Automation and Expertise

What is expertise

and

How can automation work against it?

Presented at the WDM III Workshop

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Warning Decision Training Branch

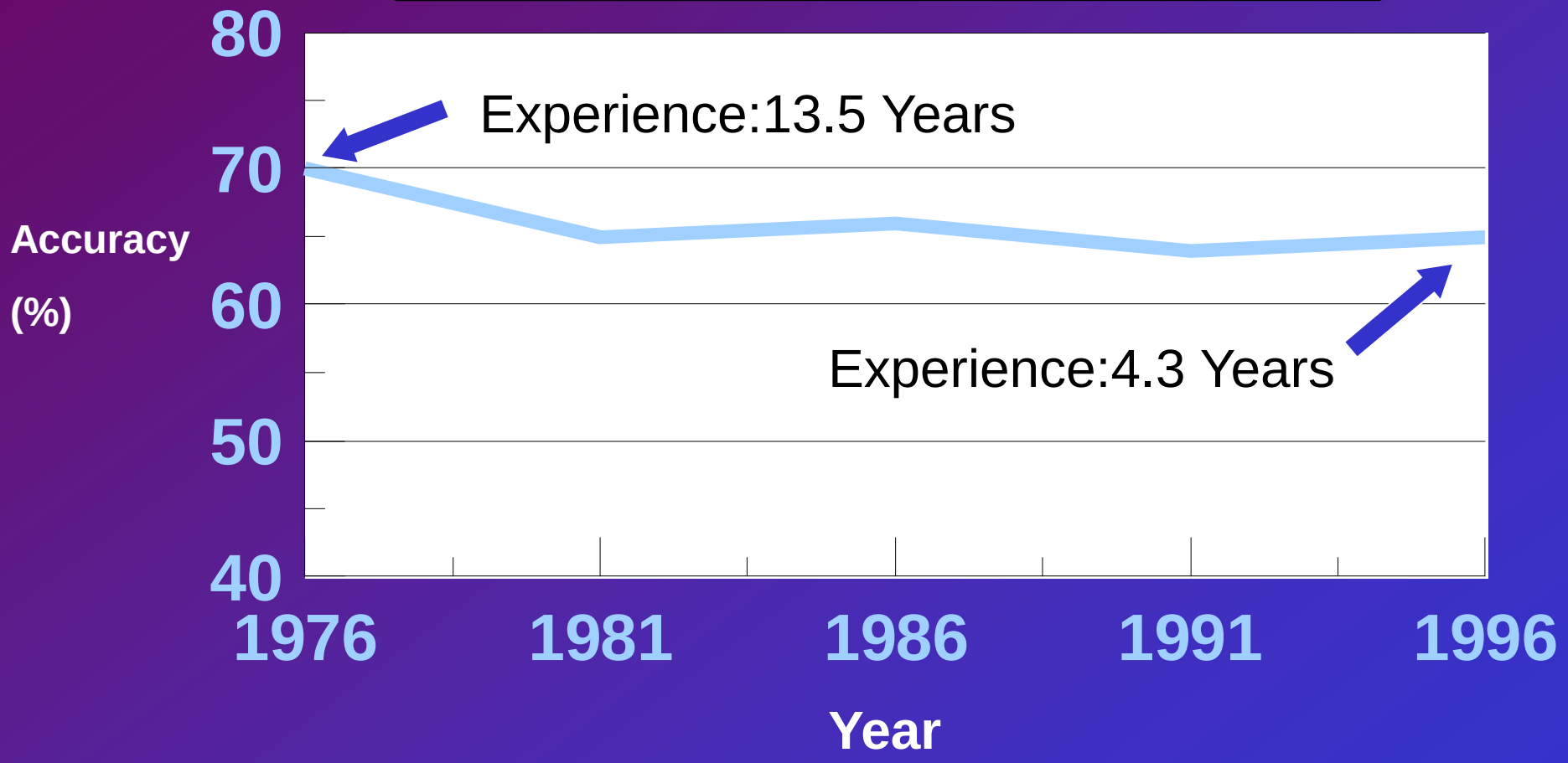
Sources

- Information technology and expertise - Klein, HPSSA
- USS Vincennes disaster - decision making and stress (TADMUS)
- Report on Shady Grove Metro incident, NTSB
- How people make decisions in real environments, Klein
- Interfaces between flightcrews and modern flight deck systems, FAA
- Study of AWS forecasters, Pliske, SRL Brooks AFB

Expertise is *critical* when automation fails

Study of Expertise with AFW Forecasters

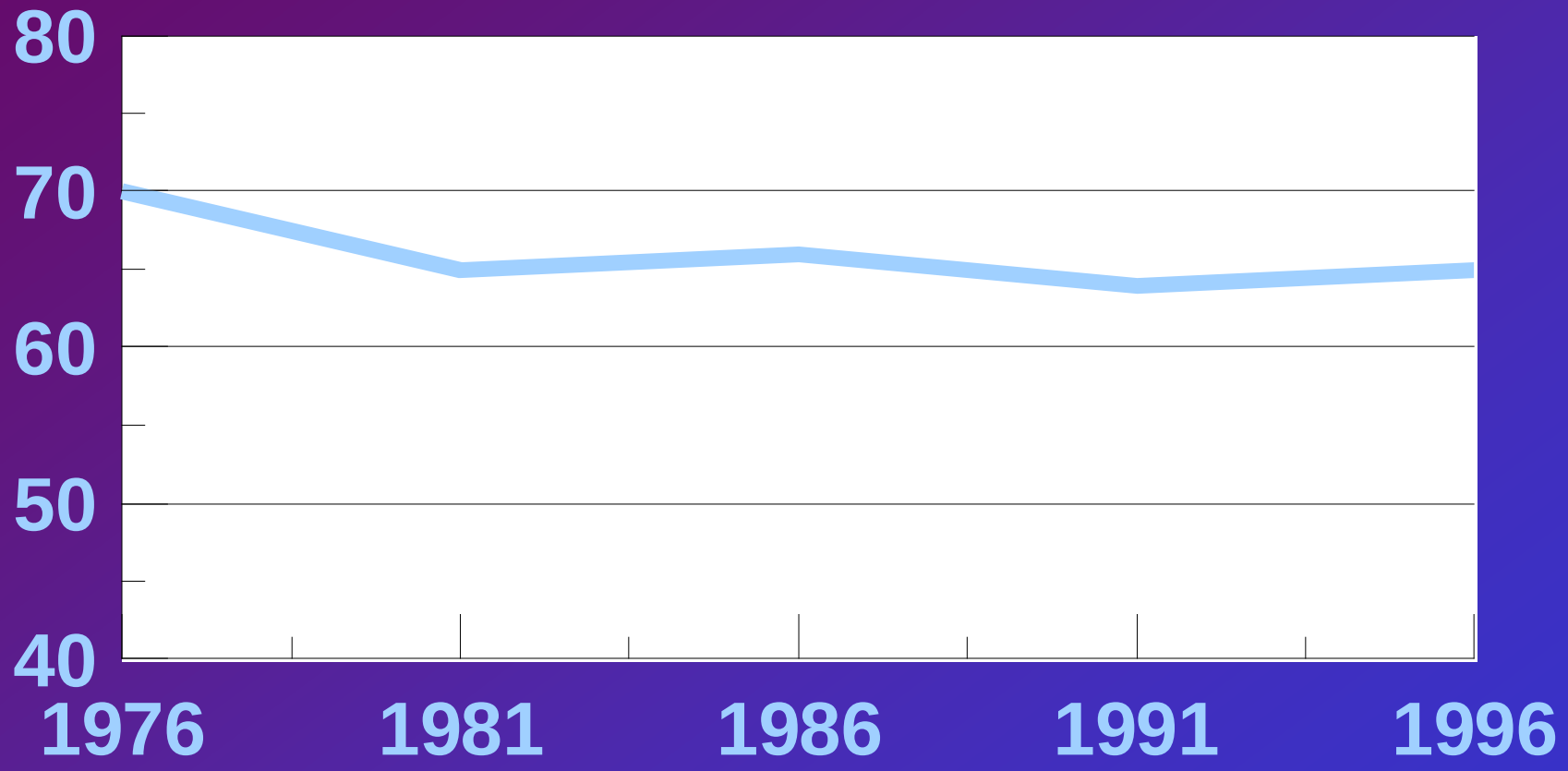
Historical Forecasting Skill



Forecast Accuracy

From Pliske et al 1997

Historical Forecasting Skill



Forecast Accuracy

Question asked by USAF :

Why has a significant investment in advanced technology yet to produce improvements in forecast accuracy?

Answer by Klein:

Expertise in AFW is gone.

His observation:
Expertise in the NWS is following the same path.

What is an Expert?

- Expert
  - Connects the past to the present and can can usually project options for the future.
    - More easily adjusts when any one option turns bad
- Novice
  - Lives in the moment. Can’t recognize complex relationships. Produces limited options.
- Imposter
  - Has mastered procedures and tricks, but
  - Lacks a sense of dynamics
  - Can’t improvise when assumptions fail

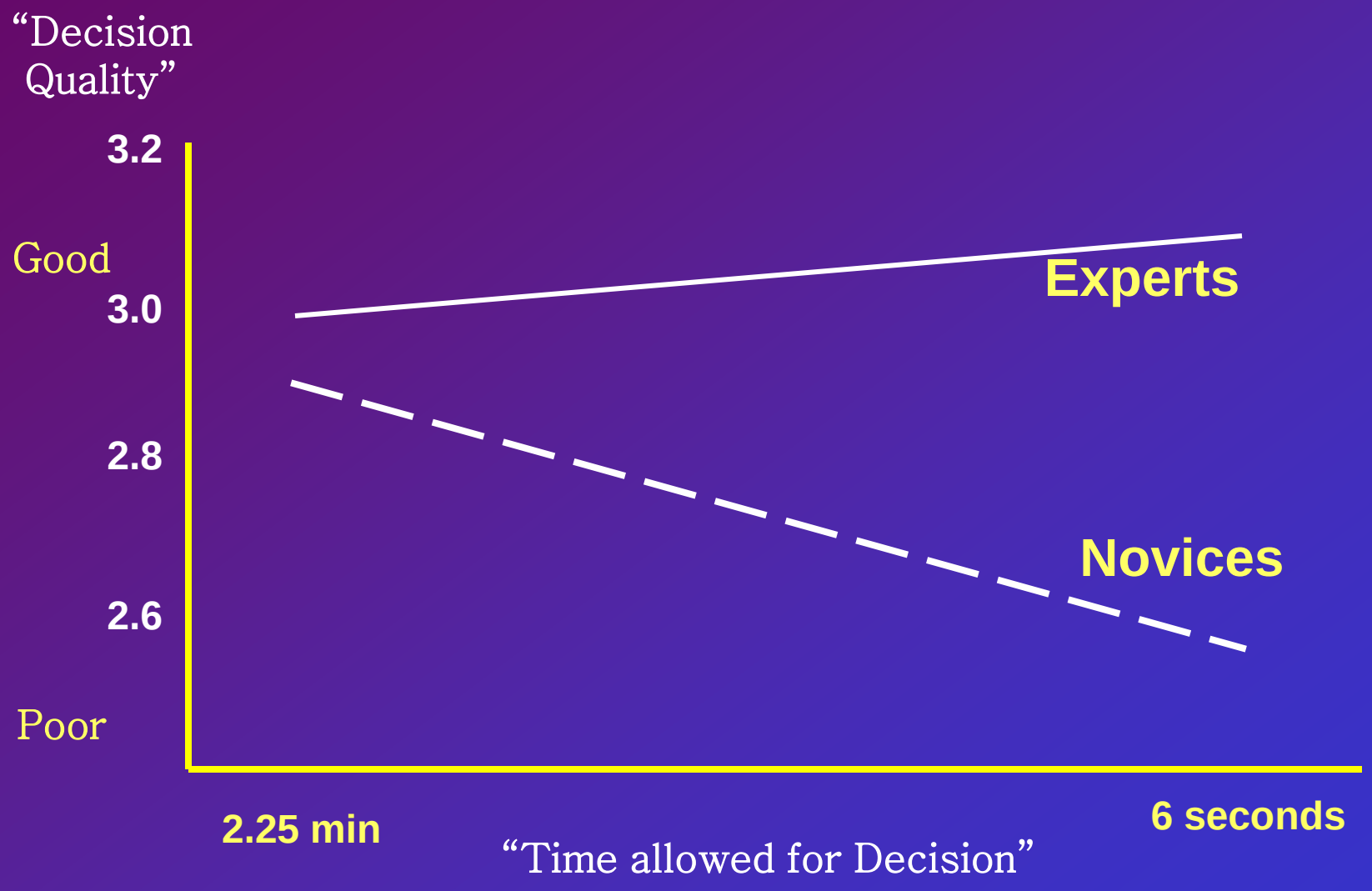
What is an Expert?

- Routine Expert
  - Great at everyday stuff, strong procedural knowledge
    - Runs into trouble when problems are ill-structured or novel
- Adaptive Expert
  - Has a deep comprehension of conceptual structure of the problem domain

Why is expertise so valuable?

- Some disciplines require 10 years to build up expertise
- Time alone is not enough to guarantee it
- Person with expertise can be very difficult to replace
  - Many companies protect equipment…overlook the value of an employee with expertise
  - Money can replace the former, only time (maybe) can replace the latter

Experts under pressure



What do experts do so well that others don't?

- Recognize patterns
- Detect anomalies
- Keep the big picture (SA)
- Understand the way things work
- Observe opportunities, able to improvise
- Relate past, present, and future events
- Pick up on very subtle differences
- Address their own limitations

1) Experts recognize patterns

The ability to see patterns gives us SA

- Fireground commanders
  - Look at burning building and can infer what's happening inside. *They relate cause and effect*

Experts relate cause and effect

“Yep it’s the darnedest thing. Whenever that bell sounds, it means somebody’s fixin’ to knock on the door.”

2) Experts detect anomalies

Including:

Erroneous events

and

Missing events

3) Experts keep the big picture

Situation Awareness

- **Have an overall sense of what's happening**
  - **Relevant cues are monitored**
  - **Plausible goals pursued**
  - **Actions are weighed**

Novices are often confused by all the data elements

4) Experts understand the way things work

- Can see inside events and objects
- Know how tasks are suppose to be done
  - Also know when to do them differently
- Know how teams coordinate
- Know strengths and limitations of equipment

Electronic Warfare Technician: "This console is a liar. But it's OK since I know how to work around it"

5) Experts observe opportunities, able to improvise

- Have learned not to rely too heavily on data
  - Can generate explanations and predictions which are inconsistent with data

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"What would cause these times to be off or these ceilings to be higher or lower?"

6) Experts relate past, present and future events

- Connect all events
  - Understand primary causes and can apply them to run mental simulations
  - Generate expectations
- They don’t get caught “flying behind the plane”
- Can view from the other’s eyes

6) Use of Past and Future cont…

The Cuban Missile Crises and May 3rd Tornado Outbreak

- **Found an alternate explanation for the "2nd" response from Russia**
  - **Result: Global Nuclear War avoided**

- **Found an alternate explanation for the phones not ringing**
  - **Result: Warning allowed to continue**

7) Experts pick up on very subtle differences

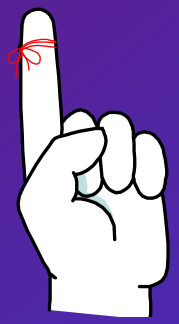
- Detect nuances that novices can't even force themselves to see
  - i.e., they get it
    - novice's don't because "it" is NOT a fact or insight but rather the sum of varied experiences

A 1925 Bordeaux from the Entre-Deux-Mers vineyard, with a slightly pungent bouquet; the crop was stressed for 2 weeks before harvest.

Yes I agree. It's wine.

8) Experts manage their own limitations

- See inward – thinking about thinking
  - Have good SA and can tell when losing it
  - Perform self critique and learn
  - Modify strategy when necessary
  - Work around memory limitations



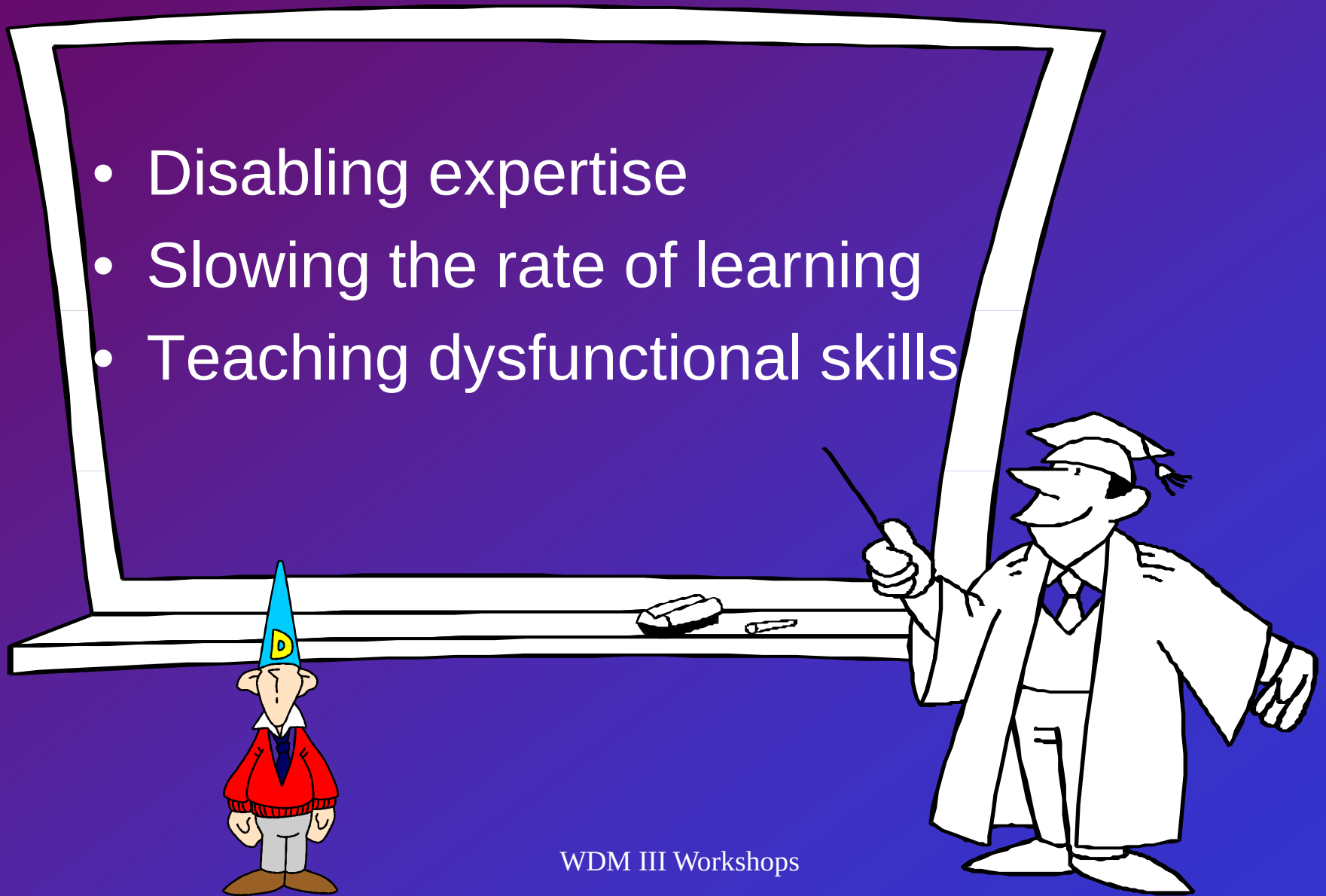
Now enter automation

- Automation is not bad, just often misapplied
- Automation can work to keep the expert from using his/her expertise
- Automation can work to keep the novice from gaining expertise

"Technology is often set up to make it easier for those writing programs, not those interpreting the data." ***Klein***

The unwanted by-products of automation
(or how to make people stupid)

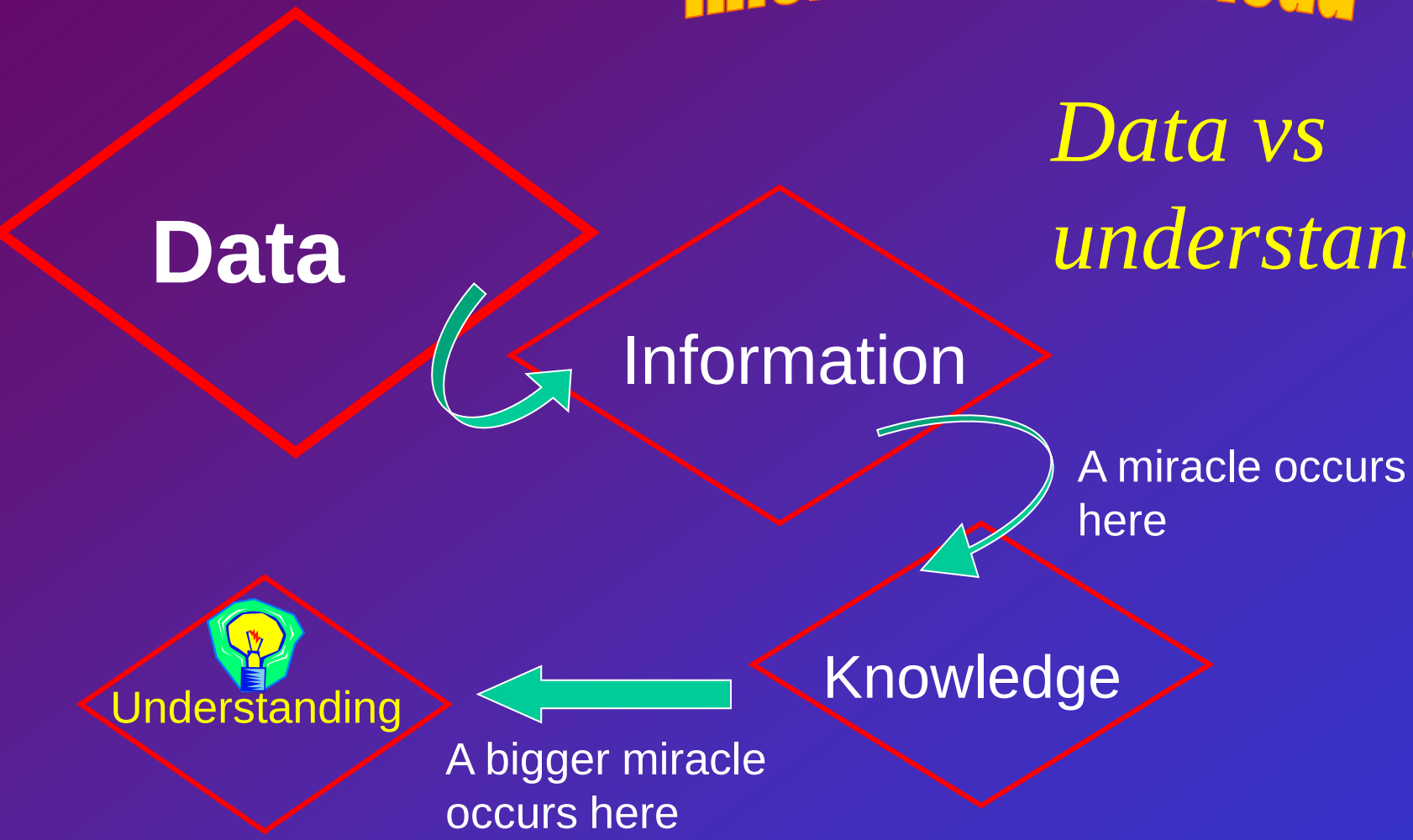
- Disabling expertise
- Slowing the rate of learning
- Teaching dysfunctional skills



Expertise is disabled when you…

- **Achieve** **Information Overload**

Data vs understanding



Expertise is disabled when you…

- **Increase Uncertainty via**
  - **Missing data**
  - **Mistrust of data**
  - **Missing inferences and projections**
  - **Data inconsistencies**

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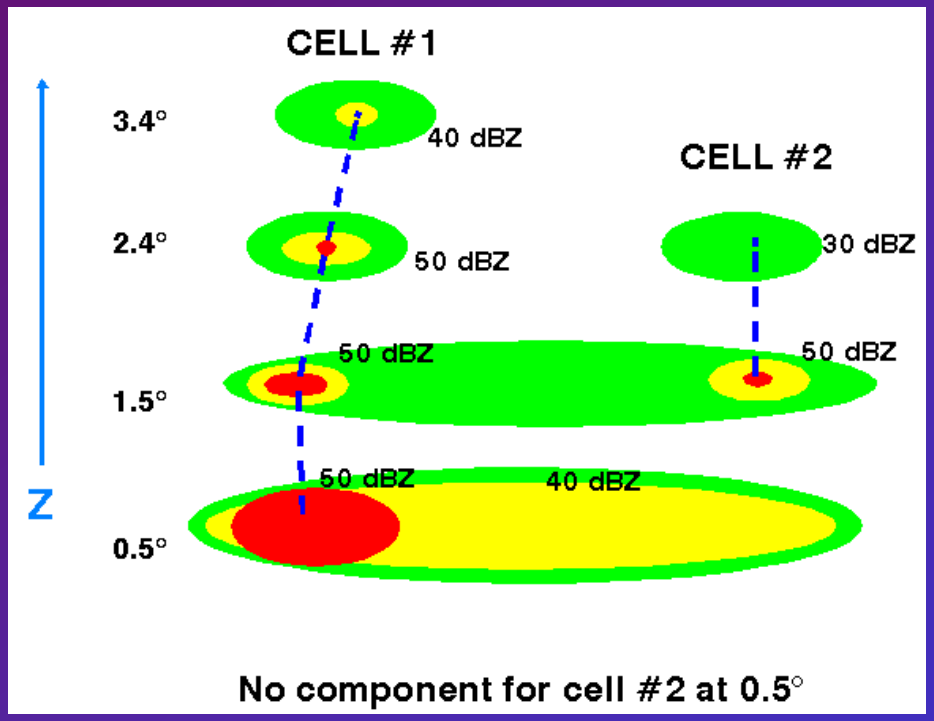
AFD...

EXTENDED...LATEST MODELS HAVE CHANGED DRAMATICALLY FROM EARLIER RUNS...ESPECIALLY FOR THE SUN-MON TIME PERIODS. AVN/MRF NOW BRING A CLOSED LOW DOWN THE LENGTH OF CALIFORNIA FROM SUN EVENING THRU MON EVENING...

Expertise is disabled when you…

- **Prevent evaluation**



Can you tell what components were used to define Cells 1 and 2?

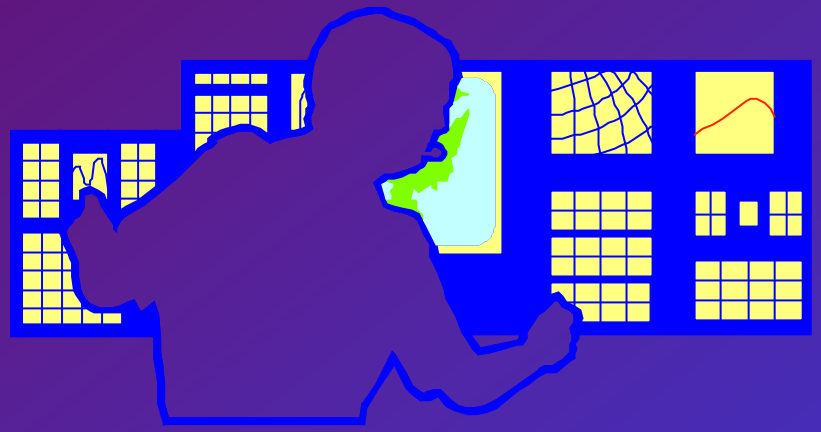
Expertise is disabled when you…

- **Disengage the decision maker**

"My inexperience led me to attempt to generate a computer solution for a simple manual VOR problem. Attempting to reduce the workload through automation created a more demanding situation, distracting us from the basics of flying." **Pilot entry in Aviation Safety Reporting System**

Expertise is disabled when you…

- **Turn the decision maker into a clerk**



“I’ve learned that the more gizmos installed (FMC,TCAS,ACARS,etc), the less time you have to devote to the primary job of flying the aircraft.”

Pilot entry in ASRS

Expertise is disabled when you…

- **Reduce confidence**
  - **What happens next time?**

"FMC can give you a false sense of security because it's *always* accurate. This time it was off 3-5 miles…" (Pilot ASRS)

"…who was I to say numerical guidance is wrong?"

(forecaster after East Coast snowstorm)

The rate of learning is slowed when….

- Rapid feedback is provided
  - Without a means to assess why decision is right or wrong
  - Don’t get a chance to develop own solutions

The rate of learning is slowed when….

- Data are so preprocessed
  - Can’t tell what’s fixed, if anything, and what’s real

The rate of learning is slowed when….

- An Auto-Pilot mentality is encouraged
  - Don’t involve human until there’s a problem
    - Unfortunately, at that point the human doesn’t know:
      - What led to the problem
      - How to reverse it
    - Rust factor – never use or practice skills, until the need for such skills is critical

Shady Grove Metro Stop

January 5th, 1996

"AT NO TIME WILL TRAINS BE PERMITTED TO OPERATE IN A MANUAL MODE…except in an emergency situation."

WMATA Notice to all OCC Personnel

Dysfunctional skills are taught by…

- Misuse of attention management
  - Focused on method instead of mission

"My first priority was data entry rather than situation awareness." ASRS

"Concentration on automation rather than just flying the aircraft was enough distraction to fly through the altitude." ASRS

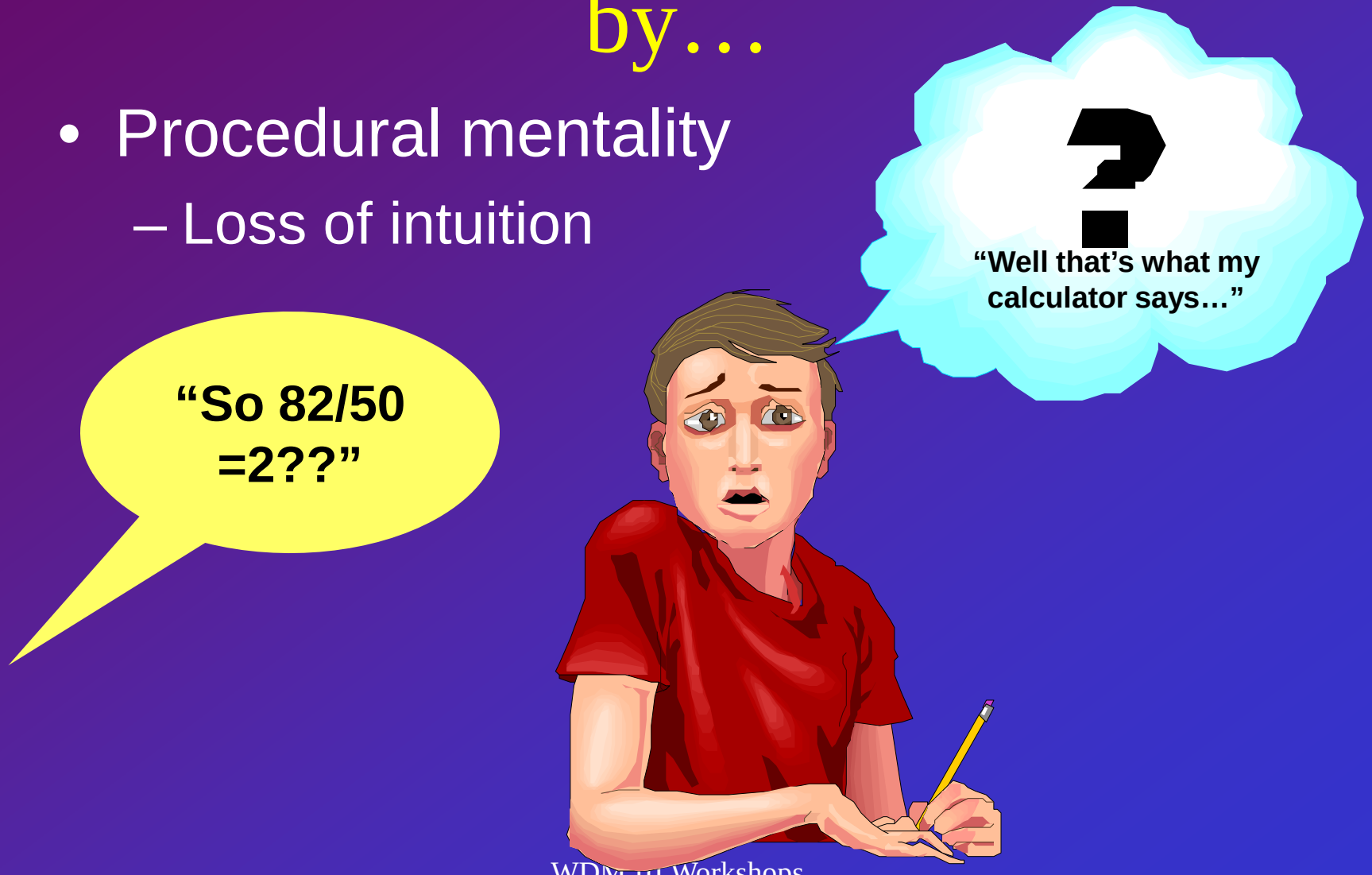
Dysfunctional skills are taught by…

- Using simplistic metrics to measure value

- Radar gun measures
  - Speed
- Radar gun doesn't measure
  - Control
  - Pitch selection
  - Pitch variety
  - Stamina

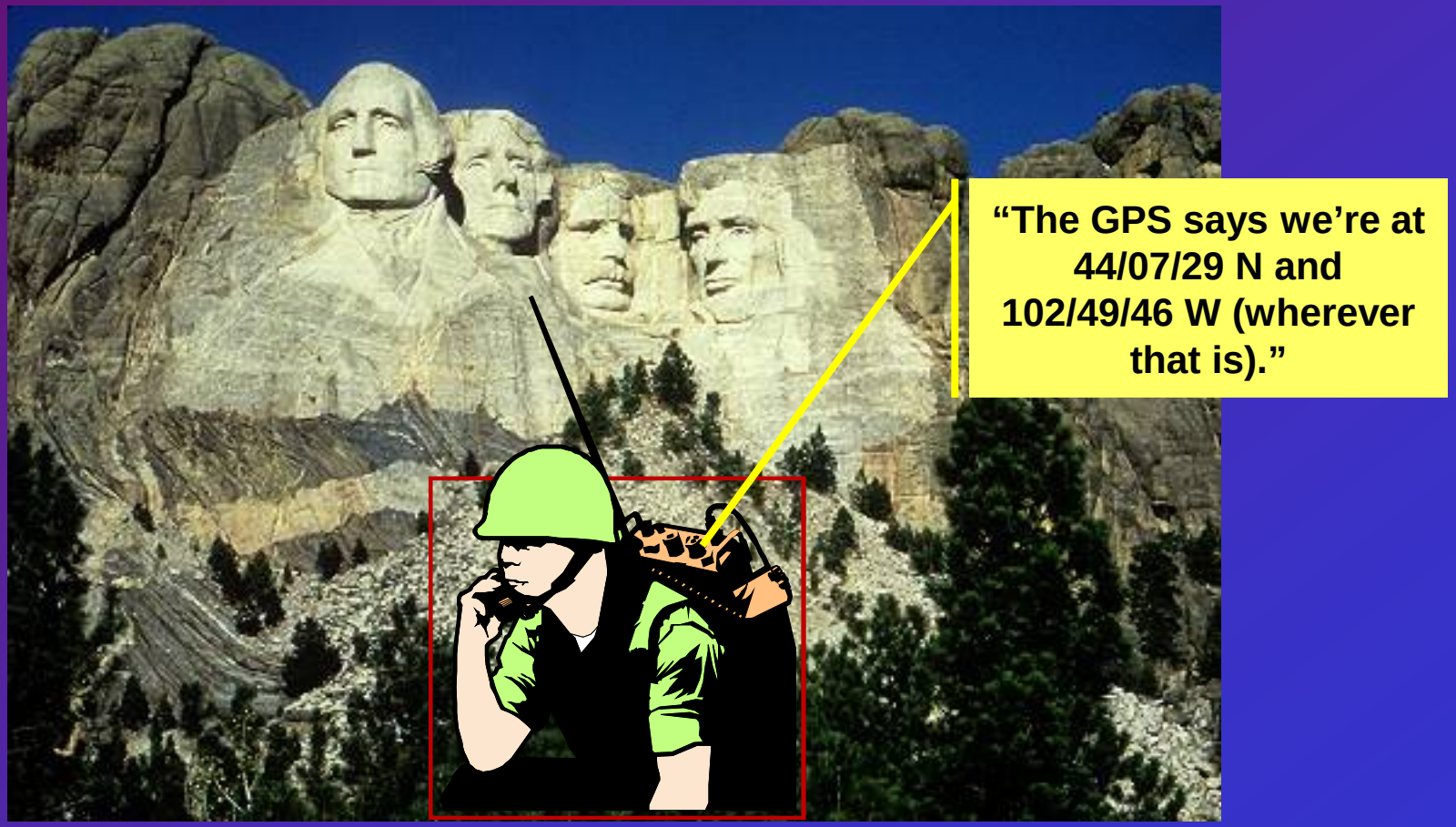
Dysfunctional skills are taught by…

- Procedural mentality
  - Loss of intuition



Dysfunctional skills are taught by…

- Inefficient strategies
  - Inability to relate automation in a context



How to Retain/Develop Expertise

Unfortunately the easiest (and often chosen)solution is to interject more automation

A better option can be to rethink how we use automation, and do it in a way that supports expertise, not tries to replace it

How to create a “culture of expertise”

- Identify sources of expertise
  - –Do you think who’s working? Who wrote that?
  - –Focus on expertise, not just experts
- Assay the knowledge
  - –See what expertise is there- design drills around this
  - –See what expertise is not – find resources
- Extract the knowledge
  - –Use of “stories” or “accounts” to elicit this
- Codify the knowledge
  - –Refine it for your particular needs, locate decision points
- Apply the knowledge
  - Simulations, OJT, Mentoring, others?

How to Retain/Develop Expertise

- Support efforts to develop
  - perceptual skills and pattern recognition
  - Constructed mental models
  - Sense of typicality, ability to spot anomalies
  - Routines and workarounds
  - Form expectations, and learn why they did or did not pan out

How to Retain/Develop Expertise

- DRT
  - 25 hours of *well done* simulations can achieve the same effect as 2 years of experience (or much more)
  - Simulate as many of the “real” parts as possible
    - Including personnel interactions, time, stress, resource allocations, “bogus” data
  - Interject problems
  - Critique reasoning, not just outcomes

How to Retain/Develop Expertise…cont

- Post Mortems
  - Why? Why? Why? and Why not?
- Look at raw data when possible
  - Stay as close to the “truth” when possible
  - Form opinions with this first then look to automated input

Questions?

References

1) "Can Information Technology Reduce Expertise?" aka "How to Make People Stupid" Gary Klein, 2000 Human Performance, Situation Awareness and Automation Conference, Savannah, GA

2) Making Decisions Under Stress: Implications for Individual and Team Training, Cannon-Bowers, Salas, 1998

3) "Railroad Accident Report Collision of Washington Metropolitan Area Transit Authority Train T-111 with Standing Train at Shady Grove Passenger Station, Gaithersburg, Maryland January 6, 1996", NTSB

4) Sources of Power: How People Make Decisions, Gary Klein, Klein and Associates, 1998

5) "The Interfaces Between Flightcrews and Modern Flight Deck Systems", FAA Human Factors Team Report June 1996

6) "Understanding Skilled Weather Forecasting: Implications for Training and the Design of Forecasting Tools", Pliske et al, Systems Research Lab Brooks AFB, June 1997