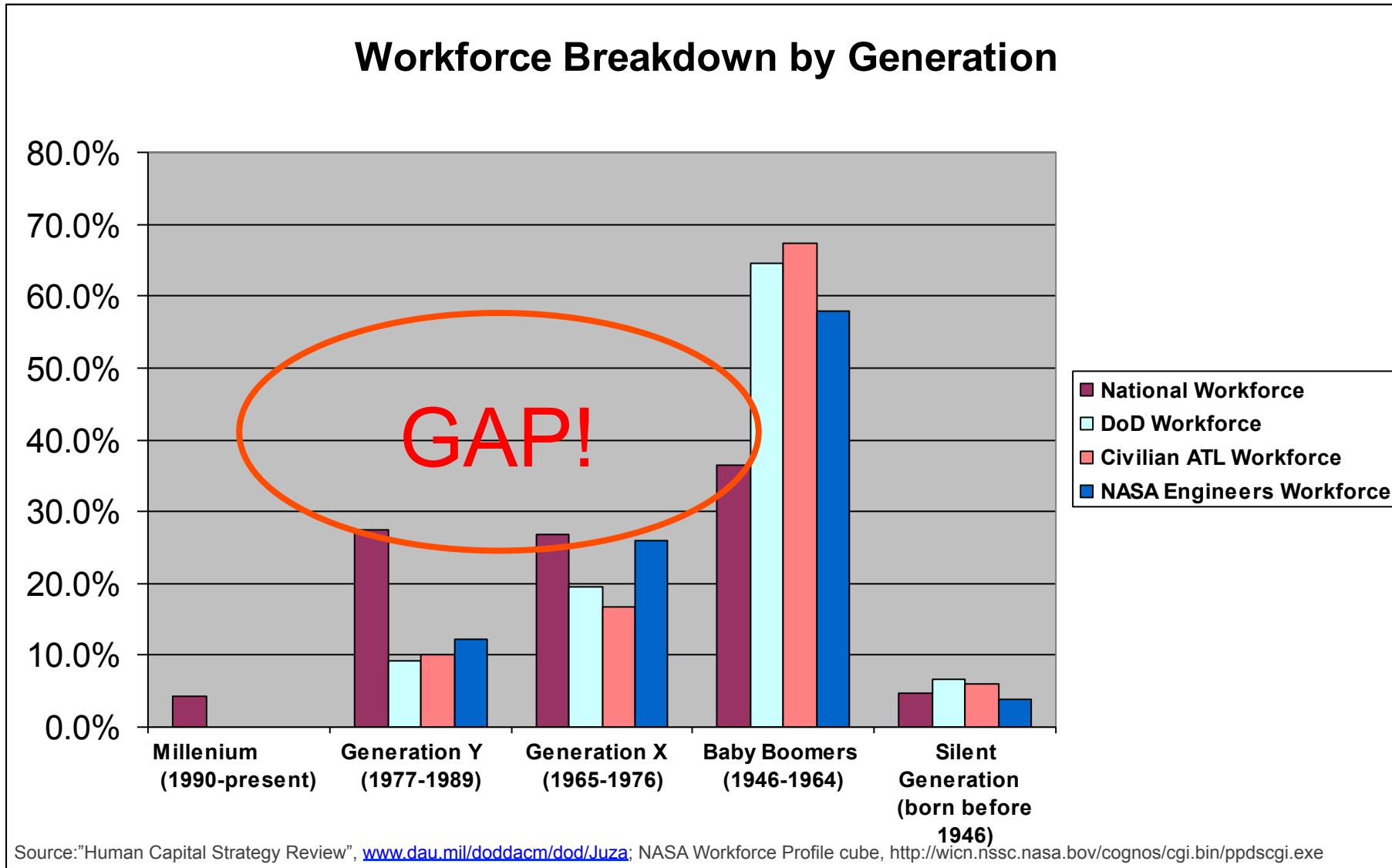
Hypothesis & Goals

Hypothesis: *By using technology we can create a simulation that will put the learner in an experiential, emotional state and effectively compress time and greatly accelerate the learning of a systems engineer faster than would occur naturally on the job.*

Goals: To build insights and "wisdom" and hone decision making skills by:

- Creating a "safe," but realistic environment for decision making where decisions have programmatic and technical consequences
- Exposing the participants to job-relevant scenarios and problems
- Providing rapid feedback by accelerating time and experiencing the downstream consequences of the decisions made

SE Maturity

Maturity in Systems Engineering requires:

- Viewing a program through the entire lifecycle

- Seeing the relationships between elements of the system, and the system developing the system

- Encountering the challenges faced in a complex system development

- Being able to navigate through the "gray" zone

- Creating mental templates which can be applied to similar future situations

EA Capabilities and Features

- Relevant, Authentic Experiences
  - Experiential focused…incorporates experience base of DoD Chief Engineers
  - Realistic simulations of complex system development
  - Skill level adjustment, initial focus on expert level

- Cost Effective, Available and Open
  - Approximately 1 hour time limit for each sessions
  - Low Server utilization per client user…highly scaleable
  - No special client hardware or administrative needs
  - Open architecture + Open Source Software with no-cost licensing
  - User-friendly tool-set in parallel development

EA Modes of Operation
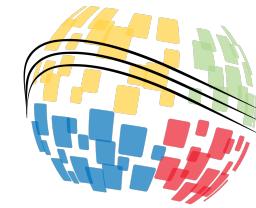
Modes:
- Single Learner mode
- Single Learner with supervisor (PM & Mentor)
- Multiple Learner
- Multiple Learner with supervisor
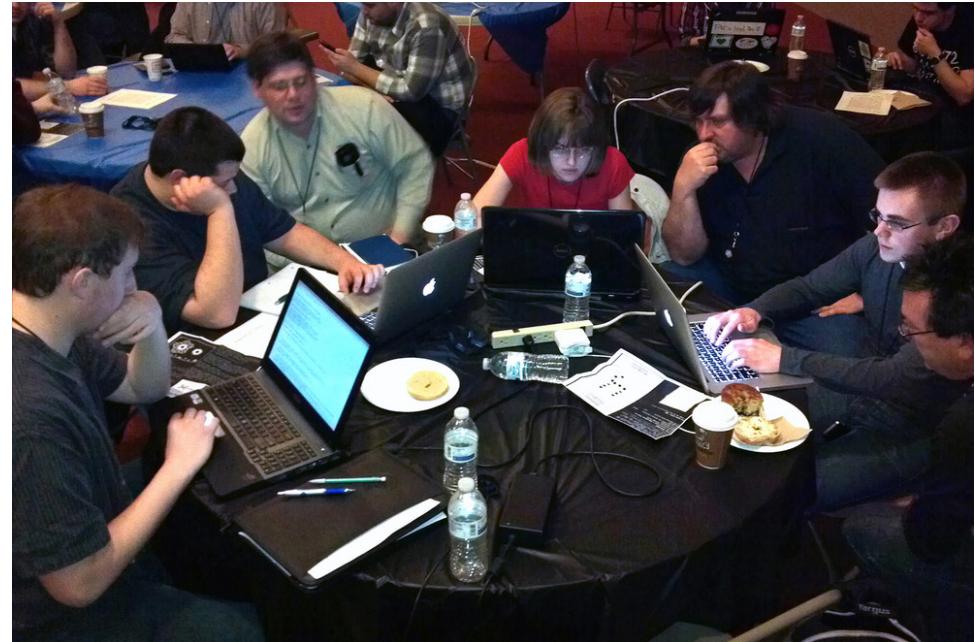
Multi-learner capabilities have been developed for the Experience Accelerator. The capabilities have been provided for multiple learners to create and join games asynchronously, share documents, communicate directly with one another, and make decisions that affect the outcome of the simulations.

What's More Effective?

Learning Process
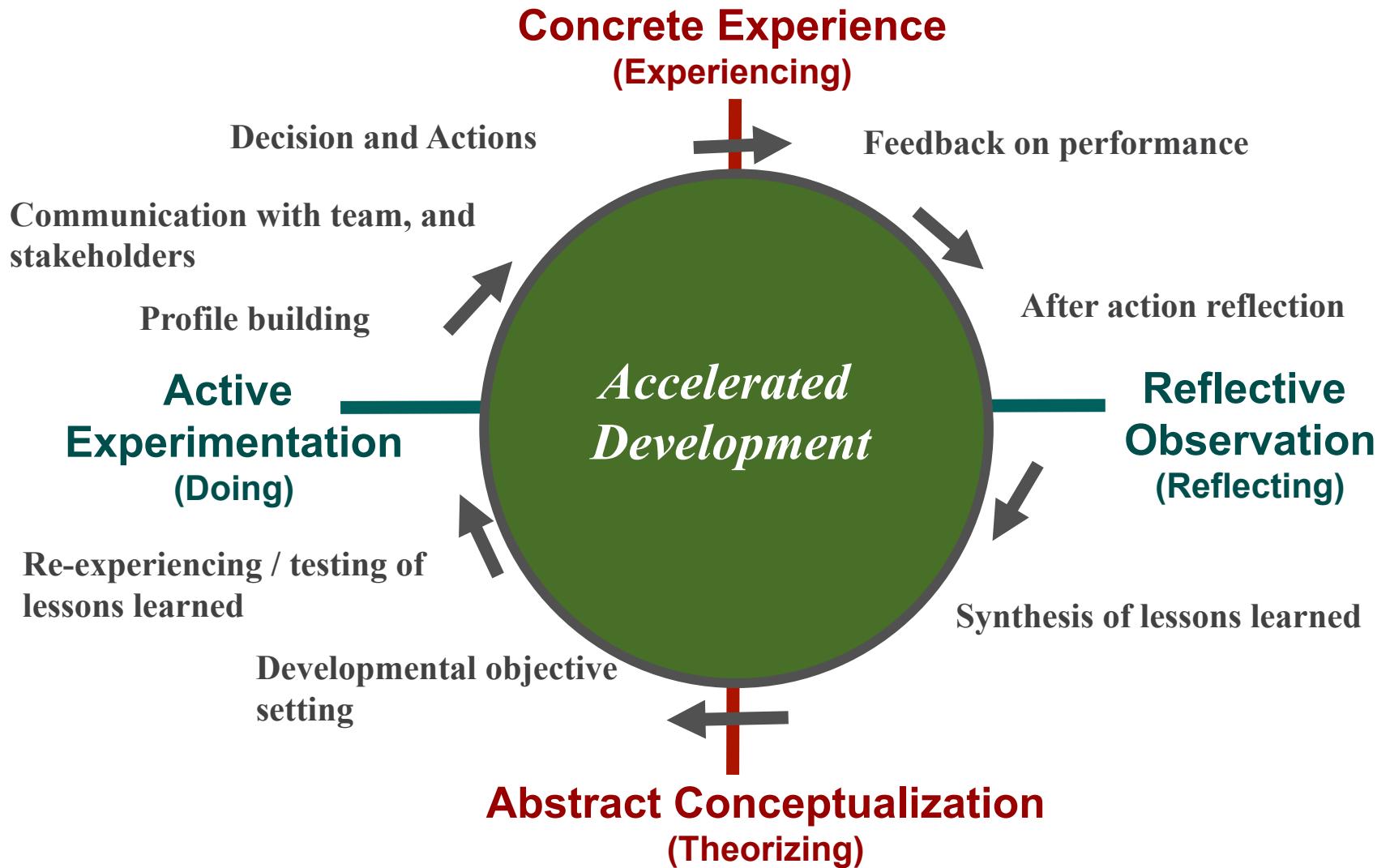
Performance & Learning

With the EA Simulation, we have the means to directly measure learner's performance, actions and self-assessments:

- Measure quantitative score of simulation results
- Compare decisions and actions of the students with those of experts
- Review students evaluation of the lessons learned
- Compare changes in the above results through students' iterations in the Experience
- Perform longitudinal studies to assess how learning is transferred to the workplace

US DAU UAV Experience

Context:
- Based on SME interviews and a systems dynamics model of large system acquisition and development
- **Complex experience** that (when complete) covers the entire lifecycle

US DoD UAV System Acquisition:
- Prime Contractor – System
- Subsystem 1 – Airframe and Propulsion
- Subsystem 2 – Command and Control
- Subsystem 3 – Ground Support
- *Subcontract for each subsystem*

UAV KPMs:
Schedule, Quality, Range, Cost
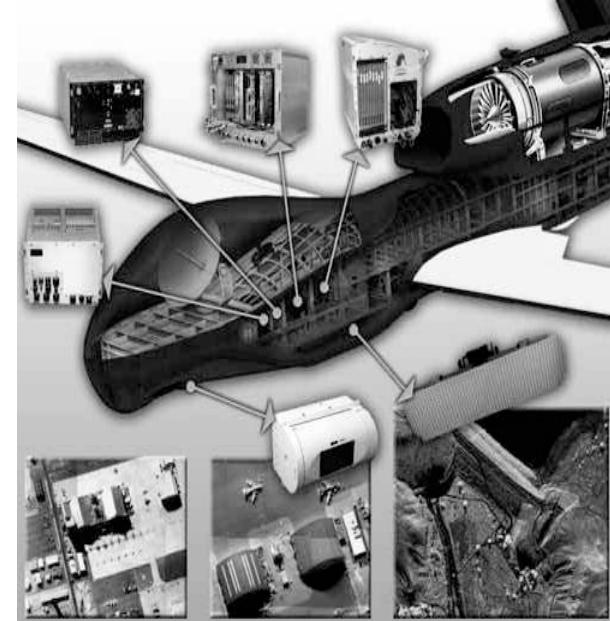
Phases:

- EA Introduction
  - Phase 0: New Employee Orientation

- Experience Introduction
  - Phase 1: New Assignment Orientation

- Experience Body
  - Phase 2: Pre-integration system development -> CDR
  - Phase 3: Integration -> FRR
  - Phase 4: Field Test -> PRR
  - Phase 5: Limited Production/ Deployment
  - Phase 6: Experience End

- Experience Conclusion
  - Phase 7: Reflection

Targeted Competency

Problem Solving and Recovery Approach:

– Identifying the actual/root cause problems amid often conflicting information.

– Marshaling the resources needed to solve problems.

– Recognizing the problems that have the most impact to the overall system and appropriately prioritizing plans for solving them.

– Making recommendations, using technical knowledge and experience, by developing a clear understanding of the system.

– Identifying and analyzing problems using a systems approach, weighing the relevance and accuracy of information, accounting for interdependencies, and evaluating alternative solutions.

Development Process & Tools

The Big Picture

- **Learning Objectives**

- **Experience Concept**

- **Experience Development**

- **Experience V&V**
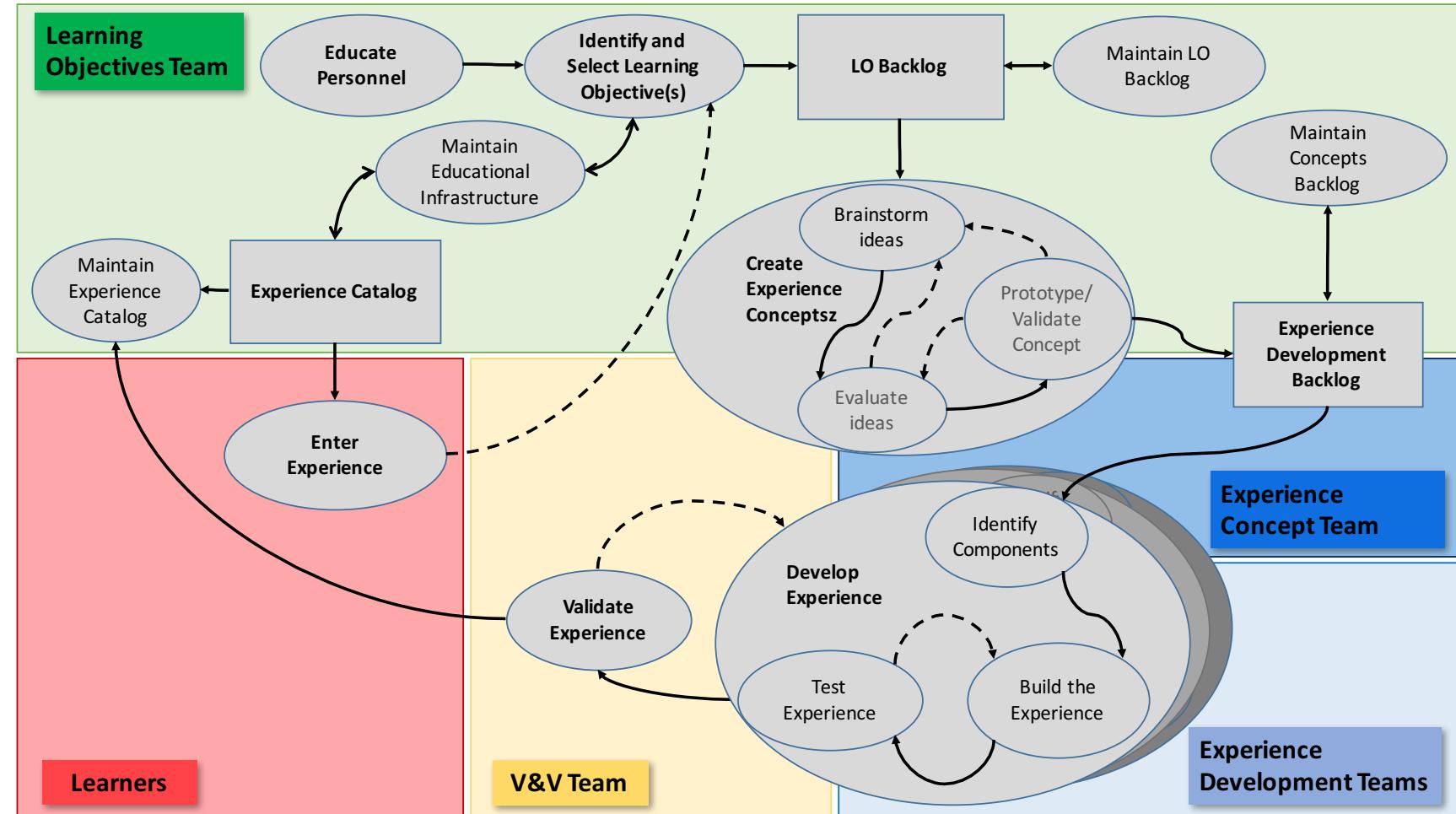
Learning Objectives

- Traditionally, a learning objective is a statement of what students will be able to do when they have completed instruction.

- A learning objective has three major components:
  1. A description of what the student will be able to do
  2. The conditions under which the student will perform the task.
  3. The criteria for evaluating student performance. *

- In the EEA, learning objectives are aimed at a specific skill or a critical situation where significant experience is particularly useful.

* Arreola R. A. and Aleamoni, L. M.,1998, "Assessing Student Learning Outcomes: A Workshop Resource Document," Western University, London, Ontario, CA.

Identifying the "aha!" moments

- We gain experience in many ways, but most useful experience comes from an aha moment – the moment when seemingly unrelated information clicks into place

- Accelerating experience is primarily creating scenarios that help the learner arrive on their own to these aha moments, usually with somewhat less noise than is often found in vivo

- Aha moments are often associated with anti-patterns or worst practices because they are often only understood in the breach

- Identifying these moments is a significant challenge

- SMEs and mentors are the best source for capturing both the moment as well as the various ways people come to them

"Aha" Examples

- Believing a single source of information

- Looking at the data you have rather than the data you need

- Not reexamining assumptions when conditions have changed

- Losing sight of the principles behind the process (letter vs. spirit) or believing that creating the artifacts (even after the fact) is the same as following the process

- Putting off integration and validation until the end

- Over reacting to near term issues - the "bullwhip" effect where reacting quickly to higher demand leads to long-term over provisioning

- Ignoring Brooks' Law and other human communication factors

- Using the technology that you have rather than the technology that you need

Challenge/Landmines & Linkages

System	Challenge	Phase	Evidence	Situation	Desired Actions	Inputs to Simulation
S2	range too short	P2	range projections	weight during development is too high	Reallocate resources - focus resources on weight reduction	Change assignment of labor within sub-system development
					Change subsystem allocation - reallocate weight from S2 to S1	Change weights
					Change system level feature - reduce expectations for range	Change range target
S1	range too short	P3	range projections	drag is higher than expected in wind tunnel testing	Reallocate resources - focus resources on drag reduction	Change assignment of labor in S1
S1, S2	schedule	P2	completion rates	productivity lower than expected	Add resources - hire additional labor	Hire new personnel
S2	schedule	P3	completion rates	more changes had to be made than anticipated	Adjust schedule	Change schedule target
S0	schedule	P3	completion rates	unexpected integration issues	Add resources - hire additional labor; purchase additional test equipment	Hire new personnel for S0; add test equipment resources
					Reallocate resources - focus on integration, get help from other areas	Change assignment of labor in S0
S2	quality	P2, P3	defect rates	software defect rate is too high	Reallocate resources - focus resources on design/code reviews	Change labor assignment

Creating Context and a Story Line

- The most fun part of building experiences

- Identifying and building the personas of the non-player characters

- Identifying the scenes (phases) of the experience that provide the necessary technical, relational, and temporal context

- Setting up the various information chains that provide the learner with clues to lead him to the aha moment

- Establishing the events and outcomes that result from the learner's choices

- One way to approach this is by building a results chain that tracks the events, information and actions from the aha moment backwards

Learning Experience Pattern Components

Learner Modes	Learner Authority	Learning Objective	Associated Learner Skills	Associated Learner Activities
Individual	Directive (do)	Recognize	Understand information	Monitor, measure, recognize, interpret
Collaborative	Responsive (recommend)	Define	Articulate a problem	Gather information, analyze, confirm, create
	Passive (observe)	Plan	Articulate possible solutions	Gather information, create, confirm, propose
		Choose	Decide on a solution	Structure, analyze, confer, select
		Act	Implement the solution	Communicate, advocate
		Evaluate	Determine if solution works	Monitor, measure, recognize, interpret

Trade Study
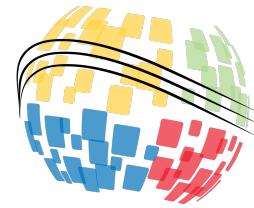
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		Choose	Decide on a solution	Structure, analyze, confer, select
		Act	Implement the solution	Communicate, advocate
		[Evaluate]	Determine if solution works	[Monitor, measure, recognize, interpret]

Problem is provided to learner who must identify alternatives, select one, advocate for it, and possibly evaluate results.

Architecture and Tools
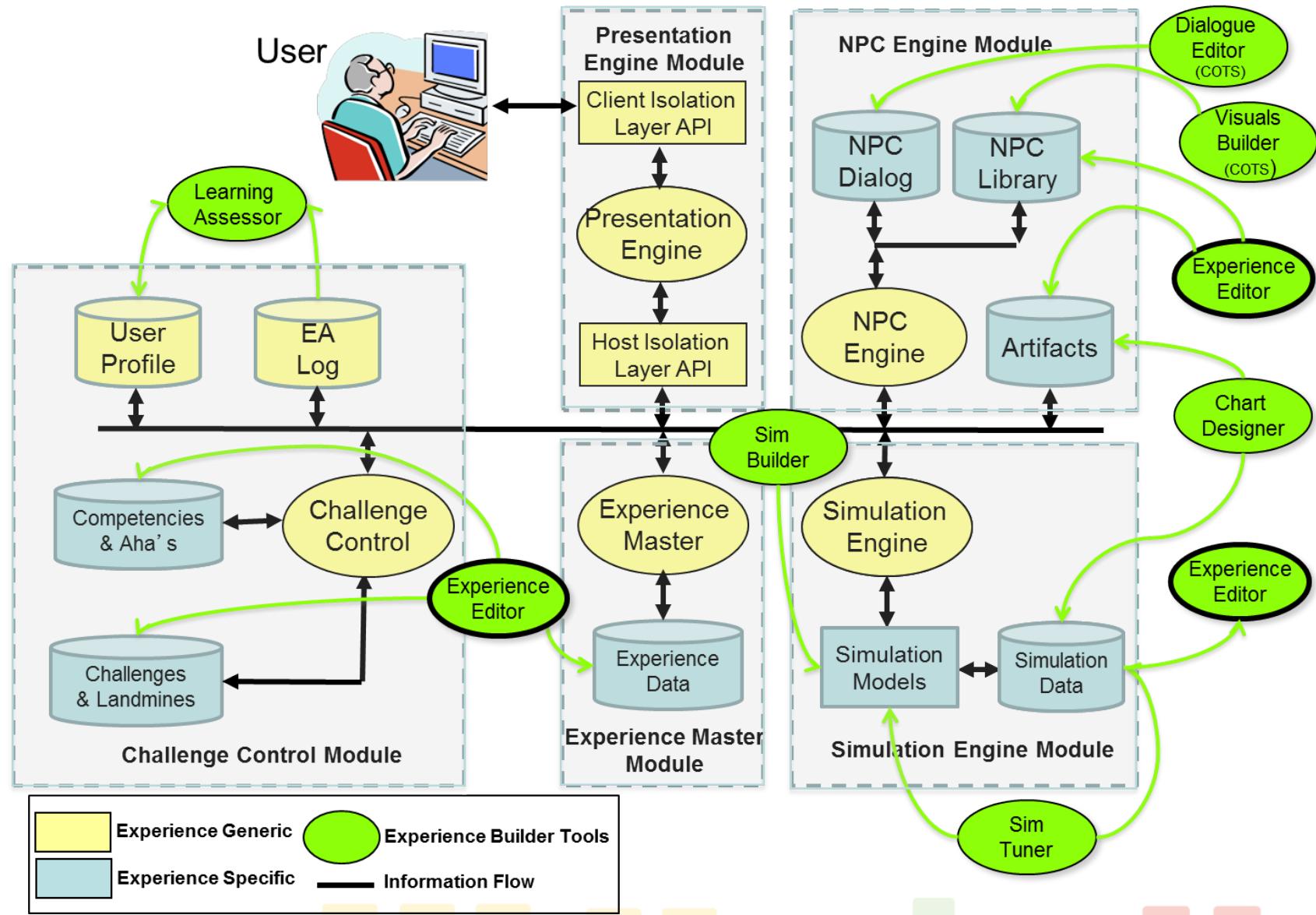
Experience Building Tools

The experience building tools provide multiple options for experience designers to alter different aspects of the experience.

- **Phase Editor**
  This tool provides the ability to change the finite state machine that controls the phases within an SEEA experience.

- **Event Editor**
  This tool provides the capability to create and edit events during an experience and the activities that may trigger them.

- **Artifact Integrator**
  This tool provides an experience designer with the ability to quickly upload an experience change, be it a new artifact such as a document, report, or a change phase and or event, and test the results without having to do any programming.

Simulation Building Tools

The simulation building tools provide the ability to efficiently create and update models, tune them for the desired behaviors and create custom charts of the simulation results.

- **Sim Builder**
    Simulation model builder using libraries/templates.

- **Sim Tuner**
    Parameter tuner that automates the tuning of parameters to yield desired outputs via batch processing of different combinations of settings.

- **Chart Designer**
    Automates design of simulation output charts.

Learning Assessment Tools

The learning assessment tools provide the ability to measure, analyze and respond to the experience results from individuals, classrooms, and historical results.

- **Learning Assessor**
  Assessment tool-suite that provides automated performance scoring and decision comparisons against proven baselines.

Case Study: UK MoD In-Service Safety

UK MoD HMS Tempest Safety Call

- Based on actual accidents: Space Shuttle Columbia, UK reconnaissance aircraft Nimrod, and UK submarine Thetis.

- Context is design authority safety decision making:

  – SE must balance the risk of delaying a specific ship's maintenance versus desire to keep a tight fleet-wide maintenance schedule driven by dry dock availability

- Simple phase structure, no simulation, flow determined by the learner's actions

Learning Objectives

The LOs identified are mainly associated with management situations and specific technical risks. They include:

- The learner will be able to understand the difficulties that could occur when dealing with different stakeholders. They need to demonstrate their understanding by using an informed approach to a conversation.

- The learner will be able to prioritize different stakeholder needs under deadline pressure. They need to demonstrate their capabilities by performing tasks in the correct order.

- The learners will be able to use the right communication skills to channel information during in-service scenarios. They need to demonstrate their skills by asking the correct questions and asking the questions correctly.

- The learners will be able to discover a safe and effective solution among mixed information under time-pressure. They need to demonstrate the capability by analyzing mixed information and providing the best solution available.

Phase Design

Phase	Phase Description		
	Phase Activity Focus	Ending Event	Activities
0	Pre-work	Learner feels ready to "go to work"	Learner is advised of the team status (only the learner is on duty) and to study information relative to the team's purpose
1	Interruption	Tasked to investigate and make recommendation	Message from Tempest re: damage to torpedo tube
2	Investigation	Completes investigation	Contacts other personnel about the safety issues involved
3	Decision and Recommended Action	Experience ends	Considers all information; makes recommendation
4	Reflection	News report based on the performance	Receive information about their decisions and reflect on learning objectives

Experience Interactions

During the development, tasks are specified to better define the experience and to provide define the types of implementations of the experience. Including the use of emails, phone calls, the presents of a deadline pressure, the pressure from higher ranked officers and the attitude of the peers. For example, the following experience components were specified during the development:

- Learner can access the background information about the experience in the forms of emails and pdf files.

- Learner is presented with a time-sensitive issue which are both challenging and complex.

- Learner can receive intel about different aspects of the problems by talking to NPC characters.

- These players are automated and interact with the learner in different kind of mood, depending on the relationships between the two and the way learner(s) ask questions. There are limits on the time available and the number of NPCs the learner can talk to.

- Supervisor NPC asks the learner to explain the issue after the investigation.

The Experience

Introduction

Gather Information

Discussions

Outcome

Results and Future Work

Summary

The SEEA was used successfully by an organization outside of the SEEA development team to create and deliver an experience.

Unlike the prototype experience, which was built around a complex system dynamics model, the Tempest experience was primarily built around personal interaction.

It also had a much shorter time frame and more limited scope.

Results

- **Experience Framework:** The underlying EA framework supported the existing MOD scenario well.

- **EA Tools:** The basic structure of an EA toolset fit the MOD scenario. Both followed a similar mix of high level linear chapter to chapter flow, with a non-linear exploration within chapters. The EA toolset was surprisingly easy to use.

- **Emphasis:** The MOD scenario explored a different aspect of the experience accelerator than the original UAV scenario. The scenario timescales were not as compressed as the UAV the student could stop a major accident from happening. This offers the potential to contribute to the MODs maritime safety strategy, as it lets everyone experience very low likelihood but high impact events.

- **Exercise Conversion:** Converting from a classroom-based exercise to an SEEA-based one had some challenges. It was necessary to think through the issues in much more detail than when using an expert delivery team.

- **Working Relationships:** Finally, the work required good working relationships. Two factors helped successful delivery. First, The Technical Cooperation Programme provided an overarching legal framework to work within (http://www.acq.osd.mil/ttcp/). Second, the team could build upon existing relationships between key players developed during previous INCOSE work.

Future Work

- The SEEA team is continuing to test the tool set internally, and will continue to conduct tutorials and workshops in experience development to validate and improve the tools.

- The Delivery System is being revamped and upgraded to an HTML5 infrastructure to provide better capability and meet the web accessibility requirements.

- The Development System is also evolving; new features are being added and new tools developed. Interest in using the SEEA technology has extended beyond the defense systems engineering community to include education, healthcare, and other industrial environments as well.

- The SEEA is currently being used in three academic environments. The US Defense Acquisition University, the University of Alabama Huntsville and the Air Force Institute of Technology are planning to collect additional metrics from their systems engineering classes in the spring, summer and fall of 2017.

- As an open source, openly available tool, the team is actively building a community of users and developers around the Experience Accelerator. As the community evolves, more types of simulations will become available and additional interaction techniques developed.

Experiences

- DAU UAV experience – being deployed

- UK MoD Experience – nearing completion

- Assessment of Systems Thinking capabilities – Doctoral Dissertation in progress

- Robot Design Game – concept complete

- Wright Brothers experience – in development

- Air Force Institute of Technology Architecture – to be developed

Questions?

Join the Experience Accelerator Team!

Contact for information:

Jon Wade
jwade@stevens.edu

Doug Bodner
doug.bodner@gatech.edu

27th annual **INCOSE** international symposium

Adelaide, Australia
July 15 - 20, 2017

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