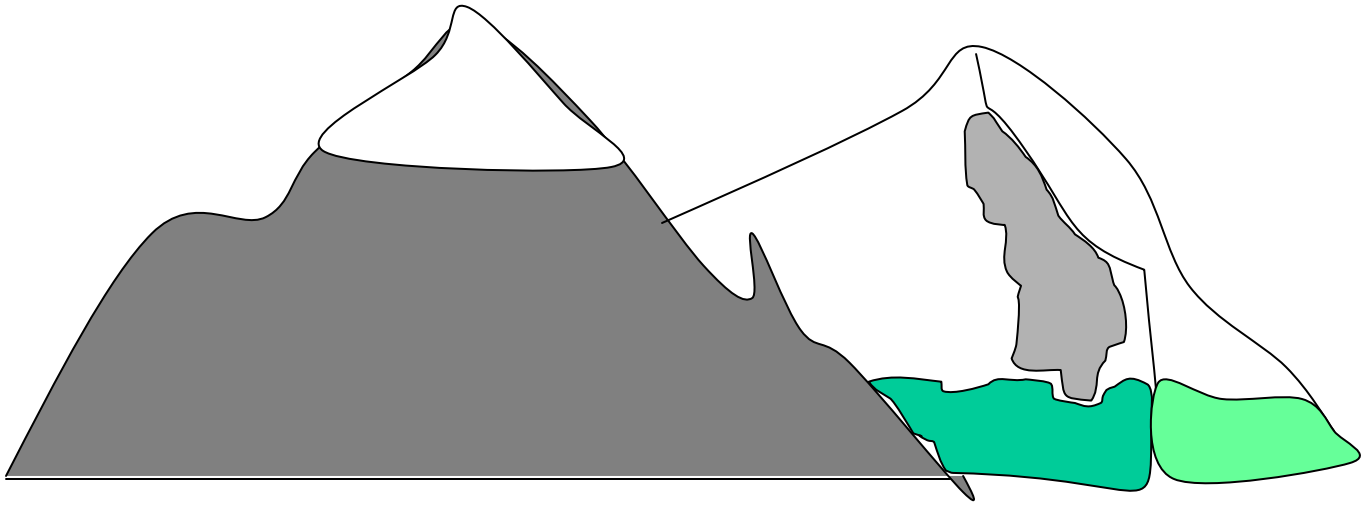
Function allocation and the degree of automation

Chris Wickens

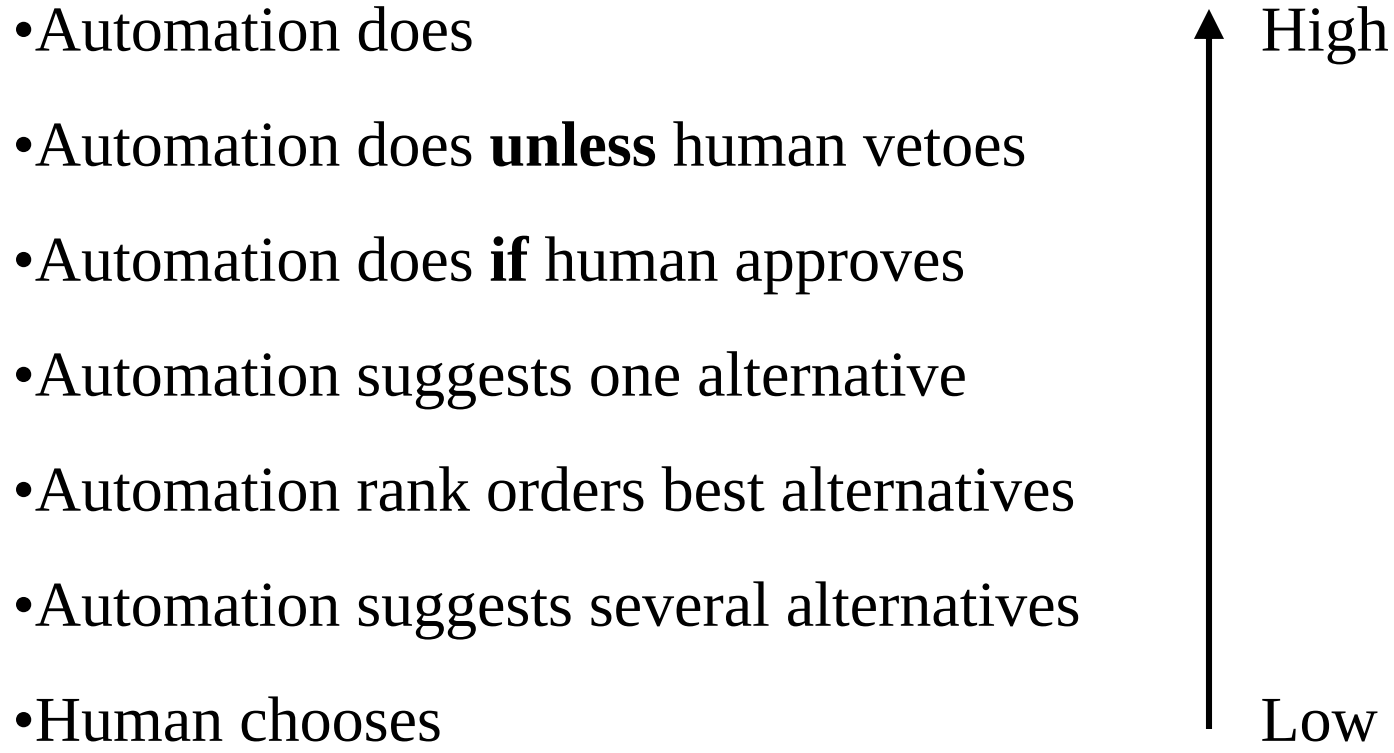
Rocky Mountain Chapter HFES



Traditional Fitts List of function allocation (MIBA-MIBA)

- Black-white allocation of function to **either** “man or machine” (Human or Automation)

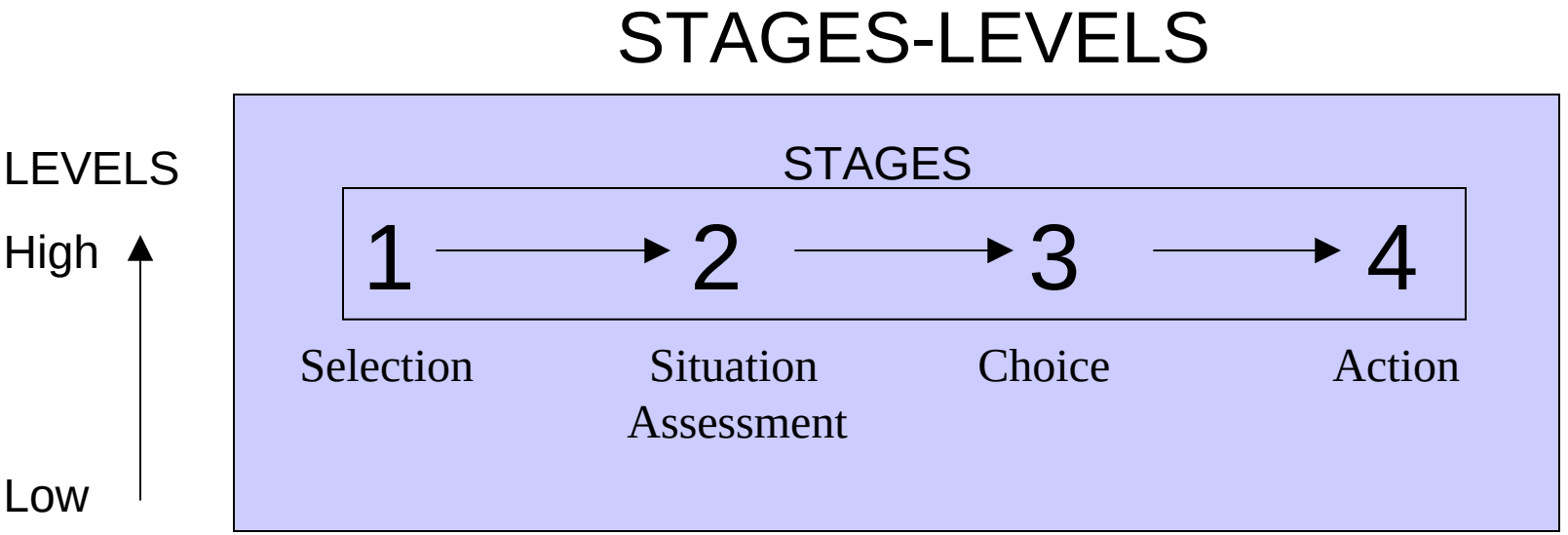
- Sheridan & Verplank (1978) originally put the “grey” in the allocation: **level** of automation; a **graded continuum**



1998: National Research Council panel to recommend to FAA, human factors approaches to automation of ATC system

•We (Sheridan, Parasuraman & Wickens) struggled to use the unidimensional levels scale to accommodate all forms of proposed ATC automation tools. (Height as the single measure of size in basketball; weight matters too): We couldn't do it.

•What emerged was the stages-levels automation taxonomy (Parasuraman, Sheridan & Wickens; 2000)



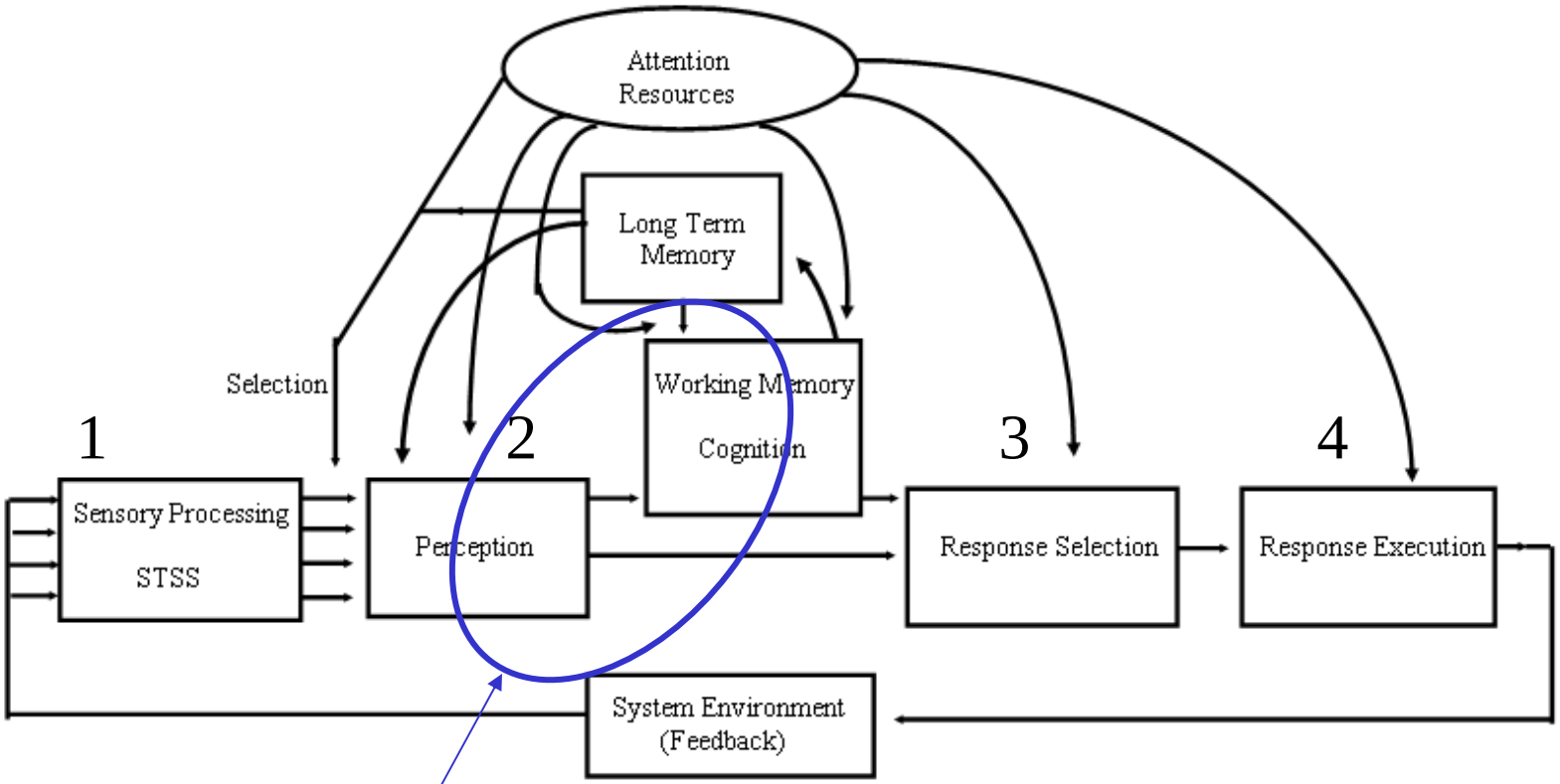
High Level: automation exerts greater authority.

Automation does more “cognitive work”.

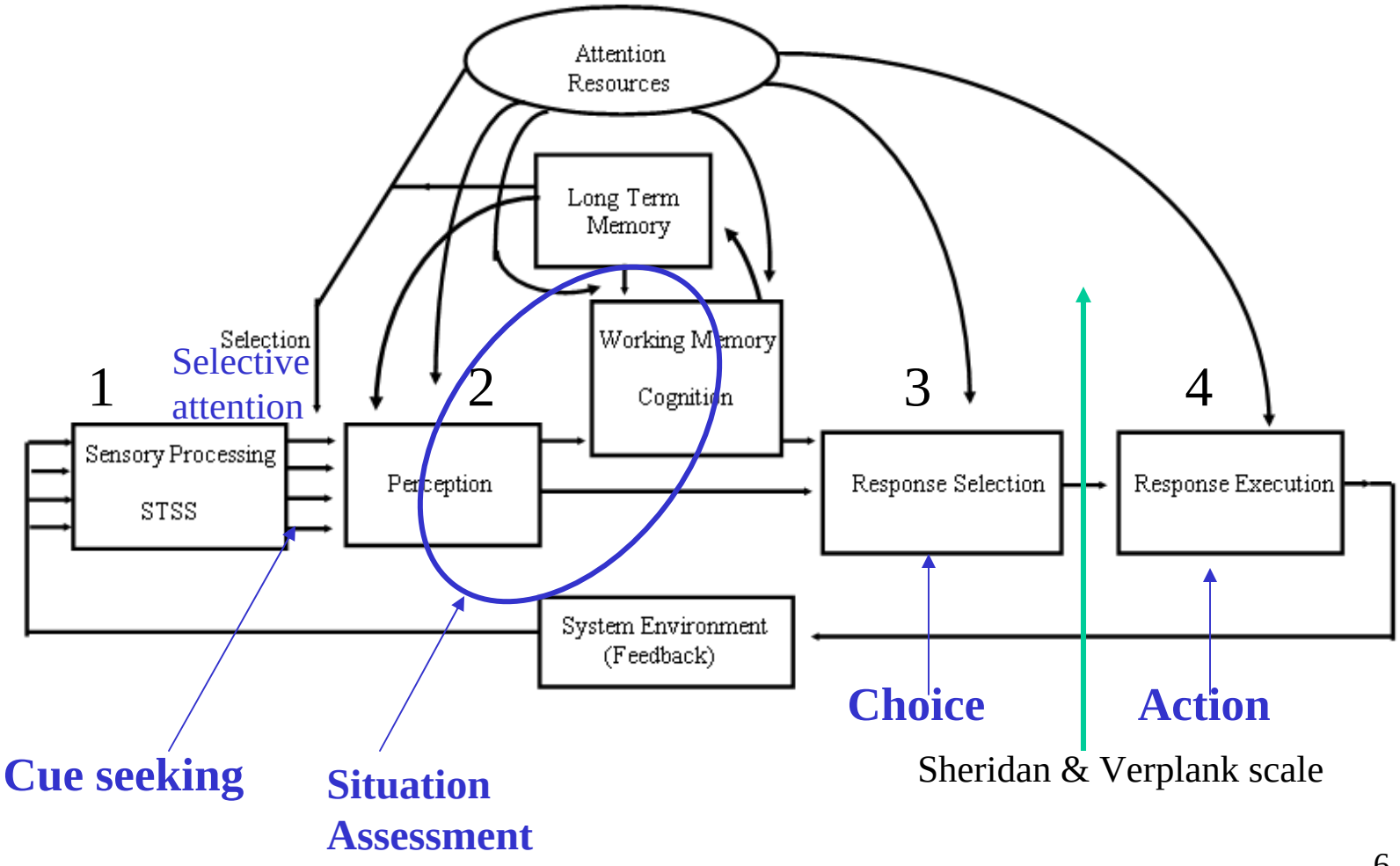
Human does less

Stages: the human information processing model

Stages of automation map to the general 4 stage information processing model. How automation can assist performance at each stage



Mapping Stages of Information Processing to **Decision Support**



An example of automation support for medical decision making

Stage of Decision Automation

1.Cue seeking 2. Situation Assessment 3. Choice

LOA attention guidance **Electronic Medical Records**

High (filtering)

a

Only most important symptom

Lower (highlighting)

a b c d

Print several symptoms.
Highlight most important
(unusual) symptom

Lowest (raw data) map

a b c d

Print all symptoms

Stage of Decision Automation

1.Cue seeking | **2. Situation Assessment** | 3. Choice

LOA attention guidance

High (filtering)

a

Lower (highlighting)

a b c d

Lowest (raw data) map

a b c d

Diagnostic Aid

Patient has Disease X

Rank order with probabilities

Disease X (.60)

Disease Y(.30)

Disease Z (.10)

All plausible diagnoses

Disease X

Disease Y

Disease Z

Stage of Decision Automation

The Sheridan scale

1.Cue seeking

2. Situation Assessment

3. Choice

(Treatment)

LOA attention guidance

High (filtering)

a

Lower (highlighting)

a b c d

Lowest (raw data) map

a b c d

Medication Y

Ordered by preference

1. **Medication Y**
2. **Surgery**
3. **Medication X**

Medication Y

Surgery

Medication X

Stage 4

Automatic drug administration

•A FEW CAVEATS.

•High levels at later stages often assume automation will be high at earlier stages. (If automation recommends a treatment, automation will typically also have made a diagnosis).

•Stages 1 & 2 have in common **signal detection theory** approach to evaluating Automation and automation-human performance: Misses (important event not highlighted or diagnosed) and False alarms (unimportant event highlighted, or the wrong state is diagnosed).

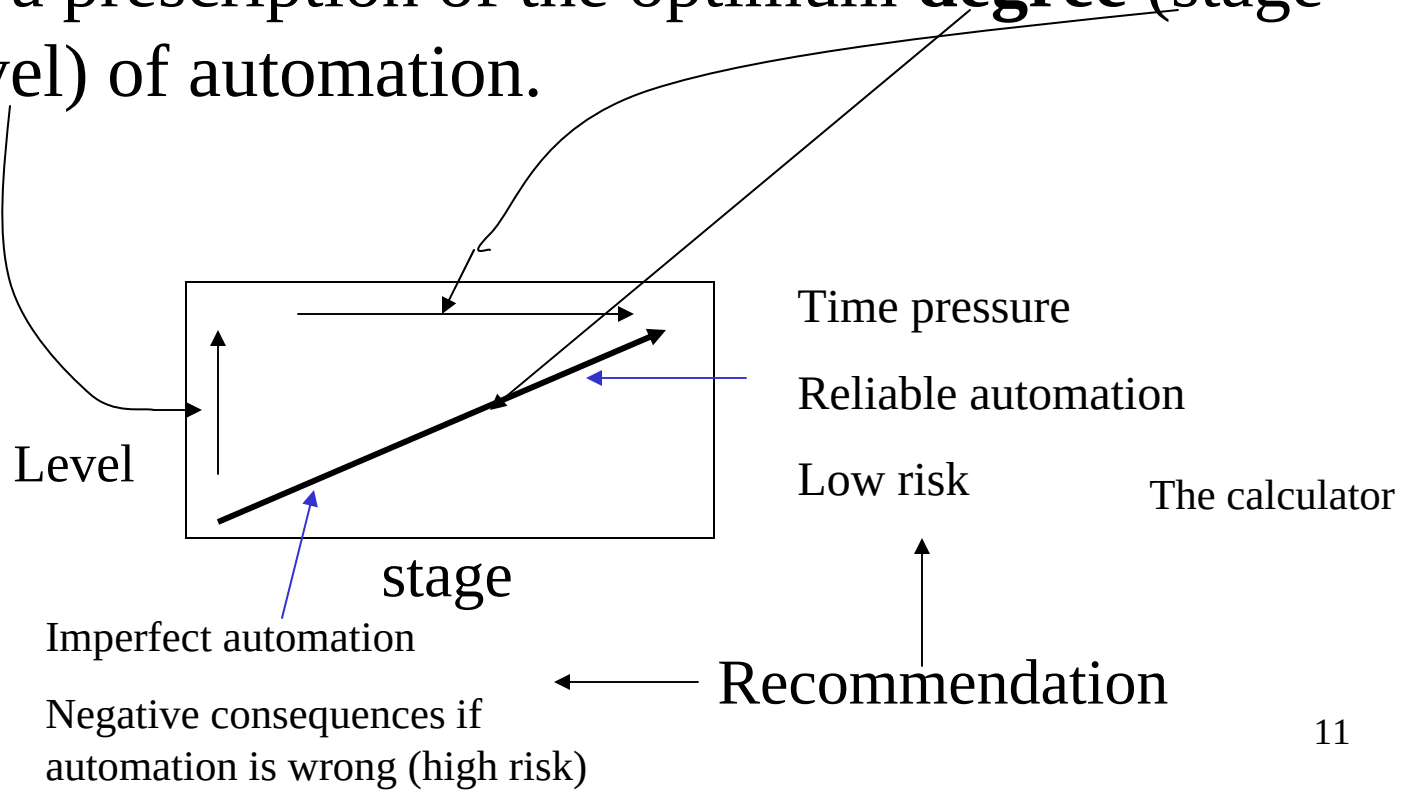
•Stages 2 & 3: contrast: **Status displays** vs **Command displays**

•Taxonomy is applicable in many contexts: ATC conflict alerts vs conflict resolution; pilot hazard displays; battlefield decision aiding; financial advising and stock trading; bank loan lending.

Why does the stages/levels taxonomy matter?

•It helps the designer analyze what automation is doing in human performance terms; where human performance limitations need to be overcome (by higher levels); or strengths can be preserved (by choosing lower levels).

•It can be a prescription of the optimum **degree** (stage and/or level) of automation.



Evidence that later stage is more desirable when automation is right, but more problematic when automation is wrong (imperfectly reliable).

The Sarter and Schroeder smart icing study.

An experimental example: Sarter & Schroeder In flight Icing Effects

Wing versus **Tail Icing**

Symptoms

Situation assessment

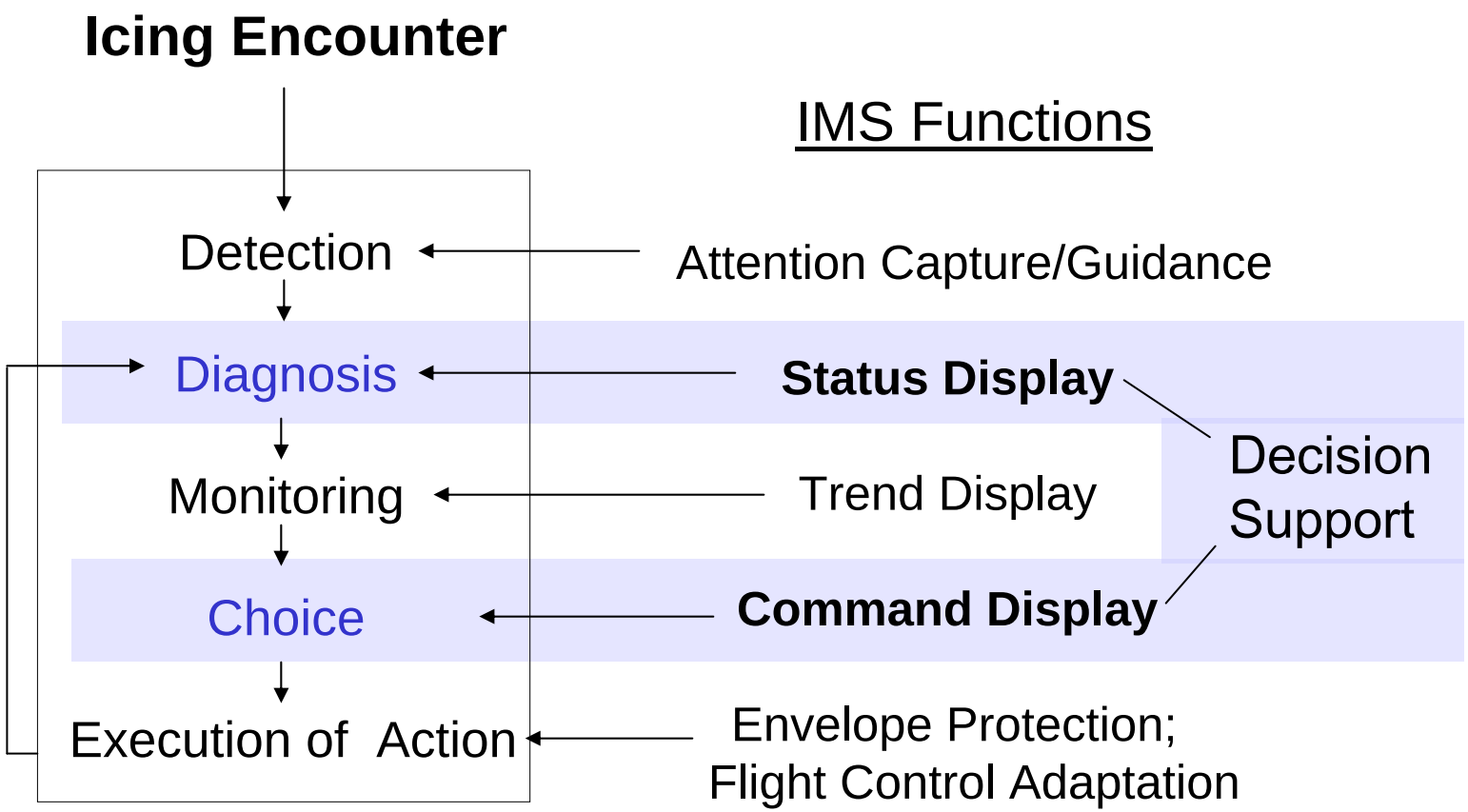
- increase in descent rate
- airframe buffet

- increase in descent rate
- yoke buffet
- forward pull on yoke

Response Choice

- add power
- maintain/extend flaps
- reduce pitch

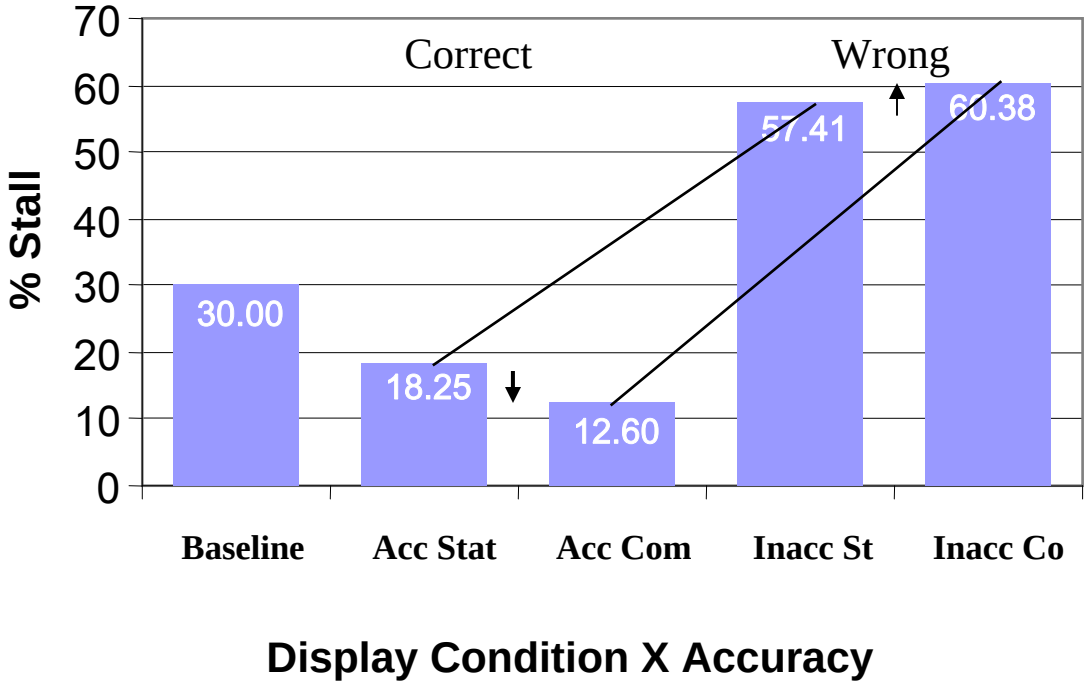
- reduce power
- retract flaps
- increase pitch


Icing Encounter
IMS Functions
Detection
Attention Capture/Guidance
Diagnosis
Status Display
Monitoring
Trend Display
Decision Support
Choice
Command Display
Execution of Action
Envelope Protection;
Flight Control Adaptation

Status display: icing on forward wings

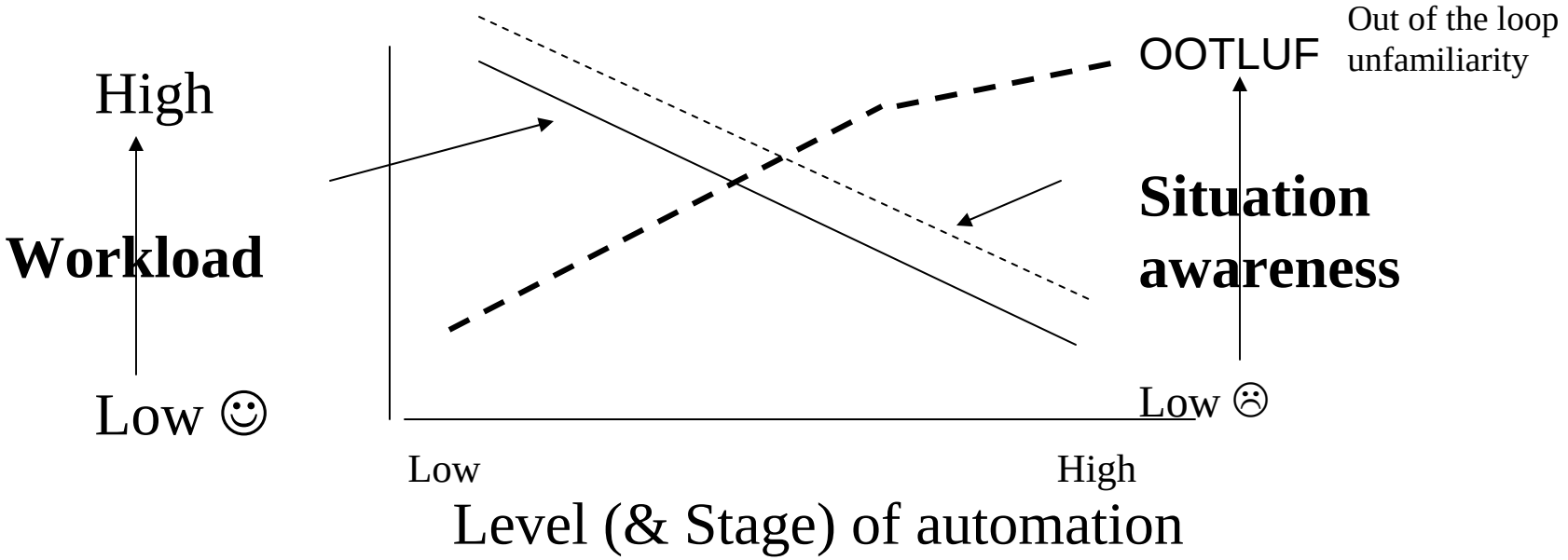
Command Display FOR icing on wings

Stall frequency as function of display condition and accuracy of Imperfectly reliable IMS information



Lower degrees of automation when imperfect and risky.

Why is this recommendation made? The automation-mediated tradeoff between workload and loss of situation awareness



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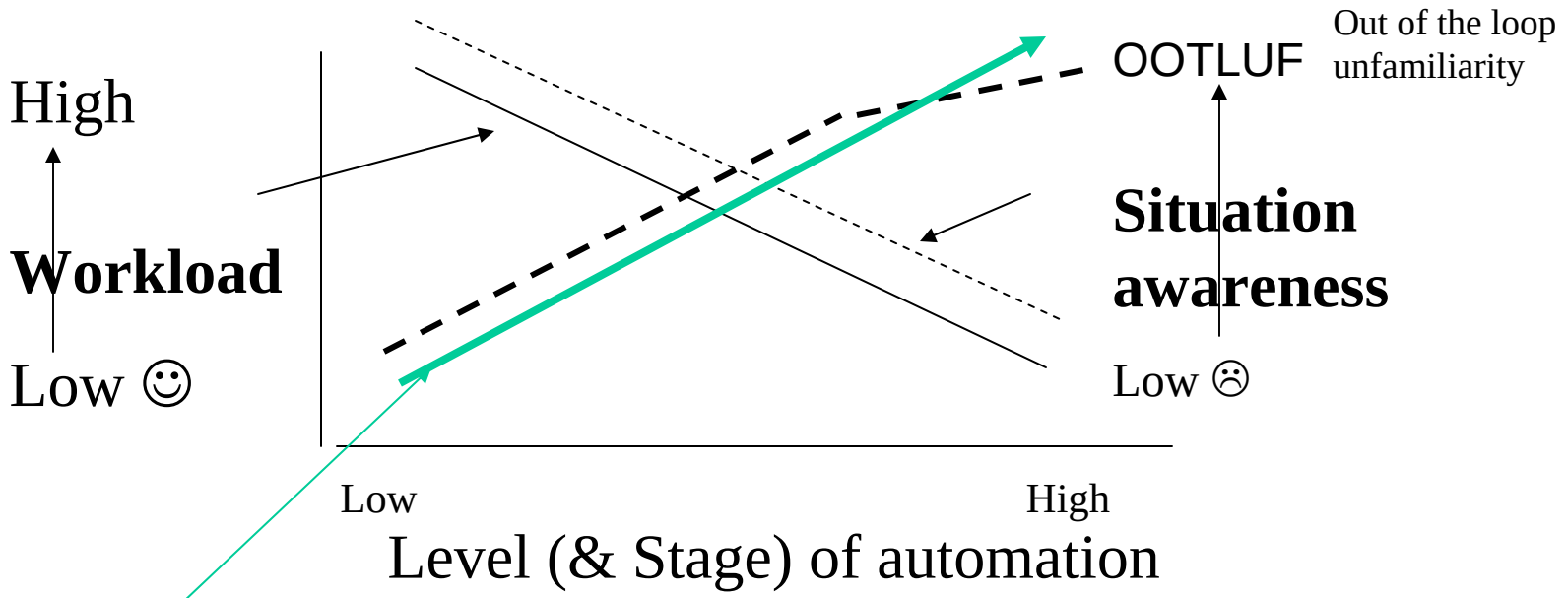
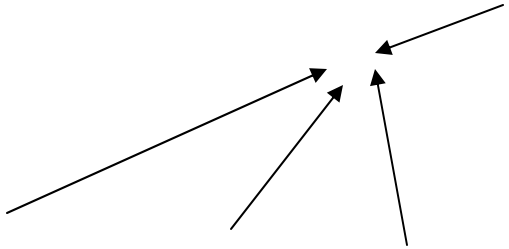


Productivity: **Derivatives: complex financial instruments: "bet on a bet on a bet"**

Dooling: "Only computers can understand and derive a **correlation structure from observed collateralized debt obligation traunch spreads**...how much of the world's financial stability now lies in the "hands' of computerized trading algorithms" [*Rapture of the Geeks: when AI outsmarted I.Q.]*

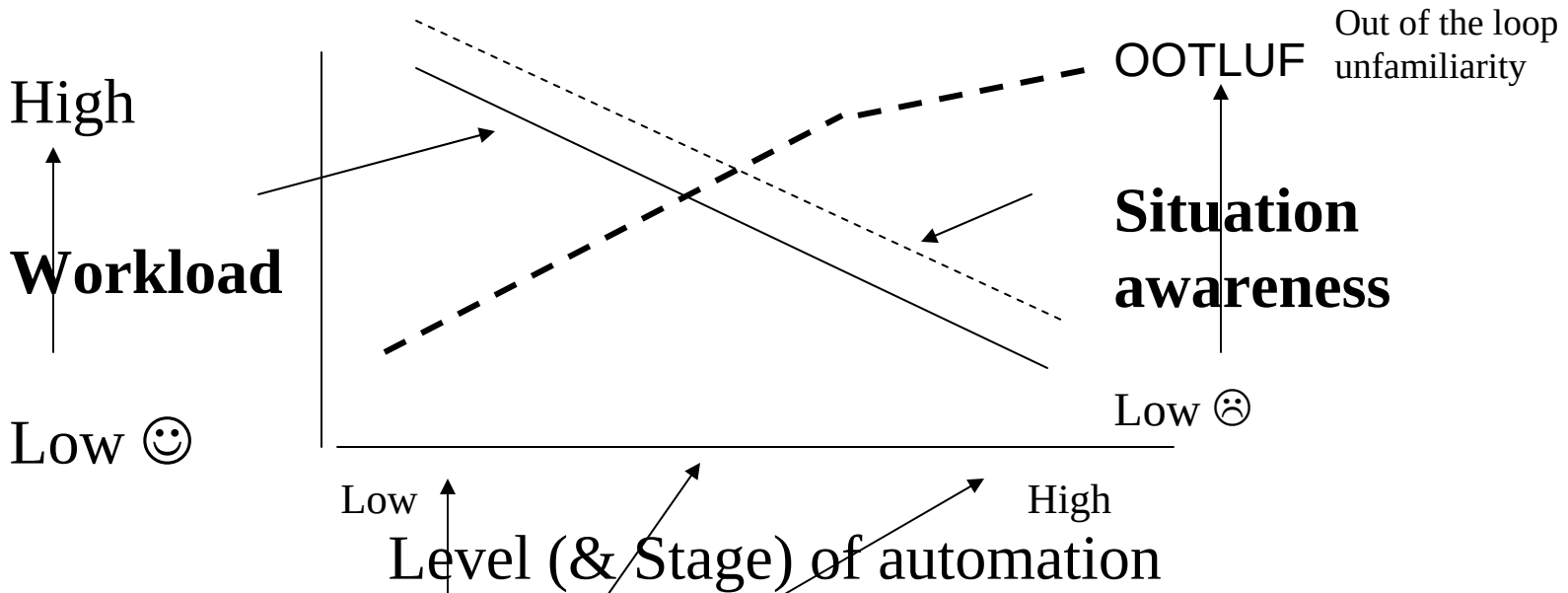
Increasing automation. Why does SA decline?

1. If automation **is** reliable, human stops monitoring the automated processing or the raw data (complacency)
2. If human is not making active choices, but may be passively watching those choices being made, the changing state of automation is less well represented in memory: the **Generation Effect**. Being thus out of the loop, severe consequences when (if) automation "fails" (algorithms cannot handle the input– programmers limitation – or catastrophic failure – loss of power)
3. The more complex and **coupled** the algorithms, the less capable is the human of entering the loop. The story of the Aircraft flight management system (coupling of altitude and thrust– speed); the air traffic control automation conflict resolution advisor: the four plane conflict:



4. And, of course, the complex financial instruments

Balancing tradeoff between workload and Situation Awareness



Where to set it? An "optimal" level **can be** found somewhere in the middle

Conclusion

- Stages and levels taxonomy is a useful extension to guide function allocation.
- A framework for understanding the tradeoff between workload reduction/productivity increase, and loss of situation awareness
- A framework for considering the imperfections (unreliability) of automation.
- Next time: the human factors of high altitude mountaineering.