Holistically improving screening decisions under uncertainty in aircraft conceptual design and technology assessment

Insights on bottom-up uncertainty quantification and propagation and integrated socio-technical group decision making

Making good decisions is difficult, especially under uncertainty. People might be biased, act irrationally and work towards different or ambiguous goals. Nevertheless – certainly in aircraft conceptual design, where early decisions shape final outcomes to a large extent – the consequences of poor decisions are substantial: higher costs, large delays, or not meeting goals defined early on. **How can we improve?**

DEFINING DECISION QUALITY

Decision making is part of problem solving. More specifically, **decision making** was defined as *the process that starts with investigating and evaluating alternative solutions to some pre-set goal and ends right at the point where a decision is made and the decision makers commit to an action or approach*. The **decision**, then, is *the conclusion of a deliberation process*. The consequences of the decision are the **outcome**.

Even though it is often thought to be the case, the desirability of the outcome does not influence the quality of the decision in any way. Rather, **decision quality** is defined as *the extent to which a (group of) decision maker(s) at the decision point can convince **an ideal observer** that the decision will yield the decision goal, insofar possible*.
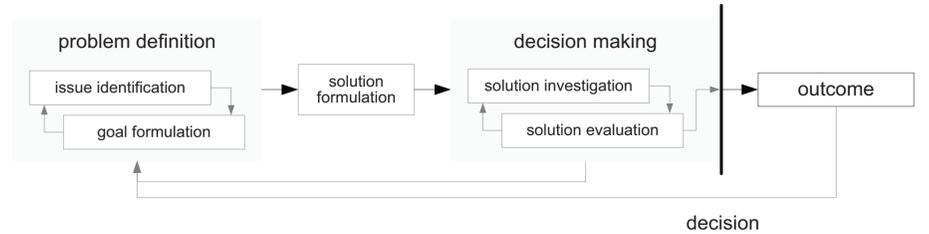
AN IDEAL OBSERVER

Inspired by the concept of an ideal gas, an ideal observer was introduced to assess decision quality. It is **transparent, independent and unaffected by the decision or its outcomes**. An ideal observer can be mental (based on social expectations, for instance) or physical (such as an inspectorate). The ideal observer bases its judgment on

objectivity
in case there is little uncertainty, and plenty of traceable, factual information

and

trust
in case there is much uncertainty, and one can do little more than observe the process

or a combination of both.

INFLUENCING DECISION QUALITY

A systematic literature review revealed many factors influencing decision quality, which were categorised in four – often interdependent – groups.

information processing
technical factors
information content
information exchange

procedures
contextual and supportive factors
time
ability to implement
implementation factors
commitment
clarity

composition
participation
conflict
team
leadership
socio-psychological factors
fit
cognitive reasoning
discussion

BALANCING TASK AND RELATIONSHIP

Using the theoretical basis established, decision quailty in an international, aerospace research and development public-private partnership was studied. Based on document analysis, semi-structured interviews and participant observation, it was found that the quality of decisions was negatively impacted mainly by the fact that *that goal uncertainty exists and is not sufficiently explicated, reduced or otherwise managed*.

Based on vigilent interaction theory and effective intercultural workgroup communication theory, which highlight that decision-making processes yield outcomes both in terms of task and relation, the TARE-model was developed. It connects attention paid to task and relationship goals to goal (what?) and goal-path (how?) uncertainty and group integration. This can help groups achieve balance between both aspects and improve decision quality.
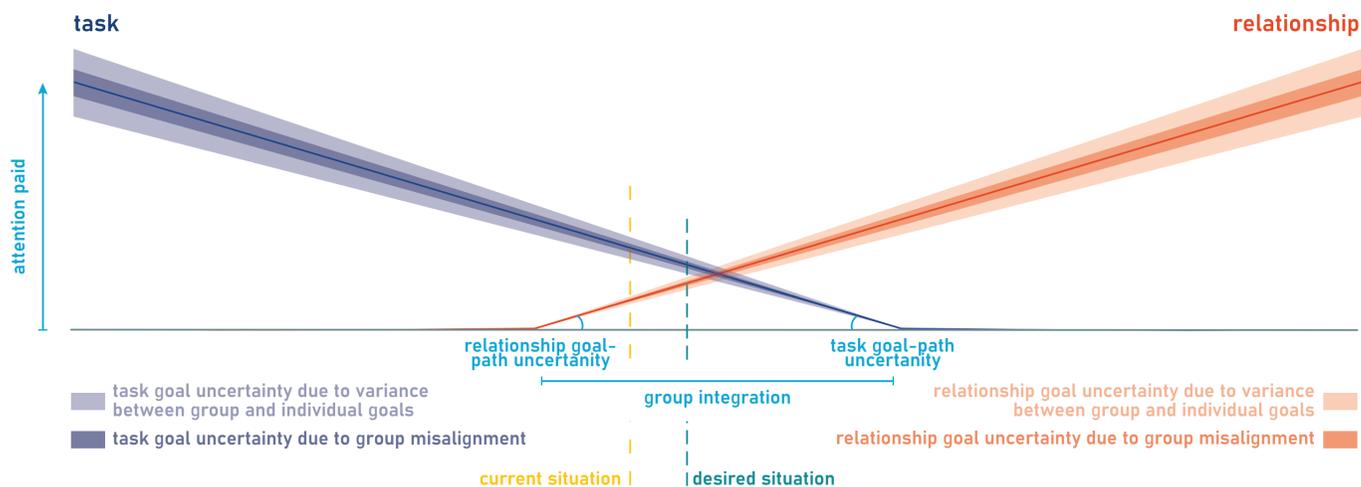
INTEGRATING TWO PERSPECTIVES

Reflecting on the work performed, similarities were found between items shown on the left (the **technical perspective**) and the right (the **socio-psychological perspective**).
It was concluded they can be distinguished, but cannot be separated. Uncertainty was hypothesized to mediate the interwovenness of the two perspectives.

Re-examining the interrelations between technical and socio-psychological factors influencing decision quality, an information processing unit is introduced, which workings are shaped by the socio-psychological factors. Information from external (fitting in the blue perspective) and internal (categorised as orange) sources comes in, is processed, and yields a decision.

Ultimately, we should not focus on the perspectives themselves, but on the decision making object from which these perspectives originate. If we only concern ourselves with the outcome (left), how can we ever determine what resulted in and determined that outcome (middle and right) – and subsequently improve?