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Using the Human Performance Envelope to inform Future Trajectory Based Operations

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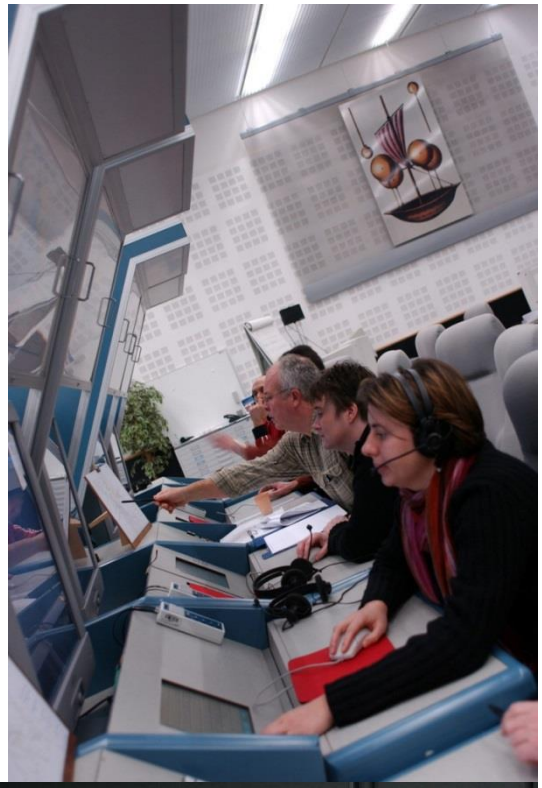
Agenda

- Human performance envelope?
- Summary of concept development
- Behavioural markers of the edge of performance
- Current research: Application of HPE to Trajectory-based operations
- Work Programme
- Conclusions

Human Performance Envelope

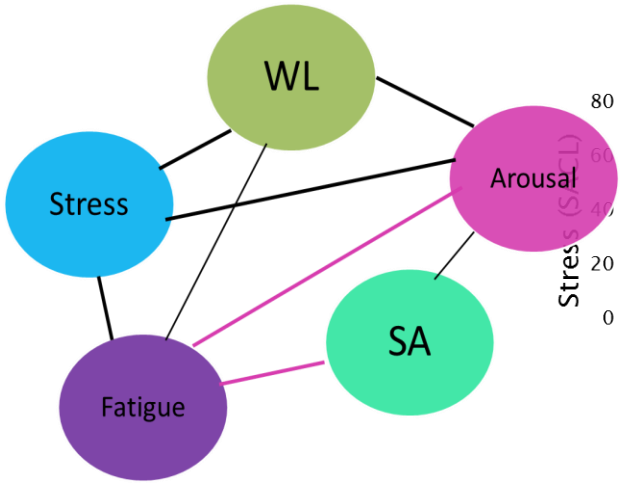
Motivation

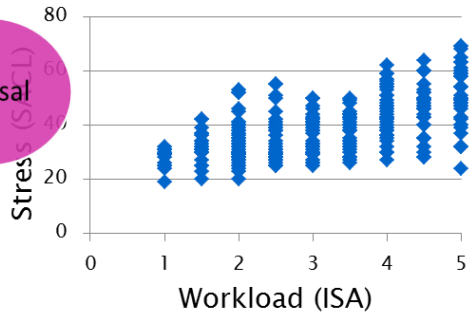
- ATM is an ‘ultra-safe’ industry
- ATM remains highly ‘human-centric’ – real-time operations
- Mitigations defend against incidents, but still occur
- Need to know when controllers are approaching the edges of acceptable performance

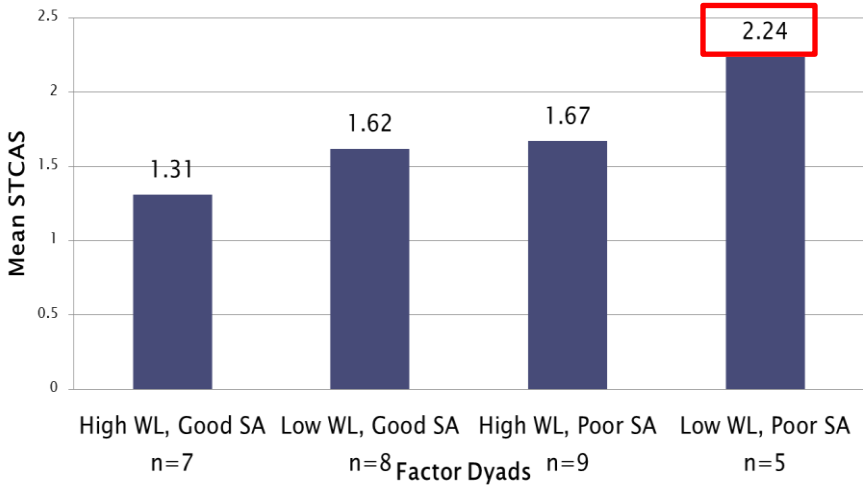


Concept development

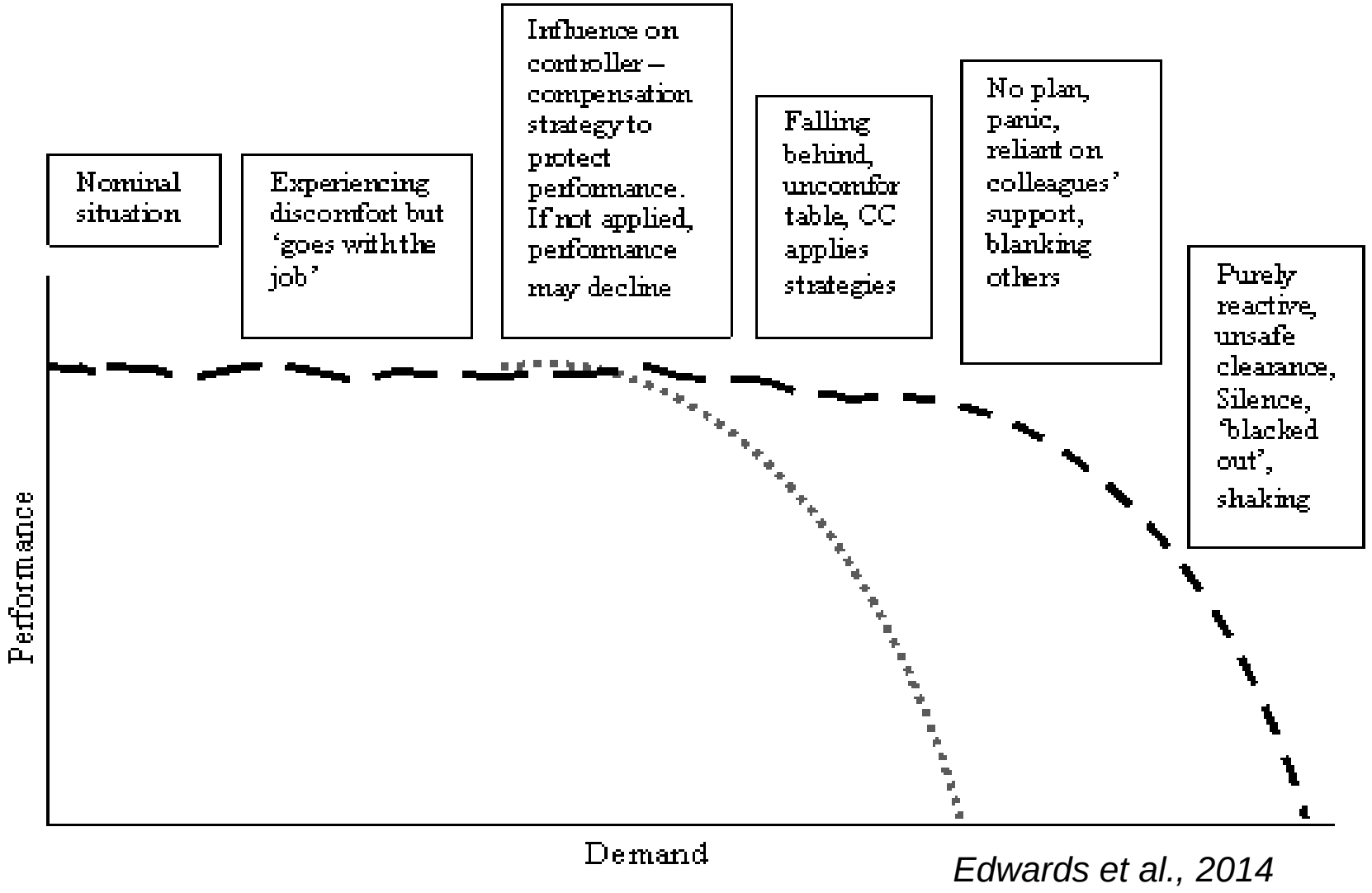
- Factor identification
  - 9 key factors in ATC
- Exploration of factor interactions and performance







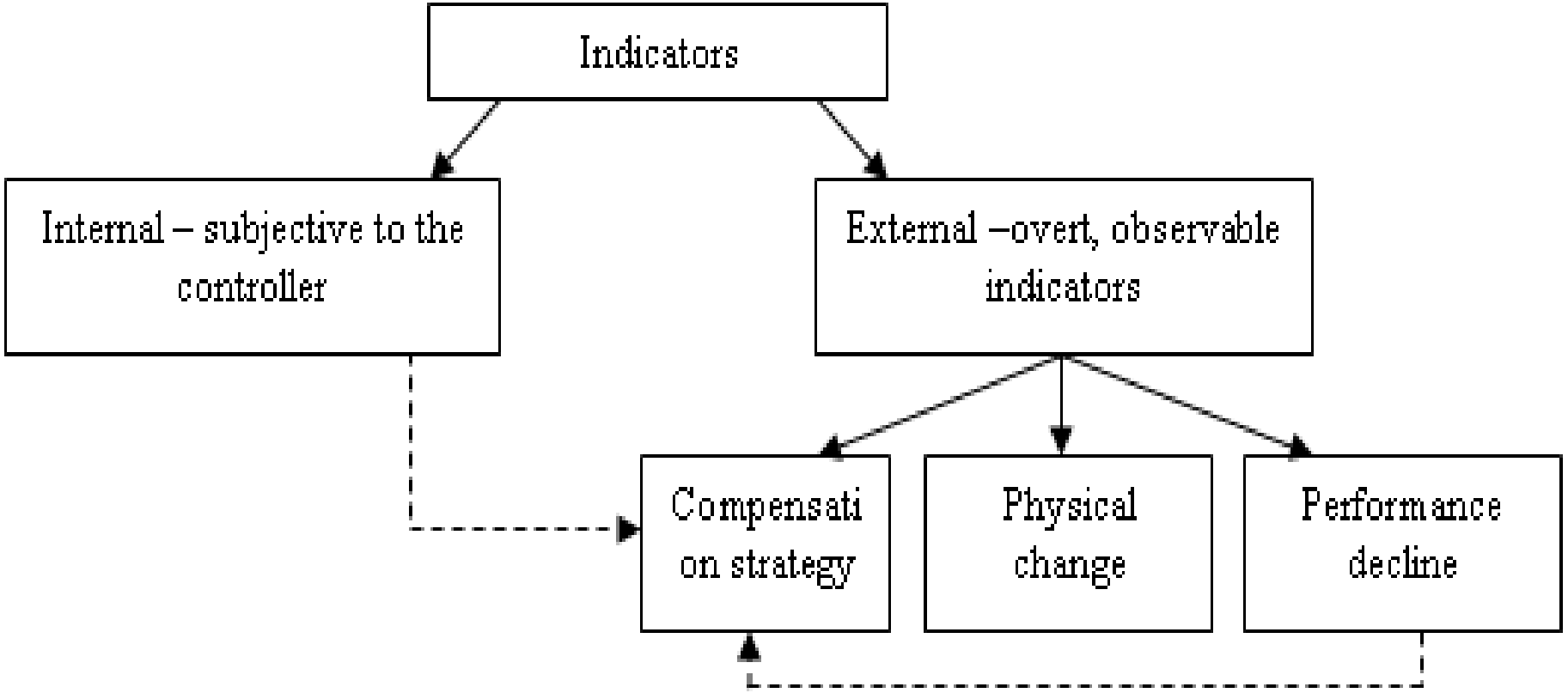
Edge of the envelope: The performance curve



Edwards et al., 2014

Behavioural markers of degrading performance

Markers are used to indicate edges of performance



Markers of workload

- Low workload:

Category	Internal Marker
Cognitive changes	Pay less attention
	Easily distracted
	Reduced self-awareness
Changes to control	Leave situations develop
	Trying to create more complex situations
	Less safety buffer
Subjective feeling	Boredom
	Relaxed

Proposed category	External Marker
Perception changes	Incorrect assessment of a situation
Visible cues	Sit back in chair
	Away from radar screen
	Talking to colleague
Performance changes	Overlooking aircraft
	Forgetting aircraft
	Repeated ‘sloppy’ mistakes
	Fall behind traffic due to distraction

Markers of fatigue

Markers internal to the controller

Cognitive changes	Subjective experience
Concentration issues	More effort to control
Increased assumptions	Don't want to work busy traffic
Slower	Force self to pay attention
Mild confusion	Feel tired
Reduced awareness	Not looking forward to shift

Observable markers

Visible cues	Demeanour
Yawning	Less active
Laid back	Not as confident
Eyes closed	Quieter
Falling asleep	Distracted

Style of control	Performance
Less flexible	Overlook aircraft
Reduction in efficiency	Multiple, small mistakes
Less safety buffer	'Running behind traffic'
Incorrect plan	Slow to solve problems
Slower communications	Forget aircraft

Markers of losing the picture

- Differentiation between markers that indicate losing the picture, and having lost the picture:

"It starts off by just falling behind a bit. So you might just be a few steps behind what you're supposed to be doing and if that builds up too much then you will get to the point where you start to lose the picture"

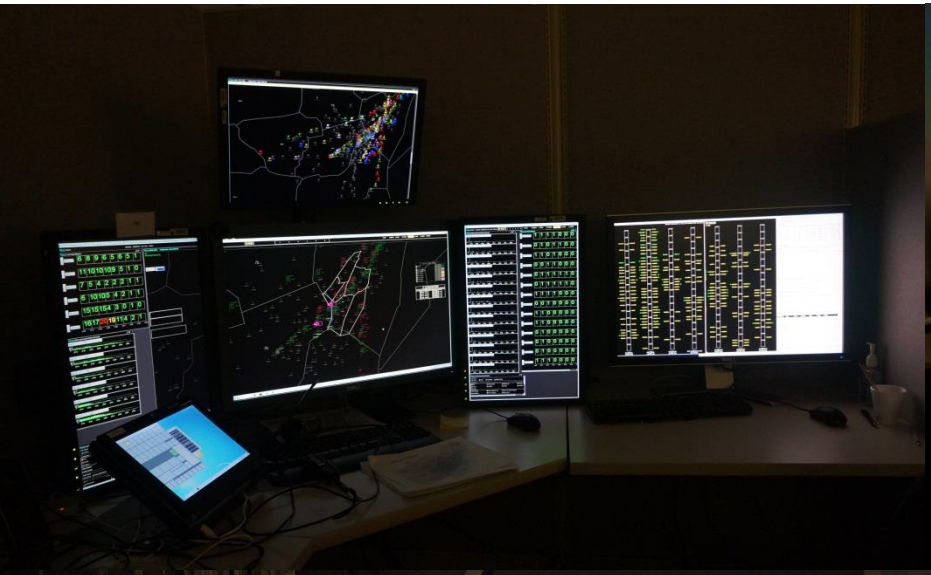
Category	Internal Marker
Cognitive changes	Difficulty selecting priorities
	Thinking whilst giving the clearance
	Tunnel vision/hearing
Subjective feeling	Under confident

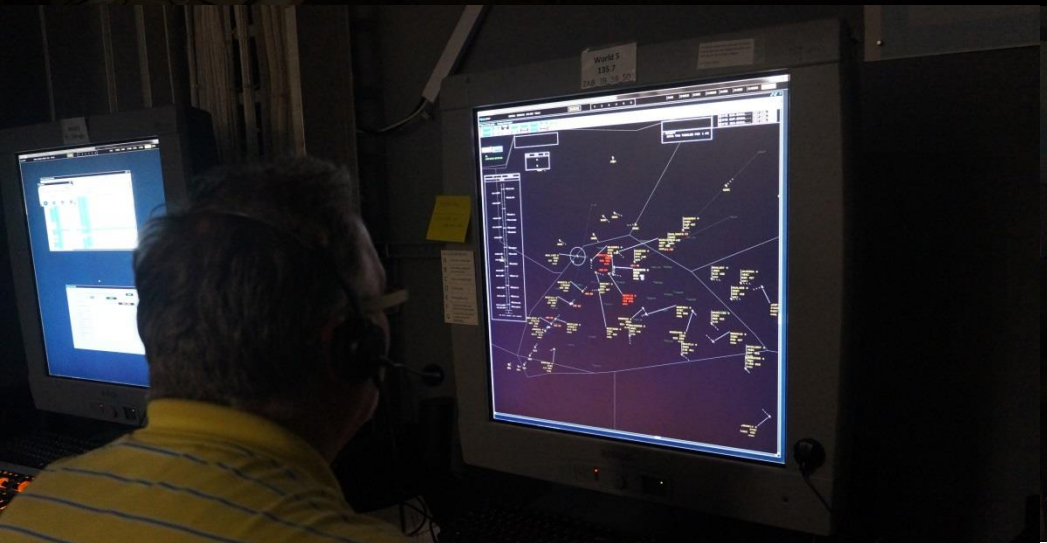
Category	External Marker
Visible cues	Slow at task
Performance changes	Running behind
	Time working ahead degrades
	Missing calls

Summary of HPE findings

- Factors that influence controller performance (e.g. workload, fatigue) co-vary and appear to interact to create cumulative effect on performance
- Markers can indicate when controllers are reaching performance limits
- Findings support a shift towards research investigating multi-factor co-occurrences and performance associations

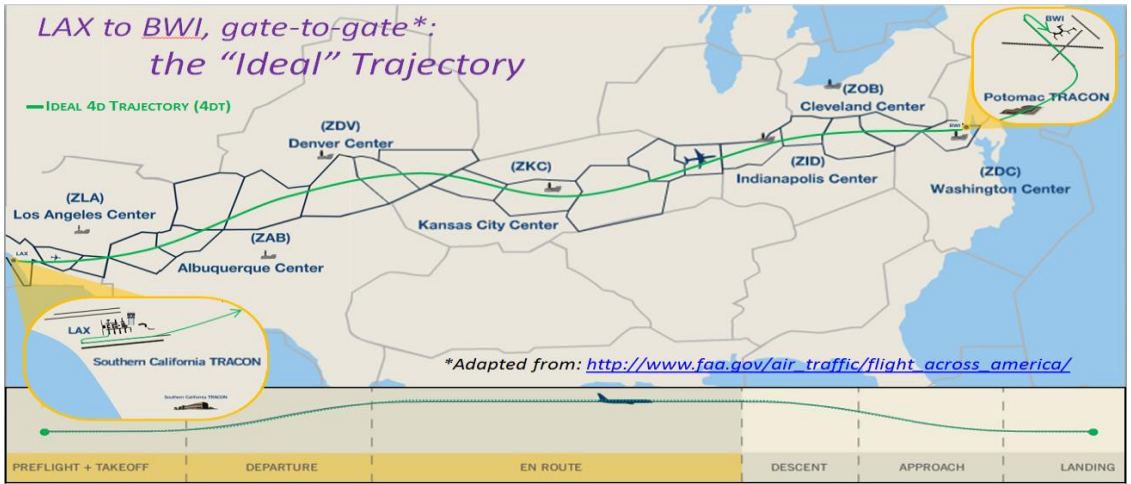
Graceful degradation in TBO: Using the HPE to inform research





Trajectory-based operations

- In order for the TBO concept to be realized, there will be a "fundamental shift in ATM" (FAA, 2014):
  - Narrower tolerances (FAA, 2014)
  - More precise trajectories
  - Strategic vs tactical
- System resilience is critical
  - TBO system must be able to gracefully degrade to maintain safe operations
- Knowledge of the causes and mitigations of degradation in TBO must be understood



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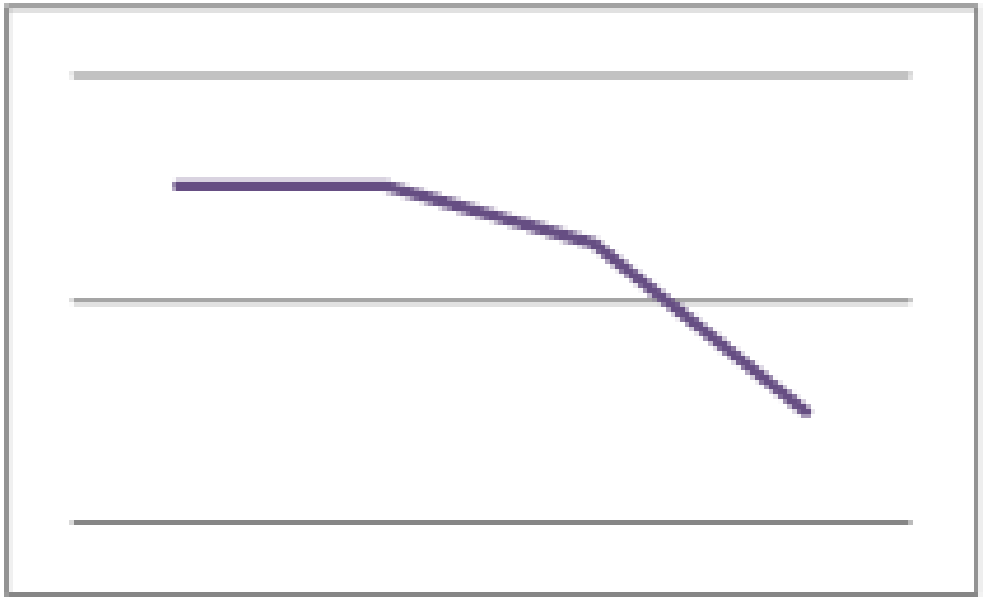
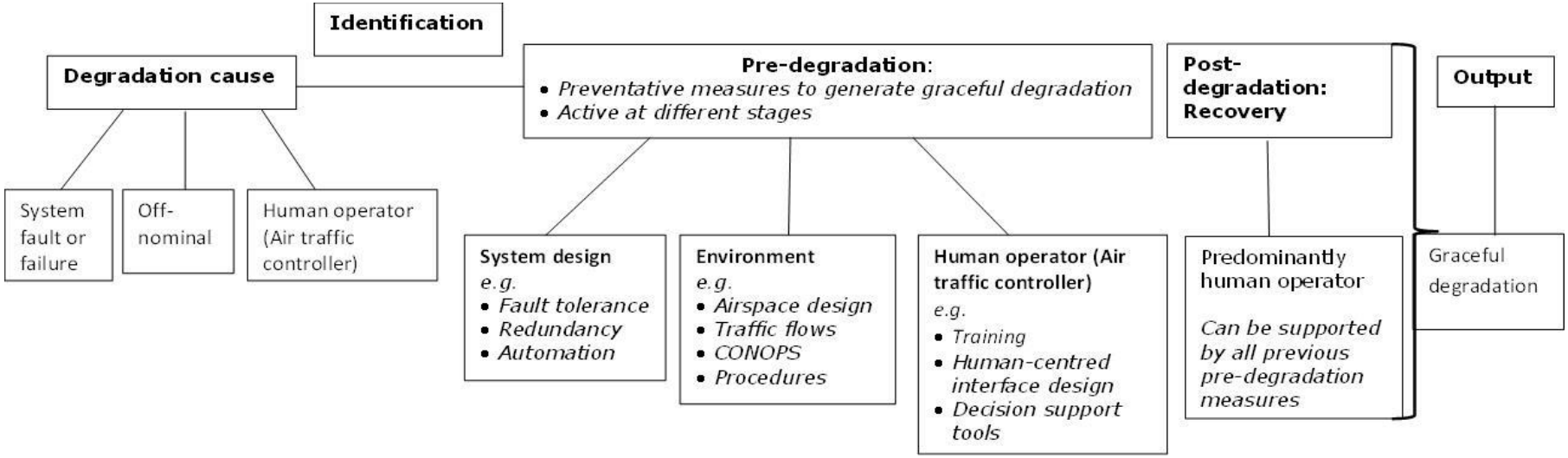
Brittle systems vs graceful degradation

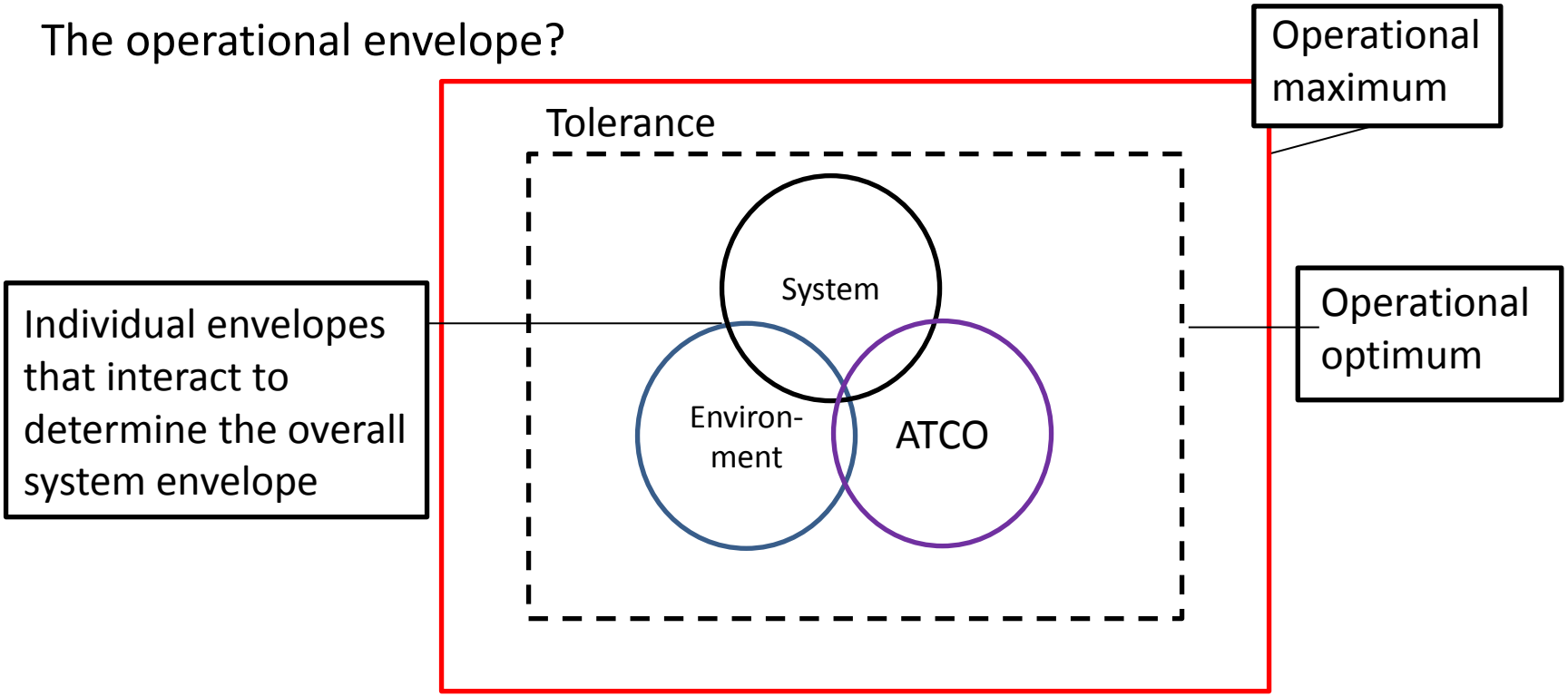


Framework of graceful degradation



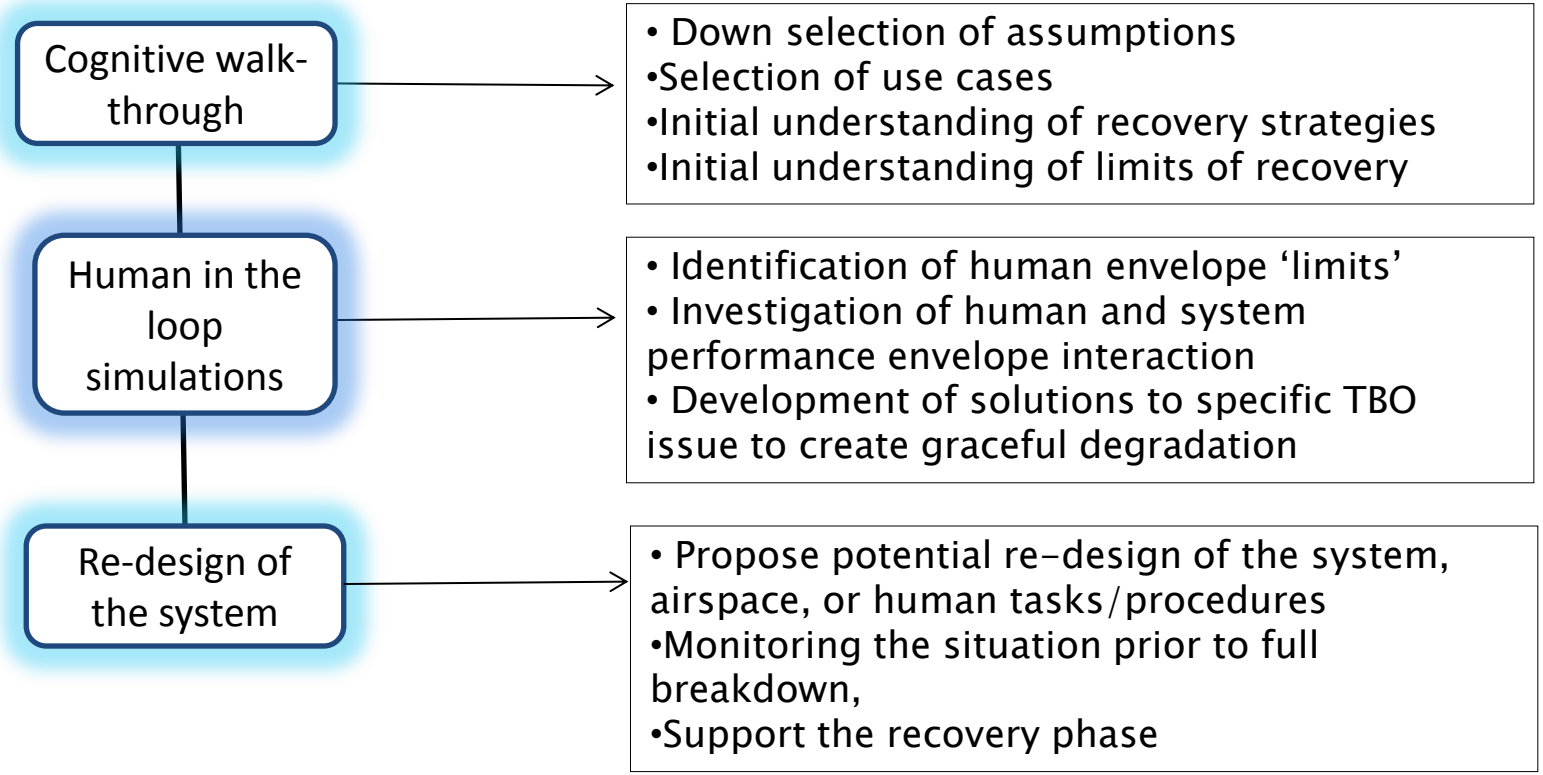
Application of the HPE: Planning research

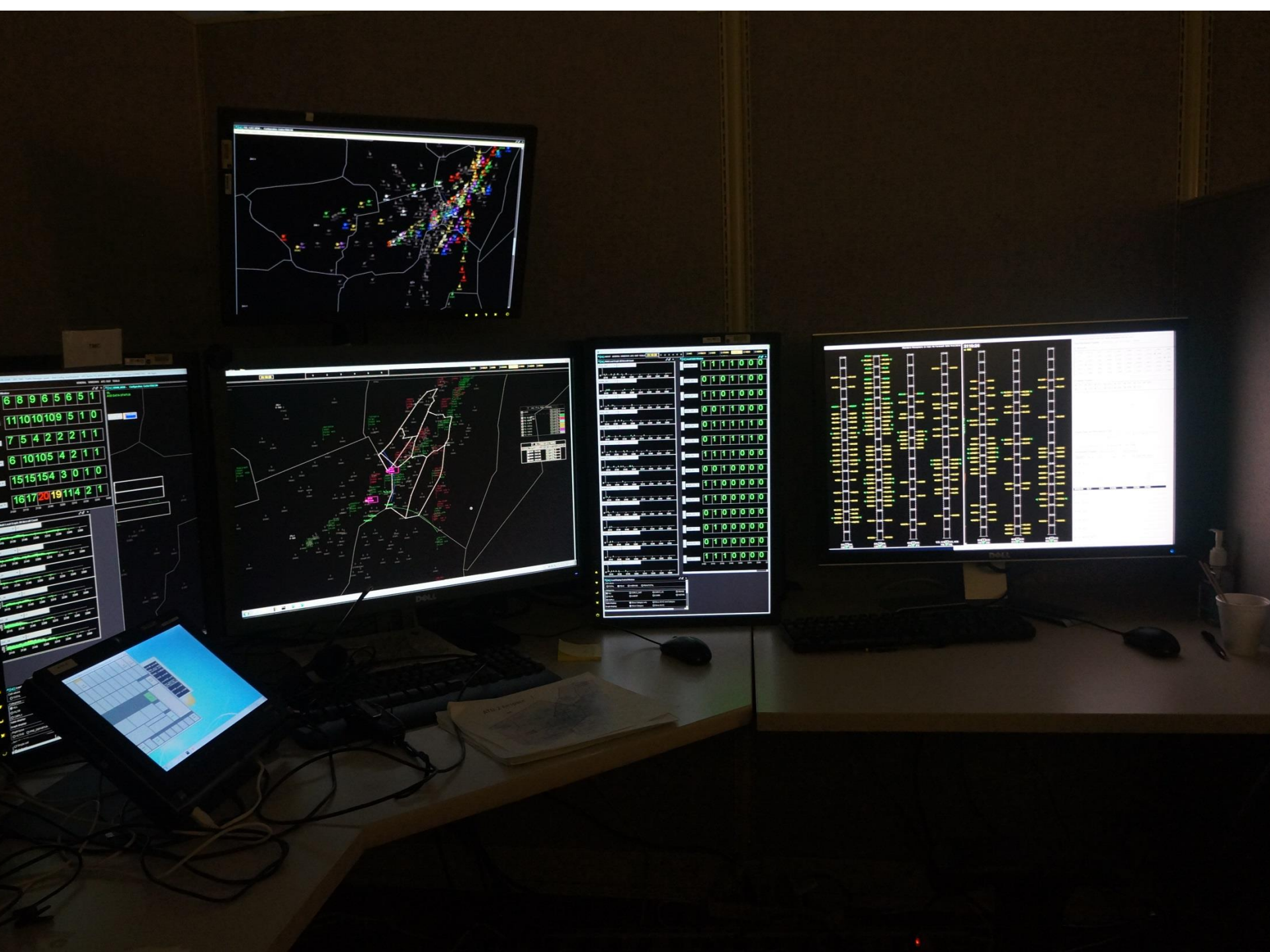
- Application of HPE:
  - How do the causes of degradation interact?
  - What are the associations of interactions on controller performance?
  - When can controllers no longer recover the system?
- The operational envelope?



Work Program

- Aims
  - Identify causes of degradation in TBO
  - Identify the limits of recovery for the human operator





Conclusions & Implications

- The Human Performance Envelope uniquely takes into account the multifactorial nature of operational environments
- The specification of the edges of the envelope can be utilized to predict and prevent performance decline and associated performance related incidents
- In relation to graceful degradation in TBO, the HPE allows us to understand the problematic nature of only focusing on solving one element of degradation
- Need to understand limits of system performance **AND** human performance
- The HPE can be applied to complex, multifactorial problems to guide areas of research
- Applying the HPE also enables hypotheses to be made regarding likely human performance outcomes

Thank you!

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