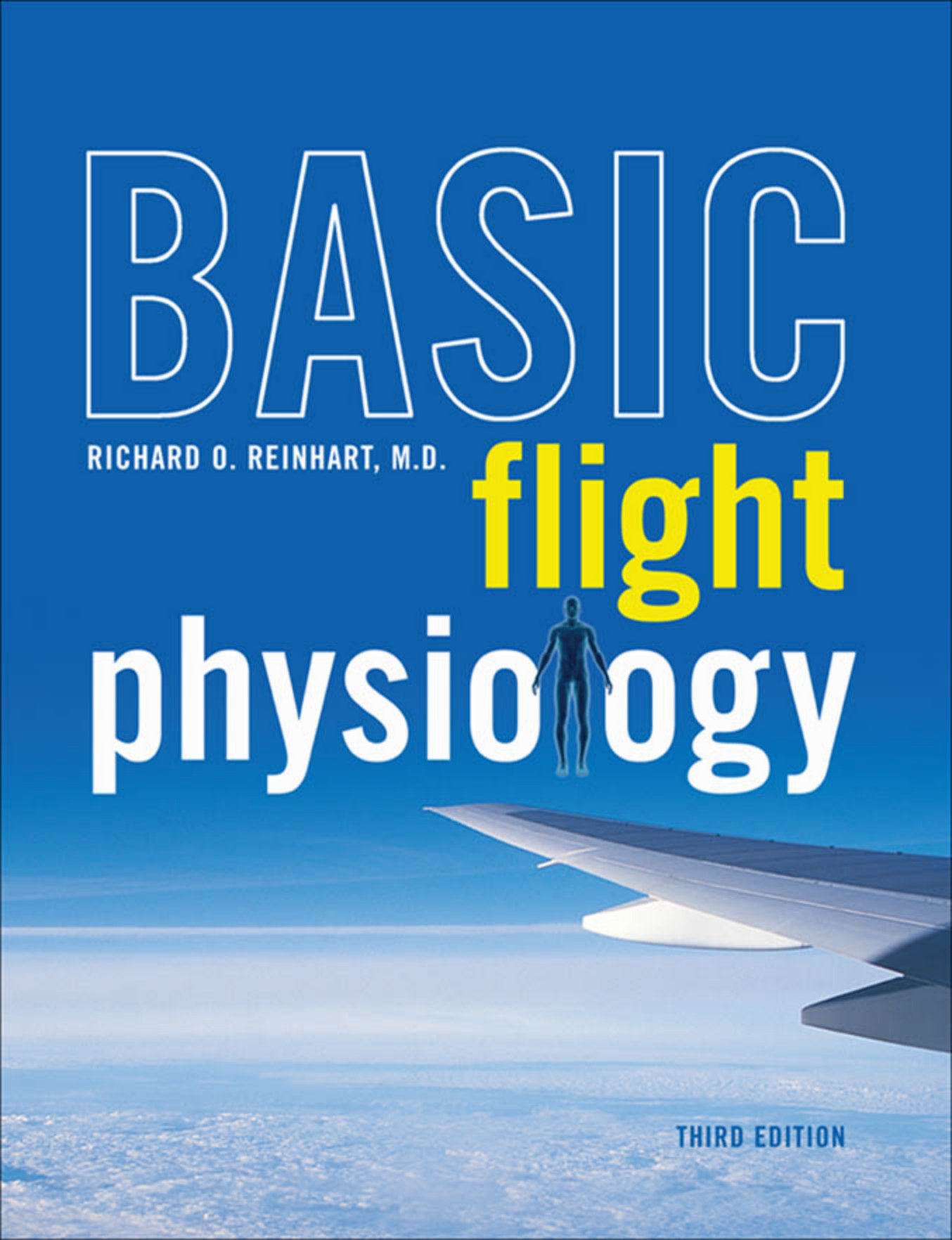
BASIC flight physiology

RICHARD O. REINHART, M.D.



THIRD EDITION

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About the author

Richard O. Reinhart, M.D., was the President of Human Factors Resources, a company that provided resources and training for FAA medical certification and on the human factors of flight. He is an instrument-rated pilot, a senior FAA aviation medical examiner (AME), and a retired US Air Force/National Guard flight surgeon. Dr. Reinhart was also the medical editor of *Business and Commercial Aviation Magazine* and publisher of *The Airworthy Aviator.*

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Richard O. Reinhart, M.D.

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To my sons Mark and Curtis,
who have shared our love of flight

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rarely are contributing factors discussed when placing blame, even though they are mentioned in accident reports. Unlike in medicine, contributing factors (the incidents in a chain of events) are mentioned in the final findings but often minimized or buried in the body of the report. And we tend to focus on who was in error, not why that pilot erred during the preceding events. Always look for the contributing factors, because those usually can be controlled. The final event and the resulting accident cannot be reversed.

ACCIDENT OR INCIDENT

Try to mentally visualize some of the insights relative to an accident. How many readers can recall pictures in the press of a major airplane accident. There's no doubt the plane flew into terrain! Now, try to visualize a picture of an incident. Not so easy. Then consider the picture of a bat and frog (Fig. 1-1). A rather amazing photograph! What's going to happen to the frog?

This is a still picture from a nature program that included actual movies leading up to the picture. Believe if or not, there were occasions when the bat missed!

For the sake of an analogy, consider this to be a picture of an *incident*—the frog (a pilot) about to . . .? How could the frog beat the odds and avoid the "accident" of being consumed by the bat? It could consciously not move—to the bat's "radar" the frog is just an extension of the rock. But the instinct would be for the frog to jump off the rock. Only experience overcomes this instinct. So, this incident wasn't the last before an accident. The frog followed "SOP" for such attacks and suppressed the instinct to jump.

Let's take this another step. A frog is cold blooded, adapting to temperature extremes by allowing its body to stay the same temperature as the environment.

Figure 1-1 Accident or incident? Bat meets frog.

THE "DUH" FACTOR (OR "NO KIDDING!?", "REALLY!?")

In 1999, Boeing, rather than restating what causes accidents, published their study of *Accident Prevention Strategies.* Their finding:

"Flightcrew compliance with established procedures is the single most effective safety prevention strategy available to airlines. For example, 50% of all accidents studied could have been prevented by the pilot flying following SOP and 35% prevented by pilot-not-flying following SOP. Design improvement: Less than 30%.

The old caveat still stands: READ THE MANUAL!!—then comply with it.

If you put a frog into a pan of cold water and then heat the water, the frog will sit there enjoying the warmth until it's cooked! Nothing signaled the frog that it was in danger. Next scenario: take the deceased frog out, drop another frog into the hot water, and watch what happens. The frog jumps; instinct properly applied. FYI, humans and other animals can train themselves to tolerate extreme heat (or other pain). For example, when first touching the bare handle of a hot pan, you instinctively let go. With practice and will power, you can pick up that hot pan without dropping it.

Lesson learned: After years of flying, a pilot can virtually fly a specific aircraft "instinctively," not having to think about what to do until there's a variation in conditions. If the conditions become risky (rough weather, aircraft, rapid ATC changes, computer malfunctions, etc.), the alert pilot can stay ahead of developments and declare an emergency, if necessary. Continuing the analogy: If a pilot is in a risky situation, what could interfere with that pilot's response to the risks and how can he/she take appropriate and timely action? What would erode the pilot's inherent ability to use good judgment, make safe decisions, and recover? How about fatigue, hypoxia, disorientation, a "legal" hangover, stress, and myriad other physiological impairments?

The point of this analogy? Keep this image in mind whenever flying. Throughout this text there will be occasional sidebars with this picture as an icon next to those topics which can catch up to an unsuspecting pilot at work. These "Gotchas" are exactly those situations that allow a recoverable incident to evolve into an accident—the last incident.

DEFINITIONS OF HUMAN FACTORS AND FLIGHT PHYSIOLOGY

Human factors has a variety of definitions, depending on whom you ask. For example, an engineer will consider the positioning of controls and instruments within the cockpit a human factor, the man-machine interface. The

psychologist will define it as how the pilot deals with stress, how he/she communicates, and how he/she manages available resources (CRM).

A pilot might say that it means the ability to perform under extreme conditions, how he/she judges what action to take when things turn sour. A physiologist or physician will consider the effects of fatigue, hypoglycemia, illness, noise, and other "medical" and "psychological" issues. The result is the same: how to get the human pilot from point A to point B in a flying machine without a human factor interfering or the aircraft's onboard computers having to intervene.

Flight physiology is how the body and mind work in the flying environment. It includes such topics as understanding how our organs function, what keeps them from functioning in a hostile environment, and what the pilot can do to protect these functions before and during flight. Hypoxia, dehydration, fatigue, vibration, visual illusions, noise, disorientation, jet lag, self medication, alcohol, smoking, and many more topics are included in the list. Furthermore, how to define health and then how to protect health becomes an important goal.

Flight physiology is not dull. It is not just "nice to know." It is essential to safe flight.

However, we tend to take these issues for granted because our bodies and minds are usually very tolerant and forgiving of the abuses to which we subject ourselves. "Human factors events happen to the other pilot—I can control those factors." Denial of the importance of human factors compared to flying proficiency begins to take over our reasoning. The near-hit or dumb incident usually gets our attention and brings us back to the reality of the significance of human factors and our vulnerability. Now, these are the pilots who don't have to be told to learn because they know its importance, at least until they fall back into old habits. We experience this all the time when driving; the near-collision with another car gets us back to driving safely again.

Flight physiology, therefore, is an integral part of human factors and safe flight. We expect our aircraft to be airworthy. We look to our mechanics to keep the aircraft airworthy. Before we fly, we preflight the machine to ensure that it is airworthy. Our expectations are high for that aircraft. We should have the same expectations for the pilots and the other flight crew. They must also be airworthy—medically airworthy. This text will concentrate on keeping the pilot medically airworthy while discussing human factors in general. Obviously, the pilot's airworthiness is directly related to whether or not there are any human factors in flight. Flight physiology is the most important part of human factors. It's the human element of human factors and safe flight, and it has a direct effect on performance.

Throughout this text, the term "medical airworthiness" will be used. As stated above, this will be the single designation to summarize the physiological and psychological state of the pilot. It will also relate to any illness and medical or physical impairment that might be present. It will be used in the same context as with expressing the flying status of an aircraft; is the pilot "medically airworthy" before being subjected to the stresses inherent in flight? And can that pilot maintain his/her airworthiness throughout the entirety of the flight?

Safety is the prime goal of all flight for all pilots. The best trained pilot, however, isn't safe if he or she isn't medically airworthy. Experience, even that associated with the more mature pilot, will not overcome any or all impairments. Knowing flight physiology, being aware of its effects on performance, and maintaining a high index of suspicion when performance becomes substandard will continue to make everyone a better and safer pilot. Without this knowledge insight, the pilot is practicing "crisis management," making an assumption that a problem can be dealt with when and if it arises.

THE "SHEL" MODEL

The International Civil Aviation Organization (ICAO) has used the concept of the SHEL model (developed by Edwards and Hawkins) to better define the role of human factors in aviation and how they interrelate. It is helpful in recognizing the importance of every factor when looking at the big picture of flight (Fig. 1-2).

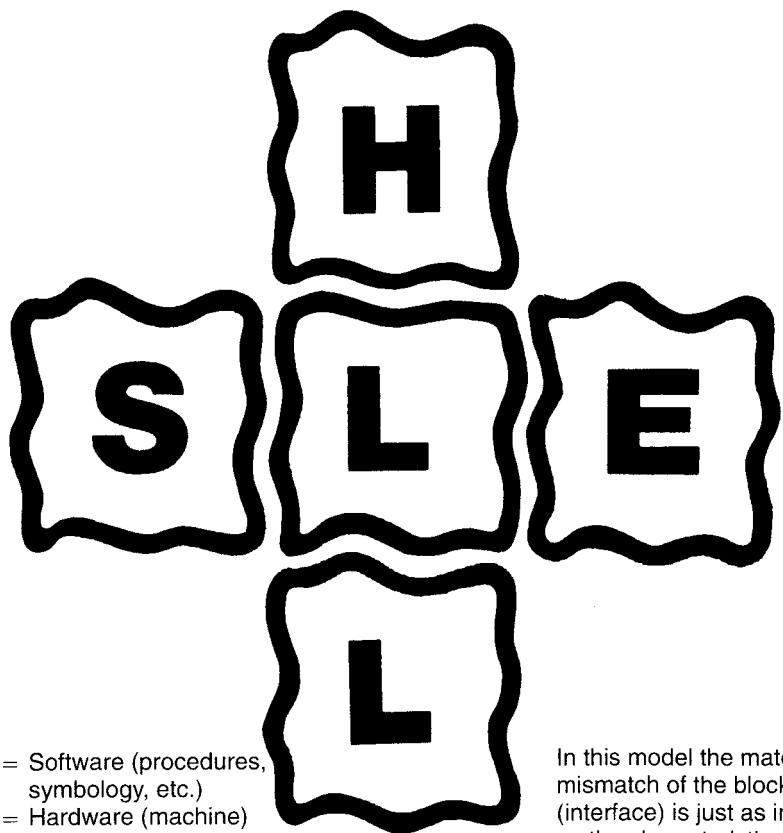

Figure 1-2 The SHEL model examines the interrelationship of human factors and the aviation environment.

The term comes from the basic components:

- Software (procedures, documentation, symbology, etc.)
- Hardware (machines and equipment)
- Environment (internal and external)
- Liveware (human element)

Liveware becomes a component as well as the central figure upon which each component will have an effect; thus, we can talk about the "human-machine" interaction (pilot moves a control), for example, while keeping in mind that there are other interactions (turbulence caused by weather). It is this model that helps to visualize how and why CRM works and that CRM is not limited solely to "human-human" interactions (see Chapter 13).

The model is also important in explaining why the physiology of flight is important, since the human element is obviously crucial and central and every aspect of physiology will affect every other interaction as defined in

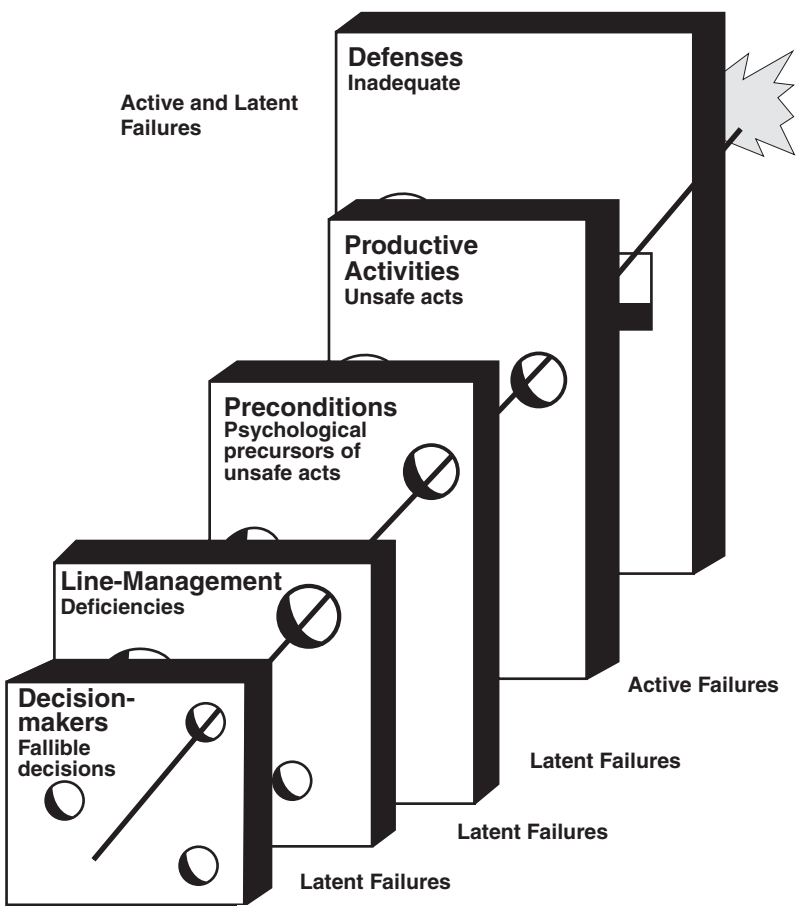

Figure 1-3 Reason's model.