Motor Sports Accelerates SySTEM Learning

Moderator: Jack Ring, Educe LLC, USA

Panelists: Dr. Stan Settles, University of S. California, USA
Dr. Al George, Cornell U., USA
Dr. William Mackey, Systems Engineering Solutions, USA
Prof. Peter Hylton, Indiana University Purdue University Indianapolis, USA
Richard Martin, Tinwisle Corporation, USA
Ken Berg, Motor Sports Education Foundation, USA

Abstract

The Motor Sports WG is developing ways to leverage the excitement and enthusiasm in motor sports to accelerate education, especially SySTEM education. Each panellist will address a pro and con for each of four claims:

Claim 1:The real payoff from revitalizing science, technology, engineering and mathematics, STEM, education will come from learning to meld these and other disciplines/technologies into whole systems solutions, SySTEM.

Claim 2: SySTEM learning can be accelerated by experiences that are meaningful to the learner, notably, intellectual and visceral immersion in real world, rewarding, reflective, learning environments.

Claim 3: Because meaningful learning sessions about systems are difficult to create in a campus-only setting this panel will address ways that motor sports can augment campus-centered SE education

Claim 4: A 'laboratory on many wheels' has been and can be used to accelerate SySTEM learning.

Biographies

Moderator

Jack RING has applied systems engineering to motor sports and leveraged motor sports in education for four decades. He was first to use aerospace telemetry in 1961 on the #614 Corvette driven by Bob Bondurant in SCCA racing and instigated performance improvements for Bob Joehnck (SCCA, SCTA), Bill Thomas (SCCA), Carl Axtell (AMA) and Vic Edelbrock (APBA), He installed systems engineering at the Edelbrock Corp. in 1989 (described in best paper award at NCOSE Conference 1994). He co-authored Conceptual Design of an Environment for Systems Engineering Education, at INCOSE IS05 with Dr. Dennis Buede and Prof. Fred Bolling, As enterprise architect advisor to the burgeoning Starshine Academy (K-12) he is evolving a SySTEM learning environment energized by motor sports. Jack was named INCOSE Fellow , 2003, served as co-chair, Intelligent Enterprises Working Group, 2002 – 2007, and currently serves as co-chair of the Motor Sports WG and co-chair of the Autonomous Systems Test and Evaluation WG. He serves as Industrial Fellow at Stevens Institute of Technology, School of Systems and Enterprises. He co-founded three current enterprises, Kennen Technologies LLC, OntoPilot LLC and Educe LLC. He earned a BA, Physics, Emporia State University, Kansas, and continues selective formal education in systems, innovation and learning.

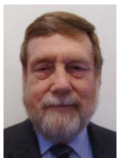
In addition to driving at over 247 MPH on the Bonneville Salt Flats in 2009, **Stan Settles** now offers a course entitled “Systems Engineering through Motorsports” and is a new co-sponsor of the Formula SAE activity at University of Southern California, USC. Stan is a Professor in the Daniel J. Epstein Industrial and Systems Engineering Department in the Viterbi School of Engineering, USC. He holds the IBM Chair in Engineering Management and is Co-Director of the Systems Architecting and Engineering Program. He is a Past President of IIE, a fellow of INCOSE, IIE and INFORMS, a member of Alpha Pi Mu, IEEE, SAE International, and ASEE; and was elected to the National Academy of Engineering. He is currently the INCOSE Board member for Academic Matters. Prior to his USC career he spent 30 years at AlliedSignal and two years with a combination of the White House Office of Science and Technology Policy and the NSF. He can be reached at settles@usc.edu. He holds a Ph.D. from Arizona State University.

Panelists

Al GEORGE received his PhD in Aeospace and Mechanical Engineering from Princeton, U. He has directed Mechanical and Aerospace Engineering, the Center for Manufacturing Enterprise, and the Systems Engineering Program at Cornell. The Cornell Formula SAE team he leads has won the Formula SAE championship nine times including four of the last nine years. Presently, he leads a Cornell team entering the Progressive Insurance Automobile X-Prize competition for a 100 MPG, four passenger automobile. His industrial experience includes stints as BMW and Harley Davidson Motor Company. George is an fellow of the American Institute of Aeronautics and Astronautics (AIAA) and the Society of Automotive Engineers (SAE). He is also a member of the American Helicopter Society, the American Society of Mechanical Engineers, and the American Society for Engineering Education. Directly relevant publications include: William B. Riley and Albert R. George, Design, Analysis, and Testing of a Formula SAE Car Chassis, SAE Paper 2002-01-3300; Punith Doddegowda, Aleksandr Bychkovsky, Albert R. George, Use of Computational Fluid Dynamics for the Design of Formula SAE Race Car Aerodynamics, SAE Paper 2006-01-0807; and Matthew S. Zipfel and Albert R. George, Compliance and Friction in Elastic and Mechanical Joints of Race Car Suspensions, SAE Paper 2006-01-3650.

William (Bill) MACKEY, Ph.D., J.D., President of Systems Engineering Solutions, is also an adjunct professor at the University of Maryland University College. He attended the U.S. Naval Academy and has B.S. and M.S. degrees in physics from the University of Pittsburgh and the Rensselaer Polytechnic Institute. He received his Ph.D. in systems engineering from the University of Pennsylvania and his J.D. from the Washington College of Law, American University. Dr. Mackey, an avid follower of open-wheel auto racing, was an original member of the Motor Sports Working Group (MSWG), wrote the Charter for the MSWG, and drafted a curriculum for the Motor Sports System 101 course. Dr. Mackey has more than 40 years experience in scientific research, engineering, and management applied to homeland security, aerospace, energy, transportation, systems integration, and law. He has held a number of progressively responsible management positions, including leadership of 120 professionals involved in systems engineering, telecommunications and networking, office information systems, and major systems development in the CSC Systems Division. He was recently Vice-President of Professional Services, Vitech Corp. Dr. Mackey is a member of both the District of Columbia and the State of Virginia legal bars. He has served on several INCOSE WG/IG's and was Chairman of the Systems Engineering Applications Technical Committee from 1995 to 2001. He served as the INCOSE Technical Board Chairman from June 2001 to June 2004. He chartered the Anti-Terrorism International WG within INCOSE in October 2001. Dr. Mackey is also the Chair of the INCOSE Fellows, having served as Vice-Chair from 2005-2010.

Peter HYLTON is the Director of Motorsports and an Associate Professor at Indiana University Purdue University Indianapolis (IUPUI). IUPUI currently offers the only Bachelors Degree in Motorsports Engineering in the United States. Professor Hylton was the primary author of this program and has been extensively involved in the creation of the curriculum for the program, in student projects that have led to multiple student designed and built race cars and a successful student run race team, and in the development of motorsports themed STEM initiatives that utilize the high-energy aspect of motorsports to draw interest and attention to various engineering related educational opportunities.



Richard MARTIN is President of Tinwisle Corporation in Bloomington, Indiana, USA, where he is responsible for the provisioning of information systems services focused on enterprise integration to companies in the manufacturing and distribution sectors. He is a senior member of the Society of Manufacturing Engineers, and member of IEEE, ACM and INCOSE. He served as a member of the INCOSE Intelligent Enterprise Working Group and is now a member of the Motor Sports Working Group where his expertise is that of spectator and observer of the world's most competitive technologically enabled sport with mass appeal. He participates in an active research program at Indiana University to formalize the architectural frameworks now in use for enterprise management and is the convener of ISO TC184/SC5/WG1 working on International Standards in the domain of Automation systems and integration - Architecture, communications and integration frameworks. His public service includes appointment to the Plan Commission of Monroe County, Indiana.

Ken BERG is a biographer of motorsports notables such as: Leo Goossen, Dale Drake, John Drake, Lou Meyer and others as well as of WWII veterans of the Battle of the Bulge and the Battle of Britain and of baseball player Smoky Joe Wood. His research into motorsports developed into a concept for improving education in which the relentless and continuous pursuit of improvement in a competitive environment could be exploited to bring the work ethic of racing and the winning attitude of racers into the classroom. Ken is currently developing a pilot program for motorsports education with the Orange County (CA) Department of Education to leverage the excitement and enthusiasm of motor sports to encourage teachers and learners to adopt SySTEM knowledge, adapt it to their individual needs, and use it in their lives and careers. Previously, Ken was purchasing manager in pulp & paper, open-pit and underground mining operations in Canada, China and Australia. He established and managed performance contract systems for heavy machinery to achieve continuous quality improvement, greater production and lower costs.

He was awarded the Governor-General of Canada Confederation Medal 1992. He has actively supported Burgess Shale Foundation 1998, and the East Kootenay Childhood Foundation. His papers can be found on Academia.edu.

Andrew BORME currently serves as Lecturer, Motor Sports Engineering, Purdue School of Engineering and Technology, Indiana University Purdue University at Indianapolis. Also he is Faculty Advisor for Formula SAE race car student project. He has 20 years of engineering experience in motor sports with Toyota Motorsports F1 Team, BMW-Sauber Formula 1 Team, Panther Racing Indycars, Kelley Racing Indycars, Conquest Racing Indycars, Penske Racing Indycars, Hogan Racing Indycars, Players-Forsythe Racing Formula Atlantic, Tasman Motorsports Indy Lights, General Motors Electric Vehicle, Budweiser King Racing, Nissan Performance Technology Inc., and an earlier role with General Dynamics Fort Worth. Andrew earned a MSME, California State University Long Beach, and a BSME, Rensselaer Polytechnic Institute (Dean's List of Distinguished Students). He is affiliated with the Indiana Motorsports Association (IMA) and Society of Automotive Engineers (SAE). Publications include "Turbulent Flow Downstream of a Wing-Body Junction with Horseshoe Vortices Present," MSME Thesis, CSULB, 1991. Patents include "Heating and Cooling of Electric S10 Pickup Truck Battery Pack" General Motors, 1996.

Position Paper

For INCOSE IS10 Panel

Motor Sports Accelerates SySTEM Learning

By

Jack Ring

Panel Moderator

Chair, Motor Sports Working Group

4/6/2010

Motivations

The Motor Sports Working Group claims that the excitement and enthusiasm associated with motor sports can accelerate learning regarding science, technology, engineering and mathematics thereby benefitting learners of all ages. Acceleration comes not only from the fun facet of motor sports but also the systems thinking, doing and being facet. Once learners advance in thinking capabilities include a) perceiving distinctions, b) perceiving relationships, c) organizing systems and d) respecting various points of view [Cabrera] the focus becomes SySTEM learning. SySTEM establishes a basis for all other learning including language, literature, music, art, athletics, etc.

One motivation comes from the frustration of educating systems engineering students without the benefit of laboratory and practicum. This frustration has been articulated by William Mackey, Dennis Buede, Fred Bolling, Albert George, Stan Settles, Pete Hylton, and Andrew Borme. It is supported by Ken Berg's motor sports documentaries and from Jack Ring's action research during several kinds of racing as well as discussions at Bob Bondurant School of High Performance Driving. Also, we acknowledge two who could not join us today, Diandra Leslie-Pelecky, physics professor at the University of Texas at Dallas and David Ronfeldt, RAND Corp. Both bring new insights to students regarding social science as well as SySTEM.

Another motivation comes from the opportunity to involve pre-college students in SySTEM. Toward this end MSWG members are developing curricula guidelines and learning resources regarding Motor Sports and Systems Engineering. The objective is not to create expertise in engineering motor sports but to leverage motor sports to accelerate SySTEM learning world-wide.

A third motivation is the NETP National Educational Technology Plan 2010, (draft) March 5, 2010. Office of Educational Technology U.S. Department of Education. This plan poses Grand Challenges as:

- Design and validate an integrated system that provides real-time access to learning experiences tuned to the levels of difficulty and assistance that optimizes learning for all learners and that incorporates self-improving features that enable it to become increasingly effective through interaction with learners.

- Design and validate an integrated system for designing and implementing valid, reliable, and cost-effective assessments of complex aspects of 21st century expertise and competencies across academic disciplines.
- Design and validate an integrated approach for capturing, aggregating, mining, and sharing content, student learning, and financial data cost-effectively for multiple purposes across many learning platforms and data systems in near real time.
- Identify and validate design principles for efficient and effective online learning systems and combined online and offline learning systems that produce content expertise and competencies equal to or better than those produced by the best conventional instruction in half the time at half the cost.

Clearly this plan must foster SySTEM education. More importantly, although perhaps not obvious to federal officials, this plan is futile unless staffed with systemists – those already expert in identifying, designing, architecting, engineering, constructing, assaying and adapting systems on behalf of beneficiaries.

The pre-college campaign

Kids like to learn. Kids learn best when they feel that learning is safe and fun. Fun is their word for joy, the natural state of a human being [Suarez], a state of heightened awareness. Safe means not only physical safety but also the safety to be adventurous, to be wrong without damage or even embarrassment.

Kids like learning that is meaningful to their immediate interests and goals [Novak]. In too many cases they are underserved. The dismal state of educational achievement we see today is not due to the kids. It is due to the lousy learning environments they must endure. Schools and regulators focus on narrow, standardized curricula and textbooks while the students focus on 256 color multimedia cell phones with videogames, social networking and sexting.

Two kinds of learning are important. One kind is concerned with names for things, vocabulary, a stack of factoids. A person's repertoire of factoids is often associated with the brain left lobe. According to [Bickerton] this repertoire may be extensible without limit. This kind of learning is the focus of most public education. Another kind is concerned with thinking, organizing things, anticipating the results of activities in which the things engage. Recent findings regarding conceptual blending [Faucannair] are an example. This repertoire is often associated with the brain right lobe and may be extensible without limit, as well.

Usage Scenario 1

One method will be to retrofit existing learning environments with motor sports artifacts, personalities, and vignettes that augment the STEM curricula while infusing system notions. Envisioned learning resources include:

- Twelve part video of Diandra Leslie-Pelecky's view of NASCAR
- Race vehicle component model
- Cut away visualization of engine simulations
- http://powermechanics.com/camshaft.html
- http://www.nsf.gov/news/special_reports/sos/?WT.mc_id=USNSF_51
- http://www.allamericanracers.com/home.html
- http://www.break.com/usercontent/2008/3/Top-Fuel-Dragster-Facts-473754.html
- www.UTI.edu
- http://www.jonescams.com/circle_track_story.pdf
- Race track risk model
- Pit stop process model
- Pit stop competition videos
- Race course control models

- Spectator risk model
- Engine and/or chassis dynamotor test
- Wind tunnel test
- Videos (Lime Rock, Gull Wing at Twilight, Andretti)
- Visiting celebrities (Bob Bondurant, Ross Bentley, etc.)
- FSAE student/advisor/achievement experience
- Video of successes, failures and learning (NHRA film of crashes and attempts to make run-off safe. Richard Petty grinding #43 apart against the safety wire fence … and walking away)
- Race Track Tour
- Engine shop tour
- Chassis shop tour
- Drag racing team fuel mixture presentation
- rear engine evolution at Indy
- Wally Parks and Stu Hilborn ran impromptu quarter mile in about 1948
- Why 1320 feet?
- First NHRA drag meet Great Bend, KS, 1953.
- Texas International G-force affects
- Jumbotron interference in Urban Challenge
- Tradeoff of boost pressure vs. horsepower vs. heat vs. engine life
- The Indy Buick engine that was 3/16ths of an inch too short to last for 500 miles at Indy.
- George Bignotti had a very high ‘finishing high’ rate in midgets, Indy and other USAC venues
- Danny Sullivan stressed physical and mental fitness
- John Fitch innovations included yellow barrels and displaceable guard rails and cockpit containment.
- SAFR Barrier
- Arena-cross barrier (the plastic water filled jersey walls)
- First use of telemetry in 1961 on #614 Corvette
- Where the ‘road’ meets the rubber a much neglected science.

This approach to SySTEM learning may not work out in regular public school settings because it implies added cognitive and physical workload on the teachers. We must find ways to assist teachers without presuming that they are enthusiasts even if some become enthusiasts as they see their students respond positively.

Usage Scenario 2

Another method will consist of focused learning sessions perhaps as an extracurricular activity or through private schools. These sessions will focus on the intersection of systemics, system praxis and the world of motorsports. Although the material is about motorsports, the learning objectives are about thinking, learning, and STEM. These will engage the ‘students’ in the clinical method of learning, that is, See One, Do One, Teach One, and Reflect [Schon]. Learning scenarios will be composed of a web of 20 minute learning sessions. Curriculum mapping will increase learning pace by a factor of 3X or more. A summary of the envisioned curricula for Motor Sports and Systems Engineering is:

- Motor Sports Vehicles
  - kinds of, e.g., drag, NASCAR, Indy car, sports car, rally ,
  - major components of,
  - component relationships,
  - behaviors when organized as system
- The Race Track
  - Components, Layout and Behaviors
- The Race Scenario and Vehicle Key Behaviors
- Driver Selection and Preparation
- The Race Team
- Distinctions
- Relationships
- Behaviors
- The Race Conductor
- Spectator Management and Logistics

Safety
Preparatory Test and Evaluation
Motor Sports Organizations
Knowledge and Technology Transfer
Field Trip Model and Report

Usage Scenario 3

Although many schools may engage students in actual motor sports others may opt for the virtual digital world and engage their students in modeling, simulation and emulation. A variant of this may formulate a contest in which they create their own vehicles and compete in virtual contests via the world wide web.

Effects Test and Evaluation

We intend to quantitatively evaluate our claim in selected schools, e.g. www.starshineacademy.com in 2011.

Measures of effectiveness will be objective, e.g., quantity, cycle time, retention and application as well as subjective, e.g. degree of meaningfulness to the learner and degree of resistance from stakeholders.

The college campaign

As various colleges evolve their education practices in systemics and systems praxis the MSWG will offer learning objects as above. Targets include the colleges already involved in motor sports education as evidenced on this panel or those involved in systems engineering education and in need of laboratory or practicum resources. Examples of the latter may be the INCOSE Fellows effort led by Joe Kasser and the BKCase effort of the SERC.

Recap of Claims

Claim 1: The real payoff from revitalizing science, technology, engineering and mathematics, STEM, education will come from learning to meld these and other disciplines/technologies into whole systems solutions, SySTEM.
PRO – increasing the relevance to the learner of STEM will encourage learning. SySTEM will help learners understand the relationships among the underlying concepts.
CON – Motor sports may be viewed negatively by the “green” movement. Motor sports may be associated with gangs. Motor sports may be associated with street racing and other unlawful activities.

Claim 2: A SySTEM approach will accelerate learning by creating experiences that are meaningful to the learner, notably, intellectual and visceral immersion in real world, rewarding, reflective, learning environments.
PRO – Enables visceral learning about current interests.
CON – Highlights shortcomings of current education programs and regulations.

Claim 3: Because meaningful learning sessions about systems are difficult to create in a campus-only setting this panel will address ways that motor sports can augment campus-centered SE education
PRO – Accelerates learning amount and cycle time. Increases application and retention.
CON – Entails extra effort by educators or volunteers.

Claim 4: A 'laboratory on many wheels' has been and can be used to accelerate SySTEM learning.
PRO – Proof of concept.
CON – Motor sports may be viewed negatively by the "green" movement. Motor sports may be associated with gangs. Motor sports may be associated with street racing and other unlawful activities.

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Systems Engineering Through Motorsports Course

Stan Settles, Professor
Systems Architecting and Engineering
University of Southern California

Presented at the IS2010 Symposium - Motor Sports Working Group Panel

Background

Starting in late 2006 I made a decision to return to landspeed racing on The Bonneville Salt Flats. I had first been there in 1958 and drove a streamliner at 193 MPH in 1960. My initial goal in 2006 was to drive at 200 MPH or faster. After considering a number of alternatives I decided to buy an existing lakester (a specially-constructed open-wheel racecar) and make major modifications to it. In August 2007 I drove it at a maximum speed of 206 MPH. The continuing changes resulted in reaching 247 MPH in 2009. We are working on increasing this to over 300 MPH this year.

We found that there were a number of active INCOSE leaders who shared a passion for motorsports and had discussed a working group based on this. Our focus from the beginning has been on creating a generic syllabus for a course that uses motorsports as a means of attracting students to systems engineering. Many great ideas for course content, including simulators, have surfaced in the MSWG. Efforts are underway to find funding sources to make these visions a reality.

USC Course

Drawing on the general work of the MSWG, I decided to create a course entitled Systems Engineering through Motorsports at USC. (There are some advantages of being a tenured full professor.) The course was first offered in the fall semester of 2009, and attracted 20 students from five different engineering majors. It is in process again this spring incorporating many changes that resulted from the first experiment. It has cleared the university curriculum approval process to become a regular course in the fall semester of 2010.

I use my experience from The Bonneville Salt Flats as a way to create interest from the start. In the opening class session I bring in my racing helmet and top half of my driving suit. The first charts that they see are photos from Bonneville. We do get to the usual syllabus and such later on. I make it very clear that I am an amateur racer, but that we plan to focus on the professionals for our learning basis. The professional areas that I have chosen are Formula 1, NASCAR, and NHRA drag racing. The course uses two textbooks: "The Physics of NASCAR", by physics Professor Diandra Leslie-Pelecky; and "Formula 1 Technology" by Peter Wright. The INCOSE SE Handbook and a paperback "The Mechanic's Tale" by Steve Matchett are suggested readings as well. We have a Formula SAE racing team which is in the process of designing and building their car. A number of these students have been in the course and give us a means to share in practical lessons from their project.

Through the vast number of motorsports venues and participants in Southern California and connections with the INCOSE MSWG, we have been able to draw on a number of experts to give guest lectures. The course meets on the USC campus and is also available on our Distance Education Network (DEN). The general approach requires weekly homework and a term project/paper. One assignment is to attend a live motorsports event and write a brief paper about it based on the content of the course. No exams are included.

Lessons-Learned and Future Plans

Like any experiment there has been a series of lessons-learned that have impacted our plans for the future, including the following:

1. Both individual and group projects/papers have been used as learning mechanisms. It is interesting to note that many students are not used to working in teams. That is a normal part of many courses in our Systems Architecting and Engineering (MSSAE) curriculum. Some are not used to writing technical papers either. I have had to spend more time on these learning elements than I had anticipated.

2. In addition to my original vision of attracting students to SE through this course, I have found motorsports to be an excellent metaphor for learning SE. Most of our MSSAE students are employed full-time working on large programs. They often do not have the opportunity to see their work results in the testing and evaluation.

3. The Formula SAE student leaders have commented about the change that this course made in their understanding of the entire project.

4. Offering the course on our DEN system in parallel with our on-campus session has inherited challenges of encouraging participation by the distance students. In most DEN courses, students can access the archived lectures at a later time. I have experimented with ways to encourage their participation and am now considering requiring live attendance either in the classroom or on DEN.

5. Many of the lessons are learned from the day-to-day events from the various motorsports venues and other related issues (e.g. Toyota). This means that the course is quite different when offered in the fall when the various racing is finishing up as compared to the spring when they are starting out.

6. I recognize that some of the features of my offering this course are based on my unique role as a owner/driver of a racecar. Succession planning is a challenge.

Motor Sports Accelerates SySTEM Learning

Al George
Cornell University
Mechanical, Aerospace, and Systems Engineering

Presented at the IS2010 Symposium - Motor Sports Working Group Panel

INTEREST AND ENTHUSIASM ARE EXTREMELY IMPORTANT TO LEARNING

Pro-

In order to revitalize science, technology, engineering and mathematics (STEM) it is imperative that the students see some relevance of these subjects to things that they find interesting. They need to be able to apply STEM to the things or activities they are interested in.

In order to see how STEM subjects interact with each other, and with other subjects, it is also very important to have some of the STEM learning applied to systems which are complex. Within complex systems there are usually many different relevant STEM applications. And, more important, the students will see and begin to understand the interactions, trade-offs, and necessity of including and coordinating the different STEM areas to be successful.

Motor sports are interesting to many people and also intrinsically involve complex systems that include every STEM area as well as other areas.

On the negative side, not all students are interested in MS per se and interest seems higher among men than women. However, people who do not have a direct interest in motor sports are often interested in relates aspects as esthetics, writing, publicity, web presence, and business. And there are many roles for various kinds of interests in most motorsports activities from design, modeling, and driving/operating, and them ranging to budgeting, styling, competition arrangements, organization, and publicity.

FAVORABLE TEAMWORK AND SOCIAL ASPECTS

On of the most important favorable aspects of motorsports is that is necessarily includes team performance. In almost any motorsports activity one needs a team of at least several people. This helps counter the image of the lone nerd scientist/engineer in lab away from other people and larger society.

COMPETITION ASPECTS ARE IMPORTANT

One thing that makes motor sports an excellent platform for building STEM education upon is that it is intrinsically competitive. If the students are involved in something where there will be a competition, especially one based on a team, they find it more interesting. Competitions and the accompanying deadlines, including intermediate deadlines set by the instructors are very helpful for motivation and learning.

Competitions can range from in-class to local, regional, national and even international competitions and goals can be minimum performance or team best as well as winning.

MOTOR SPORTS IS USEFUL FROM ELEMENTARY TO UNIVERSITY LEVEL

In principal, motor sports can be used in STEM education out at many levels from elementary school through university.

At lower levels there already exist competitions like the Cub Scouts "Pinewood Derby" which can be built upon. As the students move up from the elementary levels through high school, increasingly complex STEM ideas can be introduced starting from weight, addition, strength of materials, and timing. Then ideas can move up to velocity, acceleration, trigonometry, energy, power, Newton's laws and mathematical modeling of performance using EXCEL integration. In motor sports the ideas necessarily arise of systems made up of necessary parts like powers source, wheels, steering, structure, and operator that have to be integrated at an acceptable cost for a successful system. The differences and symbiosis between technology and engineering can also be explored.

Also, the competitive nature of motor sports will automatically lead to consideration of how to improve and optimize systems. And the variations between competitors and over time lead to considerations of statistics and data management.

Con – It is not easy to work up assignments are made to allow all people with a range of interests to have some meaningful STEM experience.

HOWEVER COSTS ARE OFTEN HIGH

If one moves from very small scale vehicles toward manned vehicles the costs and space requirements can become severe. Also the travel and lodging costs and the costs of transporting vehicle to test areas or competitions are usually high.

On the other hand, the competition's rules can help control the costs to run competition-based programs. Rules can include re-use of materials and parts, restrictions materials, components, and costs. Another method employs awarding some competition points for low cost.

Space availability and costs become large for people carrying motor sports vehicles. It is also expensive to supply and maintain the supporting lab equipment at the higher levels of motor sports that are needed to maintain interest at the university level.

One partial solution to keeping down expenses is to use a largely-fixed configuration standard base vehicle. However it then gets more difficult to include as many STEM subjects and systems aspects and to still keep all the students interested. This is because it is difficult to strike a balance between reducing the costs with a largely fixed standard vehicle but still allow enough inexpensive modification that will need a range of STEM and systems knowledge to be implemented.

Contact and Background Information

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The Origins and Benefits of the Fellows Youth Outreach Project and the Motor Sports Working Group -

Dr. William F. Mackey,
INCOSE Fellows Chair

Presented at the IS2010 Symposium - Motor Sports Working Group Panel

The Origins of the Motor Sports Working Group

At the INCOSE International Workshop, held in Phoenix, Arizona, in January 2001, a small group of members (including Fellows Dennis Buede, William Mackey, and Jack Ring) met to discuss how to revitalize undergraduate and graduate engineering within existing universities. One element suggested was automobile racing. All three were interested in auto racing and were frequent attendees of the Indianapolis 500, the U.S. Grand Prix, and NASCAR and Busch Series events. Jack Ring had a race car in his younger years and became personal friends with Bob Bondurant, who has raced at LeMans and who is presently the executive of his own famous Bondurant Racing School in Phoenix, AZ. Jack Ring had arranged a personal meeting with Bob Bondurant in late January 2001. We discussed the possibility of developing a systems engineering curriculum with auto racing as the venue domain of interest. Bob Bondurant indicated that he would be willing to participate.

At the INCOSE International Workshop held in Albuquerque, New Mexico, in January 2007, Fellow Stan Settles mentioned that he was in process of acquiring a race car to use at the University of Southern California. Bill Mackey sat with Stan at the Corporate Advisory Board banquet and revived the idea of a Motor Sports Working Group (MSWG). Stan was very enthused at the possibility. At the 2007 symposium a Charter for a Motor Sports WG was written by Bill Mackey and introduced to interested INCOSE members. At the INCOSE International Workshop 2008 the Charter for the MSWG was formally approved during the first MSWG meeting.

The first objective of the MSWG is to develop a semester course in systems engineering applied to the sport of motor racing. With adaptation, we believe this same course could be taught at the high school level.

An outline for a semester course in “Applying Systems Engineering to Motor Sports” was proposed and is undergoing development.

Lessons Learned

This MSWG has INCOSE members as well as persons who are not involved in INCOSE as participants. Membership is growing rapidly and has gained the interest of professors all over the world. Professors at universities such as Carnegie Mellon University (CMU), Indiana University Purdue University of Indianapolis (IUPUI), and the University of Southern California (USC), which are well-known in providing undergraduate and graduate courses in such subject matter, are now involved with the MSWG.

Several professors are from universities (e.g. Cornell University) which have involvement in Formula SAE. Formula SAE is a College-level motor sports design competition [http://students.sae.org/competitions/formulaseries/]

Professor and INCOSE Fellow Stan Settles, the present INCOSE Academic Council Chair, is moving rapidly ahead on this issue. He is racing at Bonneville Salt Flats attempting to set land speed records for his class of vehicle and he has been teaching a graduate course in motor sports at USC.

We are very optimistic that we have indeed found an exciting option that will gain the attention of high school and university students.

The INCOSE Fellows Youth Outreach Project

The “Mission” of the Fellows Committee is to advance the state of the science, art and practice of Systems Engineering. There is great concern among Fellows that the science and engineering community may not be reaching our youth at an early enough age to inspire them to pursue science and engineering disciplines in our colleges and universities. The Fellows believe that the use of systems engineering principles, techniques, and practices can be made interesting enough to young students that they will continue their studies and interests into undergraduate and graduate institutions. While the systems engineering approach is most amenable to solving complex problems because of its use of multi-disciplines to examine all facets of the problem space; it can also be used to examine motor sports, baseball and other entertainment activities of interest to youth

To carry out this mission and vision the Fellows have adopted the following goals for the Youth Education Outreach Project.

Goal 1: Identify and describe projects which have been successfully applied to groups of youth

Goal 2: Create relationships with other professional societies and support interaction with those that are known to address youth interests in science and engineering such as the Intel International Science and Engineering Fair (ISEF), the Science, Technology, Engineering and Mathematics (STEM) Program, the Boy Scouts of America merit badge activities, science and engineering magnate high schools (e.g. the Thomas Jefferson High School in Alexandria, VA), and corollary organizations around the world.

Goal 3: Advise the BOD and TLT on issues relevant to Youth Education Outreach.

Other important goals are to:

- Demonstrate the value of systems engineering through its application to Youth Education Outreach
- Increase the influence and prestige of INCOSE among the youth of the international community
- Provide motivation and opportunity for INCOSE members to join in Youth Education Outreach activities that INCOSE believes important to improving the systems engineering profession

A Youth Education Outreach Report has been written and made available to the INCOSE membership on January 15, 2010 to demonstrate that these principles have already been applied to many youth activities with significant success by individual Fellows.

Youth Education Outreach Activities and Projects Successfully Applied by Fellows

The Youth Education Outreach activities and projects successfully applied by individual Fellows were accumulated by polling the INCOSE Fellows and asking what experiences each Fellow had with youth on technical subjects and what did they learn about successful Youth Education Outreach.

The request to the Fellows was as follows:

"The INCOSE Fellows have been requested to develop ideas for teaching systems engineering below the college level in grades K-12. Since no financial resources have been assigned to this effort, I caution each Fellow not to incur expenses to any formulation effort. Obviously, no cost ideas will be given greatest consideration.

It is now your challenge to:

1. Develop ideas to suggest to INCOSE to teach systems engineering and reach out to the K-12 student population.
2. If the Fellows are to be involved in the implementation of these ideas, I need a Fellow to step forward to lead this effort.

Try to present your ideas in paragraph form similar to the scenarios presented above with the resources you believe are required to implement them."

Many persons have indicated that such a task is presently beyond the realm of possibility. After personal experience, several other Fellows and I are convinced that it is possible to apply the basic concepts of systems engineering at least to the high school level.

As a result of the above request, there were twelve (12) responses from eight (8) INCOSE Fellows. The list of these responses is as follows and is discussed in Section 2.1 of the Youth Education Outreach Report.

1- T. Bahill – Baseball Tutorial with Examination

2- D. Hitchins – STELLA (Systems Thinking Environment and Learning Laboratory Approach) via ISEE and Systems Dynamics Society
3- J. Kasser – Radio Amateurs: A Source of Systems Engineers?
4- W. Mackey – Boy Scout Skiing Campout Example
5- W. Mackey – Boy Scout Space Systems Seminar
6- W. Mackey – Applying the Concept of Intellectual Property to Computer Science
7- W. Mackey, J. Ring, S. Settles, and D. Buede – Motor Sports and SE Curriculum
8- M. Maier – Lego Robotics and First Robotics Competitions
9- M. Maier – "Hands On Science" Program at Caltech

Some guidance submitted for evaluation is discussed in Chapter 3 of that report and includes:

1- J. Ring – The 'Systemics @ K-12' Initiative
2- S. Friedenthal – K-12 Education Goal Setting
3- T. Bahill – SIE-498a Senior Design Project

Two additional projects involving INCOSE Fellows that are directed at Youth Education Outreach are discussed in Chapter 4 of that report:

1 – The Intel ISEF Project
2 – The SEANET Doctoral Research Network

The Benefits and Claims of Systems Engineering Applied to Motor Sports

Claim 1: The real payoff from revitalizing science, technology, engineering and mathematics, STEM, education will come from learning to meld these and other disciplines/technologies into whole systems solutions, SySTEM.

Motor sports involve more than just an automobile, motorcycle, speed boat or race car developed for the purpose of racing. In fact, this sport more than any other involves the systemization of several engineering disciplines. Some of the systems and specialties include:

- The Race Car System and Components (Engines, Transmission, Chassis, Communications, Driver, Navigator, Telemetry, etc.) and Behaviors (top speed, acceleration, decision error, etc.);
- The Race Track System and Components (Track, Safety Barriers, Scoring Mechanisms, Pit Structures, Garages, Emergency Equipment, Emergency Crews, Race Officials, etc.) and Behaviors;
- The Race Car Operational Availability System and Components (Pit Boss, Pit Crews, fuel replacement, tire replacement, aero and suspension adjustors) and Behaviors (pit stops, reliability for all machine components and systems, etc.);
- The Race Conductor System and Components (Signal Flags, Rules of Racing, safety for all drivers, race personnel, and spectators) and Behaviors;
- Spectator Management and Logistics System and Components (food for spectators, restroom facilities, etc.) and Behaviors.

Impediments to Claim 1:

1. There may be very few students interested in auto racing as a venue.
2. Only male students may be interested in auto racing.
3. There may be very little literature upon which to build such a systems engineering course.

Claim 2: Enthusiasm is a key ingredient to revitalizing science, technology, engineering and mathematics (STEM). It is often expressed by youth that STEM is not fun.

My experience with Boy Scouts several years ago was that these young men were willing to spend an entire weekend contemplating what functions a yet to be built International Space Station System should have. Most of these young men went on to study STEM disciplines at our country's finest universities. I believe this exposure to systems engineering was influential in their decisions.

Impediments to Claim 2:

1. The real enthusiasm in such a course will come from hands-on activities.
2. Race cars and tracks can be very expensive and out of the reach of undergraduate students.

Claim 3: SySTEM learning can be accelerated by experiences that are meaningful to the learner, notably, intellectual and visceral immersion in real world, rewarding, reflective, learning environments.

Again referencing my Boy Scouts experience with young people, I used the merit badge books combined with real life experiences to inculcate the principles. During a five year span we explored Engineering with the real world experience of measuring vehicle speed rates; Law combined with the trip to meet a judge in a court of law, prisoners being booked in a local jail, a visit to a major penitentiary to talk with inmates; Communication combined with a filming of a live TV program; and many other such experiences. These young men found these experiences very useful in their choice of fields of study and also their professions.

Impediments to Claim 3:

1. Again, race cars and tracks can be very expensive and out of the reach of undergraduate students.
2. Resources are very limited and generally unavailable to most campus settings.

Claim 4: Because meaningful learning sessions about systems are difficult to create in a campus-only setting this panel will address ways that motor sports can augment campus-centered SE education

The mission of the Motor Sports Working Group (MSWG) is to initially use the motor sports venue to enhance understanding and proficiency in the use of systems engineering principles, techniques, and practices. The systems engineering approach is most amenable to such evaluations because of its use of multi-disciplines to examine all facets of the problem space. In so doing, our mutual primary goal is to increase interest in the study of systems engineering as well as specific engineering disciplines at undergraduate and graduate colleges and universities.

The secondary goals are to:

- Demonstrate the value of systems engineering through its application to a sports challenge
- Increase the influence and prestige of INCOSE to the international community
- Provide motivation and opportunity for INCOSE members to contribute to sports and recreational challenge.

We hope to combine modeling and study exercises with race track visits and participation.

Impediments to Claim 4:

1. Auto Racing is an outdoor sport and usually done in climates and seasons during the spring, summer and fall.
2. Auto Racing may not have international appeal.

Claim 5: A 'laboratory on many wheels' has been and can be used to accelerate SySTEM learning.

An ideal college or even high school experience would involve the development of a competitive race car. Such a laboratory on wheels would become the mechanism for improving a system and truly understanding all of the elements necessary to race the vehicle.

1. Creating such a mobile laboratory may be beyond the cost level normally associated with college and high school courses.
2. Courses such as this have traditionally been associated with vocational education curricula rather than college-bound student curricula.

Motorsports as a Vehicle for STEM Education

Pete Hylton & Andrew Borme
Motorsports Engineering
Indiana University Purdue University Indianapolis

Presented at the IS2010 Symposium - Motor Sports Working Group Panel

There is uniform agreement that the United States is facing a shortage of engineers and that there is inadequate diversity among the engineers that are currently being produced by U.S. universities. In order to address these two critical problems, education in Science, Technology, Engineering, and Mathematics (STEM) fields needs to change, at both the collegiate and the K-12 levels.

One of the changes that is needed is that students must be trained to think of problem solutions in terms of total system solutions. It is the integrated solution that carries the day in today's world. Engineers can no longer design a single component without regard to how it fits into the overall system. They also cannot design a system of components, disregarding how that system impacts the environment in which it operates or the society for which it provides a service. Students in engineering programs need to understand this and practice it during the projects and problem solutions that they execute in their university classes. They need to be well prepared to look at the "big picture" when they reach industry, and synthesize solutions that solve the problem as a part of the system, not as an isolated endeavor.

This system solution also requires a more interdisciplinary approach. Designing components from a system viewpoint requires better understanding of other engineering disciplines outside of one's own specialization. But even beyond that a better appreciation of societal and global issues is required. This means that engineering programs must put more emphasis on the social sciences and humanities, which have traditionally been given short shrift in engineering education. The engineer of the next generation needs to be less of a specialist, and more acquainted with topics and skills across the broad spectrum required to focus on system solutions. There are those, especially in academia, who are inclined to focus their attention on their specific area of research expertise. It will be necessary to open their eyes to the interconnectedness of various fields before they are truly prepared to teach from a system-wide STEM approach.

To produce an engineer who is prepared to address design from a system-wide viewpoint, educational opportunities must provide experiences that provide challenging, horizon-broadening scenarios that place the student in the environment of real world problem solving. When student paradigms are connected to STEM concepts through authentic exposure, then the learning becomes truly meaningful. Solving textbook problems as a means to learning engineering skills is no longer adequate. It must be partnered with challenges that involve open-ended solutions to system-wide problems. This is most definitely true at the university level, where students need to learn not just rudimentary design skills, but need to do their design work in the context of the overall engineering system, and incorporating program management skills such as budgeting, scheduling, risk management. Seeing this total system solution approach and being placed in situations where they have to apply it, is the best preparation future engineers will experience in their collegiate career.

However, this is true not just in the university environment, but in K-12 pre-engineering programs as well. In order to build or strengthen interest in STEM careers, younger students must also be presented with real world learning opportunities. Secondary school students do not fully synthesize fundamental math and science concepts until they see how those concepts are applied to solve real world problems. Additionally, when they recognize how these problem solutions fit into a system solution, they are even more likely to steer towards STEM careers. This is particularly true of young women who have been shown repeatedly, in engineering education research studies, to seek a global or societal connection to their engineering studies before their interest in a STEM career solidifies. In order to broaden the gender diversity of engineering graduates, a system-wide solution approach is most definitely required, and if societal results can be connected, then the chances of engaging more women in engineering careers will definitely increase.

Motorsports engineering is not just a colorful, high-energy, attention grabbing educational alternative, it also lends itself readily to meeting all of the STEM needs just discussed. A motorsports plan of study has to involve real world experiential learning. When Indiana University Purdue University Indianapolis (IUPUI) created its new Motorsports Engineering curriculum, an advisory panel of motorsports industry experts was constructed. Without exception they indicated that the program needed to emphasize hands-on activities that involved the students actually learning to work on cars and implement the designs they came up with in the classroom. To this end, IUPUI has four race cars involved in its program, all designed, built, crewed, and driven by students. The necessity of implementing their designs into actual hardware, and then following these products to the racetrack is unique. At the track, unexpected situations create perhaps the most unique and unparalleled experiential learning opportunities imaginable. As regards hand-on and real world learning, motorsports is unparalleled.

The race track becomes the ultimate learning laboratory for engineering studies. When things go wrong at the track, or when improvements are needed to enhance competitiveness, the student must think quickly and pragmatically. Designs must be brainstormed, refined, detailed, analyzed, and implemented rapidly in the field. And everything must be considered in the context of the overall system, to make sure that the changes being made to solve a particular problem interface correctly with other components and sub-systems, and do not introduce problematic issues with any other aspects of the overall system.

Beyond that, the systems aspect of motorsports engineering is significant. Although an engineering student may be tasked with designing a single component, he or she must consider how that component fits into the entire system, interfacing with all the surrounding components. For example, a suspension component cannot be designed in a vacuum, it must take into account the design of the chassis which it attaches to, and the brake or axle components which it supports, etc. Structural concerns must run hand-in-hand with aerodynamic concerns, weight concerns, and the need for built-in ability to adjust on the fly to achieve better performance.

Even the need for societal impact is met by motorsports engineering. Across the decades, the number of improvements which have been made in street vehicle design, after they originated in motorsports, is amazing. While motorsports has correctly been given credit for the invention of everything from rear view mirrors to disk brakes in the past, it is perhaps the current trend of designing energy absorbing structures that will ultimately carry the prize as providing the greatest benefit for vehicles driven by the general public. It is impossible to imagine the number of lives that will be saved in crashes of road-going vehicles once all the recent safety designs migrate from motorsports to street cars.

In summary, one of the changes that will have to take place in the near future in engineering education is the move toward system solutions. Motorsports provides an excellent learning laboratory for engineering students because it forces them to address solutions in a system environment, and provides excellent experiential learning opportunities for taking designs from concept to hardware to implementation and testing in a very short time period, just like the real world.

Motor Sports Accelerates SySTEM Learning

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Presented at the IS2010 Symposium - Motor Sports Working Group Panel

What is there about motor sports that draws huge crowds to over 1,500 race tracks around the US and attracts billions of dollars in capital investment? More importantly for us, how can we leverage this enthusiasm for racing competition to increase teenager's interest and capability in science, technology, engineering and mathematics? In the enterprise that is motor sports is there the spark to ignite the desire for excellence in educational attainment necessary to propel our youth into non-motor sport careers that will benefit us and future generations?

Aside from the reality of weekend racing, motor sports is a metaphor for the use of competitive technological capability to achieve clearly defined short-term results – qualifying on-the-pole, finishing first in today's race, going faster than someone else. However, our goal is not one short-term result or even several of them. We aim for sustained improvement in the application of system knowledge to solve problems of all kinds. For the metaphor to be meaningful in this expanded context, we need to broaden the scope of racing beyond the vehicles that move from start to finish. We must include the track garage, venue management, spectator event promotion, engine and body shop, team dynamics, and financing. All of these areas utilize aspects of science, technology, engineering, and mathematics (STEM). If we are to succeed, it is the whole motor sports enterprise with its many inter-related system components that we need to grasp in the development of student curriculum targeting the SySTEM objectives.

The motor sports industry has achieved tremendous technical depth in the components of its competitive systems. Race cars, hydroplanes, motorcycles, and aircraft can be finely crafted instruments honed for top performance in tightly prescribed conditions. While the recognized top performer is most often the driver, such performance is always a team effort. A student has many opportunities as a team member to engage in the success of a particular event or in activities in support of a winning effort. A particular advantage of motor sports is the continuity in learning opportunity as student's transition from heroes to teams to SySTEM excellence.

A particular challenge of motor sports as a curriculum focus is the down side of competition – not winning. For SySTEM to succeed in furtherance of the core competencies it must maintain relevance as an exemplar for learning and not become an extra-curricular activity focused solely on racing success. Critical thinking, analytical skills, and comprehension are as important to understanding the causes of failure as they are to understanding what critical advantage was achieved to win. Many of the best anecdotal examples that appeal to younger learners are spectacular failures; particularly those few that were overcome leading to a win.

My interest in SySTEM is the development of youngsters, middle and high school age students, whose career choices can be very much influenced by an engaging course of study that both challenges and rewards the learning activity. The attraction of motor sports for me is the breadth of experiences and opportunities it offers for curriculum design and delivery. This breadth is found in the SE in MS 101 course outline prepared by the MSWG. Everything from very sophisticated material on engine design through innovative safety response and technology transfer are topics for presentation and discussion. There is a clearly increasing extent of knowledge for use at different grade levels and extent of system dynamics. The thrill of competition and desire for success can engage students at many levels of study and should lead to career choices well beyond motor sports and system engineering.

The SySTEM initiative has much to offer in support of our national goals for STEM education and a knowledgeable resource of INCOSE members upon which to draw in preparing curriculum materials. What is needed is the financial support to make it all happen. Developing, testing and deploying a new curriculum is a very expensive proposition that gets more expensive as the students become younger. And it is the younger students for which such a curriculum will have the most impact for instilling pursuit of a career in science, technology, engineering or mathematics.

Motivating SySTEM Learning with Motor Sports

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Presented at the IS2010 Symposium - Motor Sports Working Group Panel

SUMMARY

By extracting 'Lessons Learned' from high performance, high achievement activities such as motorsports, lessons can be created for classroom delivery of SySTEM knowledge along with a competitive work ethic for learning, implementation of knowledge, and for continuous improvement of the teach/learn/implement/improve process. The process is self-sustaining. Participants will become teachers, in the classroom, in the work place, in their team!

BACKGROUND

The real payoff from revitalizing science, technology, engineering and mathematics (STEM) education will come from learning to meld these and other disciplines into 'total systems solutions' derived from the practice of Systems Engineering, or … SySTEM.

SE is the discipline within Engineering that employs Science, Technology and Math in a systematic or 'engineered' way to achieve total systems goals in a competitive arena … whether on the race-track or in global commerce.

Specific performance can best be achieved by those able to visualize and deal with the complexity of 'systems'. This ability will not come from merely learning the rote of science, technology and math.

SySTEM learning can be accelerated by experiences that are meaningful to the learner, notably, intellectual and visceral immersion in real world, rewarding and reflective learning environments. Motorsports is the only sport combining high performance and high technology in which mastery of the technology is the essence of the sport!

Meaningful learning sessions about systems are difficult to create in a campus-only setting. This panel will address ways that motor sports can augment campus-centered SE education. Motorsports can provide a real-time or an observed experience of the high performance, competitive mastery of technology.

Unfortunately, motorsports are anathema to many academics, not withstanding the significant presence of academically-trained participants in: NASA, US Navy and Marines carrier-deck operations … and actual university level performance competitions such as FSAE, EcoCar and others, which too often, are conducted in virtual anonymity and the lessons learned are quickly lost as the competitors segue into their next competition. The bulk of US educators seemingly have not grasped the great values that are being lost in all of these performance competitions by the failure to conduct Lesson Learned programs to capture the values!

A 'laboratory on many wheels' has been and can be used to accelerate SySTEM learning. The laboratory should be capable of carrying individually variable content to suit individual needs of teachers/learners at all ages, stages and levels, to teach/learn SySTEM. The concept and content must ideally be driven by class-room teachers, and be drivable and improvable by them. At this time no such process exists. It is barely imaginable. The cost and energy to develop such a process will be immense. This might be shared by industry, military, health and other institutions having the same needs for SySTEM 'education' as our formal schooling systems.

SITUATION

Several members of the Motor Sports Working Group (MSWG) of the International Council on Systems Engineering (INCOSE) have delivered motorsports-oriented university-level courses bringing much-needed and much-wanted SE and STEM (SySTEM) knowledge to their students. There are other university motorsports classroom courses; and there are university design contests also deploying SySTEM--but these have not yet seized the opportunity to develop classroom courses for wide-spread teaching of SySTEM--using the Lessons Learned from their own programs. Eg. University-led FormulaSAE teams design, build and compete in a variety of judged categories, including teamwork, report writing, safety, quality, appearance, technological performance and other factors. Many students become enthusiastic users of SySTEM knowledge as a result of their motorsports experience! The Lesson is inescapable … this paper proposes a way to capture the Lessons Learned from motorsports for dissemination in a variety of ways to restore a national imperative for Competitiveness!

PROPOSAL

The opportunity exists to extract and convert SySTEM knowledge and its delivery systems into teach/learn/implement/improve programs for K-12 students and others (including industry and other institutions) seeking an exciting model exemplifying the use of SySTEM in a competitive way as occurs historically in motorsports. Mining and downloading of the data and human experiences would yield raw materials for processing, with the vital aid of classroom teachers, into curricula. Digital programs could be developed to provide wider dissemination as aids to class-room teachers of the nation.

PROCEDURE

In order to capture this opportunity it is suggested that MSWG encourage INCOSE to create an alliance of the engineering brotherhood to rationalize and coalesce the labyrinth of government agencies and non-government groups professing an interest in the promotion of SySTEM. (Eg see America Competes) Each group could state its needs for graduating and hiring people having SySTEM skills to advance their aims.

Ultimately this should bring DoEnergy, DoEducation, National Science Foundation, National Academies et al into a consortium supporting the improvement of the teach/learn/implement/improve process for SySTEM, while exploiting the attention-grabbing aspects of high-performance, high-achievement activities such as: university-led system design competitions, motorsports (land, sea, air), NASA, carrier-deck launch and recovery operations, and others.

Presumably this would take the case into the political realm through Secretary of Education Arne Duncan who would bring educators and funding into programs meeting the expressed needs of the nation to improve the teaching, learning, implementation and continuous improvement of SySTEM--driving the nation to compete in a global economy.

Delivery by digital means, based on the techniques of the best teachers in the country will require that classroom teachers participate in bridging the gap between their needs for the delivery of SySTEM--into digital systems appealing to the specific needs of individual students. This will involve learning from the best teachers, and translating their needs into digital formats for animation, simulation, virtual reality etc. This will necessarily involve (at great cost) major commercial studios having skills for creating games and entertainment for all levels from K to adult … while continuing to develop new digital processes that must be incorporated into 'education' in a timely fashion--as is learned by observing the continuous improvement carried out in motorsports.

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