# Unobtrusive Measurement and Autonomous Estimation of Human Internal Cognitive States

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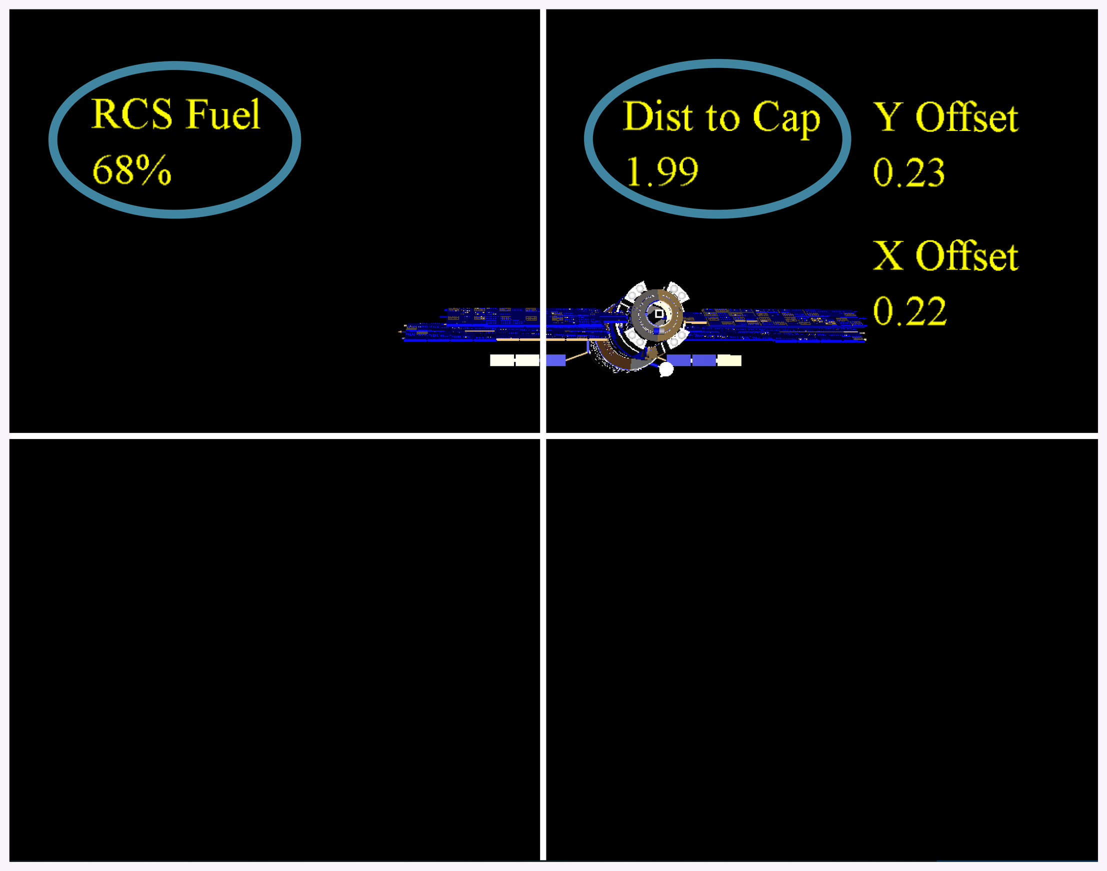
## Traditional methods interrupt primary task

- Post-hoc surveys (NASA TLX, Modified Bedford Workload Scale, trust questionnaires, SART)
- System freezes (SAGAT)
- Probes and queries by experimenter (SPAM)

## Unobtrusive methods and validation

| | Embedded | Psycho-physiological | Gold standard for validation |
|---|---|---|---|
| **Trust** | • Time to accept or reject "trust action" recommendation | • EEG [1]<br>• EDA sensing<br>• fNIRS | • Propensity to Trust Scale [2]<br>• Overall Trust Scale [3] |
| **Mental workload** | • Secondary workload task responses [4]<br>• Time spent monitoring secondary workload task | • EEG [5]<br>• Eye tracking [5]<br>• fNIRS | • Modified Bedford Workload Scale<br>• NASA TLX |
| **Situation awareness** | • Tertiary task callout response time/accuracy [4] | • EEG<br>• Eye tracking<br>• fNIRS | • SART |

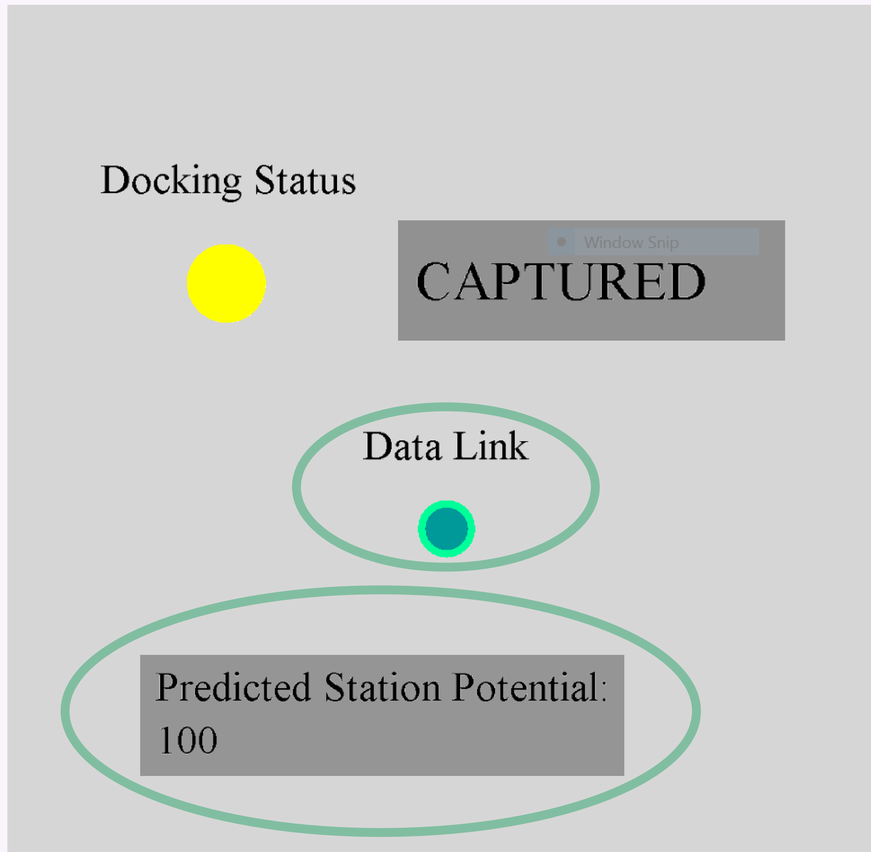
## Embedded measures and psychophysiological signals can inform real-time estimates of operators' trust, mental workload, and situation awareness




**Primary task:** station docking simulation

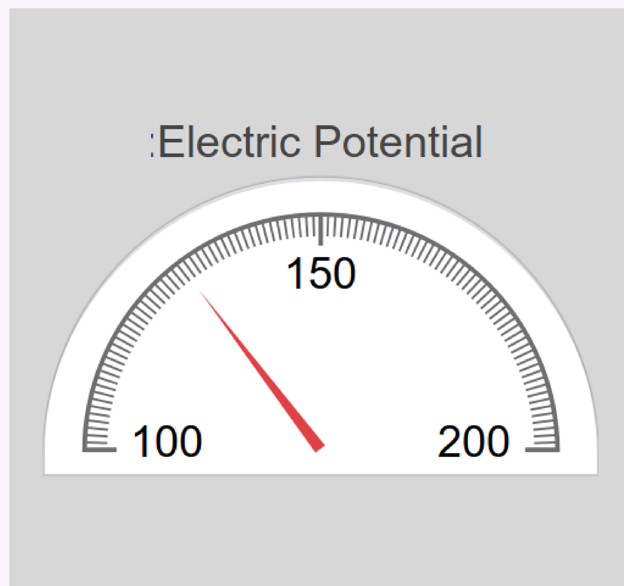
**Situation awareness embedded measure:** verbal callouts at intervals for RCS fuel level and distance

**Mental workload and trust embedded measures:** two choice visual secondary task and autonomous system trust recommendation




### Trust action

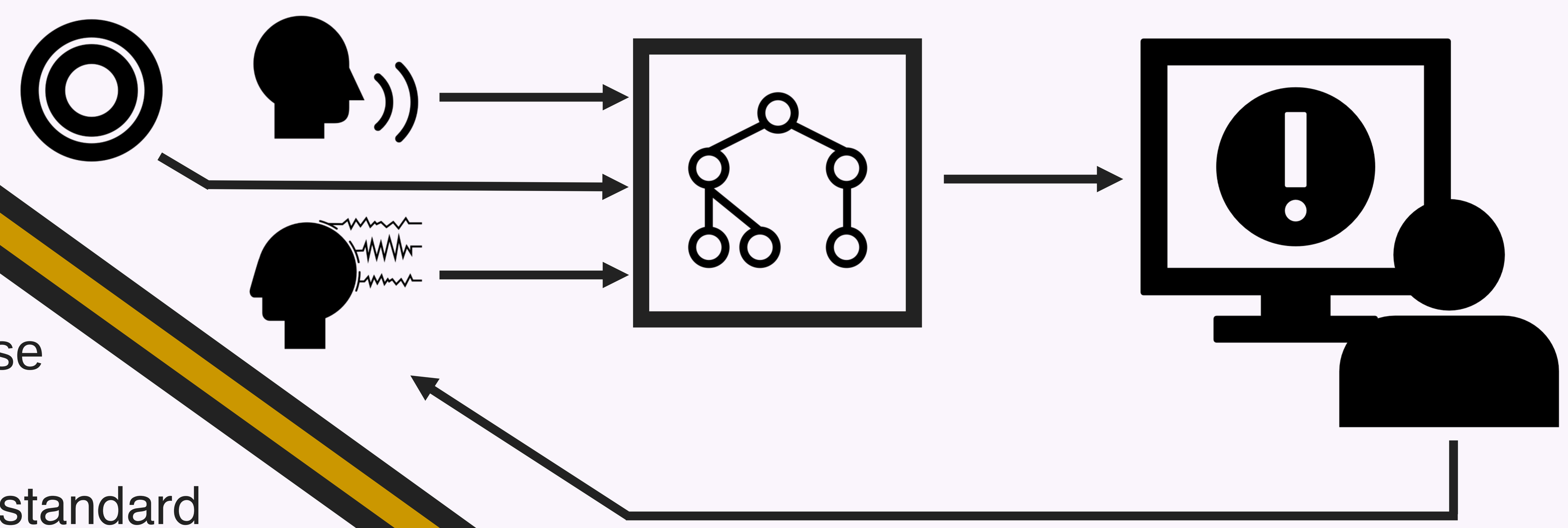
Subjects set an electric potential level for their vehicle to try and match that of the station, based on comparing an imperfect "sensor" to the system's recommendation.




## Challenges

1. **Are "unobtrusive" measures truly unobtrusive?**
   - Secondary workload measures will have some influence on primary task performance
   - Simultaneous tasks can confound each other, and are contrived/don't always have a real life analogue
   - Biomedical sensors can inhibit motion and limit operational use
2. **Internal cognitive states are impossible to know for certain**
   - Difficulty of "validating" unobtrusive measures when the gold standard measures themselves are not direct measurements
   - Psychophysiological signals may provide more objective measurements, but a baseline is needed to define signal artifacts
3. **How can an absolute value of trust be quantified?**
   - Influenced by different subject's predispositions to trust autonomous systems
   - Easier for an operator to report changes in trust rather than an absolute level
   - "Blind" trust tasks vs. "informed" trust tasks
   - Trust should be measured in a way that can be easily used by an adaptive system

## Future work for autonomous estimation



Estimation methods (Kalman filtering, neural networks) will combine and weight real-time unobtrusive measurements with predictions from computational models, generating estimates of cognitive states for an adaptive human-automation interface. **We hypothesize that if an adaptive interface can know its operator's cognitive states, it can adapt to best aid the operator.**

## References

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