HUMAN FACTORS OF Automation In The Airline Cockpit
We incrementally automated aspects of the flying job:


1. Hands and feet off the controls: AUTOPILOTS (1914) and AUTOTHROTTLES (1945)
2. Pursue target courses, altitudes, and speeds: FLIGHT DIRECTOR (1950s)
3. Series of targets that comprise an entire route: FLIGHT MANAGEMENT COMPUTER (1983)
4. Detect and deal with abnormalities: ELECTRONIC CENTRALIZED AIRCRAFT MONITOR (1983)

Our practice is to use automation during most phases of flight. We assume that pilots will monitor the automation to maintain awareness and understanding of what it’s doing, and be ready to intervene when the automation misbehaves or is overwhelmed.
MONITORING TO MAINTAIN AWARENESS

The hardest and most persistant problem we face. Reasons:

**DEPLETION**
Sustained vigilance (monitoring) is known to be arduous and depleting.

**OTHER COCKPIT TASKS**
Pilots avoid long periods of “sit and stare” as they perform other cockpit tasks. But these also result in monitoring lapses (Loukopoulos and Dismukes, 2001).

**TASK-UNRELATED CONVERSATION AND THOUGHT**
Pilots quickly turn to task-unrelated conversation
“Sterile cockpit rule” in 1981 (Wiener, 1985)
When not talking about it, they’re thinking about it (Casner and Schooler, 2014)
Craig (1978): Do pilots adjust their attention-paying to match perceived need?

Many demonstrations of lowered awareness (Endsley and Kiris, 1995; Casner, 2005).

**Status:** Lots of attention drawn to this problem but no solutions. We currently use a “catch as catch can” approach to monitoring. We do little to train monitoring. The idea of designing a more interactive conversation between pilot and automation (Hutchins, 1990), or using less automation to maintain target levels of workload (Bainbridge, 1983) have never been explored.
Even when pilots actively monitor, understanding what’s going on is far from guaranteed. 

Cockpit automation is a complex collection of moded sub-systems that interact with each other in sometimes surprising ways: 


**Wiener’s Three Questions (Wiener, 1989)**

*Why did it do that?*  
*What’s it doing now?*  
*What will it do next?*

**Status:** “Shared understanding” is known to be effective (Norman, 2007) but we don’t teach conceptual models of how automation works or pursue human-centered cockpit designs despite some promising proposals (Hutchins, 1996; Feary et al., 1998). Instead, industry is moving even more toward the use of pre-written procedures and slimming ground school syllabi. Meanwhile, automation is becoming more complex.
BEING READY TO INTERVENE

Situations that require pilot intervention are often unexpected and sometimes unique. Accidents continue to result from failures in these situations. Reasons:

**LACK OF MONITORING AND/OR UNDERSTANDING**
The flight crew has lost awareness and fails to make sense of the situation before it is too late (e.g., Asiana 214).

**ATROPHIED SKILLS**
Hand-eye skills stick even when not regularly practiced, if once well-learned. Cognitive skills (recalling procedures and reasoning steps) need regular practice.


**GENERALIZABLE SKILLS NEVER REALLY ACQUIRED**
Airlines practice intervention during abnormal events using a single example of each.


If we rely on humans to deal with abnormalities, the training requirements are heavy.
Automated Systems That Take Over
A few early and painful examples of automation overriding pilot actions and leading to an accident. But does the automation perform better than the crew (yet)?

Automated Systems That Tell Pilots What To Do
We have many simple examples of this now: TRAFFIC COLLISION AVOIDANCE SYSTEM, GROUND PROXIMITY WARNING SYSTEM. Procedure: “Don’t think, just do.”

Historical efforts to offer advice under more sophisticated circumstances:


Automated Systems That Leave The Pilot In Command
The use of “informative” displays that provide information to the crew. Many accidents in which the flight crew, left in charge, did the wrong thing.
THEN WHAT MAKES FLYING SO SAFE?  
(How Much of This Is True For Driving?)

WE MINIMIZE ERRORS
Pilots Are Hand-Selected (and we pick “carbon copies”)

Pilots Get Lots of Training (initial and recurrent)

Pilots’ Observable Actions Are Highly Policed

Standard Operating Procedures (SOP)

We Learn A Lot From Our Accidents and Incidents

WE TOLERATE ERRORS
Many Redundancies
Reliable automation is handling much of the flying
Two pilots in the vehicle, alerts and alarms
Air traffic control, FAA, pilot culture

Big Sky, Little Planes
Wide tolerances, time to think and react, LUCK.

AIR TRAFFIC CONTROL
Master plan
Little airplane autonomy


Maintaining Awareness
Driver inattention in an entirely manual car is bad now. Task-unrelated activity (e.g., phones) and thought running wild:


Drivers seem to welcome new distractions. Talking, stereos, phones, smartphones, wearables.

Attentive drivers of semi-automated cars ... ?

Who *wants* to drive? (safety concerns about automated cars aside)
Understanding the Automation
We don’t have this problem much in cars (yet).

Possible with a conceptual model of the automation that is taught and shared between car and driver.

But might require a tear-down of what we have now.

Being Ready To Intervene
No opportunity to select drivers; little opportunity to train them.

Requires success in above two areas (awareness and understanding).

My Impression: Full automation, hard takeover approach