Using the Generalized Intelligent Framework for Tutoring (GIFT) to Support Adaptations in Challenge Levels for Collaborative Problem Solving in Digital and Virtual Reality Team Training Environments

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INTRODUCTION

Team training practices have evolved in parallel with advancements in technology, most notably as advancements in computer technology allowed for the low-cost creation of immersive and realistic environments in which participants can train together in. Environments created with rich immersion, compelling stories, believable characters, and the ability to adapt scenarios to participants' levels of skill are prevalent throughout many industries, of note, the Military and Entertainment industries, and have allowed industries to begin training both individuals and teams in new and effective ways.

It is the Military and Entertainment industries that Synaptic Sparks, Inc. assists with bridging, and through a recent partnership with a local hi-tech escape room company has created a prototype research framework utilizing the Army Research Laboratory's Generalized Intelligent Framework for Tutoring (GIFT) software suite with technologically-advanced escape rooms. Each research effort, GIFT and the hi-tech escape rooms, stand alone in their respective disciplines. GIFT allows for unprecedented Intelligent Tutoring System (ITS) design, integration with external applications and sensors, and provides experimental frameworks with which to test Team Models and Adaptive Instructional Systems. And, the other party provides the only existing software framework compatible with military simulation paradigms and software interfaces into and out-of an adaptable, virtual reality environment that currently tests both individuals and teams throughout their scenarios.

Together with these agencies, SSI is continuing to research and develop an integrated framework that uses the intelligent tutoring, adaptive learning, and experimental metrics aspects of the GIFT software suite to experiment and test with active players participating inside of adaptable difficulty scenarios. Grades of scenario-level and individual puzzle-level of challenges serve as the adaptable content implementations within the escape rooms and are resulting in experiment data usable for further research into how best to challenge

groups and individuals as they progress through high tech training simulations and games.

INITIAL SCENARIO DESIGN AND GAME THEORY

GIFT requires fundamental constructs in order to be used in conjunction with a to-be-created team training system, namely a Learner (or Learners), Training Content, Adaptive/Remedial Content, a Training Goal, Sensors, Software/Instructor Controls (whether automated or not), and an objective Measure of Training Success.

These fundamental requirements are not necessarily defined only by current GIFT documentation, but a combination of Intelligent Tutoring System requirements, entertainment industry standards for group activities, current and/or upcoming military training readiness standards, and Synaptic Sparks partners' engineering knowledge.

When designing a team training scenario, retail and entertainment environments must follow a rigorous set of scenario design and game theory practices in order to create a positive customer experience. These goals are not unlike training goals, though the end result of satisfied customers is replaced by stringent sets of desired training outcomes in serious gaming domains.

The following general rules of game theory are adhered to by the design team to set the stage for a software suite such as GIFT to perform adequately (represented visually below in Figure 1):

- **Entry criteria are established for the customers/learners**

- **Goals and evaluations are established (possibly unknown to learner)**

- **Individual and shared means of accomplishing goals are provided to/discovered by learners**

- **Systems of discovery, inputs, processes, and teamwork are iteratively repeated to satisfy learning goals**

- **Assessments are either performed throughout or at the conclusion of scenarios**

- **Conclusions and debriefing (after action reviews) are performed to fully enforce training goals**
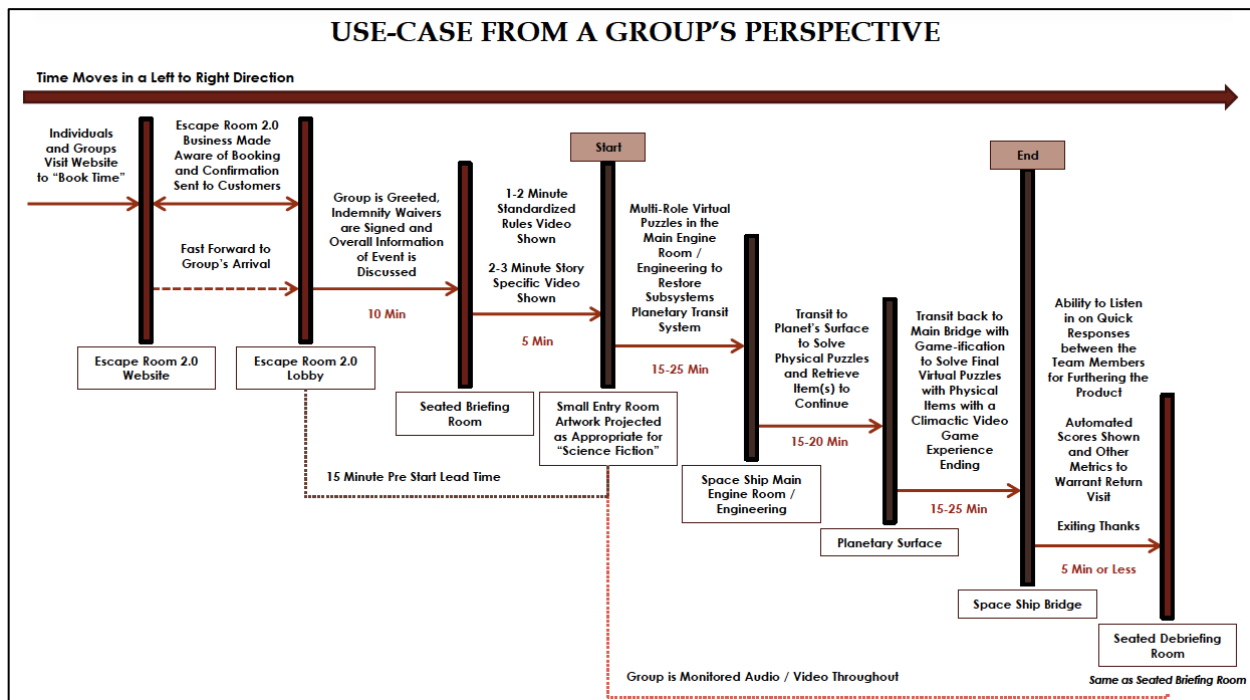
USE-CASE FROM A GROUP'S PERSPECTIVE

Time Moves in a Left to Right Direction

Individuals and Groups Visit Website to "Book Time"

Escape Room 2.0 Business Made Aware of Booking and Confirmation Sent to Customers

Fast Forward to Group's Arrival

Escape Room 2.0 Website

Escape Room 2.0 Lobby

Group is Greeted, Indemnity Waivers are Signed and Overall Information of Event is Discussed

10 Min

15 Minute Pre Start Lead Time

1-2 Minute Standardized Rules Video Shown

2-3 Minute Story Specific Video Shown

Seated Briefing Room

Small Entry Room Artwork Projected as Appropriate for "Science Fiction"

5 Min

Start

Multi-Role Virtual Puzzles in the Main Engine Room / Engineering to Restore Subsystems Planetary Transit System

15-25 Min

Space Ship Main Engine Room / Engineering

Transit to Planet's Surface to Solve Physical Puzzles and Retrieve Item(s) to Continue

15-20 Min

Planetary Surface

Transit back to Main Bridge with Game-ification to Solve Final Virtual Puzzles with Physical Items with a Climactic Video Game Experience Ending

15-25 Min

Space Ship Bridge

End

Ability to Listen in on Quick Responses between the Team Members for Furthering the Product

Automated Scores Shown and Other Metrics to Warrant Return Visit

Exiting Thanks

5 Min or Less

Seated Debriefing Room

Same as Seated Briefing Room

Group is Monitored Audio / Video Throughout

Figure 1 – Escape Room (Team Training) Use-Case Flowchart

With these similarities between retail entertainment scenarios in a hi-tech, focused, results-oriented environment and serious training environments established, Synaptic Sparks moved to include the GIFT software suite into adaptive challenge determinations based on both individual and team performance throughout a scenario's operational time limits.

GAMES VS. PUZZLES (VIDEO GAMES VS. SERIOUS GAMES): INDIVIDUAL, SMALL TEAM, AND LARGE TEAM PERFORMANCE

With overarching User Stories (and Training Goals) for scenarios defined by a partner company, the Synaptic Sparks team then began to analyze similarities between GIFT monitoring and assessment capabilities and software analytics, difficulty settings, and operator interactions present within the hi-tech escape rooms.

Of first note was the module nature of GIFT training content when compared to escape room (training scenario) puzzles. Unlike traditional games, the hi-tech escape room puzzles maintained key similarities with training content, visually represented in Figure 2 below, namely:

- **Victory conditions were not always a 1 or a 0**

- **Time bounds were nearly always a factor for success**

- **Individuals could assist or hinder team performance depending on their actions**

- **Team performance is more than a sum of the parts of individual performance**

- **Populations of teams exhibited standard deviations of performance (80% of all future performance is within bounds based on past team performance with a data set of significant enough size)**

- **Discovery of puzzle rules and goals, no matter the proficiency of the learner, is more important to the training and learning process when considering success and knowledge retention than being told the rules and simply executing them given limited training time and first-time exposure to a challenge**
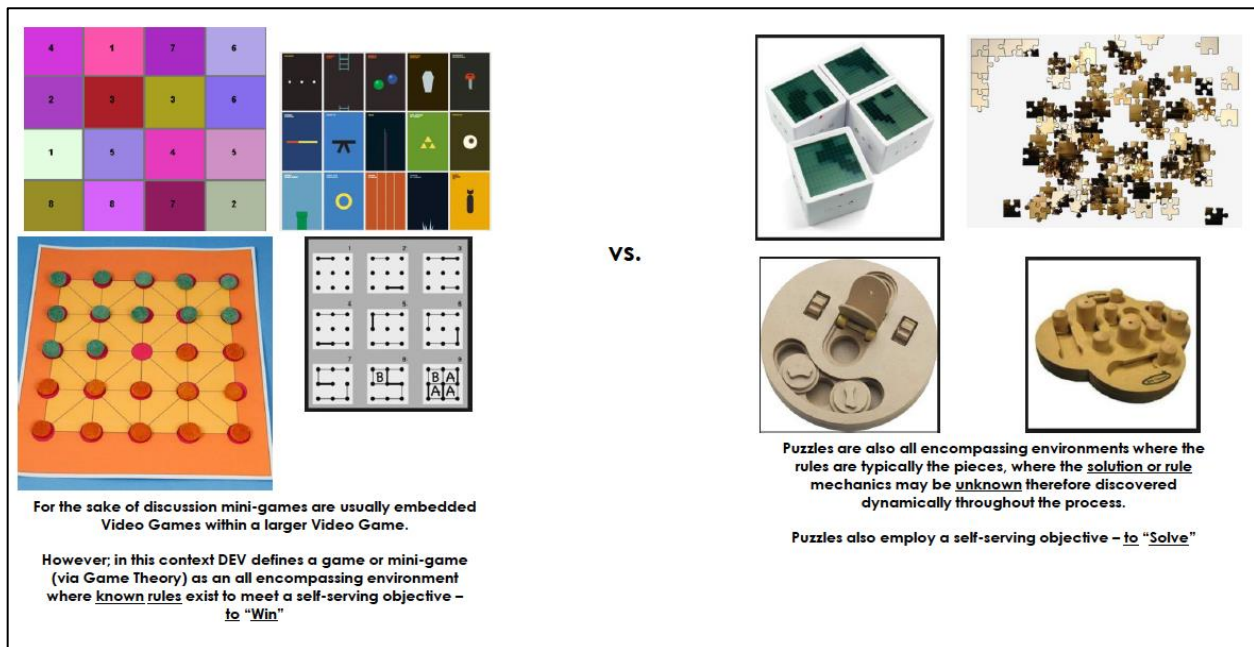

For the sake of discussion mini-games are usually embedded Video Games within a larger Video Game.

However; in this context DEV defines a game or mini-game (via Game Theory) as an all encompassing environment where known rules exist to meet a self-serving objective – to "Win"

vs.

Puzzles are also all encompassing environments where the rules are typically the pieces, where the solution or rule mechanics may be unknown therefore discovered dynamically throughout the process.

Puzzles also employ a self-serving objective – to "Solve"

Figure 2 - Games Vs. Puzzles: A Visual Representation of Potential Negative Learning Vs. Critical Thinking Development, Concerning Real-Life Tasks

Elements of Social Utility – Encouraging Team Performance and Monitoring Success

When taking into account the similarity of effective training content to correctly-designed puzzles in a hi-tech training scenario, Synaptic Sparks personnel then analyzed customer data to best-define what social utility elements GIFT may be able to use as it evolves to intelligent tutoring adaptations for teams as opposed to individuals.

To generalize and as represented in Figure 3 below, when SSI observed roughly 5,000 participants in groups of up to 6 individuals per team, the **perceived** Social Utility of the team experience was most-relevant to customer satisfaction and team performance, and also learning retention.
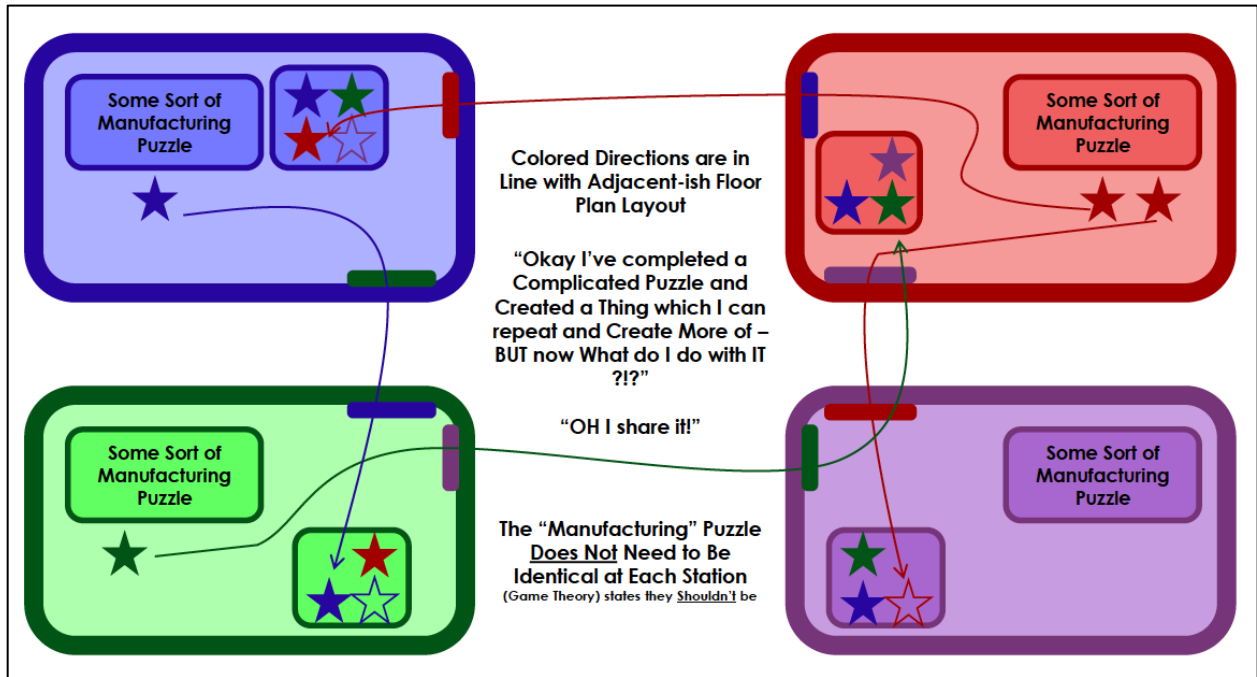

Figure 3 - A Conceptual Diagram of Social Utility for Training Content

During all escape room scenarios, Synaptic Sparks was given license to add software "hooks" into the escape room experience, and direct all metrics to a GIFT software suite monitoring station via methods explained, in-part, in the following section.

The analytics resulting from the metrics analysis gave new insight into individual, team, and overall performance for groups, and how GIFT can be used to adapt puzzle (and therefore training) content to better serve participants.

UTILIZING THE GIFT SOFTWARE SUITE TO ENHANCE CONTENT ADAPTATION WITHIN A TEAM TRAINING SCENARIO

Synaptic Sparks identified some existing feedback loops between GIFT and the escape room software to create low-cost, high-value experiments. SSI created:

- **A GIFT-Monitored Statistic Set Constisting of Elapsed Time Based on Puzzle Start and Completion Time to Adapt Early/Late Puzzle Exposure to Team Performance**

- **A Failsafe "Easy Mode" Monitoring System to Skip Puzzles for "Overwhelmed" Participants**

- **Messaging Between Escape Room Manager and SubComponents, and GIFT (Figure 5)**

Puzzle ID	Dependency IDs	Puzzle Name	% Complete	Assumed Time	Tested Time	GO Y/N
R1PP1	-	ABC	25%	5 min	7 min	N
R1PP2	-	IOP	0%	3 min	5 min	N
R1VP1	-	BCD	0%	8 min	-	N
R2PP1	R1VP1 (Complete) R1PP2 (Complete)	FGH	0%	7 min	-	N
R2PP2	-	JKL	35%	5 min	2 min	N
R2PP3	R2VP2 (Partial)	RTY	100%	5 min	5 min	Y
R2VP1	-	LKL	0%	6 min	-	N
R2VP2	-	DDW	0%	5 min	-	N
R3PP1	-	MNC	0%	8 min	-	N

Puzzle ID	Description
R1P1	
R1P2	
R2P1	
R2P2	
R2P3	
R3P1	

(Complete) is R1VP1 and R1PP2 must be completed by Player before R2PP1 Starts

(Partial) is R2VP2 has a trigger within the Puzzle that Starts R2PP3

Development % Complete

Must Highlight Known Areas where Puzzles are Longer / Shorter From Estimation
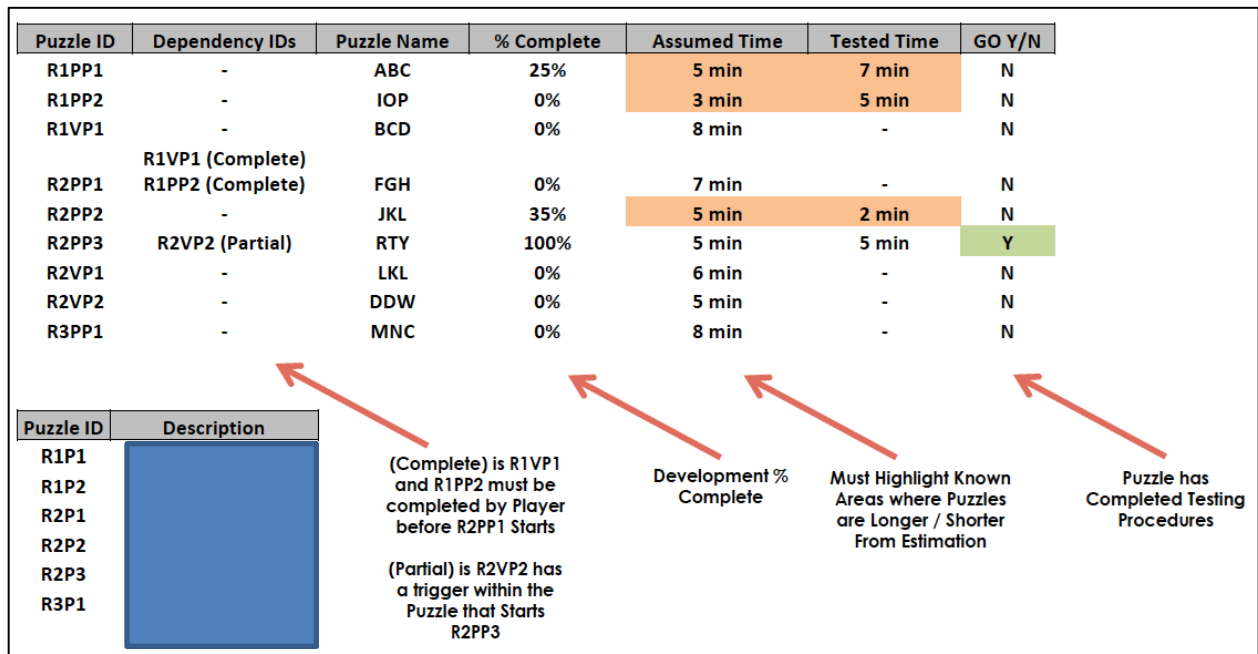
Puzzle has Completed Testing Procedures

Figure 4 - Metrics Visualization for Estimated Vs. Actual Team Performance Monitored by GIFT

These systems allowed the escape rooms software to utilize, as the private company sees fit, GIFT recommendations on content adaption concerning two main elements of the experience; namely the time at which a new puzzle is given to a team, and the difficulty level of a puzzle selected from Easy, Medium, or Hard levels.

Communications between scenarios and the GIFT software suite were established through message broadcasts, broadly defined and represented in Figure 5 below.

The results of these experiments are still being compiled, but a fully autonomous system that can adapt to any team performance is expected by the end of 2Q 2018.
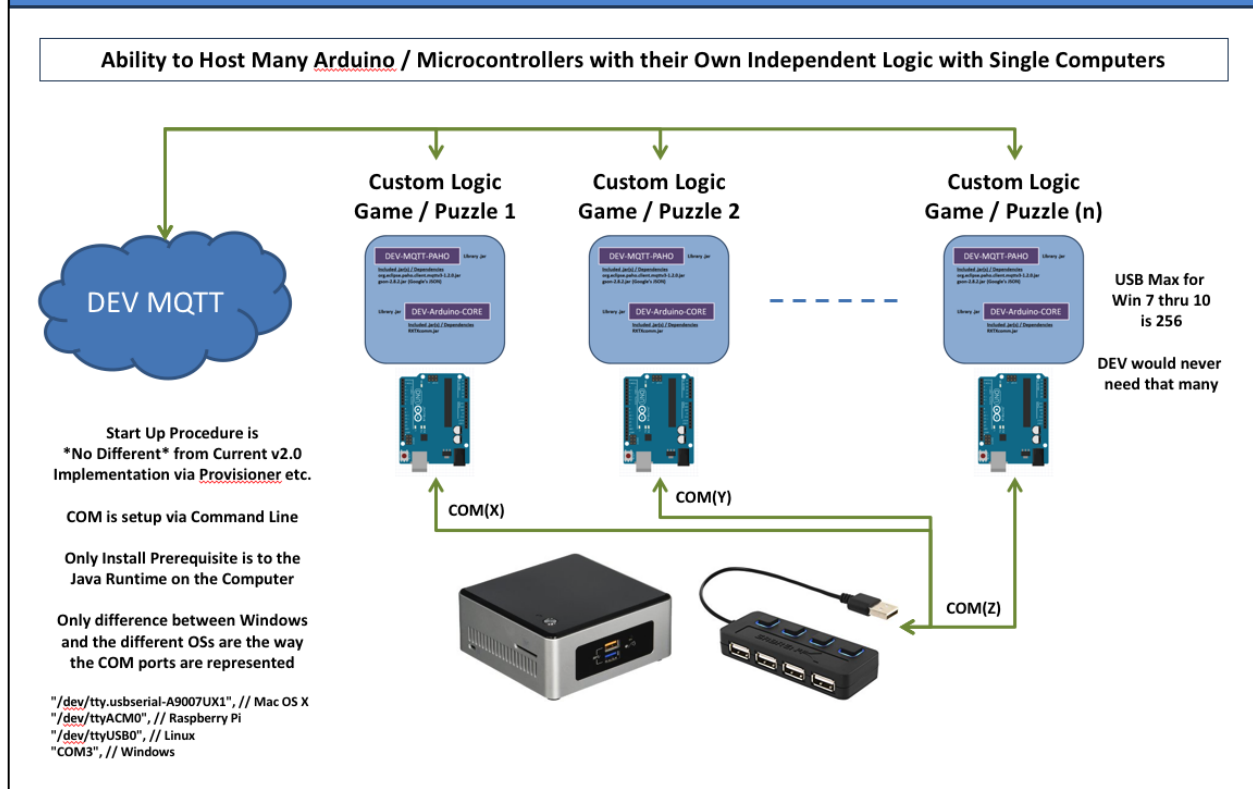
Figure 5 - A Sample Messaging Scheme Between Puzzles in Hi-Tech Escape Room Sub-System and GIFT

CONCLUSIONS AND RECOMMENDATIONS FOR FUTURE RESEARCH

Currently, the SSI team is performing the same level of integrations as described above for an even more modernized, fully-digital escape room experience in Virtual Reality. While scenarios described above are currently being adapted for various military training scenarios that have a "real world" environment with which GIFT can interact, the new Virtual Reality project is limited only by the art asset content and training knowledge of Subject Matter Experts.

With GIFT operating alongside the hi-tech escape room scenario manager, adaptive content can be served and adapted not only to individuals, but teams as they collaborate together in a proprietary virtual environment.

While the SSI team consists primarily of experienced engineers, this new experimental platform is provided to the ARL GIFT team researchers to further evolve and experiment with as research representatives see fit.

ABOUT THE AUTHORS

Christopher Meyer leads the Synaptic Sparks team as the President and CEO of the Board, and holds a B.S. and M.S. in Computer Science obtained from Kansas State University, with minors in Economics and Modern Languages. Chris specialized in Artificial Intelligence studies in Chukyo University, Japan, and holds 15 years experience in business and engineering.

Zach Heylmun holds the Chief Scientist position in Synaptic Sparks, and holds a B.S in Computer Science obtained from Florida State University. Zach specializes in software optimizations and graphics processing after 5 years of professional experience.

Mike Kalaf is the Chief Operating Officer in SSI, and has over 30 years of Modeling, Simulation and Training leading large scale efforts leveraging cutting edge technology. Mike also serves on several non-profit boards dedicated to STEM outreach in the Orlando, FL locale.

Lucy Woodman is currently studying to graduate with a B.S. in Information Technology and assisting SSI in her early career. Lucy specializes in System Administration, Computer Security, and Programming.