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Risk assessments and their techniques are processes that have been studied by many scientists over the years. Their correct application is just as much art as it is science, as they protect life and property of civilization.

Risk Assessments for a Growing World

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Risk assessment in engineering is a vital part of the design process for any project and requires a large amount of research into the final nature of the project. In class room and lab it provides a way to mitigate wasted time and basic injury but in the professional field it can prevent not only bodily harm but dangers to both the environment and civilization in general. It also works as a useful deterrent of lawsuits and can be used as a body of proof for many legal scenarios. The true challenge is getting them right and using the correct set of guidelines plays a big role in correct execution of risk management. There are plenty of resources available on the subject and can provide team leaders with the necessary tools they need to complete an assessment.

When looking at the subject for the first time there are two definitions that need to be made. Risk itself can be defined as “probability distribution of loss” (Munier) and risk management itself can be defined as “the set of techniques for controlling the uncertainty in a project.” (Merritt) Due to the nature of modern engineering projects there are many assumed risks. Anyone involved could be hurt, whether they are a builder, designer, bystander, or commissioner, only one card needs to fall for a house of cards to crumble. With luck modern standards prevent the creation of such houses of cards but one can never know if they do not do diligent research into their creation first. By looking at all weaknesses in the model and design, by using testing tools and environments to ensure all parts work as they should, and by following a standardized procedure for going about the project one can ensure that they are working as safely as possible. By using these as stepping stones going forward we can dive into the subject of risk assessment in the university environment.

In the fall of 2015 Doctor Spalleta’s Robotics course met for the first time that year at the University of Scranton. Many things would be learned in the class over the course of the semester but one of the most important things would be the use of GANTT charts and PERT charts. These two methods were a large part of project management and provided a way to effectively plan out an entire project. The GANTT chart, named after Henry Gantt in 1915, provided a way to schedule tasks for a project and made it very detailed. Each task is laid out in such a way that anyone can see the natural progression of the project with ease, making its completion very straightforward in terms of the next step. The PERT chart on the other hand provided a way to plan the projects interconnectivity and provided a place to lay out all of the risks associated with the project itself. It allows the estimation of time, energy, cost, and risk associated with every individual part of the project. The final and one of the most important parts of the GANTT chart is the Critical Path Method developed by du Pont de Nemours in 1958. It called for the creation of a critical path line in the GANTT chart that could be followed to complete the core concepts first and provide a safe solution for crashing the project if needed. All are involved in the projects timeline directly and in its planning, therefore by appropriately planning the timeline of a project can alone provide a very simple solution to the many risks involved with an unorganized plan. (Munier) Risk assessment by the use of timelines is not the only way to effectively mitigate risk. By dealing with all the factors that go into project completion in these ways however allows the manager to see all of the factors. This bigger picture is what is necessary for the safe completion of any project, as the risk assessment should go well beyond the design, building, testing, release process, it should account for the life of the follow-on product. Products designed in the lab are small scale, a dancing robot, a green house, a claw machine, and therefore have a much shorter or less taxing lifespan, making them simpler cases. Full scale projects however, such as the International Space Station, require significant assessment to ensure they do not randomly fall out of the sky one day and hit the ground. The military uses a simple process to mitigate risk in the form of DD2977.

The United States Army’s DD2977 is a form that allows a commander to plan the risks their unit is going to face and how to mitigate the dangers they present. Before the unit takes any action their commander submits one of these forms to their superior so that the chain of command knows exactly what the units is doing. The form is laid out so that one can see exactly what part of the plan the commander is referencing, the exactly defined hazard identified, the initial risk level, what control measures will be in place, how and who will implement the control measures, and finally what the residual risk level is. All of these are laid out like this so anyone can look at it and know exactly what is happening. The commander will even type out a narrative of the event so everyone involved knows what is what. They then get passed along all the way up the chain of command for the unit until every officer has seen it, so everyone knows what the risks are and they know the controls for them. Engineering, like the military, sometimes cannot afford to not take risks for the sake of advancement and therefore there are many forms like this that are used by corporations and governments. The DD2977 is a requirement for United States governmental workers to use and provide a way to provide for best laid plans. With these in use the project is more organized, yet again.

When implementing risk management there are nine steps that are generally considered the correct by the industry. The first is data collection and initial conditions of the project, which has to do with the organization of information that is relevant to the project. In this step the projects actual objective is actually established, what the team wants to do with it. The scope of what the team wants to do is also laid out and the actual capabilities of the team are assessed, along with the assessment of potential risks to the team taking on the specific task, which is called SWOT analysis. The next part of the first step is the identification of how the risk’s sources themselves relate to the consequences of those risks, which is called the Bowtie model. Finally the threats that can be seen at this stage are assessed, through the Analytical Hierarchy Process. (Munier) The second step is planning the project’s development and includes the discovery of the tasks, their order, and the organization of the projects budget and schedule. There are many things included in this planning, starting with the Work Breakdown Structure and finding its individual components. The GANTT chart is next along with its critical path, these are where the project is almost fully laid out. PERT analysis is used to find the interconnectivity and find the project’s completion date. Finally an S-curve is generated to show how the projects budge is a function of the time spent on the project. (Munier) The third step is the threat identification for the project. All of the dangers that can affect the project are taken into account here by doing a Risk Breakdown Structure. The major risks are identified and evaluated by a Z-Matrix analysis and then good old fashion brainstorming is used to try to mitigate these problems and try to find ways to keep the methods of problem solving fresh. Individual experts can and should be brought in at this stage to analysis the risks to the best of their ability, sharing the load using the Delphi method. A Risk Register is set up of the risks and all the data available on them. It is suggested that experts again review this register and add as they can, public opinions and ideas can be brought in at this stage if useful, as this really allows for a wide variety of information that can prove invaluable. (Munier) The fourth step is the actual risk assessment and analysis; the probability of a threat actually occurring and how they can impact the project. By multiplying these values together one can get the risk value. At this stage statistical information is to be collected and experts brought in to evaluate the information. Interviews should then be conducted with those who would be effected by the project and the consequences then reevaluated. Then the uncertainty of the consequences are evaluated with Monte Carlo analysis and the capital budget is established for the projects duration. Then probabilistic tree analysis is conducted to find the local area and global risks involved and a graphic risk comparison is created to show the relation between the importance of the risks and the reliability of the risks. The risks and gains are then looked at in a risk matrix and since risks are usually very tough to truly evaluate for very high end projects Event Tree Analysis is used to further break it down. Using Fault Tree Analysis one estimates the risks and any correlating series from all available sources. Next the risks in what the final product will be are determined and how it could fail. The project’s network is finally set up and Pareto Principle is used to organize and analysis select costs items. (Munier) The fifth step is the execution and remediation procedures to take if the worst should happen. This includes the possibility of delays and costs that are not planned for and the ownership of risk is organized and negotiated. (Munier) The sixth step is sensitivity analysis and how certain specific variables can change the outcome of the project. This includes looking at financial indicators and delay indicators, and how much their variance will affect the project. Also the comparison of the GANTT chart and WBS to the real life cost and work of the project on a day to day basis is done here so as to find the risk of not meeting planned expectations. (Munier) The seventh step is updating, monitoring, and controlling the project over its lifetime and is the comparison of that which was predicted to that which is actually occurring for the education of all those involved. It makes use of Earned Value Analysis as the work is observed and logged and an honest assessment of third parties, such as vendors, suppliers, and contractors. General statistics are included here as well and they will be some of the most telling when comparing what happened to what was planned. (Munier) The eighth step is project closing and all the things needed to be done to prepare for the handover of the project to the owner. This is making sure all the contracts terms were met and that the owner themselves are satisfied with what has been done. At this stage final drawings are generated for the owner, which leads right into the final step, which is reporting. At this stage all technical reports are written and all documents needed for replication or organization are made and handed over. (Munier) At last all the steps are laid out and one must remember that this progression is not always linear. Projects will need constant feedback to grow and the many specific techniques mentioned are the ones recommended to use. (Munier)

Risk assessment is a vital part of any project and no matter how simple the project is a risk assessment should always be used to keep all involve safe. As technology constantly evolves many problems can be alleviated by following proper safety techniques. Skynet only took over the world because it was not kept in a box and properly evaluated and the Death star was only blown-up because they failed to cover the opening to a simple ventilation shaft. Risk assessments save lives, used them to the best of their ability.

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