

I/E FORUM: ACS PANEL

NEW KNOWLEDGE REQUIREMENTS

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New Requirement: Energy Management

- Why is it important?
- Where and what is required?
- Challenges with new requirement
- Questions for Educators/Trainers
- Suggestions for the FAA
- Final thoughts

Why is Energy Management Important?

Failure to manage energy associated with vertical flight path (altitude) and airspeed



Where and What is Required?



U.S. Department
of Transportation

Federal Aviation
Administration

FAA-S-ACS-6A

Private Pilot – Airplane Airman Certification Standards

June 2017

- Demonstrate understanding of *energy management concepts*

Flight Standards Service
Washington, DC 20591



U.S. Department
of Transportation

Federal Aviation
Administration

FAA-S-ACS-7
(Change 1)

Commercial Pilot – Airplane Airman Certification Standards

June 2017

- Demonstrate understanding of *energy management concepts*
- Demonstrate ability to identify, assess, and mitigate risks resulting from *failure to manage energy*

Flight Standards Service
Washington, DC 20591

Where and What is Required? (Private Pilot)

- IV. Takeoffs, Landings & Go-Arounds
 - Approach & Landing **Tasks** (B, D, F, H, J, L)
 - **Knowledge (K1)**: demonstrates understanding of a stabilized approach, to include **energy management concepts**
 - Forward Slip to a Landing **Task** (M)
 - **Knowledge (K1)**: demonstrates understanding of **concepts of energy management** during a forward slip approach
 - Go-Around/Rejected Landing **Task** (N)
 - **Knowledge (K1)**: demonstrates understanding of a stabilized approach, to include **energy management concepts**
- IX. Emergency Operations
 - Emergency Approach and Landing (Simulated) **Task**
 - **Knowledge (K4)**: demonstrates understanding of a stabilized approach, to include **energy management concepts**

Where and What is Required? (Commercial Pilot)

- IV. Takeoffs, Landings & Go-Arounds
 - ▣ Same **Knowledge** requirements as Private Pilot

- IX. Emergency Operations
 - ▣ Same **Knowledge** requirements as Private Pilot

- V. Performance & Ground Reference Maneuvers
 - ▣ Chandelles (C), Lazy Eights (D), Eights on Pylons (E)
 - **Risk Management (R6)**: demonstrates ability to identify, assess and mitigate risks related to **failure to manage energy**

Challenges with New ACS

- No adequate explanation or guidance in ACS or references
 - ▣ What are the **energy management concepts**?
 - ▣ How should pilot candidates **demonstrate** knowledge of energy concepts?
 - ▣ Without proper guidance, the FAA mandate may neither have an effect on every-day flying nor **impact safety**
- Do not go far enough
 - ▣ NO energy management **skills** required
 - ▣ Only knowledge

“Energy Management” References

- Of **28** reference documents listed in the Private ACS and **29** in the Commercial Pilot ACS, **only 2** mention “energy management” **1 or 2 times**
- Airplane Flying Handbook
 - ▣ 1: [Maintaining Aircraft Control: UPRT Academic Material 4-21] “Awareness of the relationship between AOA, G-load, lift, **energy management**, and the consequences of their mismanagement, is essential for assessing hazards, mitigating the risks, and acquiring and employing prevention skills.”
- Pilot Handbook of Aeronautical Knowledge
 - ▣ 1: [Aerodynamics of Flight: AOA Indicators 5-27] “These devices can give a visual representation of the **energy management state** of the airplane. The energy state of an airplane is the balance between airspeed, altitude, drag, and thrust and represents how efficiently the airfoil is operating.”
 - ▣ 2: [Flight Instruments: AOA Indicators 8-22] “These devices can give a visual representation of the **energy management state** of the airplane. The energy state of an airplane is the balance between airspeed, altitude, drag, and thrust and represents how efficiently the airfoil is operating.”

Questions for Educators/Trainers

- How is your school meeting **energy management** requirement?
- Should the FAA provide better **explanation** of energy management concepts and better **guidance** of how to teach them? If so where?
 - ▣ FAA Handbooks, Advisory Circular, other?
- Should the FAA **modify/expand ACS** energy management requirement?
 - ▣ Encompass **additional flight operations?** (e.g. slow flight and stalls)
 - ▣ Incorporate in all pilot **certificates and ratings?**
 - ▣ Add requirement to demonstrate energy management **skills?**

Suggestions to FAA

- Explain **energy management concepts** in appropriate Handbooks and other guidance materials
- Disseminate accurate information based on **scientific energy principles**

Energy Management Foundation

- **Fundamental Physics**
 - ▣ Law of Conservation of Energy
 - ▣ Newton's Laws of Motion
- **Engineering:** automated flight control system
 - ▣ Total Energy Control System (TECS)
 - ▣ Tony Lambregts at Boeing (1983)
- **Engineering:** primary flight displays
 - ▣ Energy-augmented PFD
 - ▣ Matthijs Amelink (2005)
- **Military Science:** air combat tactics
 - ▣ Energy Maneuverability (EM)
 - ▣ Edward Rutowski (1954), John Boyd (1960s)
- **Biology:** long-range non-stop bird flight
 - ▣ Fuel Energy Height (h_{fuel})
 - ▣ Colin Pennycuick (2003)



Energy Management Training Challenge

- Making laws of physics and energy management applications accessible to civilian pilots
- How do we go from this?
- To this:

TECS Generalized Airplane Control System Design – An Update

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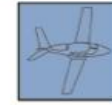
$$\frac{\theta}{\delta_{vci}} = \frac{K_{vci} g}{S V_G} \frac{(\tau_{\theta_s} S + 1) \omega_{sp}}{S^2 + 2\zeta_{sp} \omega_{sp} S + \omega_{sp}^2} \quad (10)$$



Getting a Head Start

- **Flight Energy Management Training: Promoting Safety and Efficiency** published in the Journal of Aviation Technology and Engineering (JATE 2013)
- **Articles in pilot magazines** and recognition in 2015 IATA Manual: **Guidance Materials and Best Practices for the Implementation of UPRT**
- **Energy Safety Management: Knowledge, Rules and Skills for Safe Flight Path and Airspeed Control** submitted for publication with co-author *Matthijs Amelink* (July 2017)
- New ERAU course **Principles of Aircraft Energy Management** this Fall 2017

Available online at <http://docs.lib.purdue.edu/jate>



JATE

Journal of Aviation Technology and Engineering 3:1 (2013) 24-36

Flight Energy Management Training: Promoting Safety and Efficiency

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Abstract

Poor aircraft energy management can lead to unsafe and inefficient operations. Despite their impact on safety and economy, energy management skills are not adequately taught or evaluated in civilian pilot training. This paper 1) addresses the need for better energy management training, 2) provides a conceptual and pedagogical framework for later curriculum development, and 3) suggests key attributes of an effective training program. To make the case, the study uses energy management to link safety and efficiency. It then synthesizes energy principles across disciplines and illustrates how such principles, once simplified, become powerful instructional tools. Finally, it suggests that an *integrated, energy-centered, top-down* training approach will lead to a better mental model of how the airplane works and, in doing so, to enhanced energy management and decision-making skills for safe and efficient operations.

Keywords: aircraft performance, controlled flight into terrain, energy efficiency management, energy balance, energy flow, energy gradient, energy height, energy maneuverability, energy safety management, energy state, flight control, flight energy management, kinetic energy, loss of control in flight, law of energy conservation, potential energy, specific excess power, runway excursion, total energy control system

Introduction

Aviation is a high-risk industry tasked with transporting people and goods safely and efficiently. Unsafe and inefficient operations pose a threat to public safety and confidence, and can cause significant financial losses to the aviation industry (BTRE, 2006). The incidence of in-flight energy crises leading to aircraft accidents (Airbus, 2005; Boeing, 2012; Jacobson, 2010) as well as the impact of wasted energy on increased operating costs (Airbus, 2004; Berglund, 2008; Boeing, 2004) suggest a need for better energy management training for pilots.

About the Author

Juan R. Merkt is director of the Davis Aviation Center at Jacksonville University. He has been involved in programs that educate and train aspiring airline pilots since 1994. His research interests involve aircraft and human performance limitations in extreme flight environments. His credentials include a Ph.D. degree from Harvard University and FAA Commercial Pilot and Gold Seal Flight Instructor certificates. Merkt is currently serving on the Board of Trustees of the Aviation Accreditation Board International (AABI) and is chair of its criteria and international committees. He has served as an AABI representative in the Next Generation of Aviation Professionals (NGAP) Task Force created by ICAO to address the worldwide shortage of skilled aviation professionals. Correspondence regarding this article may be directed to jmerkt@ju.edu.

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QUESTIONS?