Mousetrap — Serious Fun for Grown-ups

An Integrated Product and Process Development That Keeps Going…and Going…and Going

RANDY C. ZITTEL • ROBERT H. LIGHTSEY

The late David Packard, as Deputy Secretary of Defense in 1971, founded the Defense Systems Management College (DSMC) to establish an intensive five-month course, which covered all aspects of acquisition and state-of-the-art managerial techniques. Known as the Program Management Course (PMC), this 20-week course met the congressional mandate that all DoD Acquisition program managers be educated in the complete range of acquisition management activities prior to assuming command of their programs. Currently, DSMC uses a number of in-class simulations that put future program managers in situations where they learn proven and timely "hands-on" applications to hone their skills beyond theory.

SEGV Simulation

The Stored Energy Ground Vehicle (SEGV) simulation began in 1988 as a small elective in the PMC to provide this hands-on experience that conventional classes did not provide. Interested individuals in the PMC classes of future program managers over the past seven years have since taken the SEGV elective. This historical pool of over 500 students has organized as integrated product teams (IPT) within "corporations" to work from the contractor's perspective.

As a joint integrated simulation supported by five functional faculty departments, the SEGV simulation was done *outside* of the traditional classroom. Student teams planned and managed their personal study time, accounted for each hour in a labor accounting system while designing a simulated, scaled-down, unmanned ground vehicle capable of ammunition resupply through a mine field. The simulation proved itself so effective in achieving the curriculum objectives that students were credited for five departmental exams and the entire individual learning program, thus compensating traditional class time with learner-directed learning.

Imitation — The Sincerest Form of Flattery

The exercise has been highly successful and communicates the essence of

Zittel is a Professor of Systems Engineering Management, Faculty Division, DSMC. He is currently the editor for the upcoming DSMC Systems Engineering Management Guide, *4th Ed.*
Lightsey is a Professor of Systems Engineering Management, Faculty Division, DSMC.

program development so well, that Rockwell International Corp., integrated the Mousetrap exercise into the tutorial to their extensive Computer-aided Systems Engineering Tool Set (CASETS™).[1] One of the great equalizers of the original SEGV simulation is that it used up to four commercial rat traps as the sole power source. (We originally used mousetraps in 1988; the nickname "Mousetrap" stuck.) The use of such a novel power source helps to equalize engineers and non-engineers to apply integrated product development without making everyone an engineer. In addition, the Universities of Arizona and South Australia are separately adding DSMC's SEGV exercise to their graduate systems engineering curricula.

They're On Their Own

At the simulation start, work groups analyze a Request for Proposal and develop a proposal in response. Starting at contract award,[2] the teams operated on their own with no faculty assistance, unless requested. The first faculty evaluation was at the Systems Requirements Review held five weeks later by a government Program Management Office's IPT staffed by the five faculty departments.

> As teams progressed through the simulation, they applied the systems engineering process iteratively, as their system took form. They extracted the requirements, conducted trade studies and engineering analyses on the government-designated power source, and considered different solutions to each problem.

All technical design reviews were held outside of formal classes and were strictly time limited. Figure 1 shows a company's program schedule.

When Enough Engineering is Enough

Over the past seven years, teams have averaged 50 to 200 manhours *per team member*. It is remarkable to see that the most successful teams always expended fewer labor hours than the less effective teams. We ascribe that to more cooperative and effective IPT operations, team personnel chemistry, and simply but critically deciding *when enough engineering is enough*. It is interesting to note that the more actual engineers on a team, the more difficult it was to finish their design *and move on*.

As teams progressed through the simulation, they applied the systems engineering process iteratively, as their system took form. They extracted the requirements, conducted trade studies and engineering analyses on the government-designated power source, and considered different solutions to each problem. Each IPT member was continuously exposed to all issues, even when not directly involved. This made the business manager more understanding of the engineering problems, and the engineers saw how their continuous designing ramped up labor and material costs.

Figure 1. IPT Program Schedule

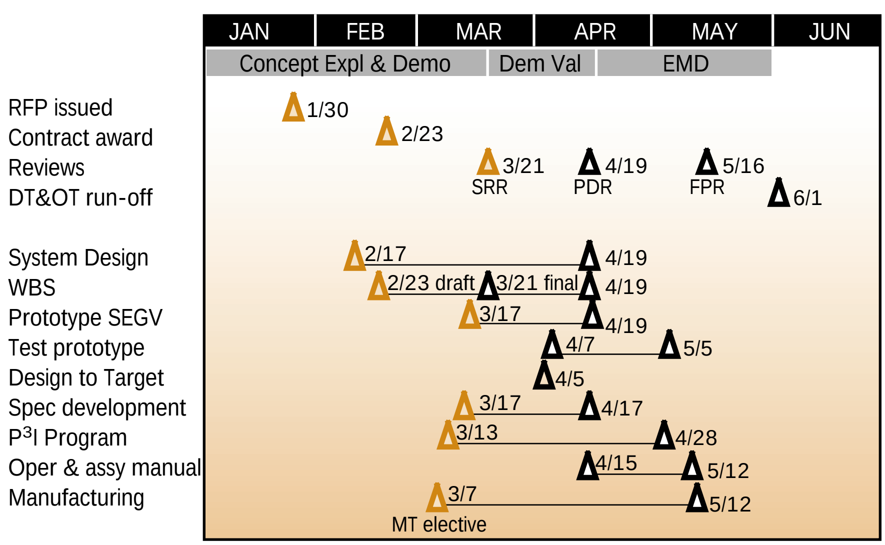
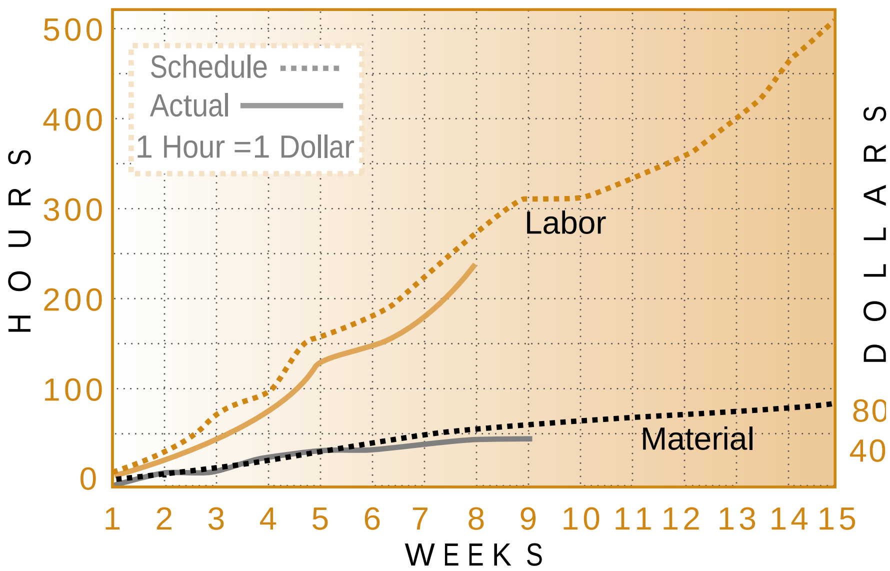


Figure 2. Labor/Material Baselines



The Proof of Their Decisions

The teams developed a pre-planned product improvement concept that incorporated software into the system. Operated in parallel with a decision briefing requirement for each student, Mousetrap required the team to succeed or fail as a team and demonstrate their ability to brief to a clear decision. They knew the prototype demonstrated the strength of their information and judgment far better than any set of assumptions, which forced them to be accurate and correct.

At the third technical review, the proof of their decisions was the Engineering and Manufacturing Development (EMD) prototype, which sat on the table between their "company" and the government Program Management Office staff.

The Performance "Run-off"

The simulation was complete when all technical documentation, a formal accounting audit by the contracting officer, end-item-vehicle (EIV) material/cost audit, and performance "run-off" were accomplished. The competitive "run-off" brought the conflicting performance requirements together to see how well the companies actually managed their red teaming to win the production contract through a four-hour developmental test and evaluation (DT&E). Additionally, each team developed their manufacturing capacity analysis using the Factory Simulation™ software, and was evaluated on their prototype's producibility.

Open Competition — A Powerful Lesson

The constant tracking of labor hours against additional design effort resulted in a fresh appreciation for commercial cost and profit issues, as shown in Figure 2. We believe this was the greatest "reality check" the government participants took away. Mousetrap forced them to balance against what must actually be done to win against all other competitors, not against the government's minimum contract requirements. Their dealing in the obscure world of open competition was an extremely powerful lesson.

Through a best value analysis, performance and design-to-cost had equal weight. Since there was only one final winner, many of the first-place performers have historically lost to the second or third performer who provided a better life-cycle balance of performance, user friendliness, manufacturability, durability, and vehicle cost.

The entire PMC student body was released from class to observe the final results at the run-off. This reinforced the effective implementation of systems engineering to the entire student body. Nothing focuses a student's attention more than presenting in front of one's peers – all 420 of whom they've worked with for months.

Mousetrap Has No Tricks

As the largest and longest "elective" in the PMC, the remaining elements of the 14 student sections saw the Mousetrap IPT's efforts evolve from concept to the EMD prototype.

Mousetrap has no tricks, changing government requirements or "rubber baselines." The single contract extended from Concept Exploration/Definition to the middle of EMD, which gave each IPT real experience in all three phases.

Serious Fun for Grown-ups

Proving there's still a kid in all of us, the teams came up with very novel company names. Some examples are *Fievel & Friends*; "RAT"tle Trap, Inc.; *Belvoir Mouseworks (BMW)*; *KL Meowser*; and *Traps 'R Us*. Elementary and high school students and girl scout troops have attended the DT&E run-off, and marveled at the serious fun of grown-ups. The age old truth of learning more when you enjoy it reinforced this effort.

Wider Applications of Mousetrap

The key outputs of the Mousetrap simulation have found greater application in other mandatory acquisition courses, where more junior members can see where a system comes from, the documentation generated during the stages of the development process, and ultimately a final engineering hardware model. This enhances their understanding of the overall process.

The New, Improved Mousetrap!

In 1995 DSMC streamlined the PMC to 14 weeks (from the original 20 weeks) and designated the new course as the Advanced Program Management Course (APMC). The streamlined course was piloted in 1995, and the APMC format is now used for all classes. The objectives established for systems engineering instruction in the APMC included the expectation that all students would go through the process of translating operational requirements into designs that met those requirements. After analysis and consideration of alternatives, the decision was to use the Mousetrap exercise as the core around which the systems engineering instruction in APMC would be developed.

The systems engineering and test and evaluation courses of instruction now combine traditional classroom instruction with exercises that are related to the Mousetrap project. For example, students outline configuration management plans or perform risk analyses that are based upon their assessments of the requirements and circumstances associated with the design, development, and test of the Mousetrap vehicle. Teams are provided an Operational Requirements Document and a System Specification, in addition to other procurement documents, at the beginning of the course. Classes combine limited lecture and extensive discussion with hands-on exercises as the Mousetrap project is first planned for, then designed, fabricated, and finally tested against the original requirements. Each work group takes the role of contractor and acts as an IPT as they progress through the systems engineering process from requirements analysis to design, fabrication, and verification. All IPTs receive the same kit of parts to work from as they consider alternative design solutions.

Students prepare for and present two formal design reviews where they first prepare system-level designs, then preliminary subsystem designs, and then prototype vehicles. These reviews are taken by members of the test and evaluation and systems engineering faculty acting as government program managers. The final class period consists of the verification session. Here the Test and Evaluation Department and the Systems Engineering Department faculty conduct tests against the requirements of the specification to verify that the students have, in fact, produced vehicles which meet contract requirements. The requirements include performance requirements constrained against cost and producibility goals. The students trade performance against cost and producibility, and also bear in mind that they are competing with other "contractors" to win a future production contract.[3] Some students choose lowest cost minimum performance strategies, while others may take a less risky approach to ensure that requirements are met. The reviews and the run-off give everyone a chance to observe and think about the trade-off between performance and cost, and the risks associated with alternative strategies. In summary, this exercise enables the students to experience some of the difficulties, frustrations, and exhilaration associated with development and procurement in a competitive environment.

Figure 3 shows a section's results, indicating three of the five companies' engineering prototypes failed to meet all contract requirements. The remaining two companies met all requirements, but RATS, Inc., was quite superior to the other vehicle in cost and producibility. With cost as an independent variable and weighted performance criteria, a clear winner could be determined. The important aspect is the ability to compare all technical and non-technical requirements in a life cycle balance across all processes.

Conclusions

The Mousetrap SEGV exercise has gone from a small effort using single mousetraps in 1988, to rat traps, virtual prototyping, and computer-aided tools in 1996. It brings together so many issues, incentives, and forces that the participants succeed in getting a deeper understanding of the power of integrated product and process development, the integrated process team, the systems engineering process, *and* the contractor's perspective.

References

1. Hines, James E, et al., *Computer Aided Systems Engineering Tool Set (CASETS)*, Rockwell International, Space Systems Division, Downey, California, 1994.

2. Zittel, Randy C., *SEGV Contract*, DSMC-95-1-C-2222, DSMC, 1995.

3. Lightsey, Robert H., *SEGV Contract*, DSMC-96-1-C-2222, DSMC, 1996.

Figure 3. Government Acceptance Tests for APMC 96-1

Company IPT	DTC	Producibility Index	Assembly Time (sec.)	Distance Run (ft.)	Resupply (sec.)	Recovery (ft.)
Rat'l Trap Inc.	$1,061	1694	**15:00**	Pass	1:35	14'3"
Beefys Engineering	1,054	627	10:11	Pass	1:46	8'0"
Reluctant Synergists	667	476	8:30	Pass	**2:32**	7'3"
Butt 'N' Heads, Inc.	612	325	8:41	Pass	**2:08**	6'2"
RATS, Inc.	703	348	7:30	Pass	1:21	5'3"
Contract Specification	<1,100	No spec. - less is better	<12:00	25' in <7 sec.	<2:00	>5'0"

Note: Colored bold numbers reflect items that failed to meet contract specifications.