Supplementary Material

Assessing and visualizing pilot performance in traffic patterns:

A composite score approach

Methods

Flight simulator instructions

The instructions were given to the pilots as follows: "*You will need to complete four different flight scenarios: two VFR and two IFR. For each scenario, you will start at a predetermined altitude and speed (140 knots and 2000 feet for VFR, 160 knots and 4000 feet for IFR). You will be asked to maintain these flight parameters during the traffic pattern. To maintain level flight (140 knots at 2000 feet), you will need 67% N1. After the start, once you are lined up with the runway (14L or 32L), you can start the right-hand traffic pattern. You must respect the time indicated for each phase, that is one minute for crosswind leg, three minutes for downwind leg, and one minute for base leg. Start the timer at the beginning of each new phase (after the turn). Once in the approach phase, you will need to land on the corresponding runway. N1 should be around 60% during the approach to maintain 140 knots with a vertical speed of -700 ft/min, which is recommended for this aircraft. In VFR conditions, you will need to maintain 140 knots and land according to outside visual information such as the PAPI*[1]*. In IFR conditions, you will need to devote 80% of your gaze to the instruments, mainly the ILS, and 20% to the outside world for occasional checks*."

[1] the Precision Approach Path Indicator is a system of lights providing visual aid during the approach

Scenarios charts

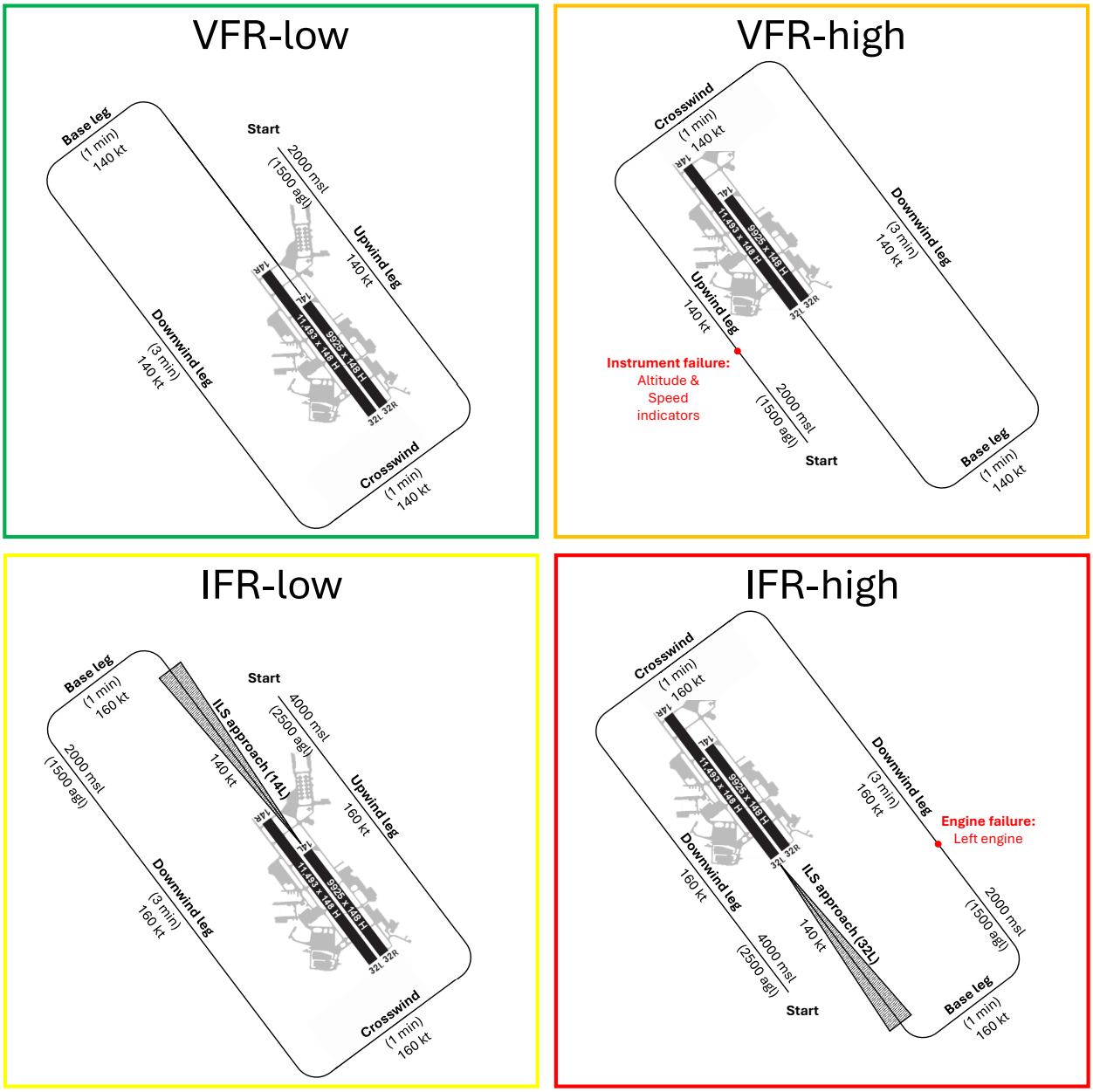


Figure S1. Illustration of the traffic pattern for all scenarios. *msl: mean sea level; agl: above ground level; kt: knots*

Preprocessing of the composite score

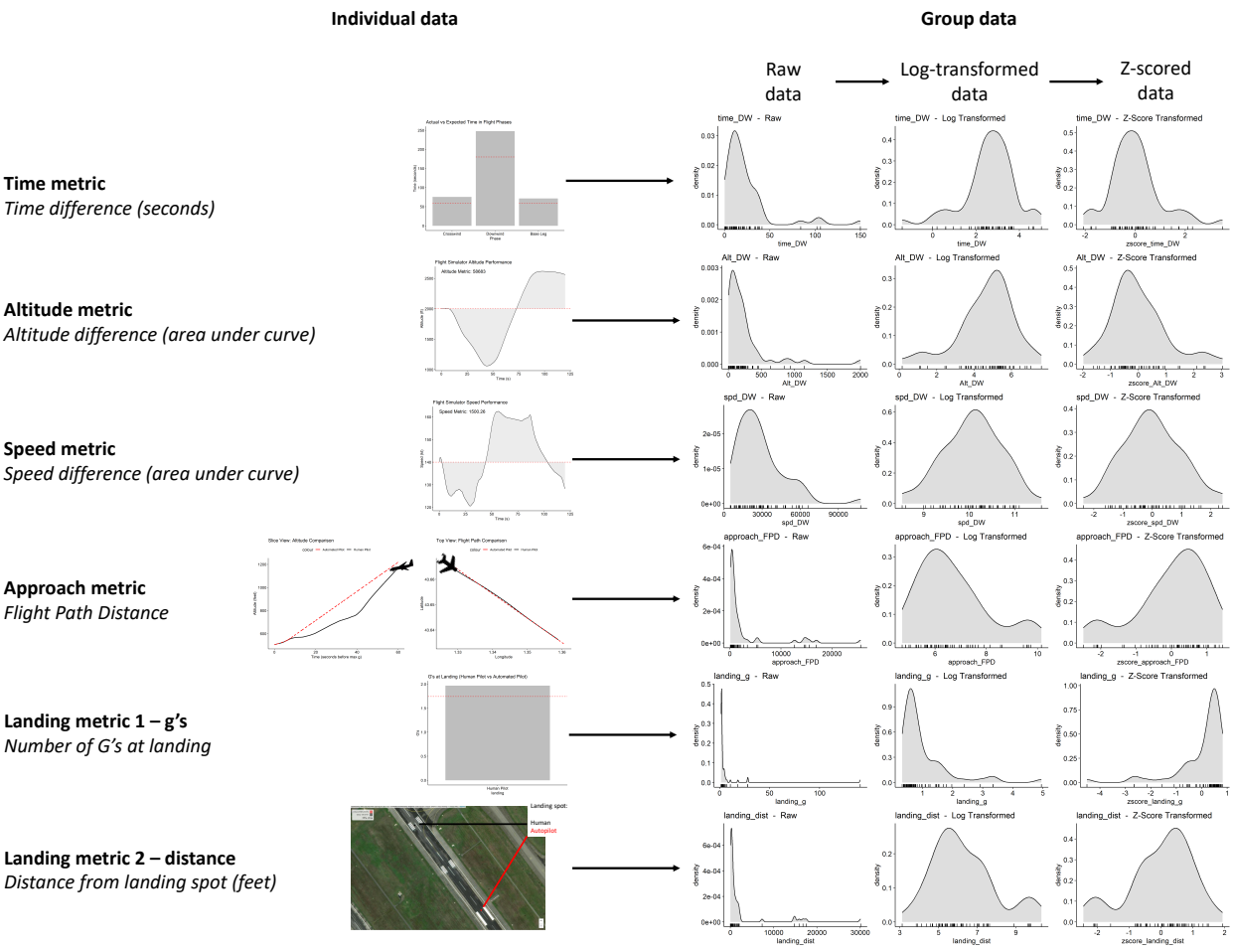


Figure S2. Illustration of the preprocessing pipeline to derive comparable sub-scores from various metrics, each of which operates on a distinct scale (*e.g.*, time difference, distance in meter, differences in g's at touchdown, etc.), typically following a Poisson distribution in the sample. The preprocessing consists of applying a logarithmic transformation to obtain a normal distribution. Then, each metric undergoes a z-scoring process, allowing to average them.

Results

Composite score sensitivity

Considering a typical threshold of 1 for Skewness, a Kurtosis threshold of 2 and a p-value of 0.05, the composite scores from all scenarios seem to follow a normal distribution (Table **??**). The only exception is the skewness of the IFR-high composite score, which has a slight negative skew (see Figure **??**). This is explained by the low score obtained by some participants due to crashes (which only happened during this scenario).

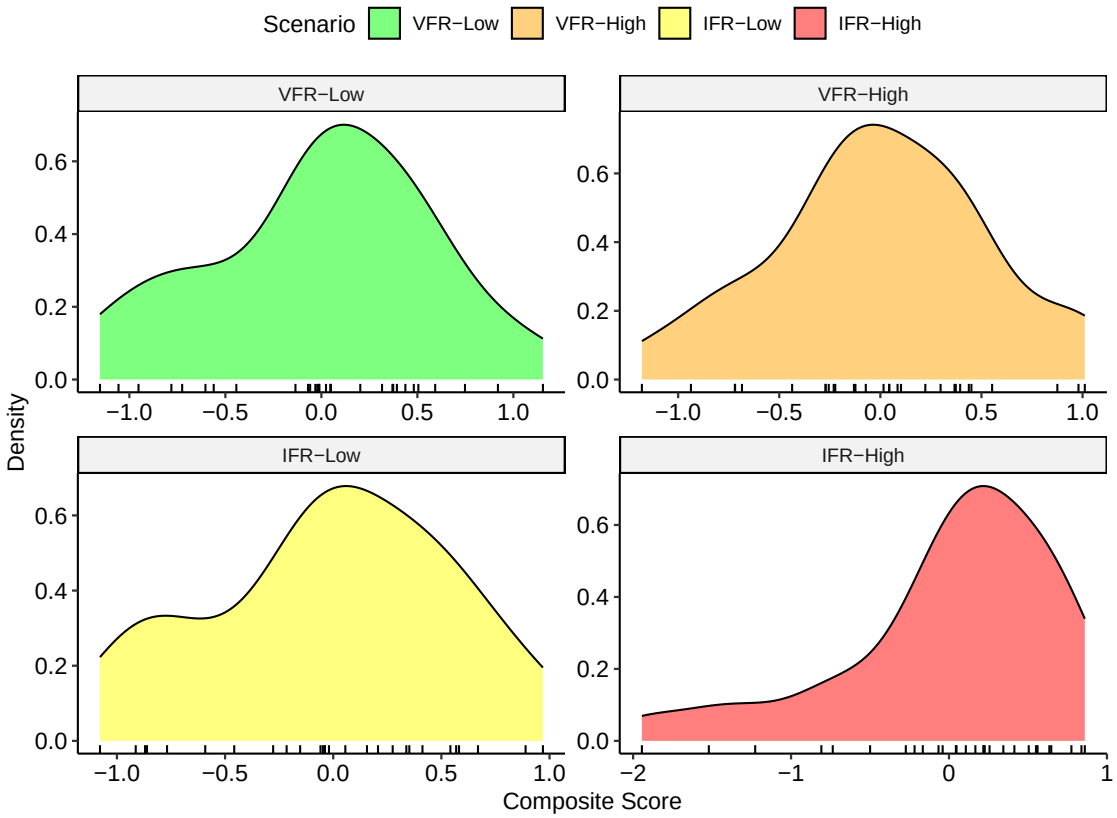


Figure S3. Density of the composite score for each scenario.

Flight hours, workload and composite score

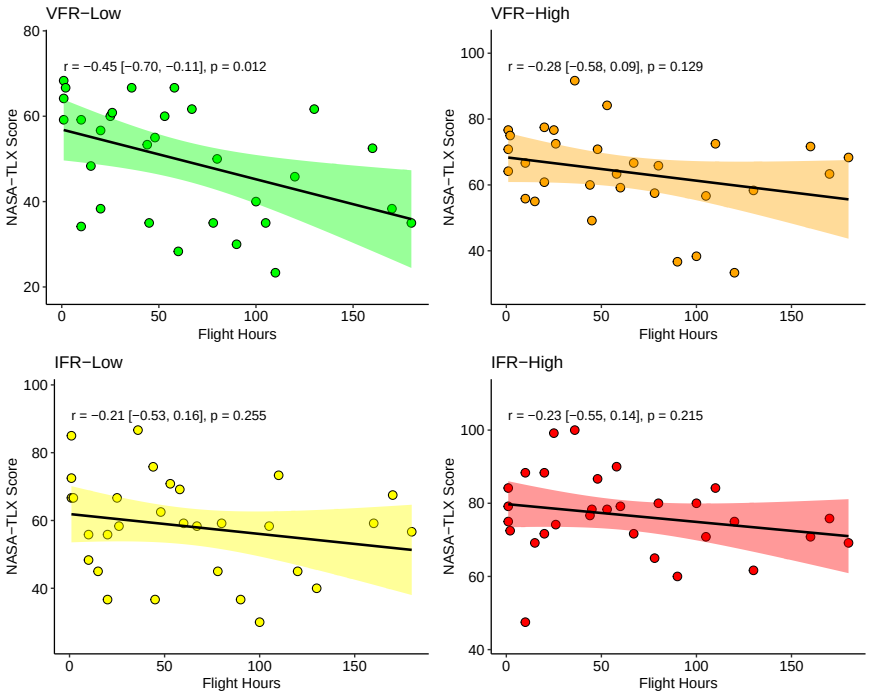


Figure S4. Correlations between Flight Hours and NASA-TLX Scores

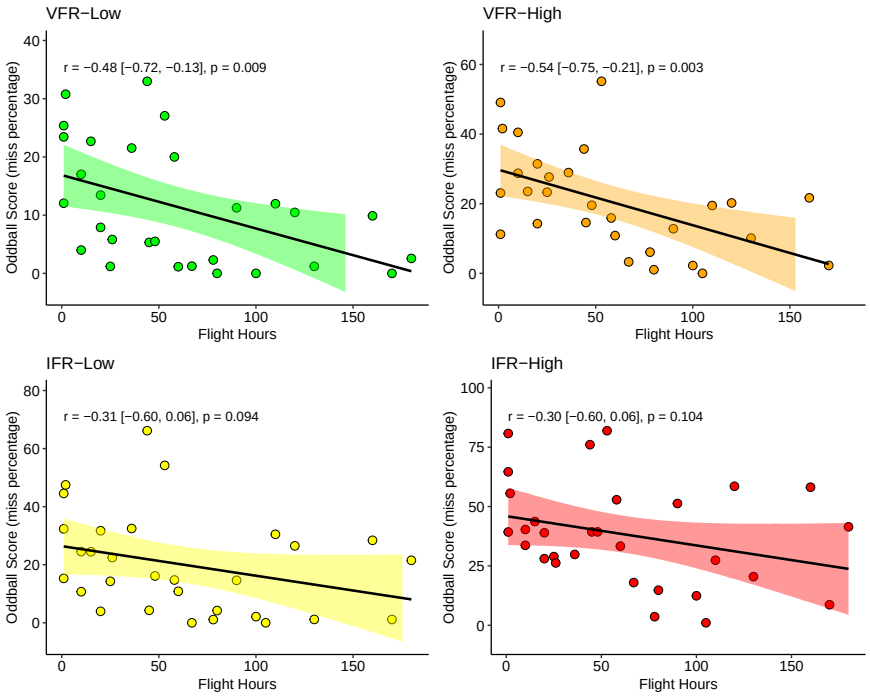


Figure S5. Correlations between Flight Hours and Odball Scores

Table S1. Competency-based task matrix by flight phase and scenario.

Flight Phase	General Task	VFR	IFR
Preparation	Review of flight parameters and set-up (altitude, speed, route)	Target speed: 140 kt Target altitude: 2000 ft	Target speed: 160 kt Target altitude: 4000 ft
Upwind Leg	Maintain altitude and speed Visual identification of the runway Perform a right turn at end of runway	*VFR-high:* ***Identify failure****: erroneous speed/altitude indicators* *VFR-high: Maintain level flight with 67% N1*	–
Crosswind Leg	Maintain altitude and speed Start and monitor the timer Perform right turn after 1 minute	*VFR-high: Maintain level flight with 67% N1*	–
Downwind Leg	Maintain altitude and speed Start and monitor the timer Perform right turn after 3 minutes	*VFR-high: Maintain level flight with 67% N1*	Descend to 2000 ft *IFR-high:* ***Identify failure****: left engine loss* *IFR-high: Compensate for asymmetric thrust*
Base Leg	Maintain altitude and speed Start and monitor the timer Perform right turn after 1 minute	*VFR-high: Maintain level flight with 67% N1*	*IFR-high: Compensate for asymmetric thrust*
Approach	Maintain speed Visual identification of the runway	Perform a visual approach *VFR-high: Reduce N1 to 60%*	Perform an ILS approach Reduce speed to 140 kt Focus 80% of gaze on instruments *IFR-high: Compensate for asymmetric thrust*
Landing	Perform a safe landing with proper runway alignment and flare	–	–

kt = knots; ft = feet; N1 = engine fan speed (percentage of maximum RPM)

Table S2. Sensitivity of the composite score per scenario. The normality test performed was the Lilliefors.

Scenario	Skewness	Kurtosis	Normality (p-value)
VFR-low	-0.25	-0.66	0.07
VFR-high	-0.11	-0.46	0.50
IFR-low	-0.23	-0.98	0.50
IFR-high	-1.12	0.66	0.08

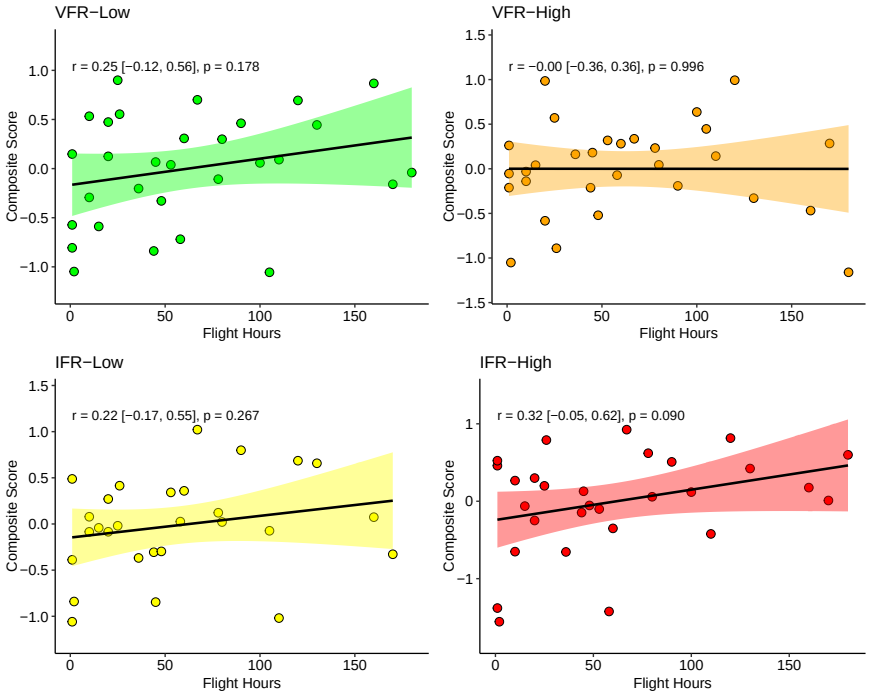


Figure S6. Correlations between Flight Hours and Composite Scores