

Space Research Project Management Can Benefit from Engineering Technology Selection Methods

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Overview

- Many methods have been developed to help select technology.
 - The simplest is to use a checklist of the important project selection criteria.
- Logical project selection methods are rarely used.
 - One reason is the methods are not proven.
- Decisions are usually made using “engineering judgment” and “gut feel.”
 - This can have very bad results.
- A sanity check using a check list can prevent serious errors.

Checklists

- Checklists are a simple way to review the important factors in technology selection.
 - Neglecting any one can be very harmful.
- The criteria include safety, availability, performance, cost.
 - Safety is measured by the probability of loss of crew, $\text{Pr}(\text{LOC})$.
 - Availability is measured by Technology Readiness Level (TRL).
 - Performance includes the required operations and other aspects such as microgravity sensitivity and contamination potential.
 - Performance includes the “-ilities,” operability, maintainability, and reliability,
 - Life Cycle Cost (LCC) includes all the costs of a mission - design, development, and test, launch and resupply, operations and maintenance.

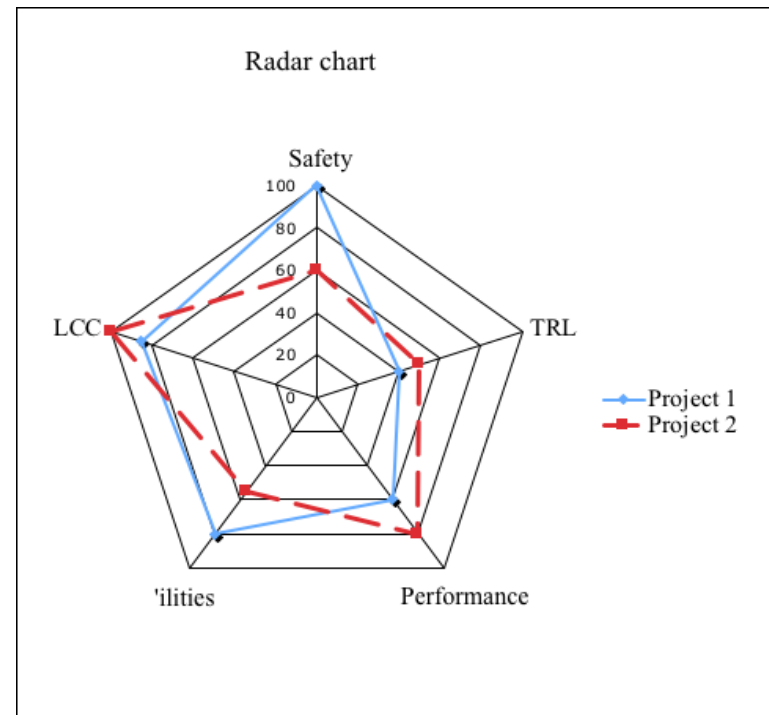
Criteria tables and radar charts

- The criteria can be estimated, weighted, scored, and adjusted so positive numbers mean better performance.

Criteria scores for Project 1 and Project 2.

categories	Project 1	Project 2	Project 1 - Project 2
Safety	100	60	40
TRL	40	50	-10
Performance	60	80	-20
'ilities	80	55	25
LCC	85	100	-15
Sum of scores	365	345	20

Radar chart comparing Project 1 and Project 2.



Project selection errors and advice

Project selection errors

1. Missing criteria
2. Dependent or correlated criteria
3. Ignored good project choices
4. Different criteria used for different projects
5. Wrong decision maker or stakeholders
6. Predetermined or biased decisions
7. Undocumented rationales for weighting, scoring, and selection

Project selection advice

1. Evaluate all the proposals
2. Use the same criteria
3. At the same time
4. Rank the proposals and have everyone understand the ranking
5. Select a balanced portfolio according to understood objectives

Formal project selection is little used

- Logical methods have poor acceptance, and questionable effectiveness when used.
 - There are no universally accepted, no proven good methods.
- Intuition is important in most management decisions.
 - Rationality is an afterthought at best.
 - A rational critique is often omitted.

Intuitive human decision biases

- Loss aversion is the fact that a loss is felt much more strongly than an equal gain.
 - Organizations turn down risky projects due to loss aversion.
- Myopia is ignoring the long term wider view.
 - Organizations pick projects one at a time rather than considering portfolios of projects.
- Portfolios of risky projects can be very beneficial.

Intuition can lead to good decisions

- Experience can produce a subject area expertise and a trained judgment that can produce highly effective intuitive decisions.
 - Managers often lead very successfully simply by following their gut.
- Most decisions seem to depend more on emerging feelings based on gut feel than on explicit conscious reasoning processes.

Problems with using intuition

- First, intuition has no conscious basis and so it cannot easily be explained.
 - After the fact justifications can seem weak, ad hoc, concocted.
- Second, intuition is specific to a particular field and is often far wrong when applied outside the area where it was acquired.
- Third, since a decision maker's intuitions seem obviously right and are strongly emotionally confirmed, it is difficult to use facts and logic to check intuition.
- Fourth, the real world is changing rapidly but intuition changes only slowly as new experience is gained.
 - A rapid real world change can invalidate engineering judgment acquired in the past.

Politics is how we resolve conflicts

- The project selection process is political.
 - Selecting projects is necessarily subjective and judgmental.
 - Organizational politics, different goals, and group loyalties influence the decision criteria.
 - Political power is used when goals clash.
 - People doubt the process is fair and honest.
- Conflicts over goals and funding cause organizational politics.
 - Some process is needed to reconcile these conflicts.

Project selection should seem fair

- Legitimate decision making requires:
 1. consistency (in procedures),
 2. bias suppression (no self-interest),
 3. accuracy (in information),
 4. correctability (criticism and revision),
 5. representativeness (of all concerned parties), and
 6. ethics (following basic moral standards).
- The use of reasonably rational and fair methods in project selection creates confidence and trust in the organization.
 - Perceived injustice can reduce team members' commitment and effort.

Why do rational project selection?

- Project selection should be rational, but it is not.
- The reason is that human intuition and “gut feel,” rather than reason, control project decisions.
- Nevertheless, we should do rational project analysis and selection.
 - The rational spirit is necessary for a scientific and technical organization.
 - Professional ethics requires an open, honest, and fair process.
 - Rational analysis can select good projects and eliminate bad ones.
 - A sanity check helps avoid egregious and embarrassing errors.

Conclusion

- Many engineering methods have been developed to select projects.
 - One of the simplest is to use a checklist of criteria.
 - Project selection methods are little used, partly because they have not been proven effective.
- The main reason that formal project selection is not used is that managers strongly prefer to rely on their own “gut feel.”
 - This often works well, but in unfamiliar technical situations, intuition and judgment can fail and lead to grievous mistakes.
- The approval of a project nearly always requires intuitive acceptance, but often omits checking its rationality.
 - It is better to always doubt intuition and rationally analyze projects before they are approved.