Aviation Investigations Bureau

Detecting Take Off Performance Errors Past "TO/GA"

A Persisting Challenge for Pilots & Safety Risk Management

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Terminology Used

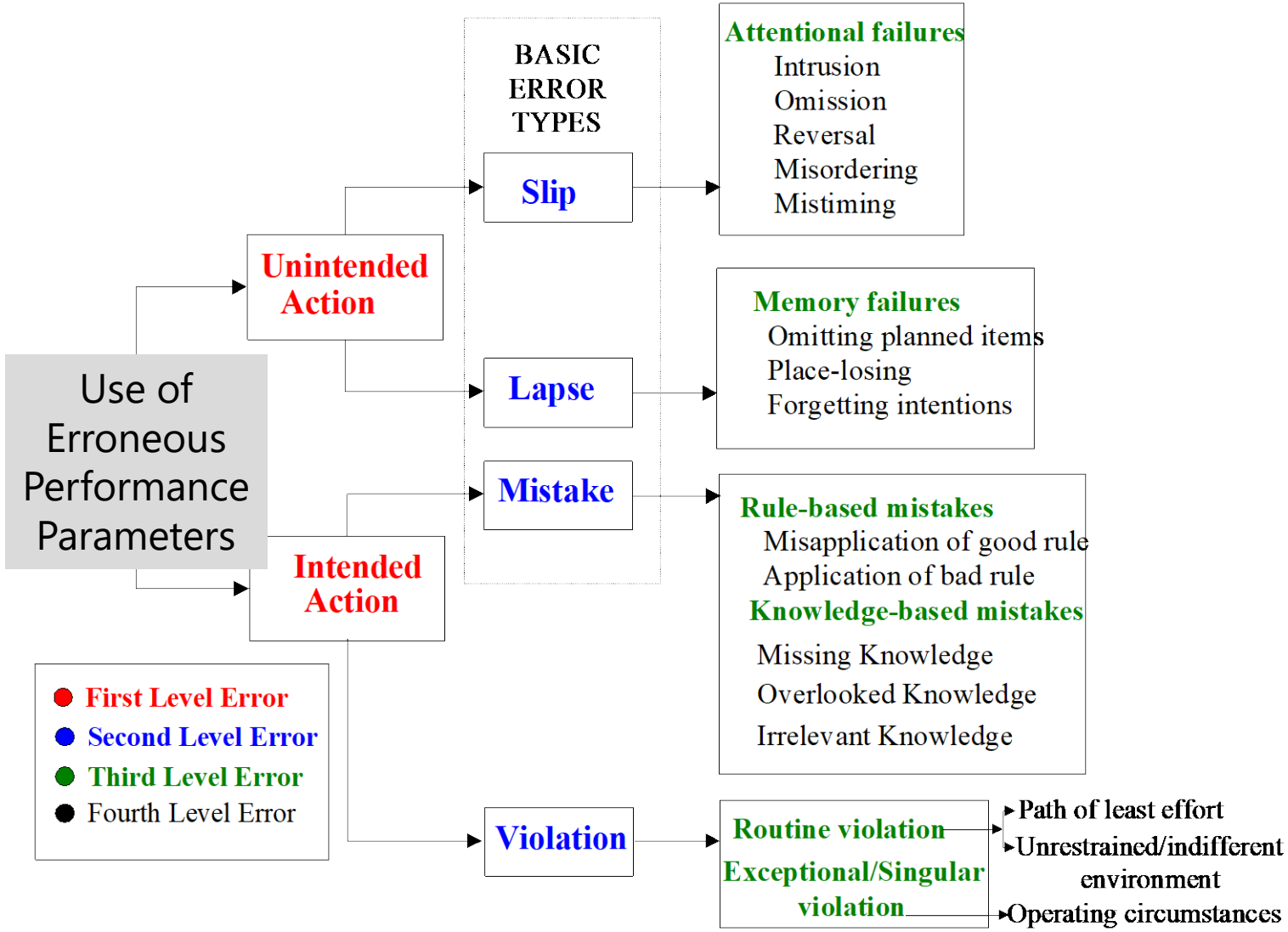
TOW: the total weight of the aircraft
ZFW: "Zero Fuel Weight", the total weight of the aircraft with no usable fuel added, i.e., weight of aircraft, pilots, cabin crew, passengers, baggage, cargo, and catering.
FLEX or Assumed Temp (AT): Performance calculated at an increased temperature than actual ambient for the purpose of increasing engine life.
V_1 Speed: A maximum speed to reject a take off and remain within the runway, also the lowest speed to allow a continued take off run to reach a safe rotation speed in an event of an engine failure.
V_R: Rotation speed, it's when the pilot initiates aircraft rotation ensuring in the event of an engine failure the aircraft will lift-off and reach take-off safety speed (V_2) by 35 ft above ground at the latest.
V_2: Take off safety speed to allow (if maintained) in the event of an engine failure after V_1 controllable flight characteristics
Balanced Field Takeoff: A condition where the accelerate-stop distance required (ASDR) is equal to the Takeoff distance Required (TODR) for the aircraft (1) ***weight***; (2) engine thrust, (3) aircraft configuration; and (4) existing runway condition. To achieve a balanced field takeoff, **V_1** is selected so the remaining takeoff distance with one engine inoperative is equal to the remaining and necessary accelerate-stop distance. Engine thrust (affected by temperature and pressure) can be deliberately reduced (Flex and AT) by the pilot when runway conditions permit.

Settings and Delimitations

- This presentation examines a class of errors with large differences between the aircraft actual weight versus the used weights for take off calculations.
- Original weight data provided to the Flight Crew being valid.
- A crew override action into the CDU/FMS for V_1; V_R; and V_2 settings.
- Airplanes of Air Transport Category at heavy operational weights.
- Required Balance Field Computations applicable to the runway in use.
- Availability of discarded operational policies and “SOP” defense measures.
- Human Error paradigm based on “Reason” and other scholars Models.
- Outcome Scenarios are for the high-risk conditions.

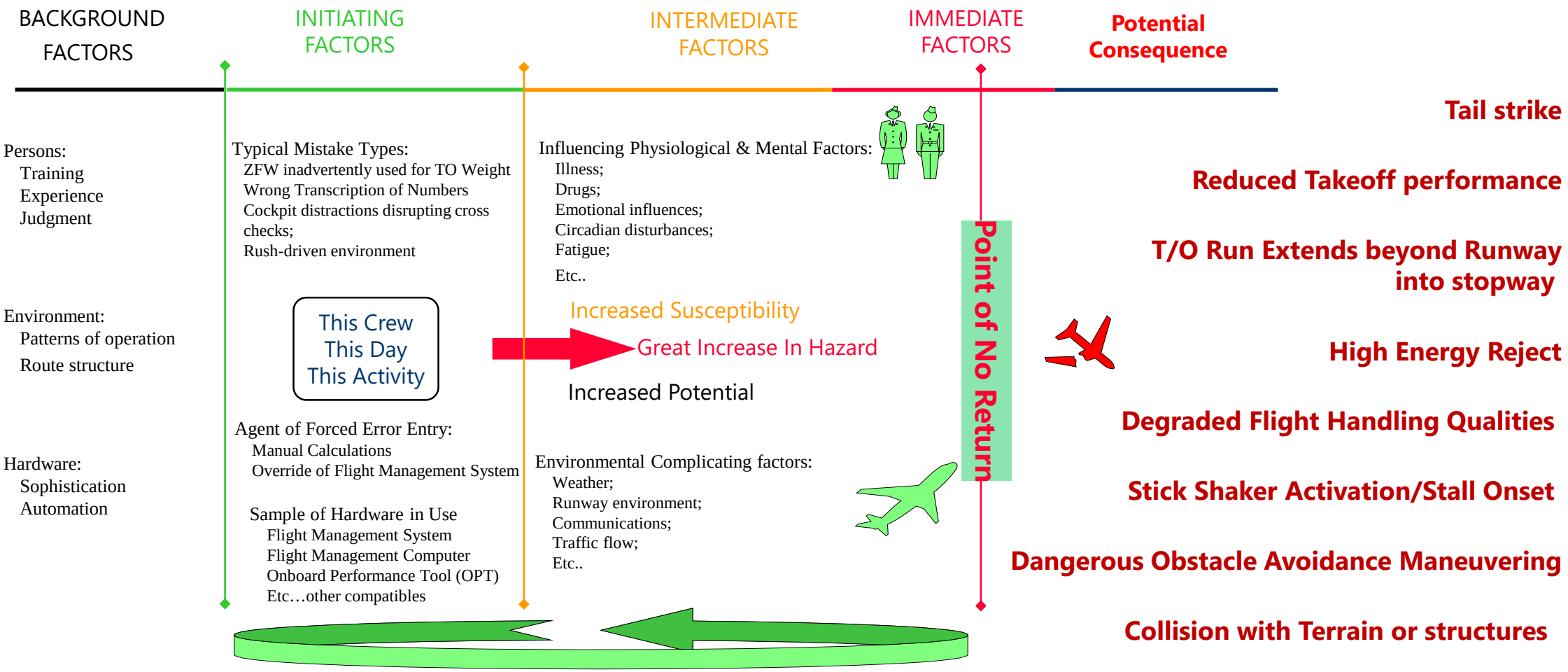
Understanding What Happens?

This figure represents a Taxonomy model that is of a hybrid composition combining primarily Reason and Silverman's error models and absorbing key concepts covered by other scholars as well.



Performance Error Past TO/GA

Events Progression with Erroneous V1; Vr; V2



Detection and Intervention Restoring Control

Target Thrust setting unusually low experience; Lower Engine Sound than usual; Sluggish Acceleration; Excessive distance for IAS or against known objects; Distance to Runway End too close; Rotation with no pitch increase or lift off

Local Case Review

Highlights of AIB-310120-092 Investigation Report of a Tail Strike at King Fahad Int'l Airport, Dammam, KSA, followed by a *HIGH RISK* continued flight. Major Flight Crew and Organizational Causal Factors were observed.

A Tail Strike with 9 ft of amage at APU door.

DFDR simulation of a tail-strike

Flight Crew Actions	Organizational Operational Control Actions
No Independent check of data	Approved flight continuation for 2 hours with pressurized hull
100 ton less-than-actual weight entry into the OPT and FMS;	No redispatch release after fuel dump initiated then arbitrarily terminated
FMS V_1, V_R, V_2 manually entered using OPT calculations to overwrite FMS displayed dashes	Authorized flight continuation without the use of the Tail Strike abnormal checklist.

Closing Words

1. Errors with Take Off Performance calculations are “fool-proof” resistant.
2. The complexity of the factors associated with performance calculations represents a difficult challenge for a technological (software) design to shield against human error.
3. Detection of performance calculations errors past TO/GA or manual thrust application is possible with heightened reliance on perceptions with visual cues, runway distance awareness; and training to react to the unexpected. Crew reactions varied from “no change to the normal takeoff” to counter strategies such as: (a) rejecting the takeoff; (b) increasing thrust; and (c) slowing or delaying the rotation.
4. Simulator training sessions (like LOFT) can introduce gross weight errors to create lower thrust with invalid $\mathbf{V_1}$, $\mathbf{V_R}$ and $\mathbf{V_2}$ values resulting in unbalanced takeoff run distances. The object is to develop best response practices and recovery guidance specific to aircraft manufacturer.

References

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Thank you