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CAPSS: The Canadian Automated Pilot Selection System

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Summary: The Canadian Automated Pilot Selection System (CAPSS) is a computerized simulator of a single engine light aircraft used in the selection of pilots for the Canadian Forces. This paper describes the characteristics of the CAPSS simulator and the types of data it collects. The development of the CAPSS equation that predicts the probability of success in flying training is discussed and the results of the initial validation and cross-validation are presented. Demographic characteristics of applicants assessed by CAPSS since its introduction in February, 1997, are presented. Finally, some of the strengths and weaknesses of CAPSS are discussed.

The assessment of officer applicants for the Canadian Forces follows the same general procedure for all officer entry programs. An additional step in the assessment of pilot applicants is testing with the Canadian Automated Pilot Selection System (CAPSS). CAPSS is a computerized moving-base simulator of a single engine light aircraft. The CAPSS simulator presents the candidates with all the information necessary to perform flight manouevres using instrument flying procedures. A computer system runs the simulator, presents all instructions and feedback, and collects the data. The entire syllabus consists of five one-hour sessions; the first four sessions are currently used for assessing pilot applicants. The sessions proceed from basic instructions and flying a simple straight and level manoeuvre to flying a complex traffic pattern. The CAPPS computer system stores each candidate's data and produces summary statistics of each candidate's performance. An outline of the complete syllabus is presented in Table 1.

Table 1. CAPSS Syllabus

Session	Tasks
1	Basic flight instruments and controls; straight and level flight; straight climb; straight descent
2	Review; take-off, climb-out and level off; level turns; standard rate turns
3	Review; climbing and descending turns
4	Review; rectangular course; airport traffic pattern
5	Review; airport traffic pattern with side tasks; landing

Note: Session 5 is not used in actual pilot selection

Ten flight parameters are monitored and recorded twice per second while each candidate is "flying", although not all parameters are relevant to every flight task. The parameters are heading, turn rate, bank angle, side slip, altitude, vertical speed, engine speed, airspeed, and "x" and "y" Cartesian co-ordinates indicating current position. This results in 1200 data points per candidate for every minute of simulator operation.

Dr. Barry Spinner of the University of New Brunswick developed the plan for taking the mass of data produced by CAPSS and transforming it into a single equation used to predict the probability of success at flying training (Spinner, 1988a, 1988b, 1989, 1990). The overall plan of analysis was to divide the data according to the basic manoeuvre being performed. Within each manoeuvre, the data were broken into a number of discrete, statistically manageable data segments. Within each of theses data segments, Summary Measures (SMs) were formed to characterize candidate operation of the simulator over a brief period of time. The SMs within a data segment were reduced using statistical methods, then the segments were combined into subgroups and the SMs were again reduced. This cycle of reduction and combination was repeated within each manoeuvre to produce a combination of SMs that optimally predicted performance in flying training.

A hierarchy of CAPSS flight tasks was designed to organize the data and to specify the order in which these subsets were combined. Flight tasks were categorized according to the type of manoeuver being flown, the context within which the flight task was performed (simple practice or part of a more complex flight task), which repetition of the task was being performed, the flight parameter being monitored, and whether the data were extracted from the beginning or end of the flight task (see Figure 1).

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Eight basic flight manoeuvres represent the highest level of the hierarchy: straight and level flight, straight climb, straight descent, level turn, climbing turn, descending turn, take-off, and landing. A ninth manoeuvre category was formed for data segments taking place just before and after the occurrence of a side task in session 5.

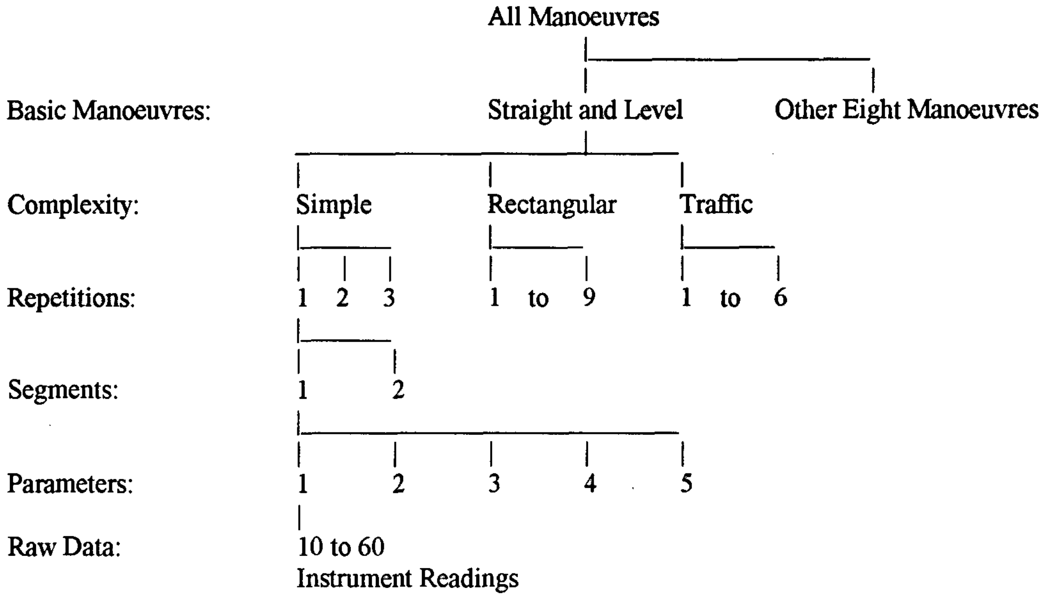

Figure 1. Hierarchical Structure for Straight and Level Flight, from Spinner, 1990

Summary Measures

The following description of the development and intended meaning of the SMs is taken from Spinner, 1989 and 1990.

"The formation of SMs had the goal of transforming the raw data into meaningful variables that represent the candidates' operation of the simulator over a specified period of time. The raw data that are provided by CAPSS consist of instrument readings (e.g., compass headings) taken twice per second. In this form, the data represent the state of the simulator, but do not indicate the candidate's proficiency in operating it. It is only when these readings are transformed into SMs that meaningful information about the candidate's ability may be obtained. It is these SMs that were used as predictors in analyzing the candidates' performance in flying training (Spinner, 1990, pp. 6-7)."

"Many of these SMs rely upon reference to the command level (CL), which is the target value for the parameter (e.g., the required heading or altitude). Other SMs refer to warnings which occur as the candidate deviates more and more form the CL: anticipatory warnings (first level), out-of-tolerance warnings (second level), and crash preventions which cause the simulator to freeze and reset (Spinner, 1989, p. 12)."

"The SMs were devised specifically for this project based upon previous empirical literature, the expert opinions of CF flight instructors and flight crew, and the author's insights gained form operation of CAPSS and flying experience. The SMs were designed to assess:

a. accuracy in keeping flight instruments on target;
b. variability in performance;
c. speed in response to errors and warnings;
d. smoothness of operation and avoidance of overcorrections and abrupt movements;
e. coordination of the flight controls, and
f. number of instances, and amount of time spent flying towards or away from the command level... (Spinner, 1990, p. 7)"

The main study which lead to the present CAPSS equation was the prediction of candidate flying training performance in Primary Flight Training (PFT) and in Basic Flight Training (BFT) or Rotary Wing Training (RWT; Spinner, 1990). Spinner used the flying training results of a sample of 309 male anglophone pilot candidates who had already been selected for pilot training by the aircrew selection tests then in place. For this sample, 62.1% passed PFT, and of those, 76.6% passed BFT or RWT. The criterion used in the study was success or failure in flying training. Each candidate was assigned to one of four groups:

a. candidates who failed PFT;
b. candidate who passed PFT and failed BFT;
c. candidates who passed both PFT and BFT, and;
d. candidates who passed both PFT and RWT (none of the candidates in the sample failed RWT).

Equations predicting flying training outcome were developed for each of the five CAPSS sessions through discriminant analysis using a four group criterion (fail PFT, fail BFT, pass BFT, pass RWT). Each session's equations were based on three discriminant functions. The best discrimination was between those who failed PFT and those who passed PFT, and most of this information was derived from Hour 1. Hours 2 through 5 added relatively more discrimination between those who failed BFT and those who passed advanced flying training (BFT or RWT).

These equations were used to generate each candidate's predicted probability of passing flying training. The classification results for each equation were then computed. Using Hour 5 results showed CAPSS to have an overall correct prediction rate of 81.9%. The percentage of candidates selected by CAPSS that actually passed at PFT and BFT/RWT were 89.9% and 83.9% respectively. The loss rate (the percentage of candidates who passed flying training that were rejected by CAPSS) was 8.2%. This result was compared to the system that was actually used to select the candidates: a pass rate of 62.1% at PFT and 76.6% at BFT. However, the author notes that these results are inflated due to the use of stepwise procedures in developing the equation and applying them to the sample that generated them. A final analysis was to examine the effect of basing selection decisions on fewer than five sessions. The classification results indicate that gains in prediction accuracy were made until the fourth session, and that the fifth session added little to prediction with this sample. In practice, only four sessions are used in pilot selection, and the fifth session is not used.

Spinner (1996) performed a cross-validation of CAPSS using a sample of 110 male anglophone pilot candidates. The best discrimination between those who passed flying training and those who failed occurred with Hour 4 results. The classification decisions compared to actual results are reported in Table 2. The author notes that the CAPSS pass predictions are still higher than the unusually low failure rate for this sample in comparison to the historical rate.

Table 2. CAPSS predictive accuracy

	Pass Rate[1]	Loss Rate[2]	Overall Correct Predictions[3]
Hour 1	84.2% (64/76)	27.3% (24/88)	67.3% (74/110)
Hour 2	88.7% (63/71)	28.4% (25/88)	70.0% (77/110)
Hour 3	87.5% (63/72)	28.4% (25/88)	69.1% (76/110)
Hour 4	89.2% (66/74)	25.0% (22/88)	72.7% (80/110)
Hour 5	85.5% (65/76)	26.1% (23/88)	69.1% (76/110)
Previous System: Current Sample	80.0% (88/110)	unknown	unknown
Previous System: Historical Rate	55%	57%	unknown

Notes:

1. The pass rate is the number of candidates who were correctly predicted to pass flying training, relative to the total number who were predicted to pass (i.e. of those predicted to pass, the number who actually did pass).

2. The loss rate is the number of candidates who actually passed flying training but who were predicted to fail.

3. The overall percent correct is the number of candidates correctly predicted to either pass or fail, relative to the total number of candidates.

Table 3. CAPSS scores and gender – all candidates

Female				Male			
Session	Mean	SD	N	Session	Mean	SD	N
Hour 1	0.543	0.219	69	Hour 1	0.649	0.228	524
Hour 2	0.513	0.271	63	Hour 2	0.612	0.250	492
Hour 3	0.466	0.241	20	Hour 3	0.604	0.287	175
Hour 4	0.494	0.348	20	Hour 4	0.527	0.308	175

Pelchat (1999) reported the demographic characteristics of a sample of 756 candidates assessed using CAPSS since its introduction as the pilot selection in February, 1997. During the implementation of CAPSS, candidates were only tested to Hour 2; in the sample reported by Pelchat, only 207 candidates completed all four sessions. No significant differences were found between the performance of Anlgophone and Francophone candidates, however, gender differences in performance were apparent. Table 3 reports the mean scores obtained by males and females for each of the sessions. CAPSS scores are reported as a probability of passing flying training; the cutoff is a score of 0.7 in Hour 4. While males performed better overall, male applicants were significantly more likely to have previous flying experience (PFE) than female candidates. Only 24% of the females had PFE, compared with 42% of the males, while 32% of the males had over 50 hours and almost 20% had over 100 hours, compared to nine and three percent, respectively, for the females. The results of males and females with no PFE (Table 4) are similar. As of 1 December, 1998, there were only 29 candidates who had attempted PFT and just five who had attempted BFT. These candidates were processed with two CAPSS sessions, using a CAPSS cut off of 0.5. For PFT, 27 candidates passed, one failed flying, and one was recoursed, for an overall 93% success rate.

Table 4. CAPSS scores and gender – no PFE

Female				Male			
Session	Mean	SD	N	Session	Mean	SD	N
Hour 1	0.540	0.207	44	Hour 1	0.547	0.232	233
Hour 2	0.494	0.279	38	Hour 2	0.494	0.246	222
Hour 3			7	Hour 3	0.441	0.242	57
Hour 4			7	Hour 4	0.385	0.258	57

Strengths and Weaknesses

The main strength of CAPSS is that it is a work sample of the complex skills needed to fly an aircraft. In selecting pilots, a range of important skills can be identified and measured by a variety of tests; the advantage of CAPSS is that it measures these skills simultaneously, just as the skills would be used in actual flying.

The main weakness of CAPSS is that it is not an easy system to modify. The CAPSS predictive equation was derived based on a sample of pilot candidates following a specific training programme, using specific aircraft. The effects of changing the training or the introduction of new training aircraft cannot be readily determined. Insofar as CAPSS measures the "right stuff" required to become a pilot, it should be relatively immune to these changes. In the CF, validation of CAPSS, or any pilot selection system, is difficult because of the small number of pilots that are trained. This effect is doubled for CAPSS because it uses performance results to derive the equations. With other systems, it may be possible to simply tweak cutoff scores within a battery of tests; the development of CAPSS equations is a statistically complex procedure.

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