Summary of Findings

The introduction of high-level automated systems in the aircraft cockpit has provided several benefits, e.g., new capabilities, enhanced operational efficiency, and reduced crew workload. At the same time, conventional "static" automation has sometimes degraded human operator monitoring performance, increased workload, and reduced situation awareness (Parasuraman & Riley, 1997). Adaptive automation represents an alternative to static automation. In this approach, task allocation between human operators and computer systems is flexible and context-dependent rather than static. Adaptive automation, or adaptive task allocation, is thought to provide for regulation of operator workload and performance, while preserving the benefits of static automation.

In previous research we have reported beneficial effects of adaptive automation on the performance of both pilots and non-pilots of flight-related tasks. For adaptive systems to be viable, however, such benefits need to be examined jointly in the context of a single set of tasks. The studies carried out under this project evaluated a systematic method for combining different forms of adaptive automation. A model for effective combination of different forms of adaptive automation, based on matching adaptation to operator workload was proposed and tested. The model was evaluated in studies using IFR-rated pilots flying a general-aviation simulator. Performance, subjective, and physiological (heart rate variability, eye scan-paths) measures of workload were recorded. The studies compared workload-based adaptation to to non-adaptive control conditions and found evidence for systematic benefits of adaptive automation.

The research provides an empirical basis for evaluating the effectiveness of adaptive automation in the cockpit. The results contribute to the development of design principles and guidelines for the implementation of adaptive automation in the cockpit, particularly in general aviation, and in other human-machine systems.

Project goals were met or exceeded. The results of the research extended knowledge of automation-related performance decrements in pilots and demonstrated the positive effects of adaptive task allocation. In addition, several practical implications for cockpit automation design

were drawn from the research conducted. A total of 12 articles deriving from the project were published.

Publications 1998-2001

1998

[1]. SINGH, I. L., MOLLOY, R., MOULOUA, M. DEATON, J., & PARASURAMAN, R. (1998). Cognitive ergonomics of cockpit automation. In I.L. Singh & R. Parasuraman (Eds.) *Human Cognition: A Multidisciplinary Perspective.* (pp. 242-253). New Delhi: Sage. [1].

[2]. SINGH, I. L., HILBURN, B., & PARASURAMAN, R. (1998). Effect of feedback on adaptive automation. *Journal of the Indian Academy of Applied Psychology, 25*, 157-165.

1999

[3]. DULEY, J. A., & PARASURAMAN, R. (1999). Effect of training on monitoring of an automated system. In *Proceedings of the Annual Meeting of the Human Factors and Ergonomics Society,* Houston, TX.

[4]. MASALONIS, A. J., DULEY, J., & PARASURAMAN, R. (1999). Effects of manual and autopilot control on mental workload and vigilance during general aviation simulated flight. *Transportation Human Factors, 1,* 187-200.

[5]. METZGER, U., DULEY, J. A., & PARASURAMAN, R. (1999). Effect of training on monitoring of an automated system. In *Proceedings of the Annual Meeting of the Human Factors and Ergonomics Society,* Houston, TX

[6]. PARASURAMAN, R., &. HANCOCK, P. A. (1999). Designing automated warning systems: A signal detection and Bayesian analysis. In M. W. Scerbo & M. Mouloua (Eds.) *Automation Technology and Human Performance: Current Research and Trends.* (pp. 63-67). Mahwah, NJ: Erlbaum.

[7]. PARASURAMAN, R., MOULOUA, M., & HILBURN, B. (1999). Adaptive aiding and adaptive task allocation enhance human-machine interaction. In M. W. Scerbo & M. Mouloua (Eds.) *Automation Technology and Human Performance: Current Research and Trends.* (pp. 119-123). Mahwah, NJ: Erlbaum.

[8]. SINGH, I. L., HILBURN, B., & PARASURAMAN, R. (1999). Effect of non-adaptive training on adaptive automation. *Journal of Psychological Researches, 42,* 35-45.

2000

[9]. METZGER, U., DULEY, J. A., ABBAS, R., & PARASURAMAN, R. (2000). Effects of variable-priority training on automation-related complacency: Performance and eye movements. In *Proceedings of t the International Ergonomics Association/Human Factors and Ergonomics Society Congress,* San Diego, CA.

[10]. SINGH, I. L., SHARMA, H. O., & PARASURAMAN, R. (2000). Effects of training and automation reliability on monitoring performance in a flight simulation task. In *Proceedings of t the International Ergonomics Association/Human Factors and Ergonomics Society Congress,* San Diego, CA.

2001

[11]. DULEY, J. A., & PARASURAMAN, R. (2001). CDTI in a non-AGATE or non-integrated information display GA cockpit: Effects on visual attention. In *Proceedings of the International Symposium on Aviation Psychology,* Columbus, OH.

[12]. GALSTER, S., & PARASURAMAN, R. (2001). Evaluation of countermeasures for performance decrements due to automated-related complacency in IFR-rated General Aviation pilots. In *Proceedings of the International Symposium on Aviation Psychology,* Columbus, OH.