

Games for Systems Engineers



LET'S MAKE A STRONG COMMUNITY

Where is everyone meeting?
Where is everyone publishing?

We need to impact multiple groups but
also would be good to have a home



Why Games?



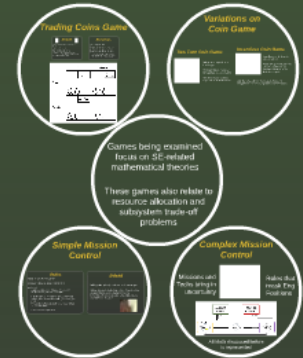
Why Now?



Why SE?



Game-Based Learning for incentives and mechanism design



Gamification of Systems Engineering

How to bring game elements into a real systems engineering process?



Dr. Bryan Mesmer

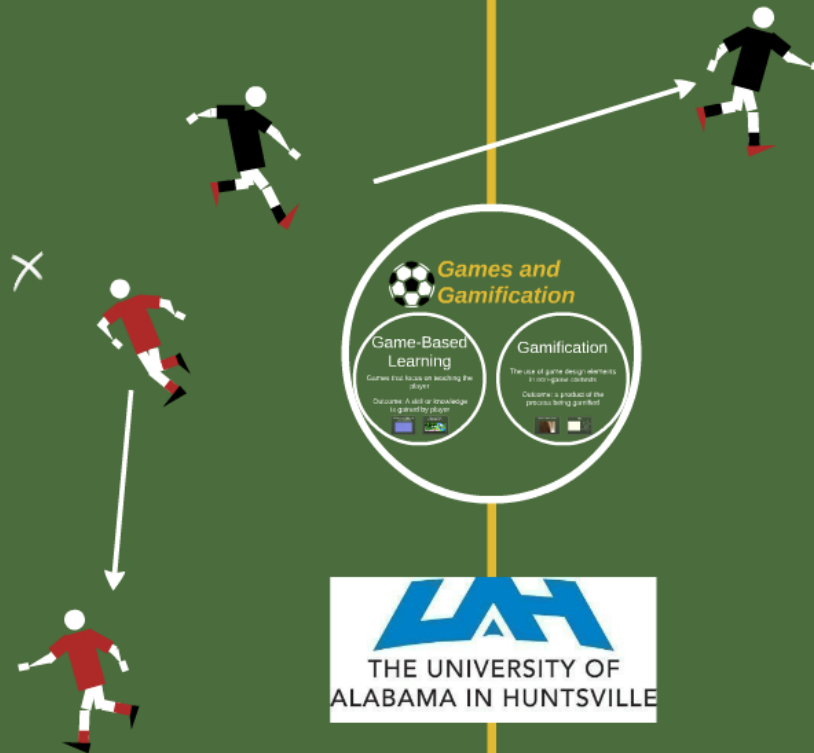
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Games being examined focus on SE-related mathematical theories

These games also relate to resource allocation and subsystem trade-off problems



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Games and Gamification

Game-Based Learning

Games that focus on teaching the player

Outcome: A skill or knowledge is gained by player



Gamification

The use of game design elements in non-game contexts

Outcome: a product of the process being gamified





Why Games?

Why games?

- Strong history of use in many fields
- Strong psychological foundations
- Ability to model complex systems and interactions
- Ability to visualize abstract concepts

Why Now?

Millennials

- More socialized to internet, gaming, experiences, and digital media
- Attending college and entering the workforce NOW
- Important to understand games to train and educate individuals interested in learning this way

Why SE?

Why SE?

- Complex products that are hard for a single person to grasp
- Need tools to enable general understanding
- May only see 2 or 3 system designs in entire career
- Repetition is a key to learning
- We have great math tools, but they are not always taught in SE programs

	Give	Trade
Give	3, L (3, L)	2, L (4, W)
Trade	4, W (2, L)	3, L (3, L)

Games being examined focus on SE-related mathematical theories

These games also require resource allocation and subsystem trade-off problems

Simple Mission Control

Rules

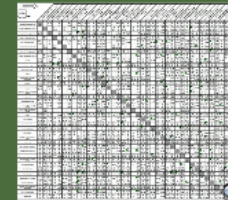
Simple Mission Control (SMC) is a two-player game. It is played on a 10x10 grid. The grid is divided into four quadrants. The top-left quadrant is the 'Mission' area, the top-right is the 'Control' area, the bottom-left is the 'Status' area, and the bottom-right is the 'Action' area. The game is played by two players, one of whom is the 'Mission Controller' and the other is the 'Control Operator'. The Mission Controller's goal is to complete the mission, while the Control Operator's goal is to prevent the mission from being completed. The game is played by taking turns to move pieces and perform actions.

Intent

Simple Mission Control is a game that is designed to be both educational and entertaining. It is a game that can be played by two players, one of whom is the 'Mission Controller' and the other is the 'Control Operator'. The Mission Controller's goal is to complete the mission, while the Control Operator's goal is to prevent the mission from being completed. The game is played by taking turns to move pieces and perform actions.

Why SE?

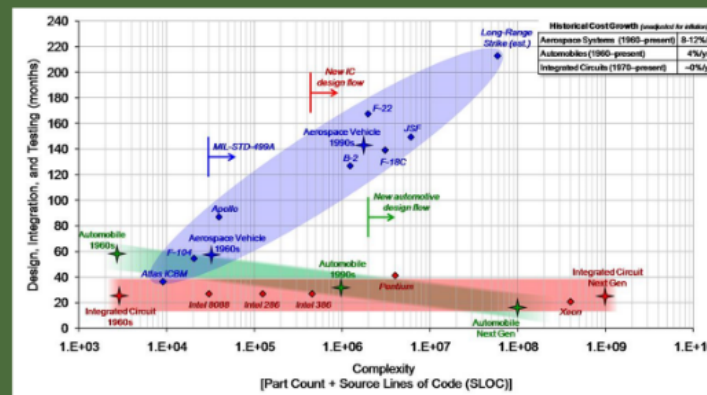
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Value Driven Design
Enables the communication of preferences through value functions.
Who Cares?
In games knowing your own and your opponents' preferences is crucial to success.

Decision Analysis
Examination of effective decision-making in a state of uncertainty.
Who Cares?
Most games have uncertainty (otherwise it would not be fun). Understanding value AND RISK is critical.

Game Theory
Considers the interaction of individuals. Mechanism Design examines the designer's influence on a game.
Who Cares?
Many games, and SE specifically, involve other players. Tools for SE: Understanding how the game designer can change the game to drive behaviors he desires is critical to incentives.

Organization Theory
Examination of the structure and path information follows in large groups.
Who Cares?
It's important to know how your decision (or game moves) outcomes will be impacted by the path it takes.



Game-Based Learning for incentives and mechanism design

Trading Coins Game

RULES		Behaviors	
<p>1. Players start with 10 coins.</p> <p>2. In each round, players can choose to 'Give' or 'Trade'.</p> <p>3. If a player chooses to 'Give', they lose 1 coin and the other player gains 1 coin.</p> <p>4. If a player chooses to 'Trade', they lose 1 coin and the other player loses 1 coin.</p>		<p>Players can choose to 'Give' or 'Trade'.</p> <p>Players can choose to 'Give' or 'Trade'.</p> <p>Players can choose to 'Give' or 'Trade'.</p> <p>Players can choose to 'Give' or 'Trade'.</p>	
Give	Trade	Give	Trade
3, 1	2, 1	3, 1	2, 1
4, 1	4, W	4, W	3, L
4, W	3, L	3, L	3, L
2, L	3, L	3, L	3, L

Variations on Coin Game

Two Turn Coin Game

Brings in concept of past knowledge.

Through 100 coins captured through knowledge.

Strategic Strategies become important as mixed NC-etc.

Incentives Coin Game

Incentives can be used to drive a behavior.

Game designer will give two coins to a player who performs a task (after the task is completed).

Now Trade slowly diminishes Give. The game designer has modified the game to drive behavior.

Games being examined focus on SE-related mathematical theories

These games also relate to resource allocation and subsystem trade-off problems

Simple Mission Control

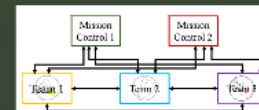
Rules	Intent
<p>1. Player to track player's actions.</p> <p>2. Players can choose to 'Give' or 'Trade'.</p> <p>3. If a player chooses to 'Give', they lose 1 coin and the other player gains 1 coin.</p> <p>4. If a player chooses to 'Trade', they lose 1 coin and the other player loses 1 coin.</p>	<p>1. Player to track player's actions.</p> <p>2. Players can choose to 'Give' or 'Trade'.</p> <p>3. If a player chooses to 'Give', they lose 1 coin and the other player gains 1 coin.</p> <p>4. If a player chooses to 'Trade', they lose 1 coin and the other player loses 1 coin.</p>

Complex Mission Control

Missions and Techs bring in uncertainty



Roles that mask Eng Positions



All Math discussed before is represented

Why Games?

Why games?



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Why SE2

Games being examined
focus on SE-related
mathematical theories

These games also relate to
resource allocation and
subsystem trade-off
problems

Simple Mission Control

Rules

Similar to Rock Paper Scissors

3 players: 1 player is mission control (MC)

on 3 count:

players can refuse aid (fist) or give aid (palm)
MC puts out fist, 1 finger, or 2 fingers

If the MC puts out as many fingers as palms then
he wins (1,3,9 points corresponding to 0,1,2 fingers
shown)

If MC loses he loses 1,3,9 points corresponding to
0,1,2 fingers shown

3 rounds, each player is MC

Intent

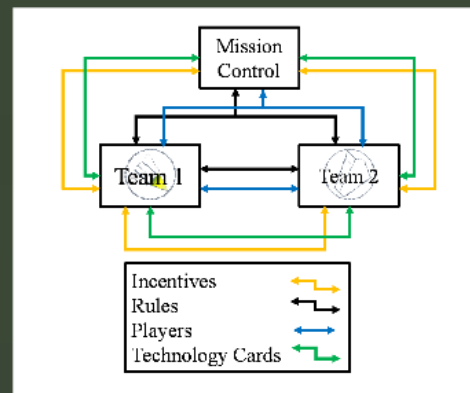
Bribing (with points) is allowed and encouraged

Drives players to delve into a form of mechanism
design where they are trying to alter the
behaviors of their opponents by manipulating the
outcomes of the game

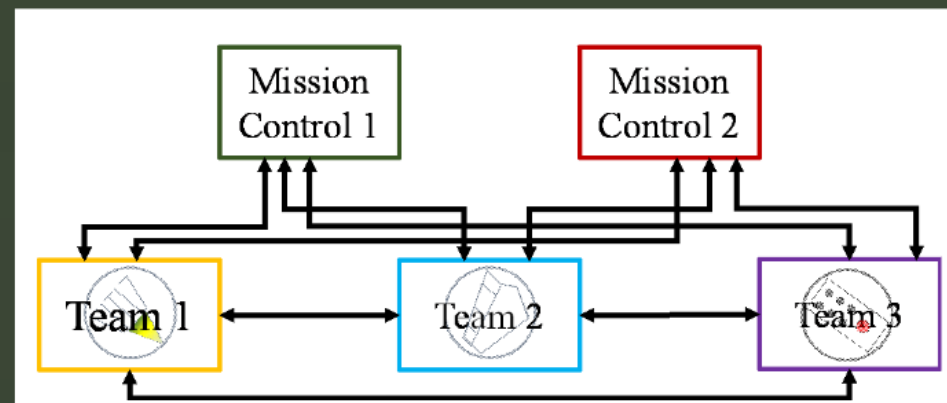


Complex Mission Control

Missions and
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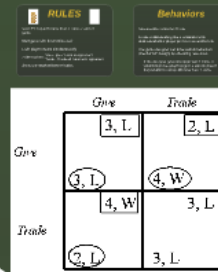
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Game-Based Learning for incentives and mechanism design

Trading Coins Game



Variations on Coin Game

Two Turn Coin Game



Things in concept of just knowledge

Changing beliefs captured through Bayesian probability

Mixed Strategies become important as mixed NE exists



Game designer will give 5 coins to a player if they perform a trade (after the trade is complete)

Games being examined
focus on SE-related
mathematical theories

These games also relate to resource allocation and subsystem trade-off problems

Simple Mission Control

Rules

2 players: 1 player is mission control (MC)
on 5 count:
players can reduce or flip or give or steal
MC puts out 1, 1 finger or 2 fingers
if the left puts out 2 fingers, fingers as palm then
the MC puts out 3.0 points corresponding to 0.5, 2 fingers
shown
if MC loses by more 3.0 points corresponding to
0.5, 2 fingers shown
2 rounds, each player is MC

Intent

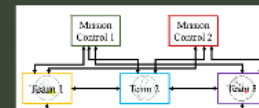
Defers players to tie into a form of reaction design where they are trying to alter the behaviors of their opponents by manipulating the outcomes of the game

Complex Mission Control



Missions and Techs bring in uncertainty

Roles that mask Eng Positions



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Why Games?

Why games?



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Why SE2

Gamification of Systems Engineering

How to bring game elements into a real systems engineering process?

Scorecards in Value-Driven Design

Gives designers at different levels the impact of their decisions on system value



Category	Value	Impact
System Value	100	100
Design Value	80	80
Implementation Value	60	60
Operation Value	40	40
Support Value	20	20

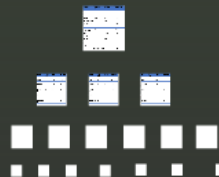
ScoreBOARDS

By taking value impact (and accounting for the degree of impact from each group) can have groups competing for top place



Group	Score	Rank
Group A	95	1
Group B	85	2
Group C	75	3
Group D	65	4
Group E	55	5

ScoreBOARDS



SCOREBOARD
1. Flight Controls 15468
2. Ground Support 12879
3. Structures 11588

This is all very preliminary work but we believe it to be a path that should be taken to align SE with the traits of future and current engineers and to address the teaching of topics that are not taught or are taught incorrectly in current SE programs

Scorecards in Value-Driven Design

Gives designers at different levels
the impact of their decisions on
system value

Attribute	Change in Status	Gradient	Value Impact
Efficiency	10%	150,000	15,000
Weight	700	-130	-91,000
Reliability	1500	2.3	3,450
Maintainability	7.8	-340	-2,652
Maintenance Cost	500	-.5	-250
Support Equipment	12	-15	-180
Radar Cross-Section	.1	-1200	-120
InfraRed Signature	1.4	-50	-70
Manufacturing Cost	700	-1	-700
Design Value Impact			-76,522

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ScoreBOARDS

Attribute	Change in Status	Gradient	Value Impact
Efficiency	15%	350,000	\$7,000
Weight	20%	-100	-\$1,000
Reliability	50%	50	\$2,500
Maintainability	+5	600	\$3,000
Maintenance Cost	10%	-5	-\$20
Support Equipment	50	15	\$80
Racer Crew-works	1	-200	-\$20
Refueling Signature	3.4	30	\$30
Maintenance Cost	20%	-1	-\$20
Energy Value Impact			\$1,500

SCOREBOARD

1. Flight Controls 15468

2. Ground Support 12879

3. Structures 11588

[illegible][illegible][illegible]

Variable	Sample mean	Standard deviation	Sample size
Age (years)	38.5	10.5	100
Gender	50%	50%	100
Education	12.5	1.5	100
Income	25.0	5.0	100
Health status	2.5	1.0	100
Family size	3.0	1.0	100
Marital status	50%	50%	100
Religion	50%	50%	100
Occupation	1.5	1.0	100
Health insurance	50%	50%	100
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Religion	50%	50%	100
Occupation	1.5	1.0	100
Health insurance	50%	50%	100
Health status	2.5	1.0	100
Family size	3.0	1.0	100
Marital status	50%	50%	100
Religion	50%	50%	100
Occupation	1.5	1.0	100
Health insurance	50%	50%	100
Health status	2.5	1.0	100
Family size	3.0	1.0	100
Marital status	50%	50%	100
Religion	50%	50%	100
Occupation	1.5	1.0	100
Health insurance	50%	50%	100
Health status	2.5	1.0	100
Family size	3.0	1.0	100
Marital status	50%	50%	100
Religion	50%	50%	100
Occupation	1.5	1.0	100
Health insurance	50%	50%	100
Health status	2.5	1.0	100
Family size	3.0	1.0	100
Marital status	50%	50%	100
Religion	50%	50%	100
Occupation	1.5	1.0	100
Health insurance	50%	50%	100
Health status	2.5	1.0	100
Family size	3.0	1.0	100
Marital status	50%	50%	100
Religion	50%	50%	100
Occupation	1.5	1.0	100
Health insurance	50%	50%	100
Health status	2.5	1.0	100
Family size	3.0	1.0	100
Marital status	50%	50%	100
Religion	50%	50%	100
Occupation	1.5	1.0	100
Health insurance	50%	50%	100
Health status	2.5	1.0	100
Family size	3.0	1.0	100
Marital status	50%	50%	100
Religion	50%	50%	100
Occupation	1.5	1.0	100
Health insurance	50%	50%	100
Health status	2.5	1.0	100
Family size	3.0	1.0	100
Marital status	50%	50%	100
Religion	50%	50%	100
Occupation	1.5	1.0	100
Health insurance	50%	50%	100
Health status	2.5	1.0	100
Family size	3.0	1.0	100
Marital status	50%	50%	100
Religion	50%	50%	100
Occupation	1.5	1.0	100
Health insurance	50%	50%	100
Health status	2.5	1.0	100
Family size	3.0	1.0	100
Marital status	50%	50%	100
Religion	50%	50%	100
Occupation	1.5	1.0	100
Health insurance	50%	50%	100
Health status	2.5	1.0	100
Family size	3.0	1.0	100
Marital status	50%	50%	100
Religion	50%	50%	100
Occupation	1.5	1.0	100
Health insurance	50%	50%	100
Health status	2.5	1.0	100
Family size	3.0	1.0	100
Marital status	50%	50%	100
Religion	50%	50%	100
Occupation	1.5	1.0	100
Health insurance	50%	50%	100
Health status	2.5	1.0	100
Family size	3.0	1.0	100
Marital status	50%	50%	100
Religion	5		

Variable	Sample size (n)	Mean	Standard deviation
Age (years)	100	30.5	10.2
Gender	100	50	7.1
Marital status	100	10	3.2
Education level	100	15	4.5
Income (USD)	100	2500	1200
Health status	100	10	2.1
Smoking status	100	5	2.2
Alcohol consumption	100	10	3.5
Exercise frequency	100	10	3.5
Stress level	100	10	3.5
Overall health score	100	10	3.5

Model	Log-likelihood	AIC	BIC
Model 1	-100.00	202.00	205.00
Model 2	-98.50	199.00	202.00
Model 3	-97.00	196.00	199.00
Model 4	-95.50	193.00	196.00
Model 5	-94.00	190.00	193.00
Model 6	-92.50	187.00	190.00
Model 7	-91.00	184.00	187.00
Model 8	-89.50	181.00	184.00
Model 9	-88.00	178.00	181.00
Model 10	-86.50	175.00	178.00
Model 11	-85.00	172.00	175.00
Model 12	-83.50	169.00	172.00
Model 13	-82.00	166.00	169.00
Model 14	-80.50	163.00	166.00
Model 15	-79.00	160.00	163.00
Model 16	-77.50	157.00	160.00
Model 17	-76.00	154.00	157.00
Model 18	-74.50	151.00	154.00
Model 19	-73.00	148.00	151.00
Model 20	-71.50	145.00	148.00
Model 21	-70.00	142.00	145.00
Model 22	-68.50	139.00	142.00
Model 23	-67.00	136.00	139.00
Model 24	-65.50	133.00	136.00
Model 25	-64.00	130.00	133.00
Model 26	-62.50	127.00	130.00
Model 27	-61.00	124.00	127.00
Model 28	-59.50	121.00	124.00
Model 29	-58.00	118.00	121.00
Model 30	-56.50	115.00	118.00
Model 31	-55.00	112.00	115.00
Model 32	-53.50	109.00	112.00
Model 33	-52.00	106.00	109.00
Model 34	-50.50	103.00	106.00
Model 35	-49.00	100.00	103.00
Model 36	-47.50	97.00	100.00
Model 37	-46.00	94.00	97.00
Model 38	-44.50	91.00	94.00
Model 39	-43.00	88.00	91.00
Model 40	-41.50	85.00	88.00
Model 41	-40.00	82.00	85.00
Model 42	-38.50	79.00	82.00
Model 43	-37.00	76.00	79.00
Model 44	-35.50	73.00	76.00
Model 45	-34.00	70.00	73.00
Model 46	-32.50	67.00	70.00
Model 47	-31.00	64.00	67.00
Model 48	-29.50	61.00	64.00
Model 49	-28.00	58.00	61.00
Model 50	-26.50	55.00	58.00
Model 51	-25.00	52.00	55.00
Model 52	-23.50	49.00	52.00
Model 53	-22.00	46.00	49.00
Model 54	-20.50	43.00	46.00
Model 55	-19.00	40.00	43.00
Model 56	-17.50	37.00	40.00
Model 57	-16.00	34.00	37.00
Model 58	-14.50	31.00	34.00
Model 59	-13.00	28.00	31.00
Model 60	-11.50	25.00	28.00
Model 61	-10.00	22.00	25.00
Model 62	-8.50	19.00	22.00
Model 63	-7.00	16.00	19.00
Model 64	-5.50	13.00	16.00
Model 65	-4.00	10.00	13.00
Model 66	-2.50	7.00	10.00
Model 67	-1.00	4.00	7.00
Model 68	0.50	1.00	4.00
Model 69	2.00	-2.00	1.00
Model 70	3.50	-5.00	-2.00
Model 71	5.00	-8.00	-5.00
Model 72	6.50	-11.00	-8.00
Model 73	8.00	-14.00	-11.00
Model 74	9.50	-17.00	-14.00
Model 75	11.00	-20.00	-17.00
Model 76	12.50	-23.00	-20.00
Model 77	14.00	-26.00	-23.00
Model 78	15.50	-29.00	-26.00
Model 79	17.00	-32.00	-29.00
Model 80	18.50	-35.00	-32.00
Best Model			Model 75

Index no.	Sample no.	Location	Species no.
101	1	100	100
102	2	100	100
103	3	100	100
104	4	100	100
105	5	100	100
106	6	100	100
107	7	100	100
108	8	100	100
109	9	100	100
110	10	100	100
111	11	100	100
112	12	100	100
113	13	100	100
114	14	100	100
115	15	100	100
116	16	100	100
117	17	100	100
118	18	100	100
119	19	100	100
120	20	100	100
121	21	100	100
122	22	100	100
123	23	100	100
124	24	100	100
125	25	100	100
126	26	100	100
127	27	100	100
128	28	100	100
129	29	100	100
130	30	100	100
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132	32	100	100
133	33	100	100
134	34	100	100
135	35	100	100
136	36	100	100
137	37	100	100
138	38	100	100
139	39	100	100
140	40	100	100
141	41	100	100
142	42	100	100
143	43	100	100
144	44	100	100
145	45	100	100
146	46	100	100
147	47	100	100
148	48	100	100
149	49	100	100
150	50	100	100
151	51	100	100
152	52	100	100
153	53	100	100
154	54	100	100
155	55	100	100
156	56	100	100
157	57	100	100
158	58	100	100
159	59	100	100
160	60	100	100
161	61	100	100
162	62	100	100
163	63	100	100
164	64	100	100
165	65	100	100
166	66	100	100
167	67	100	100
168	68	100	100
169	69	100	100
170	70	100	100
171	71	100	100
172	72	100	100
173	73	100	100
174	74	100	100
175	75	100	100
176	76	100	100
177	77	100	100
178	78	100	100
179	79	100	100
180	80	100	100
181	81	100	100
182	82	100	100
183	83	100	100
184	84	100	100
185	85	100	100
186	86	100	100
187	87	100	100
188	88	100	100
189	89	100	100
190	90	100	100
191	91	100	100
192	92	100	100
193	93	100	100
194	94	100	100
195	95	100	100
196	96	100	100
197	9		

Model	$\chi^2/\text{d.o.f.}$	χ^2_{min}	Best fit
1 (1993)	1.01	1.01	1.01
2 (1993)	0.99	0.99	1.00
3 (1993)	1.00	1.00	1.00
4 (1993)	1.00	1.00	1.00
5 (1993)	1.00	1.00	1.00
6 (1993)	1.00	1.00	1.00
7 (1993)	1.00	1.00	1.00
8 (1993)	1.00	1.00	1.00
9 (1993)	1.00	1.00	1.00
10 (1993)	1.00	1.00	1.00
11 (1993)	1.00	1.00	1.00
12 (1993)	1.00	1.00	1.00
13 (1993)	1.00	1.00	1.00
14 (1993)	1.00	1.00	1.00
15 (1993)	1.00	1.00	1.00
16 (1993)	1.00	1.00	1.00
17 (1993)	1.00	1.00	1.00
18 (1993)	1.00	1.00	1.00
19 (1993)	1.00	1.00	1.00
20 (1993)	1.00	1.00	1.00
21 (1993)	1.00	1.00	1.00
22 (1993)	1.00	1.00	1.00
23 (1993)	1.00	1.00	1.00
24 (1993)	1.00	1.00	1.00
25 (1993)	1.00	1.00	1.00
26 (1993)	1.00	1.00	1.00
27 (1993)	1.00	1.00	1.00
28 (1993)	1.00	1.00	1.00
29 (1993)	1.00	1.00	1.00
30 (1993)	1.00	1.00	1.00
31 (1993)	1.00	1.00	1.00
32 (1993)	1.00	1.00	1.00
33 (1993)	1.00	1.00	1.00
34 (1993)	1.00	1.00	1.00
35 (1993)	1.00	1.00	1.00
36 (1993)	1.00	1.00	1.00
37 (1993)	1.00	1.00	1.00
38 (1993)	1.00	1.00	1.00
39 (1993)	1.00	1.00	1.00
40 (1993)	1.00	1.00	1.00
41 (1993)	1.00	1.00	1.00
42 (1993)	1.00	1.00	1.00
43 (1993)	1.00	1.00	1.00
44 (1993)	1.00	1.00	1.00
45 (1993)	1.00	1.00	1.00
46 (1993)	1.00	1.00	1.00
47 (1993)	1.00	1.00	1.00
48 (1993)	1.00	1.00	1.00
49 (1993)	1.00	1.00	1.00
50 (1993)	1.00	1.00	1.00
51 (1993)	1.00	1.00	1.00
52 (1993)	1.00	1.00	1.00
53 (1993)	1.00	1.00	1.00
54 (1993)	1.00	1.00	1.00
55 (1993)	1.00	1.00	1.00
56 (1993)	1.00	1.00	1.00
57 (1993)	1.00	1.00	1.00
58 (1993)	1.00	1.00	1.00
59 (1993)	1.00	1.00	1.00
60 (1993)	1.00	1.00	1.00
61 (1993)	1.00	1.00	1.00
62 (1993)	1.00	1.00	1.00
63 (1993)	1.00	1.00	1.00
64 (1993)	1.00	1.00	1.00
65 (1993)	1.00	1.00	1.00
66 (1993)	1.00	1.00	1.00
67 (1993)	1.00	1.00	1.00
68 (1993)	1.00	1.00	1.00
69 (1993)	1.00	1.00	1.00
70 (1993)	1.00	1.00	1.00
71 (1993)	1.00	1.00	1.00
72 (1993)	1.00	1.00	1.00
73 (1993)	1.00	1.00	1.00
74 (1993)	1.00	1.00	1.00
75 (1993)	1.00	1.00	1.00
76 (1993)	1.00	1.00	1.00
77 (1993)	1.00	1.00	1.00
78 (1993)	1.00	1.00	1.00
79 (1993)	1.00	1.00	1.00
80 (1993)	1.00	1.00	1.00
81 (1993)	1.00	1.00	1.00
82 (1993)	1.00	1.00	1.00
83 (1993)	1.00	1.00	1.00
84 (1993)	1.00	1.00	1.00
85 (1993)	1.00	1.00	1.00
86 (1993)	1.00	1.00	1.00
87 (1993)	1.00	1.00	1.00
88 (1993)	1.00	1.00	1.00
89 (1993)	1.00	1.00	1.00
90 (1993)	1.00	1.00	1.00
91 (1993)	1.00	1.00	1.00
92 (1993)	1.00	1.00	1.00
93 (1993)	1.00	1.00	1.00
94 (1993)	1.00	1.00	1.00
95 (1993)	1.00	1.00	1.00
96 (1993)	1.00	1.00	1.00
97 (1993)	1.00	1.00	1.00
98 (1993)	1.00	1.00	1.00
99 (1993)	1.00	1.00	1.00
100 (1993)	1.00	1.00	1.00
101 (1993)	1.00	1.00	1.00
102 (1993)	1.00	1.00	1.00
103 (1993)	1.00	1.00	1.00
104 (1993)	1.00	1.00	1.00
105 (1993)	1.00	1.00	1.00
106 (1993)	1.00	1.00	1.00
107 (1993)	1.00	1.00	1.00
108 (1993)	1.00	1.00	1.00
109 (1993)	1.00	1.00	1.00
110 (1993)	1.00	1.00	1.00
111 (1993)	1.00	1.00	1.00
112 (1993)	1.00	1.00	1.00
113 (1993)	1.00	1.00	1.00
114 (1993)	1.00	1.00	1.00
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116 (1993)	1.00	1.00	1.00
117 (1993)	1.00	1.00	1.00
118 (1993)	1.00	1.00	1.00
119 (1993)	1.00	1.00	1.00
120 (1993)	1.00	1.00	1.00
121 (1993)	1.00	1.00	1.00
122 (1993)	1.00	1.00	1.00
123 (1993)	1.00	1.00	1.00
124 (1993)	1.00	1.00	1.00
125 (1993)	1.00	1.00	1.00
126 (1993)	1.00	1.00	1.00
127 (1993)	1.00	1.00	1.00
128 (1993)	1.00	1.00	1.00
129 (1993)	1.00	1.00	1.00
130 (1993)	1.00	1.00	1.00
131 (1993)	1.00	1.00	1.00
132 (1993)	1.00	1.00	1.00
133 (1993)	1.00	1.00	1.00
134 (1993)	1.00	1.00	1.00
135 (1993)	1.00	1.00	1.00
136 (1993)	1.00	1.00	1.00
137 (1993)	1.00	1.00	1.00
138 (1993)	1.00	1.00	1.00
139 (1993)	1.00	1.00	1.00
140 (1993)	1.00	1.00	1.00
141 (1993)	1.00	1.00	1.00
142 (1993)	1.00	1.00	1.00
143 (1993)	1.00	1.00	1.00
144 (1993)	1.00	1.00	1.00
145 (1993)	1.00	1.00	1.00
146 (1993)	1.00	1.00	1.00
147 (1993)	1.00	1.00	1.00
148 (1993)	1.00	1.00	1.00
149 (1993)	1.00	1.00	1.00
150 (1993)	1.00	1.00	1.00
151 (1993)	1.00	1.00	1.00
152 (1993)	1.00	1.00	1.00
153 (1993)	1.00	1.00	1.00
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155 (1993)	1.00	1.00	1.00
156 (1993)	1.00	1.00	1.00
157 (1993)	1.00	1.00	1.00
158 (1993)	1.00	1.00	1.00
159 (1993)	1.00	1.00	1.00
160 (1993)	1.00	1.00	1.00
161 (1993)	1.00	1.00	1.00
162 (1993)	1.00	1.00	1.00
163 (1993)	1.00	1.00	1.00
164 (1993)	1.00	1.00	1.00
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166 (1993)	1.00	1.00	1.00
167 (1993)	1.00	1.00	1.00
168 (1993)	1.00	1.00	1.00
169 (1993)	1.00	1.00	1.00
170 (1993)	1.00	1.00	1.00
171 (1993)	1.00	1.00	1.00
172 (1993)	1.00	1.00	1.00
173 (1993)	1.00	1.00	1.00
174 (1993)	1.00	1.00	1.00
175 (1993)	1.00	1.00	1.00
176 (1993)	1.00	1.00	1.00
177 (1993)	1.00	1.00	1.00
178 (1993)	1.00	1.00	1.00
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185 (1993)	1.00	1.00	1.00
186 (1993)	1.00	1.00	1.00
187 (1993)	1.00	1.00	1.00
188 (1993)	1.00	1.00	1.00
189 (1993)	1.00	1.00	1.00
190 (1993)	1.00	1.00	1.00
191 (1993)	1.00	1.00	1.00
192 (1993)	1.00	1.00	1.00
193 (1993)	1.00	1.00	1.00
194 (1993)	1.00	1.00	1.00
195 (1993)	1.00	1.00	1.00
196 (1993)	1.00	1.00	1.00
197 (1993)	1.00	1.00	1.00
198 (1993)	1.00	1.00	1.00
199 (1993)	1.00	1.00	1.00
200 (1993)	1.00	1.00	1.00
201 (1993)	1.00	1.00	1.00
202 (1993)	1.00	1.00	1.00
203 (1993)	1.00	1.00	1.00
204 (1993)	1.00	1.00	1.00
205 (1993)	1.00	1.00	1.00
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207 (1993)	1.00	1.00	1.00
208 (1993)	1.00	1.00	1.00
209 (1993)	1.00	1.00	1.00
210 (1993)	1.00	1.00	1.00
211 (1993)	1.00	1.00	1.00
212 (1993)	1.00	1.00	1.00
213 (1993)	1.00	1.00	1.00
214 (1993)	1.00	1.00	1.00
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216 (1993)	1.00	1.00	1.00
217 (1993)	1.00	1.00	1.00
218 (1993)	1.00	1.00	1.00
219 (1993)	1.00	1.00	1.00
220 (1993)	1.00	1.00	1.00
221 (1993)	1.00	1.00	1.00
222 (1993)	1.00	1.00	1.00
223 (1993)	1.00	1.00	1.00
224 (1993)	1.00	1.00	1.00
225 (1993)	1.00	1.00	1.00
226 (1993)	1.00	1.00	1.00
227 (1993)	1.00	1.00	1.00
228 (1993)	1.00	1.00	1.00
229 (1993)	1.00	1.00	1.00
230 (1993)	1.00	1.00	1.00
231 (1993)	1.00	1.00	1.00
232 (1993)	1.00	1.00	1.00
233 (1993)	1.00	1.00	1.00
234 (1993)	1.00	1.00	1.00
235 (1993)	1.00	1.00	1.00
236 (1993)	1.00	1.00	1.00
237 (1993)	1.00	1.00	1.00
238 (1993)	1.00	1.00	1.00
239 (1993)	1.00	1.00	1.00
240 (1993)	1.00	1.00	1.00
241 (1993)	1.00	1.00	1.00
242 (1993)	1.00	1.00	1.00
243 (1993)	1.00	1.00	1.00
244 (1993)	1.00	1.00	1.00
245 (1993)	1.00	1.00	1.00
246 (1993)	1.00	1.00	1.00
247 (1993)	1.00	1.00	1.00
248 (1993)	1.00	1.00	1.00
249 (1993)	1.00	1.00	1.00
250 (1993)	1.00	1.00	1.00
251 (1993)	1.00	1.00	1.00
252 (1993)	1.00	1.00	1.00
253 (1993)	1.00	1.00	1.00
254 (1993)	1.00	1.00	1.00
255 (1993)	1.00	1.00	1.00
256 (1993)	1.00	1.00	1.00
257 (1993)	1.00	1.00	1.00
258 (1993)	1.00	1.00	1.00
259 (1993)	1.00	1.00	1.00
260 (1993)	1.00	1.00	1.00
261 (1993)	1.00	1.00	1.00
262 (1993)	1.00	1.00	1.00
263 (1993)	1.00	1.00	1.00
264 (1993)	1.00	1.00	1.00
265 (1993)	1.00	1.00	1.00
266 (1993)	1.00	1.00	1.00
267 (1993)	1.00	1.00	1.00
268 (1993)	1.00	1.00	1.00
269 (1993)	1.00	1.00	1.00
270 (1993)	1.00	1.00	1.00
271 (1993)	1.00	1.00	1.00
272 (1993)	1.00	1.00	1.00
273 (1993)	1.00	1.00	1.00
274 (1993)	1.00	1.00	1.00
275 (1993)	1.00	1.00	1.00
276 (1993)	1.00	1.00	1.00
277 (1993)	1.00	1.00	1.00
278 (1993)	1.00	1.00	1.00
279 (1993)	1.00	1.00	1.00
280 (1993)	1.00	1.00	1.00
281 (1993)	1.00	1.00	1.00
282 (1993)	1.00	1.00	1.00
283 (1993)	1.00	1.0	

[illegible]

項目	2014 年	2013 年	2012 年	2011 年
一、營業收入	100.00	100.00	100.00	100.00
二、營業成本	80.00	80.00	80.00	80.00
三、營業利潤	20.00	20.00	20.00	20.00
四、營業外收入	0.00	0.00	0.00	0.00
五、營業外支出	0.00	0.00	0.00	0.00
六、營業利潤	20.00	20.00	20.00	20.00
七、營業外收入	0.00	0.00	0.00	0.00
八、營業外支出	0.00	0.00	0.00	0.00
九、營業利潤	20.00	20.00	20.00	20.00
十、營業外收入	0.00	0.00	0.00	0.00
十一、營業外支出	0.00	0.00	0.00	0.00
十二、營業利潤	20.00	20.00	20.00	20.00

Year	1990	1991	1992	1993
1990	100	100	100	100
1991	100	100	100	100
1992	100	100	100	100
1993	100	100	100	100
1994	100	100	100	100
1995	100	100	100	100
1996	100	100	100	100
1997	100	100	100	100
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2007	100	100	100	100
2008	100	100	100	100
2009	100	100	100	100
2010	100	100	100	100
2011	100	100	100	100
2012	100	100	100	100
2013	100	100	100	100
2014	100	100	100	100
2015	100	100	100	100
2016	100	100	100	100
2017	100	100	100	100
2018	100	100	100	100
2019	100	100	100	100
2020	100	100	100	100
2021	100	100	100	100
2022	100	100	100	100
2023	100	100	100	100
2024	100	100	100	100
2025	100	100	100	100
2026	100	100	100	100
2027	100	100	100	100
2028	100	100	100	100
2029	100	100	100	100
2030	100	100	100	100
2031	100	100	100	100
2032	100	100	100	100
2033	100	100	100	100
2034	100	100	100	100
2035	100	100	100	100
2036	100	100	100	100
2037	100	100	100	100
2038	100	100	100	100
2039	100	100	100	100
2040	100	100	100	100
2041	100	100	100	100
2042	100	100	100	100
2043	100	100	100	100
2044	100	100	100	100
2045	100	100	100	100
2046	100	100	100	100
2047	100	100	100	100
2048	100	100	100	100
2049	100	100	100	100
2050	100	100	100	100
2051	100	100	100	100
2052	100	100	100	100
2053	100	100	100	100
2054	100	100	100	100
2055	100	100	100	100
2056	100	100	100	100
2057	100	100	100	100
2058	100	100	100	100
2059	100	100	100	100
2060	100	100	100	100
2061	100	100	100	100
2062	100	100	100	100
2063	100	100	100	100
2064	100	100	100	100
2065	100	100	100	100

Year	1990	1991	1992	1993	1994
1990	1	1	1	1	1
1991	1	1	1	1	1
1992	1	1	1	1	1
1993	1	1	1	1	1
1994	1	1	1	1	1
1995	1	1	1	1	1
1996	1	1	1	1	1
1997	1	1	1	1	1
1998	1	1	1	1	1
1999	1	1	1	1	1
2000	1	1	1	1	1
2001	1	1	1	1	1
2002	1	1	1	1	1
2003	1	1	1	1	1
2004	1	1	1	1	1
2005	1	1	1	1	1
2006	1	1	1	1	1
2007	1	1	1	1	1
2008	1	1	1	1	1
2009	1	1	1	1	1
2010	1	1	1	1	1
2011	1	1	1	1	1
2012	1	1	1	1	1
2013	1	1	1	1	1
2014	1	1	1	1	1
2015	1	1	1	1	1
2016	1	1	1	1	1
2017	1	1	1	1	1
2018	1	1	1	1	1
2019	1	1	1	1	1
2020	1	1	1	1	1
2021	1	1	1	1	1
2022	1	1	1	1	1
2023	1	1	1	1	1
2024	1	1	1	1	1
2025	1	1	1	1	1
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2027	1	1	1	1	1
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2029	1	1	1	1	1
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2031	1	1	1	1	1
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2033	1	1	1	1	1
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2036	1	1	1	1	1
2037	1	1	1	1	1
2038	1	1	1	1	1
2039	1	1	1	1	1
2040	1	1	1	1	1
2041	1	1	1	1	1
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2060	1	1	1	1	1
2061	1	1	1	1	1
2062	1	1	1	1	1
2063	1	1	1	1	1
2064	1	1	1	1	1
2065	1	1	1	1	1
2066	1	1	1	1	1
2067	1	1	1	1	1

項目	1996 年	1997 年	1998 年	1999 年
1. 總計	100	100	100	100
2. 製造業	100	100	100	100
3. 非製造業	100	100	100	100
4. 服務業	100	100	100	100
5. 金融業	100	100	100	100
6. 資訊業	100	100	100	100
7. 零售業	100	100	100	100
8. 批發業	100	100	100	100
9. 運輸業	100	100	100	100
10. 倉庫業	100	100	100	100
11. 郵政業	100	100	100	100
12. 電信業	100	100	100	100
13. 其他	100	100	100	100

Year	1990	1991	1992
1990	10	10	10
1991	10	10	10
1992	10	10	10
1993	10	10	10
1994	10	10	10
1995	10	10	10
1996	10	10	10
1997	10	10	10
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1999	10	10	10
2000	10	10	10
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2003	10	10	10
2004	10	10	10
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2006	10	10	10
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2009	10	10	10
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2096	10	10	10
2097	10	10	10
2098	10	10	10
2099	10	10	10
2100	10	10	10

	2015	2014	2013
营业收入	2,175,000	2,175,000	2,175,000
营业成本	1,000,000	1,000,000	1,000,000
营业税金及附加	100,000	100,000	100,000
销售费用	500,000	500,000	500,000
管理费用	100,000	100,000	100,000
财务费用	100,000	100,000	100,000
资产减值损失	100,000	100,000	100,000
公允价值变动损益	100,000	100,000	100,000
投资收益	100,000	100,000	100,000
营业外收入	100,000	100,000	100,000
营业外支出	100,000	100,000	100,000
利润总额	1,000,000	1,000,000	1,000,000
所得税费用	250,000	250,000	250,000
净利润	750,000	750,000	750,000
归属于母公司所有者的净利润	750,000	750,000	750,000
少数股东损益	0	0	0

1990	1.0	1.0	1.0	1.0	1.0
1991	1.0	1.0	1.0	1.0	1.0
1992	1.0	1.0	1.0	1.0	1.0
1993	1.0	1.0	1.0	1.0	1.0
1994	1.0	1.0	1.0	1.0	1.0
1995	1.0	1.0	1.0	1.0	1.0
1996	1.0	1.0	1.0	1.0	1.0
1997	1.0	1.0	1.0	1.0	1.0
1998	1.0	1.0	1.0	1.0	1.0
1999	1.0	1.0	1.0	1.0	1.0
2000	1.0	1.0	1.0	1.0	1.0
2001	1.0	1.0	1.0	1.0	1.0
2002	1.0	1.0	1.0	1.0	1.0
2003	1.0	1.0	1.0	1.0	1.0
2004	1.0	1.0	1.0	1.0	1.0
2005	1.0	1.0	1.0	1.0	1.0
2006	1.0	1.0	1.0	1.0	1.0
2007	1.0	1.0	1.0	1.0	1.0
2008	1.0	1.0	1.0	1.0	1.0
2009	1.0	1.0	1.0	1.0	1.0
2010	1.0	1.0	1.0	1.0	1.0
2011	1.0	1.0	1.0	1.0	1.0
2012	1.0	1.0	1.0	1.0	1.0
2013	1.0	1.0	1.0	1.0	1.0
2014	1.0	1.0	1.0	1.0	1.0
2015	1.0	1.0	1.0	1.0	1.0
2016	1.0	1.0	1.0	1.0	1.0
2017	1.0	1.0	1.0	1.0	1.0
2018	1.0	1.0	1.0	1.0	1.0
2019	1.0	1.0	1.0	1.0	1.0
2020	1.0	1.0	1.0	1.0	1.0
2021	1.0	1.0	1.0	1.0	1.0
2022	1.0	1.0	1.0	1.0	1.0
2023	1.0	1.0	1.0	1.0	1.0
2024	1.0	1.0	1.0	1.0	1.0
2025	1.0	1.0	1.0	1.0	1.0
2026	1.0	1.0	1.0	1.0	1.0
2027	1.0	1.0	1.0	1.0	1.0
2028	1.0	1.0	1.0	1.0	1.0
2029	1.0	1.0	1.0	1.0	1.0
2030	1.0	1.0	1.0	1.0	1.0
2031	1.0	1.0	1.0	1.0	1.0
2032	1.0	1.0	1.0	1.0	1.0
2033	1.0	1.0	1.0	1.0	1.0
2034	1.0	1.0	1.0	1.0	1.0
2035	1.0	1.0	1.0	1.0	1.0
2036	1.0	1.0	1.0	1.0	1.0
2037	1.0	1.0	1.0	1.0	1.0
2038	1.0	1.0	1.0	1.0	1.0
2039	1.0	1.0	1.0	1.0	1.0
2040	1.0	1.0	1.0	1.0	1.0
2041	1.0	1.0	1.0	1.0	1.0
2042	1.0	1.0	1.0	1.0	1.0
2043	1.0	1.0	1.0	1.0	1.0
2044	1.0	1.0	1.0	1.0	1.0
2045	1.0	1.0	1.0	1.0	1.0
2046	1.0	1.0	1.0	1.0	1.0
2047	1.0	1.0	1.0	1.0	1.0
2048	1.0	1.0	1.0	1.0	1.0
2049	1.0	1.0	1.0	1.0	1.0
2050	1.0	1.0	1.0	1.0	1.0
2051	1.0	1.0	1.0	1.0	1.0
2052	1.0	1.0	1.0	1.0	1.0
2053	1.0	1.0	1.0	1.0	1.0
2054	1.0	1.0	1.0	1.0	1.0


This is all very preliminary work but we believe it to be a path that should be taken to align SE with the traits of future and current engineers and to address the teaching of topics that are not taught or are taught incorrectly in current SE programs

Gamification of Systems Engineering

How to bring game elements into a real systems engineering process?

Scorecards in Value-Driven Design

Gives designers at different levels the impact of their decisions on system value



Metric	Value	Impact
System Value	100	100
Design Value	80	80
Implementation Value	60	60
Operation Value	40	40
Support Value	20	20

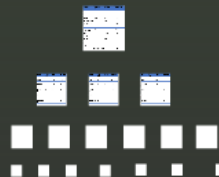
ScoreBOARDS

By taking value impact (and accounting for the degree of impact from each group) can have groups competing for top place



Metric	Value	Impact
System Value	100	100
Design Value	80	80
Implementation Value	60	60
Operation Value	40	40
Support Value	20	20

ScoreBOARDS



SCOREBOARD
1. Flight Controls 15468
2. Ground Support 12879
3. Structures 11588

This is all very preliminary work but we believe it to be a path that should be taken to align SE with the traits of future and current engineers and to address the teaching of topics that are not taught or are taught incorrectly in current SE programs



Turning Vision into Decision (TV200)



Hexagon



452 views

LETS MAKE A STRONG COMMUNITY

Where is everyone meeting?
Where is everyone publishing?

We need to impact multiple groups but
also would be good to have a home

Games in Engineering
Feedback Panel

A collection of individuals exploring games

Provide constructive criticism and avoid
repeating similar mistakes

Useful on proposals (such as CAREER
proposals) to demonstrate that this is an
organized community and there has accepted
practices/mathematics and we aren't just
making games up without rigor

Games in Engineering Feedback Panel

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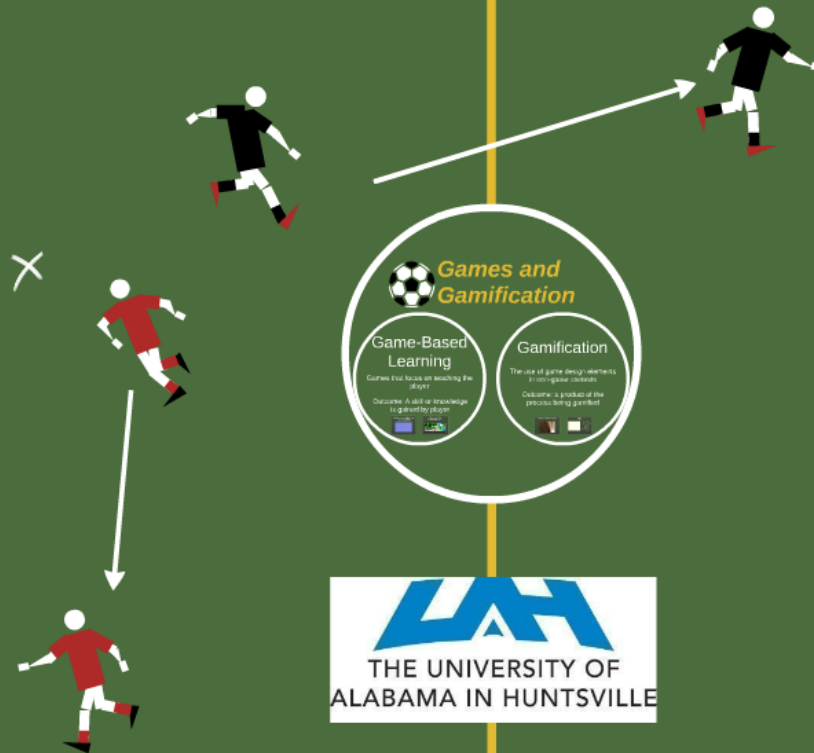
Games for Systems Engineers



LET'S MAKE A STRONG COMMUNITY

Where is everyone meeting?
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Why Games?



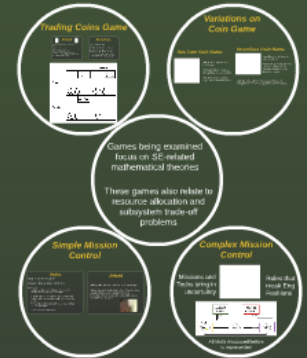
Why Now?



Why SE?



Game-Based Learning for incentives and mechanism design



Gamification of Systems Engineering

How to bring game elements into a real systems engineering process?



Dr. Bryan Mesmer