Human Error, Decision Making and Fatigue

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SHOOS


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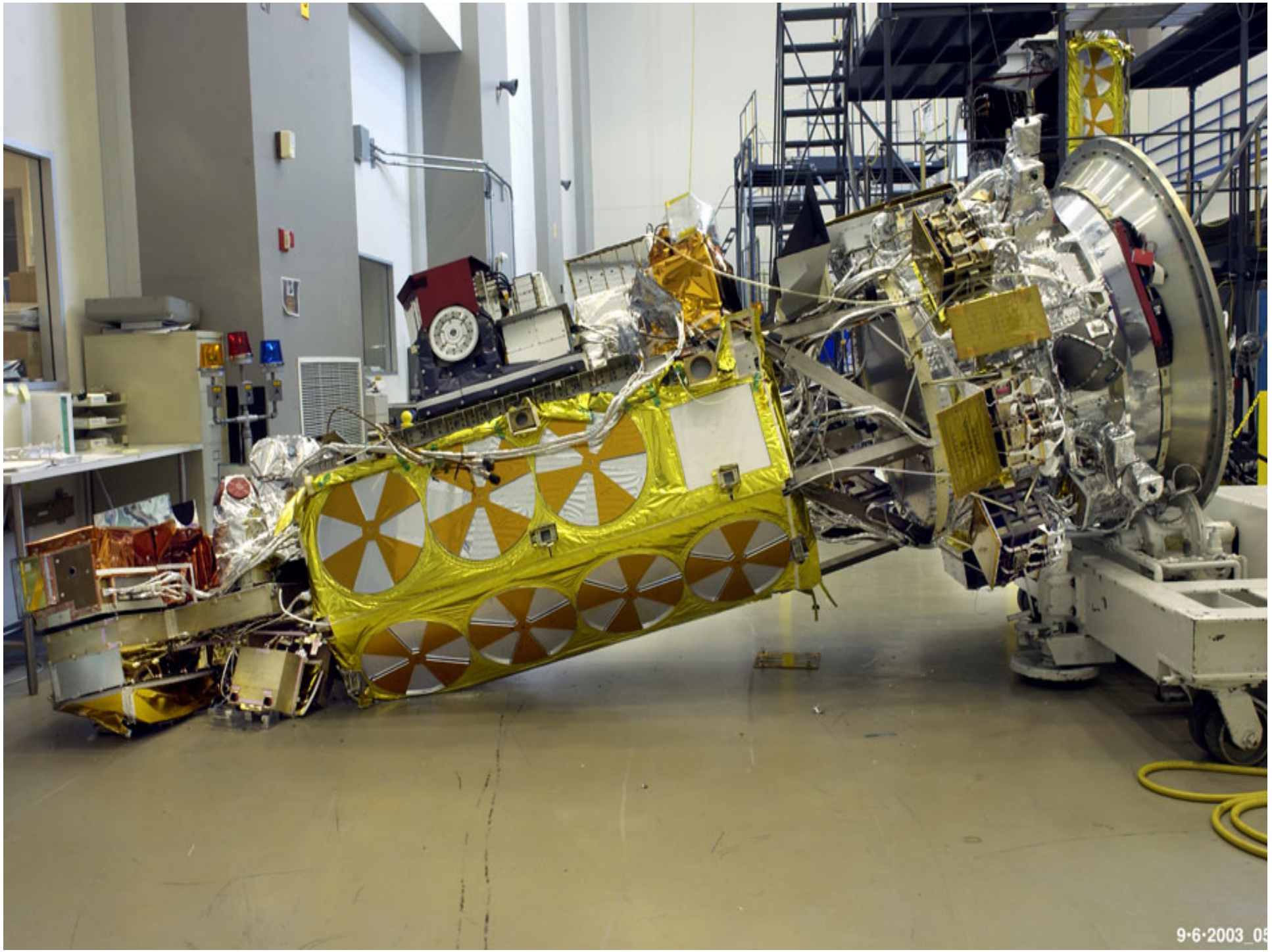
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Introduction: Individual Human Error

- Slips, Lapses and Mistakes.
- Rasmussen: Skill, Rules, Knowledge.
- Reason: Generic Error Modelling.
- Risk Homeostasis..
- Fatigue

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What is Error?

- Deviation from optimal performance?
  - very few achieve the optimal.
- Failure to achieve desired outcome?
  - desired outcome can be unsafe.
- Departure from intended plan?
  - but environment may change plan...

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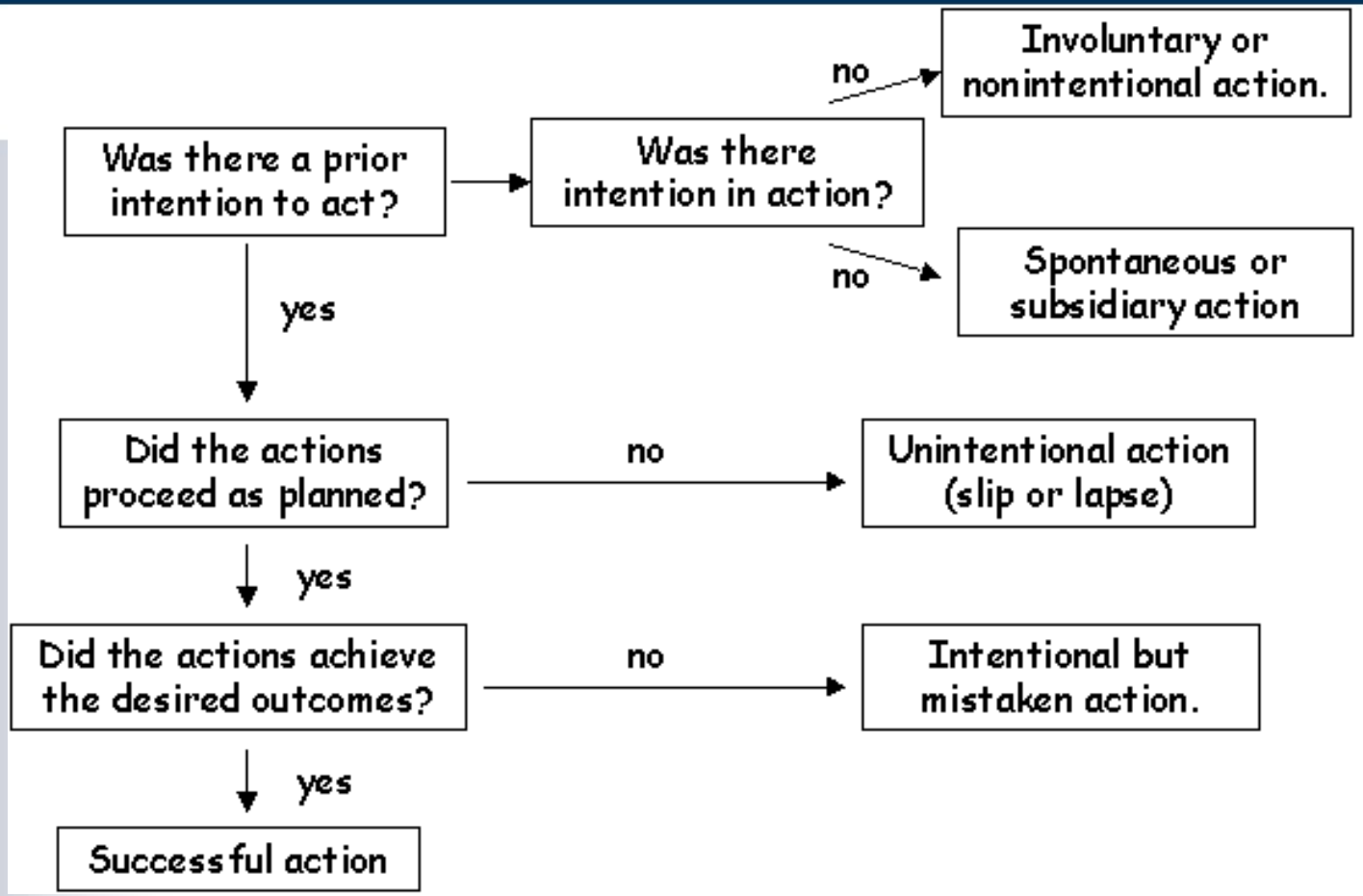
What is Error?



Acknowledgement: J. Reason, Human Error, Cambridge University Press, 1990 (ISBN-0-521-31419-4).

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Types of Errors...

- Slips:
  - correct plan but incorrect action;
  - more readily observed.
- Lapses:
  - correct plan but incorrect action;
  - failure of memory so more covert?
- Mistakes:
  - incorrect plan;
  - more complex, less understood.
- Human error models help to analyse error types.

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Rasmussen: Skill, Rules and Knowledge

- Skill based behaviour:
  - sensory-motor performance;
  - without conscious control, automated.
- Rule based behaviour:
  - stored procedures, induced by experience;
  - Taught problem solving/planning.
- Knowledge based behaviour:
  - in unfamiliar situations, explicit thinking;
  - develop plan, try it and see if it works.

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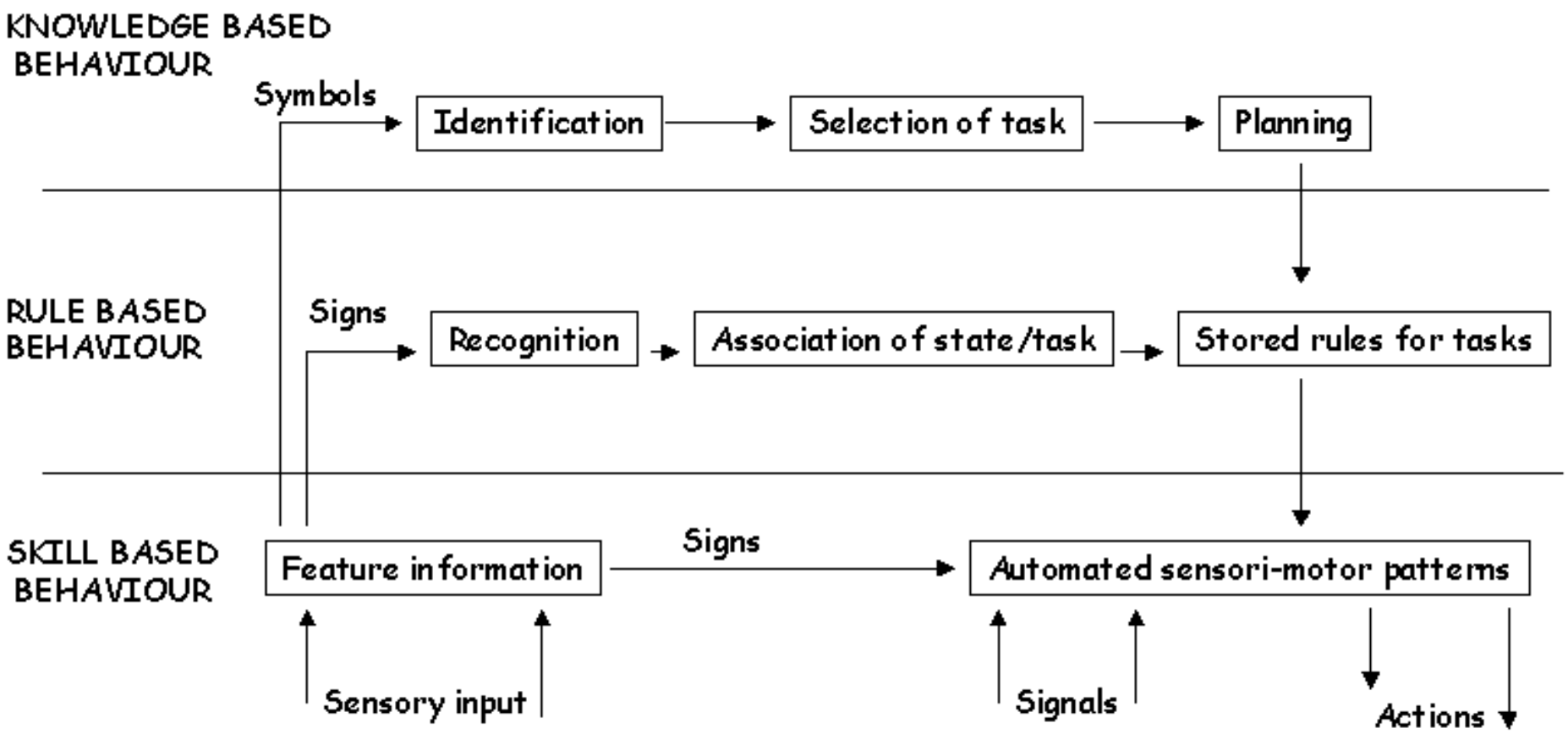
Rasmussen: Skill, Rules and Knowledge



Acknowledgement: J. Rasmussen, Skill, Rules, Knowledge: Signals, Signs and Symbols and Other Distinctions in Human Performance Models. IEEE Transactions on Systems, Man and Cybernetics (SMC-13)3:257-266, 1983.

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Rasmussen: Skill, Rules and Knowledge

- Signals:
  - sensory data from environment;
  - continuous variables, cf Gibson's direct perception.
- Signs:
  - indicate state of the environment,
  - conventions for action;
  - activate stored pattern or action.
- Symbols:
  - can be formally processed;
  - related by convention to state.

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Rasmussen: Skill, Rules and Knowledge

- Skill-based errors:
  - variability of human performance.
- Rule-based errors:
  - misclassification of situations;
  - application of wrong rule;
  - incorrect recall of correct rule.
- Knowledge-based errors:
  - - incomplete/incorrect knowledge;
  - - workload and external constraints...

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Building on Rasmussen's Work

- How do we account for:
  - slips and lapses in SKR?
- Can we distinguish:
  - more detailed error forms?
  - more diverse error forms?
- Before an error is detected:
  - operation is, typically, skill based.
- After an error is detected:
  - operation is rule/knowledge based.
  - GEMS builds on these ideas...

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GEMS: Monitoring Failures

- Normal monitoring:
  - typical before error is spotted;
  - preprogrammed behaviours plus;
  - attentional checks on progress.
- Attentional checks:
  - are actions according to plan?
  - will plan still achieve outcome?
- Failure in these checks:
  - often leads to a slip or lapse.
  - Reason also identifies Overattention failures.

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GEMS: Problem Solving Failures

- Humans are pattern matchers:
  - prefer to use (even wrong) rules;
  - before effort of knowledge level.
- Local state information:
  - indexes stored problem handling;
  - schemata, frames, scripts etc.
- Misapplication of good rules:
  - incorrect situation assessment\over-generalisation.
- Application of bad rules:
  - - encoding deficiencies/action deficiencies.

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GEMS: Knowledge-Based Failures

- Thematic vagabonding:
  - superficial analysis/behaviour;
  - flit from issue to issue.
- Encysting:
  - myopic attention to small details;
  - meta-level issues may be ignored.
- Reason:
  - individual fails to recognise failure;
  - does not face up to consequences.

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GEMS: Failure Modes and the SKR Levels

Skill-based performance

Inattention
Double-capture slips
Omission following interruptions
Reduced intentionality
Perceptual confusion
Interference Errors

Overattention
Omissions
Repetitions
Reversals

Rule-based performance

Misapplication of good rules
First exceptions
Countersigns and non-signs
Information overload
Rule strength
General rules
Redundancy
Rigidity

Application of bad rules
Encoding deficiencies
Action deficiencies
- wrong rules
- inelegant rules
- inadvisable rules.

Knowledge-based performance

Selectivity
Workspace limitations
Out of sight, out of mind
Confirmation bias
Overconfidence
Biased reviewing
Illusory correlation

Halo effects
Problems with causality
Problems with complexity
- delayed feedback
-insufficient consideration of processes in time.
- difficulties with exponential change
- thinking in causal series not nets
- thematic vagabinding
-encysting

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GEMS: Error Detection

- Cant eliminate errors, focus on detection.
- Self-monitoring:
  - correction of postural deviations;
  - correction of motor responses;
  - detection of speech errors;
  - detection of action slips;
  - detection of problem solving error.
- How do we support these activities?
  - standard checks procedures?
  - error hypotheses or suspicion?
  - use simulation based training?

GEMS: Error Detection

- Cognitive barriers to error detection.
- Relevance bias:
  - cannot consider all evidence, confirmation bias.
- Partial explanations:
  - make hypothesis fit the evidence?
  - Revise hypothesis as evidence changes?
- “Disguise by familiarity“”.

Risk Homeostasis Theory

- What if we introduce safety features?

"Each road user has a target (or accepted) level of risk which acts as a comparison with actual risk.W here a difference exists, one may move towards the other. Thus, when a safety improvement occurs, the target level of risk motivates behaviour to compensate - e.g., drive faster or with less attention. Risk homeostasis theory (RHT) has not been concerned with the cognitive or behavioural pathways by which homeostasis occurs, only with the consequences of adjustments in terms of accident loss."

T.W. Hoyes and A.I. Glendon, Risk Homeostasis: Issues for Further research, Safety Science, 16:19-33, (1993).

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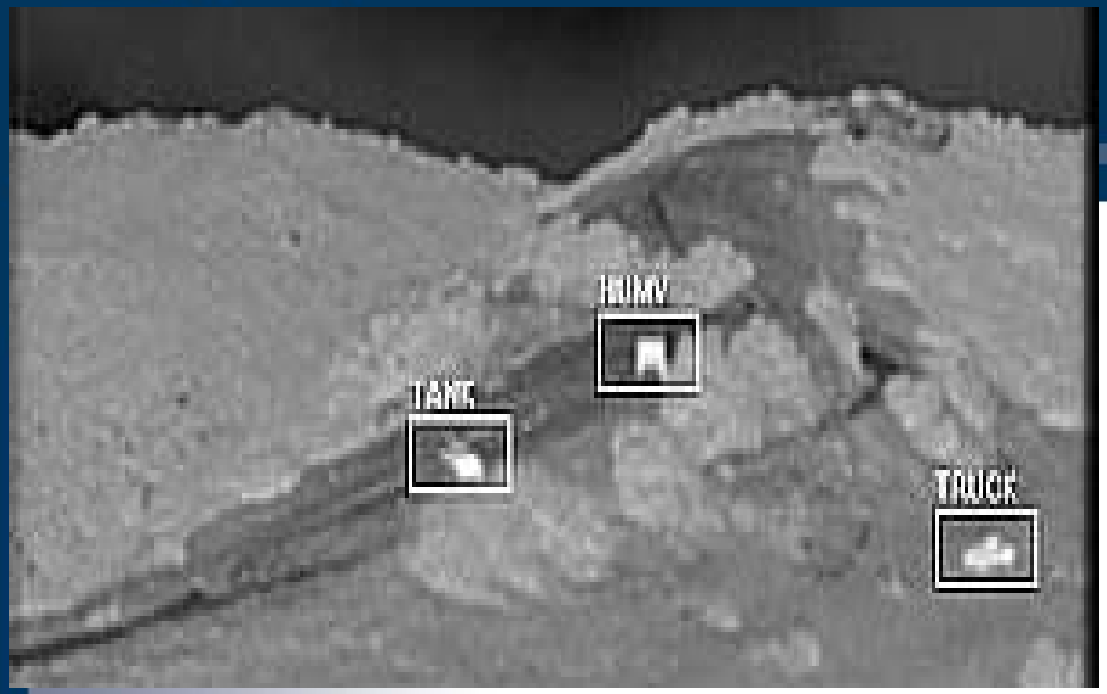
Risk Homeostasis Theory

- Very contentions.
- Bi-directionality?
  - what if safety levels fall
  - will users be more cautious?
- Does it affect all tasks?
- Does it affect work/leisure?
- How do we prove/disprove it?
  - unlikely to find it in simulators.

70% of military accidents occur in darkness.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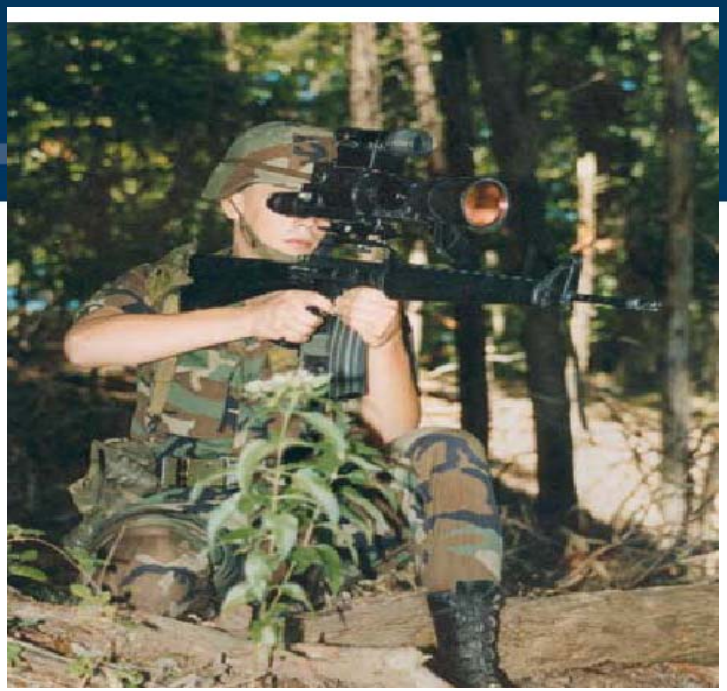

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Introduction to Fatigue and Error

- Factors influencing Fatigue:
  - Circadian rhythms; heat; noise; task profile.
- Consequences of Fatigue:
  - Loss of self awareness; lapses; false responding;
  - loss of situation awareness; risk & decision making.
- Countermeasures for Fatigue:
  - restorative sleep, motivation and task rotation;
  - monitoring; drugs, technology.

Fatigue and Systemic Interactions

- USM985 Heavy Expanded Mobility Tactical Truck:
  - Driver spent day preparing for night time 73-vehicle convoy.
  - Few opportunities to rest, join marshaling at 21:30 using Night Vision Goggles
  - At 02:30, some drivers fell asleep in halt for refueling, gaps in the convoy.
  - Truck drives off left side of a tank trail, turned over in stream drowning driver.

- Investigation argues incident caused by inadequate risk assessment:
  - ORGANISATIONAL: commander pass responsibility for rest to squad leaders;
  - TACTICAL: They did not review rest patterns on the day before the accident;
  - HUMAN FACTORS: Lack of sleep contributed to poor driver judgment;
  - TECHNOLOGICAL: Compounded by the demands of using NVGs.

US Army Helicopter Crew

- Day One:
  - By 16:00 preflight inspection for carrier op but told to return to home
  - By 00:30 ready to deploy told to sleep but stressed, managed 1 hour;
  - By 0500 back at base for fixed wing deployment then threat briefing.
- Day Two:
  - By 24:00, moved on transport aircraft to forward staging base.
  - By 02:30 they arrived to unload and prepare their aircraft.
  - By 06:00 pilot andcolleagues were waiting for clearance to takeoff.
- “I collapsed in exhaustion.

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Factors Influencing Fatigue

Circadian Rhythms

US Marine, Falluja

- Alertness, behavior and mood:
  - Need sleep most 3:00-5:00 & 15:00-17:00.
  - Most alert 09:00-11:00 and 21:00-23:00.
- Takes 3+ weeks to:
  - adjust to a new time zone or
  - adapt to a new shift pattern
- Period of adjustment influenced by:
  - degree of disruption;
  - external factors, including exposure to light.
- Tactics exploit opposition rhythms…

Fatigue and Environment

- Noise, vibration, time-stress, exacerbate fatigue.
- UK and US in relatively hot environments.
- Sleep patterns don’t improve if heat disrupts rest.
- Environment increases boredom of repetitive tasks.
- Convoy drivers, Kevlar helmets and body armor.

Fatigue and Environment

- Canadian reservist:
  - worked all day before move to exercise area;
  - training to 24:00, assigned Picket 03:00-04:30;
  - Superior requested she be rested, overruled.
- Could not sleep after duty - noise from Armory.
- Woken at 05:00, hour later fell asleep driving truck.
- Incident illustrates:
  - difficulty of sleeping in operations.
  - role of leaders in fatigue; superior over-ruled.

USMC Resting in Iraq – hole dug for comfort

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Consequences of Fatigue

325th Airborne Infantry Regiment, 82nd Airborne Division asleep on barge off Kuwait following training exercise.

Loss of Self Awareness

- High subjective assessments of ‘sleepiness’:
  - associated with poorer performance (How).
- Itoi et al use sleep-deprived participants;
  - likelihood (0-100%) to fall asleep in 2-minutes;
  - when they did fall asleep mean estimate 55%;
  - didnt think they would fall asleep as they did!
- Hard for military to assess level of fatigue:
  - especially as they become increasingly tired.

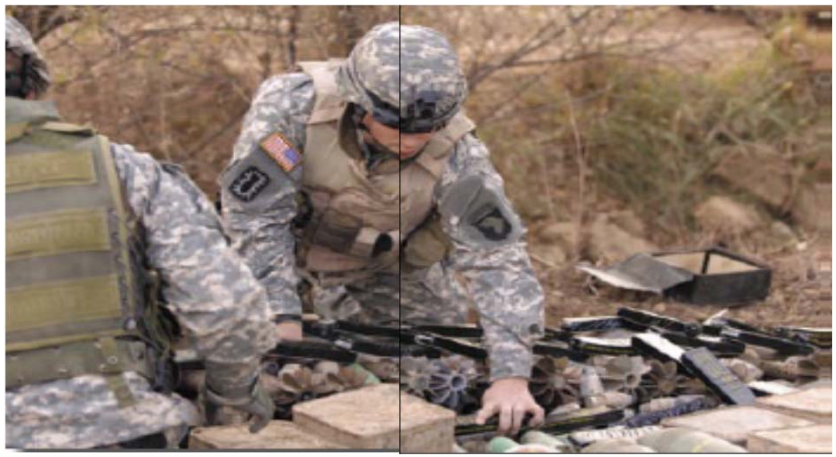
Restorative Sleep

- US Army FM22-51 ‘sleep discipline’
  - 6 to 8 hours sleep when possible;
  - 4 uninterrupted or 5 interrupted per 24 hrs;
  - wartime 12hr shift too long for some tasks;
  - shorter shifts create handover problems.
- ‘NASA nap’.
  - astronauts maintain high levels of performance in long-duration space flights;
  - normal sleep patterns might become divorced from the usual circadian rhythms;
  - 40 mins but not within 4hrs of sleep cycle.

Restorative Sleep

- Nutrition and lifestyle:
  - important for personnel to ‘switch off’ when they do get chance to rest;
  - especially if stimulants used to reduce impact of fatigue;
  - carbohydrates and sugary foods can induce sleep;
  - Small meals rich in protein provide stop-gap measures to fight off fatigue;
  - Exercise and hydration also important in managing boredom and fatigue.

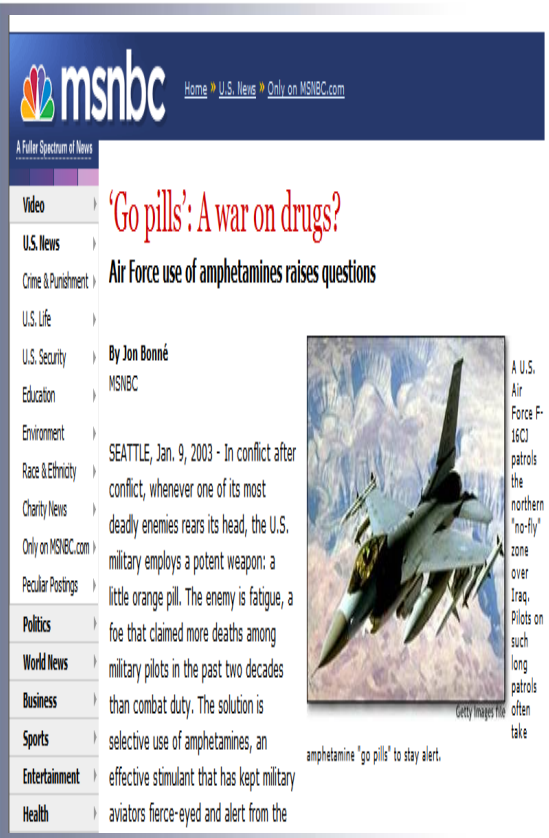
- Restorative sleeps AND task prioritization, workload, nutrition, exercise...



Monitoring

- Colleagues notice symptoms of fatigue:
  - Physiological, drooping eyelids, yawning;
  - Psycho-social, irritability and forgetfulness;
  - Dangerous countermeasures…
- US Marines leave base around 00:45:
  - 20 mins later, driver asleep, car rolled.
- “With both passengers asleep in the rear seat, no one noticed driver was getting drowsy. Despite late hour, no buddy system was in place.’
- Irritating if someone keeps you awake:
  - Persistent interruptions lead to errors?

Drugs



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'Go pills': A war on drugs?

Air Force use of amphetamines raises questions

By Jon Bonné
MSNBC

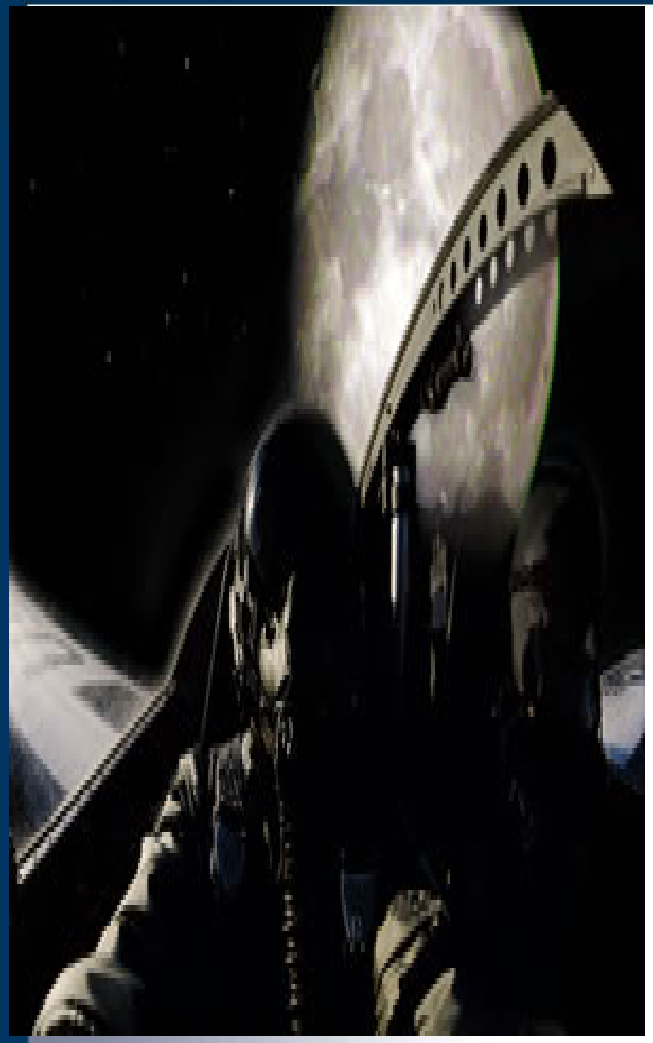
SEATTLE, Jan. 9, 2003 - In conflict after conflict, whenever one of its most deadly enemies rears its head, the U.S. military employs a potent weapon: a little orange pill. The enemy is fatigue, a foe that claimed more deaths among military pilots in the past two decades than combat duty. The solution is selective use of amphetamines, an effective stimulant that has kept military aviators fierce-eyed and alert from the

A U.S. Air Force F-16CJ patrols the northern "no-fly" zone over Iraq. Pilots on such long patrols often take amphetamine "go pills" to stay alert.

Getty Images file

- Drugs that promote sleep should have immediate effect
  - no 'hangover' if rest interrupted for operational reasons.
- 20mg, twice recommended dose, of zolpidem:
  - improves restorative sleep under field conditions;
  - No large scale trials on side-effects but limited use only.
- 0.5mg, twice recommended dosage, of triazolam:
  - did not improve daytime sleeping of troops;
  - flight from US to Europe during Operation Bright Star.
  - Mental tasks impaired up to 8 hours after administered.
- 0.5mg and 0.25mg doses of triazolam:
  - Ranger rifle platoons improved sleep in the cold;
  - Only 0.5mg impaired performance after 4 hours;
  - After 24, 0.25mg group better mental tests that control;
  - Soldiers fell asleep before getting into sleeping bags.

Drugs



- Stimulants provide short relief from symptoms of fatigue.
- Caffeine is best used for periods of up to 40 hours:
  - 200mg required, depending on background tolerance;
  - coffee (100-175mg cup), soft drinks (31 mg),
  - tea (40 mg), tablets (65 mg)
  - only stimulant for flight crews without prior approval.
- US Air Force & Army dextroamphetamine:
  - for some prolonged operations;
  - improves perceived energy levels, vigor, and alertness;
  - Impairs sleep so must be avoided in 4 hrs of sleep.
- US Army and Air Force Exchange Service (AAFES):
  - banned products containing ephedra;
  - Heart attacks and heat-related injury during physical training
  - US AHRQ yet to identify causal link with ephedra.

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Conclusions: Individual Human Error

- Slips, Lapses and Mistakes.
- Rasmussen: Skill, Rules, Knowledge.
- Reason: Generic Error Modelling.
- Risk Homeostasis.
- Fatigue.

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Any Questions…