From Chapter 6 in: Seamster, T. L., Redding, R. E., & Kaempf, G. L. (1997). *Applied Cognitive Task Analysis in Aviation*. Aldershot, UK: Ashgate Publishing Limited.

6 Determining automated skills

Analysis of aviation skills involves identifying the cognitive and psychomotor skills required for particular tasks or groups of subtasks. Traditional task analysis segments a job into behaviorally distinct tasks and their component activities, and then determines the skills needed for each. In Cognitive Task Analysis (CTA), skills are analyzed in substantially more detail based on their cognitive components. This chapter describes how to analyze a specific type of skill, the automated skill. It also presents some background information to help analysts distinguish between knowledge and skills, and to distinguish further between the different types of skills to be analyzed.

The distinction between knowledge and skills (see Chapter 5) has not been consistent in the literature, with some researchers approaching issues with a knowledge perspective and others with a skills perspective. While most skills, especially procedural and representational skills, possess a knowledge component that could be analyzed and trained as knowledge, such an approach is not practical from an operational perspective. This book treats as skills both the knowledge and skill components of skills, because workers cannot perform skills without the knowledge required to do so.

This chapter first explains the need for different skill types, and then presents automated skills. An automated skill is a basic element of aviation performance that demonstrates rapid execution and economy of effort. Automated skills require substantial practice to develop, and should be trained so the consistent condition activating the skill can be easily recognized. Several CTA methods can be used to analyze automated skills. Automated skills are not to be confused with system automation, the increasing use of computers in aviation environments. Automated skills are not directly connected with the issues surrounding system automation.

6.1 Types of aviation skills

Skills can be decomposed into the elements essential to skilled performance in aviation. Skilled performance includes some aspects of automaticity, representational skills, problem solving, decision making, and strategies. Each of these elements requires different analysis methods and different training approaches. For instance, the methods for training automaticity, with its requirement for a large number of exposures to consistent stimuli, are very

different from the training required to help an operator develop a representational skill or a strategy. This section introduces the key components of skilled performance so that automated skills may be understood in the context of the full range of aviation skills.

Most schemes for categorizing skills are hierarchical, starting with the simpler forms of skill and ending with the most complex. This continuum is based on a progression, from the primarily psychomotor skills to the predominantly cognitive skills. For example:

- Motor skills
- Perceptual skills
- Simple cognitive skills (e.g., procedural skills)
- Complex cognitive skills (e.g., decision making skills).

This section concentrates on cognitive skills, specifying several types of simple and complex cognitive skills significant to the aviation community. First, skills are defined to provide the aviation community with operational criteria for their identification. Next, evidence is briefly provided supporting the existence of different types of cognitive skills. Finally, five types of cognitive skills are identified and defined from an operational perspective.

6.1.1 Rationale for skill types

Proctor and Dutta (1995) provide a good starting point for an operational definition of skill. “Skill is a goal-directed, well-organized behavior that is acquired through practice and performed with economy of effort” (p. 18). Since skills are acquired through practice, they can be trained. In addition, skills are evaluated through performance characterized by an economy of effort. From an operational perspective, skills are linked with one or more tasks specific to a particular aviation job. While skills often include a knowledge component, that knowledge is tightly integrated with, and thus analyzed as part of, the skill.

Gagne, Briggs, and Wager (1992) provide a rationale for identifying different skill types based on cognitive skills as the building blocks for instruction. Cognitive skills form the basis for training because they can be trained in relatively short periods of time, simpler cognitive skills form the basis for more advanced skills, and cognitive skill performance can be readily observed and assessed. Their continuum of skill complexity is important from a training perspective, because the complex skills require sets of less complex skills in order to be efficiently trained. Low complexity skills include discriminations, mid-level skills include rules and defined concepts, and problem solving is at the highest end of the cognitive skill continuum.

From Chapter 6 in: Seamster, T. L., Redding, R. E., & Kaempf, G. L. (1997). *Applied Cognitive Task Analysis in Aviation*. Aldershot, UK: Ashgate Publishing Limited.

Kyllonen and Shute (1989) categorize skills based on how they should be tested. They propose six categories of skills, with each category calling for a different type of test. To test procedural skills, for example, an individual might be asked to specify the conditions of the procedure given a consequent or result, or specify the consequent given a set of conditions. Testing for representational skills would be very different, and might involve examining performance on a complex simulation where key elements of the representation were either blocked or not available.

6.1.2 Skills and cognition

A "cognitive skill" is a skill that is predominantly cognitive in nature. All skills have a perceptual, motor, and cognitive component (Proctor and Dutta, 1995). Cognitive skills can be analyzed using noncognitive methods, but most behavioral methods produce very limited results in the analysis of cognitive skills. The recognition that some skills have a predominant cognitive component, and the use of cognitive methods to analyze these skills, allows the aviation community to conduct meaningful CTAs.

Bartlett (1958) was one of the first in modern psychology to argue that thinking might be analyzed as a skill. Based on progress made in the analysis of motor skills, Bartlett suggested that similar progress could be achieved if thinking were analyzed as a complex, high level skill. Bartlett's work marks the early recognition of the cognitive component of skills, but cognitive skills are not always analyzed or trained from a cognitive approach (Royer, Cisero, and Carlo, 1993). For example, traditional behavioral approaches to training view cognitive skills as packets that can be acquired and assessed in a discrete manner. The cognitive approach is developmental, meaning that it looks at the entire process of skill acquisition, from novice to expert. The cognitive approach concentrates on analysis of expertise in order to identify the different skill types that make up that expert performance.

By recognizing the cognitive dimension of skills in conjunction with using cognitive analysis methods, the aviation community is provided with a powerful set of tools for training and system design. Proctor and Dutta (1995) make the case that the less one knows about the precise nature of skills, the more one needs higher fidelity simulation. This provides an economic argument for specifying the primary categories of cognitive skills so the aviation community can link the training of specific skill types to the appropriate level of fidelity, which is not always the highest and most expensive level.

From Chapter 6 in: Seamster, T. L., Redding, R. E., & Kaempf, G. L. (1997). *Applied Cognitive Task Analysis in Aviation*. Aldershot, UK: Ashgate Publishing Limited.

6.1.3 Skills and aviation expertise

In aviation, skills are generally divided into motor skills and cognitive skills (FAA, 1991). Emphasis on motor skills has been a strong tradition, especially in pilot training. But in the last 10 to 15 years with the advent of programs such as Crew Resource Management (CRM), the concern for cognitive skills has steadily increased. Under the Advanced Qualification Program (AQP), cognitive skills are to be assessed along with the motor skills. This increased interest has spurred a need for the analysis and training of cognitive skills.

Skills may be divided into a number of categories, with researchers likely to generate more categories than operationally practical. Table 6.1 first lists the two psychomotor skills followed by the five cognitive skill types requiring different CTA methods and different training techniques.

Table 6.1
Categories of aviation skills

SKILL CATEGORY	DEFINITION
MOTOR	Physical actions to control the work environment.
PERCEPTUAL	Sensory acquisition of information from the environment to support performance.
AUTOMATED	Physical and cognitive activities performed rapidly and with a minimum of processing in response to consistent stimuli or conditions.
PROCEDURAL	Constrained sequences of physical and cognitive activities performed in predictable situations.
REPRESENTATIONAL	Cognitive simulation of a system or its components to improve performance on that system.
DECISION MAKING	Cognitive activities involved in choosing the better of several alternatives.
STRATEGIES	Self-monitoring and integration of other skill types to enhance performance.