# Varying types and levels of automation in the support of dynamic fault management: an analysis of performance costs and benefits

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**Abstract**

A model of types and levels of automation was used as a framework for examining the effects of automation support on dynamic fault management performance. The model distinguishes between different levels of automation (LOA) to support information acquisition, information analysis, decision and action selection, and action implementation functions. The experimental procedure involved an atmospheric process control task in which automated agents supported information analysis as well as decision selection and action implementation at specified LOA. In 20% of the trials, the agent's support was withdrawn, simulating a catastrophic failure that required operators to resume manual fault management. Results of a human performance analysis suggest that in multi-loop supervisory control systems the choice of a higher LOA may enable more efficient operator information sampling strategies relevant for the maintenance of situation awareness, which becomes crucial for minimising performance costs during automation failure.

**Introduction**

Parasuraman, Sheridan, & Wickens (2000) proposed a model of types and levels of automation (LOA) providing a structural framework to evaluate human performance implications for function allocation within a human-centred automation design. Similar to a LOA analysis proposed by Endsley & Kaber (1999), the model differentiates four types of functions for which an appropriate LOA has to be chosen by applying an iterative design process based on human performance criteria. Types of functions are (1) information acquisition, (2) information analysis, (3) decision and action selection, and (4) action implementation. LOA specifies the degree to which these functions are allocated to an automated system. In the context of fault management these four classes refer to four fault management subtasks: abnormal system state detection, fault identification/system state prognosis, decision-making on procedures for recovery, and recovery execution. Dynamic fault management emphasises the notion that in a

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