The Safety of Efficiency:
The Link between Operational Performance and Operational Errors in the National Airspace System (NAS)

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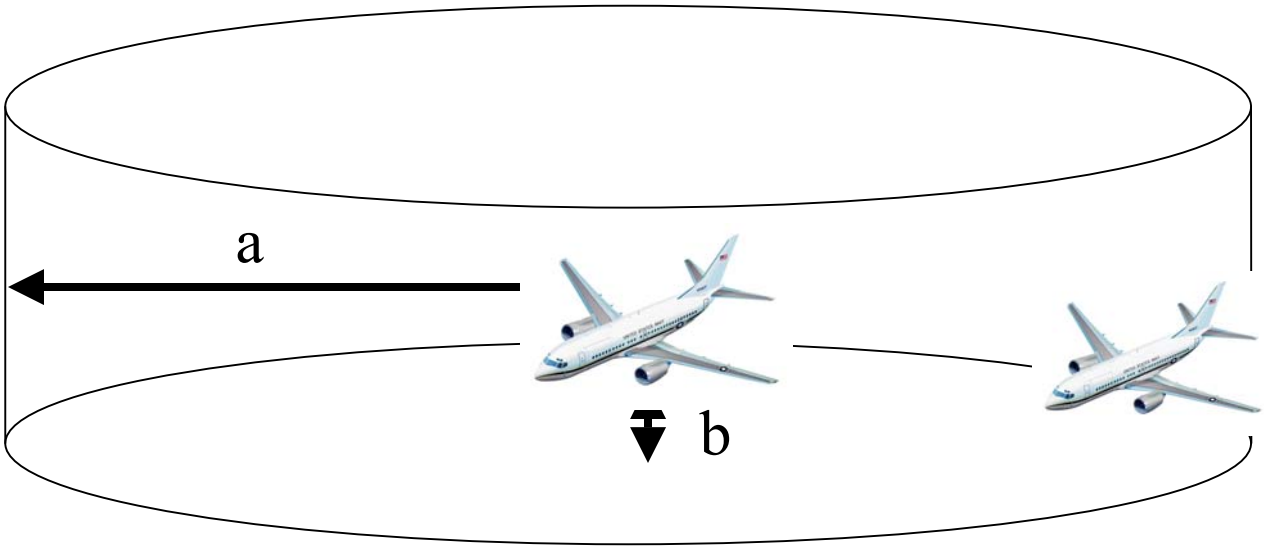
Introduction

NAS Safety Performance Measure: Operational Error (OE)



a: required horizontal separation

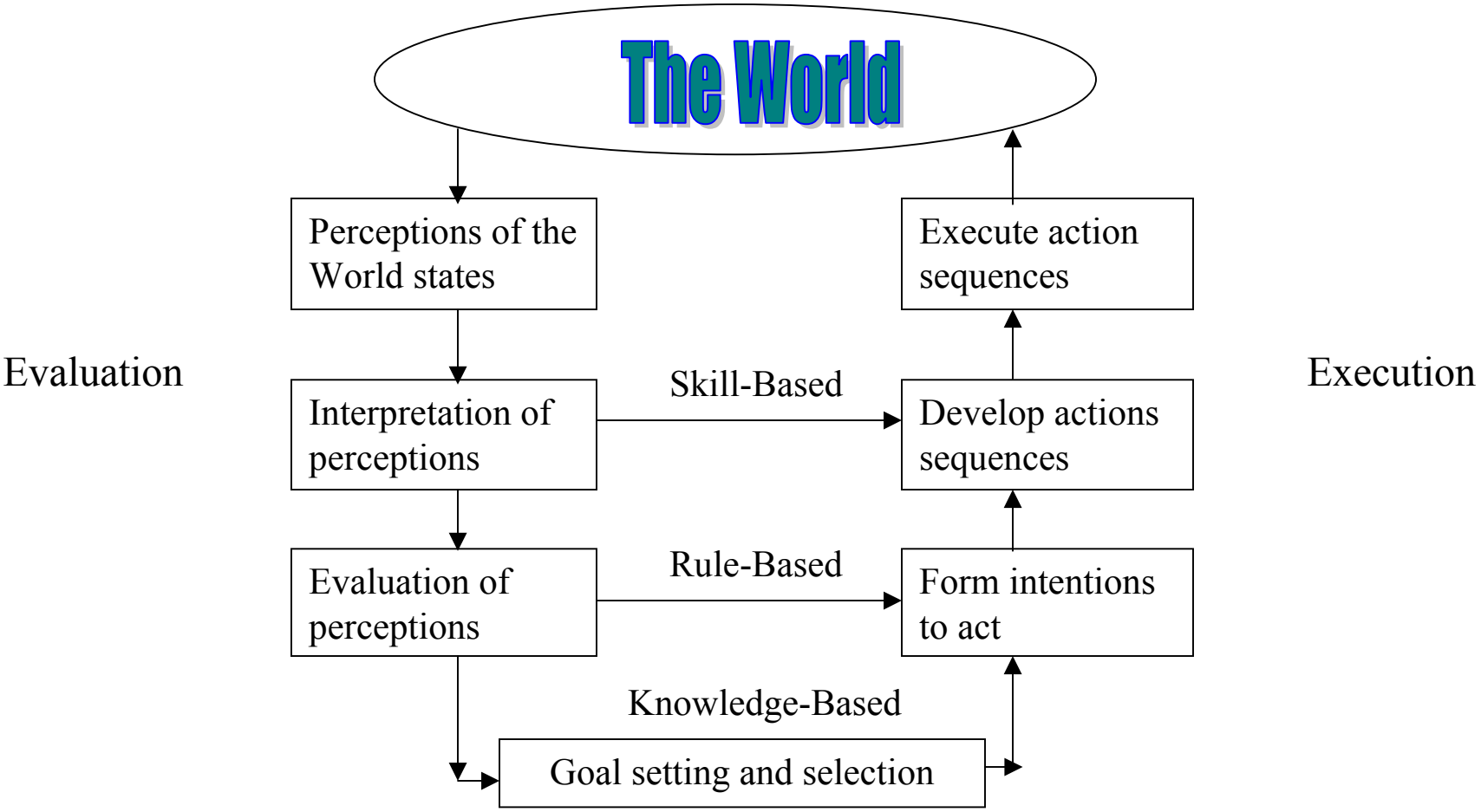
b: required vertical separation

NAS Efficiency Performance Measure

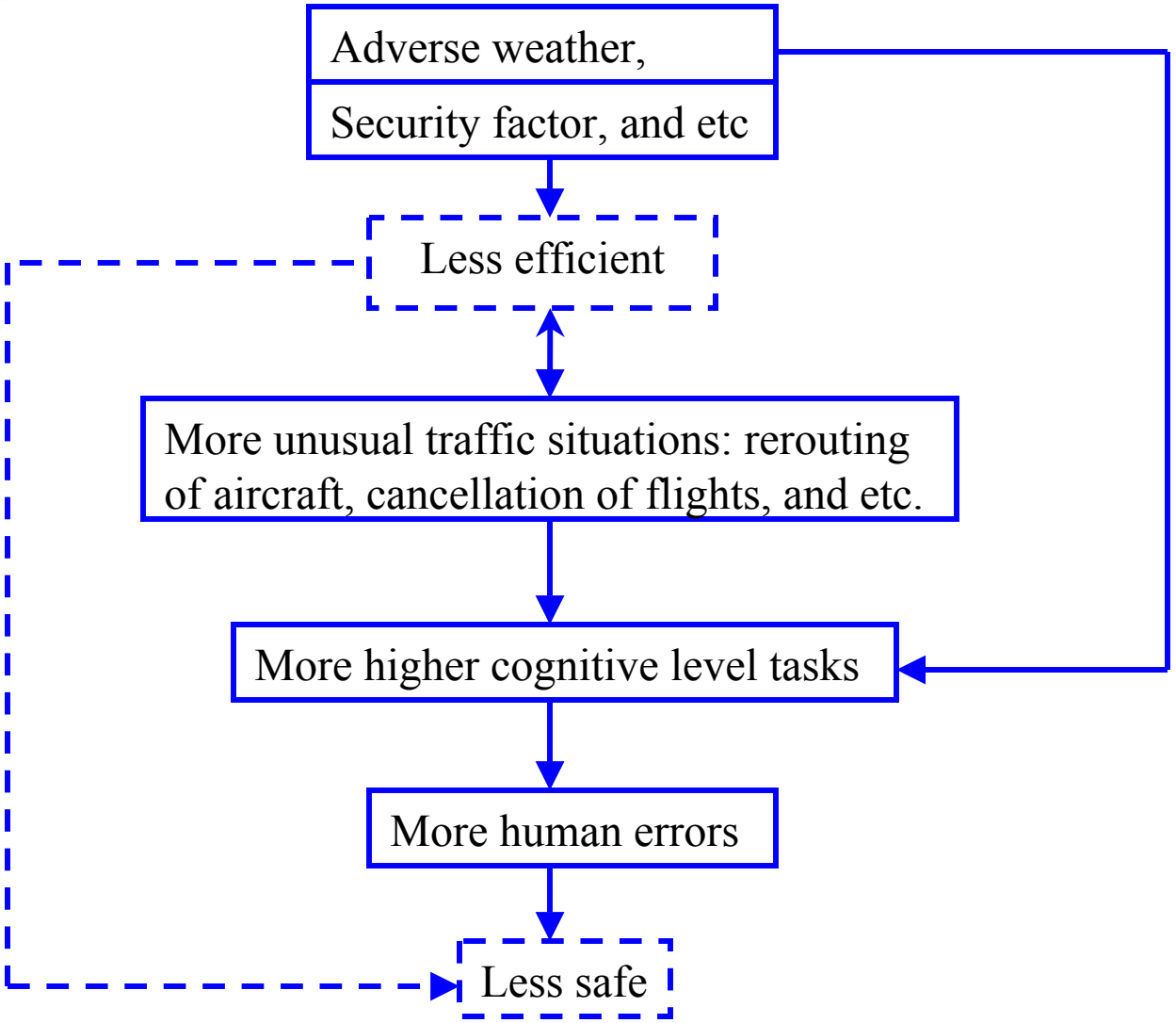
- Daily Flight Time Index (DFTI)
  - A weighted average of daily flight time
  - Based on 776 city-pairs
  - The weight for each city-pair is calculated based on its proportion of total flights
  - Higher means more delay and less efficient, lower means less delay and more efficient

Data source: Airline Service Quality Performance (ASQP) Data

Human Performance and error



	Skill-Based	Rule-Based	Knowledge-Based
Task	Human performance governed by stored patterns of preprogrammed instructions	Tackling familiar problems in which solutions are governed by stored rules	Playing in novel situations for which actions must be planned on-line
Error	The intrinsic variability of human performance	The application of the wrong rule or with the incorrect recall of procedures	Resource limitation and incomplete or incorrect knowledge
Error Probability per task	$5\times10^{-5} \sim 5\times10^{-3}$	$5\times10^{-4} \sim 5\times10^{-2}$	$1\times10^{-2} \sim 1$


Adverse weather,
Security factor, and etc
Less efficient
More unusual traffic situations: rerouting of aircraft, cancellation of flights, and etc.
More higher cognitive level tasks
More human errors
Less safe

Analysis of Daily OE Count and DFTI

- Data
  - Operational Error data
    - FAA's Operational Error/Deviation Reporting System
  - Traffic count data
    - Air Traffic Activity Data System (ATADS)
  - Daily Flight Time Index (DFTI)

Methodology: Poisson Regression

$$\text{Prob}\,(\,y_i = Y_i\,) = \frac{e^{-\lambda_i}\,\lambda_i^{\,Y_i}}{Y_i!} \qquad (1)$$

where:

y_i is the number of operational errors at date i;

Y_i is the observed number of operational errors at date i;

λ_i is the mean number of errors to be expected at date i.

$$\ln(\lambda_i) = \alpha + \beta_1 \ln(OP_i) + \beta_2 \ln(DFTI_i) + \sum_y \gamma_y D_{y_i} + \sum_q \rho_q Q_{q_i} \qquad (2)$$

$\ln(\lambda_i)$	is the log of the mean number of errors to be expected at day i;
$\ln(OP_i)$	is the log of traffic count at day i;
$\ln(DFTI_i)$	is the log of daily flight time index at day i;
D_y	is the dummy variable, set to 1 if the OE occurred in year y, y ={1998, 1999, 2000, 2001, 2002};
Q_q	is the dummy variable, set to 1 if the OE occurred in quarter q q= {2, 3, 4};
α, β_1, β_2, γ_y, and ρ_q	are the regression coefficients to be estimated.

Estimation Results

Parameter	Description	Estimate	Standard Error
α	Intercept	-25.95	2.22
β_1	Logarithm of traffic counts	1.78	0.15
β_2	Logarithm of DFTI	1.07	0.35
γ_{1998}	Yearly dummy variable for 1998	0.11	0.07
γ_{1999}	Yearly dummy variable for 1999	0.26	0.07
γ_{2000}	Yearly dummy variable for 2000	0.33	0.07
γ_{2001}	Yearly dummy variable for 2001	0.88	0.06
γ_{2002}	yearly dummy variable for 2002	0.43	0.07
ρ_4	Quarterly dummy variable	-0.14	0.05
Scale	Shows dispersion of data	1.1016	

Causal Factor Analysis

- Compared causal factors identified as contributing to OE's on high- and low-DFTI days
- Performed statistical tests to determine if factors equally likely to be cited on either set of days
- Found significant differences (at .05 level) for six of 40 factors

Comparison of Causal Factors

Causal Factors	Low	High	P-low	P-high	t-statistics
Weather Factor	134	172	0.0795	0.1402	-5.10
Training Factors	133	71	0.0789	0.0579	2.25
Weather Complexity Factor	209	251	0.1240	0.2046	-5.74
Airspace Complexity Factor	92	97	0.0546	0.0791	-2.58
Flow Control Complexity Factor	129	129	0.0766	0.1051	-2.62
Other Complexity Factor	1637	1206	0.9715	0.9829	-2.07

The sample sizes of OEs for Low- and High-DFTI days are 1685 and 1227, respectively.

Conclusion

- Human performance explanation.
- Positive association between an efficiency metric (DFTI) and a safety metric (OE).
- Should consider both competitive and complementary aspects of safety-efficiency relationship in assessing new technologies and procedures.

Questions & Comments?

Thanks!