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► **To cite this version:**

Jean-Claude Tucoulou, David Gouyon, Eric Bonjour. A student challenge in systems engineering: RobAFIS 2010. INSIGHT - International Council on Systems Engineering (INCOSE), 2011, 14 (4), pp.9-11. 10.1002/inst.20111449 . hal-00653908

HAL Id: hal-00653908

<https://hal.science/hal-00653908>

Submitted on 20 Dec 2011

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A Student Challenge in Systems Engineering: RobAFIS 2010

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RobAFIS is a student engineering competition to design robots, organized by the French Chapter of INCOSE (AFIS) each year since 2006. The competition brings together approximately 10 teams of students coming from an engineering program of a French university or a graduate engineering school. Those students may be pursuing either a bachelor's degree or a master's degree in engineering. In most cases, they will be fresh graduates with a bachelor's degree but little or no experience in systems engineering. Their lack of experience is a challenge in realizing the educational outcomes. Each team consists of at least three students, including a project manager, and is advised by a systems engineering professor who plays the role of "teaching reference."

Objectives

RobAFIS relies on a comparative evaluation that is carried out between the robots produced by the concurrent teams and represents a teaching operation of AFIS. The objective is to lead students to implement methods of systems engineering, to work in a collaborative way to design their solution, and to produce and provide a Development Document.

In the preparatory phase of the competition, it is important to check the feasibility of the mission: several teams must succeed in performing the expected mission to maintain the students' motivation. During the competition, the students and their referent have the possibility of questioning AFIS systems engineering experts who work in industry or teach systems engineering. The questions can relate to the course of the competition, to its regulation, and to technical or methodological aspects. The provided answers or comments have first a learning interest and enhance the systems engineering training.

After the competition, a debriefing is carried out with each team to emphasize the positive points and the drawbacks of their solution. A systems engineering expert gives a detailed evaluation of the project, considering whether the Development Document reflects good use of systems engineering tools and methods, and explains the results of the audits of configuration and the performance of the robot during the operational validation.

Organization and Schedule of the Competition

The place of the operational phase is within a higher-education establishment. The steering committee is composed of a team who is in charge of the management of the competition and provides the technical expertise that is necessary to answer students' questions. The schedule of the competition, covering about 10 months, is as follows:

- Communication about the general schedule of the competition (T0 - 8 months)
- Publication of the regulation, the specifications, and the reference Development Document (T0 - 6 months)
- Registration of the teams (T0 - 3 months)
- Free supply of a LEGO Mindstorms kit for the building of robots (T0 - 2

- months)
- Reception of the Development Documents (T0 - 15 days)
- Evaluation of the Development Documents by experts in systems engineering
- Final stage: Tests, configuration audit, operational validation, project audit (T0)
- Detailed debriefing with each team (T0 + from 1 to 2 months)

Organization of the Final Stage

Part I. Tests for setting up the robot and on-site checking

Before the operational evaluation, each team has an access to the zone of evaluation to perform tests for setting up the robot and functional checking *in situ*.

Part II. Configuration audits

The robot is completely disassembled and the parts are deposited on a table in front of the jury (figure 1). The team has 15 minutes to assemble the robot on the basis of the configuration written in the Development Document. A jury must make sure that the assembly conforms with the solution definition recorded in the Development Document. The audit is then completed by the feasibility checking of one of the preventive maintenance actions that are written in the Development Document, in a section on “aptitude for maintenance.”

Part III. Operational validation

The operational validation (figure 2) is performed as a succession of matches pitting two teams’ robots against three of the others. Each robot must achieve the mission described in the specifications three times, so that the jury is able to check that the solution is robust (and to give greater chances of success for each team).

Part IV. Brief closing presentation (lessons learned): project audit

After the operational phase, each team has to present a final review in front of the jury (figure 3). The team explains the reasons for their success or failure during the operational validation and analyzes the possible engineering difficulties and problems.

Part V. Public announcement of the results and distribution of awards.

The organization committee presents the final ranking of teams, and distributes awards in the presence of AFIS systems engineering experts and representatives of the AFIS board.

Assessment Criteria of the Development Document

The appreciations that are given by the members of the jury do not consist of a judgment on the technical quality of the product because this aspect is evaluated by the results obtained during the operational validation. The judges only assess the quality of the implementation of the systems engineering processes and the quality of the Development Document, taking into consideration the initial specifications. The marking system of the competition is decomposed into four points:

- 40% for the quality of the Development Document

- 10% for the configuration audit
- 40% for the results obtained during the operational evaluation
- 10% for the quality of the brief closing presentation of the project

Key Interests of the Competition for the Organization Committee

The organization committee is in charge of the processes and activities concerning the management of the competition (the competition is structured like a professional project with milestones), the relationships between the contracting authority (here the main stakeholder is the organization committee) and the prime contractor (the student team), the development of the specifications for consultation, and the feasibility studies before consultation. This results in the production of the reference documents of the competition (regulation, specification, reference document for the development).

The committee organizes and participates also in the evaluation of the Development Documents, and controls the final phase.

Major “Lessons Learned” for Student Teams

For student teams, the competition offers various interests:

- A comprehensive view of the major systems engineering processes and activities, through the realization of a concrete system and the writing of the development document.
- Understanding of the impact of the systems engineering process on the final product quality.
- Learning on key systems engineering topics:
 - Organization and management of a development project (WBS, risk management, cost control, planning, assignment of roles within the project team)
 - Requirements analysis and management
 - Configuration management and traceability
 - Architectural design, functional and physical modeling, and allocation of performances
 - Justification of the architectural choices, production of integration and validation plans
 - Guidelines for structuring of a Development Document
 - Verification and Validation for the engineering phase and for the integration phase
- Meetings and exchanges between students and with systems engineering experts.



Figure 1. Configuration audit with systems engineering experts



Figure 2. Operational validation



Figure 3. A student team during project audit