



Methods and Metrics for Real-Time Task Performance Assessment in Crewed Spacecraft

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Overview

- **Task:** Control of a complex vehicle.
- **Scenario:** Shared control between operator(s) and control software.
- **Objective:** Ability for an operator to maintain level of Workload and Situational Awareness without sacrificing system performance.
 - particularly during changes in LOA



Why Real-Time Performance Metrics?

- **HSI Metrics:** Comprehensive assessment of “human + system” state and task performance.
- **Real-time Evaluation:**
 - Provides context for interpreting operator actions
 - Include human-system performance as a feedback parameter
 - Contributes to future system design

What Constitutes Desirable HSI Metrics?

Mental Workload

Situational Awareness

- **Objective**
- **Unobtrusive**
- **Operationally valid**
- **Reported in a manner that allows the operator to make real-time adjustments to improve performance**

Simulation Platform

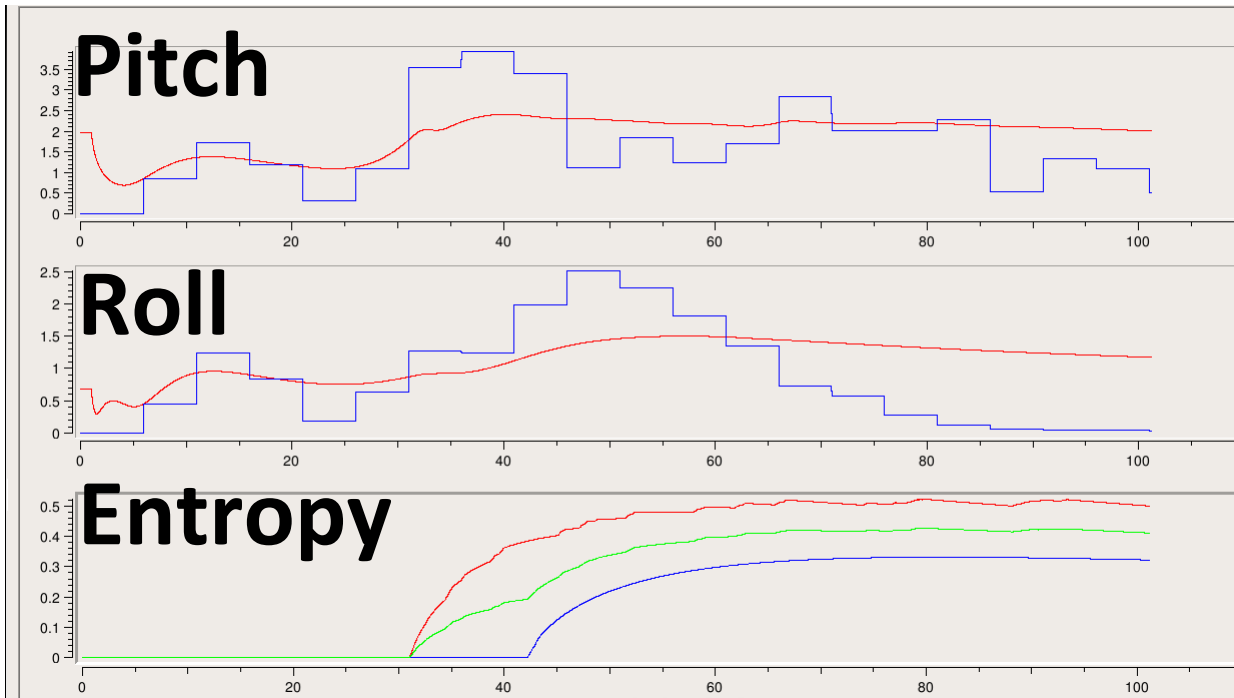
Operationally Relevant Tasks

- Piloted lunar landing
- Orion rendezvous and docking with the ISS
- Simplified Aid for EVA Rescue (SAFER)

Re-configurable Workstation



Real-time Flight Performance Visualization



Scenario Time (sec)

RMSE

Incremental

RMSE

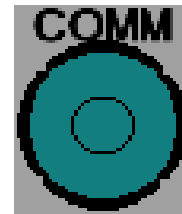
Pitch

Roll

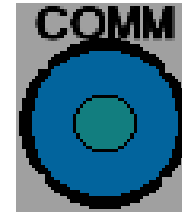
Average

Mental Workload

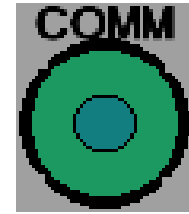
- Secondary task
- Communication acknowledgement task, proxy for operational task – has operational validity*
- Illuminated every 4-6 seconds
- Acknowledged by operator by pressing the Blue or Green button on the joystick
- Record and analyze response time



Inactive



Blue

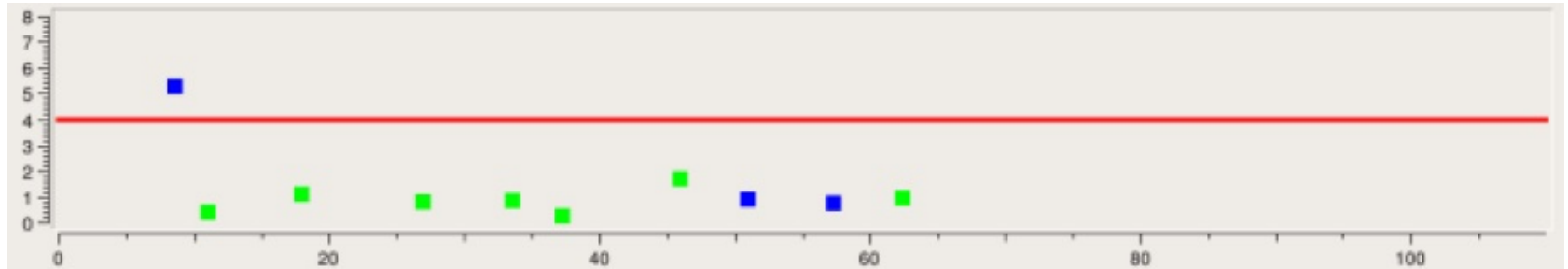


Green

*Hainley, C.J., Duda, K.R., et. Al (2013) *AIAA Journal of Spacecraft and Rockets*

Real-time Mental Workload Visualization

Reaction Time (sec)



Scenario Time (sec)

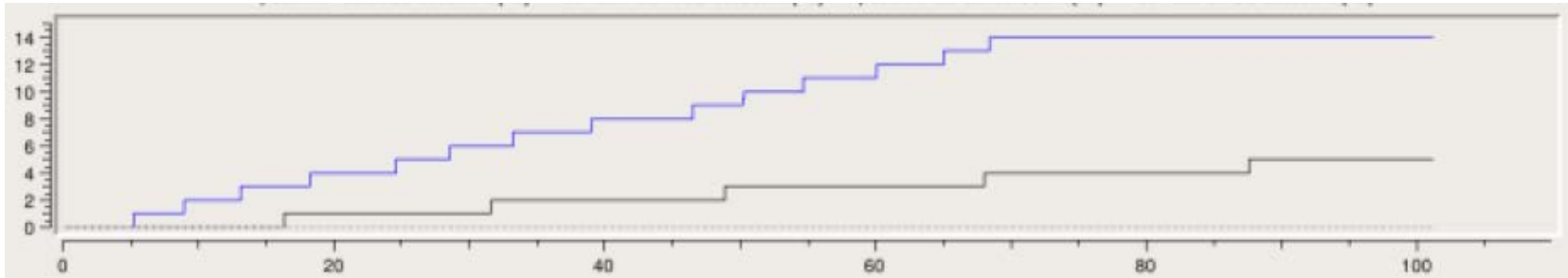
- Blue Reaction Time (sec)
- Green Reaction Time (sec)
- Threshold Reaction Time (sec)

Situational Awareness

- Verbal callouts of perceived vehicle state – fuel, altitude, proximity to a hazard)
- Sample callout: “5 percent fuel”
- Speech processed by time-synchronized automatic speech recognition (ASR)
- SA calculated by comparing actual vehicle state with verbal callout
- Callout must be made within **x** seconds of actual state to be considered correct

Real-time Situational Awareness Visualization

Callout Count

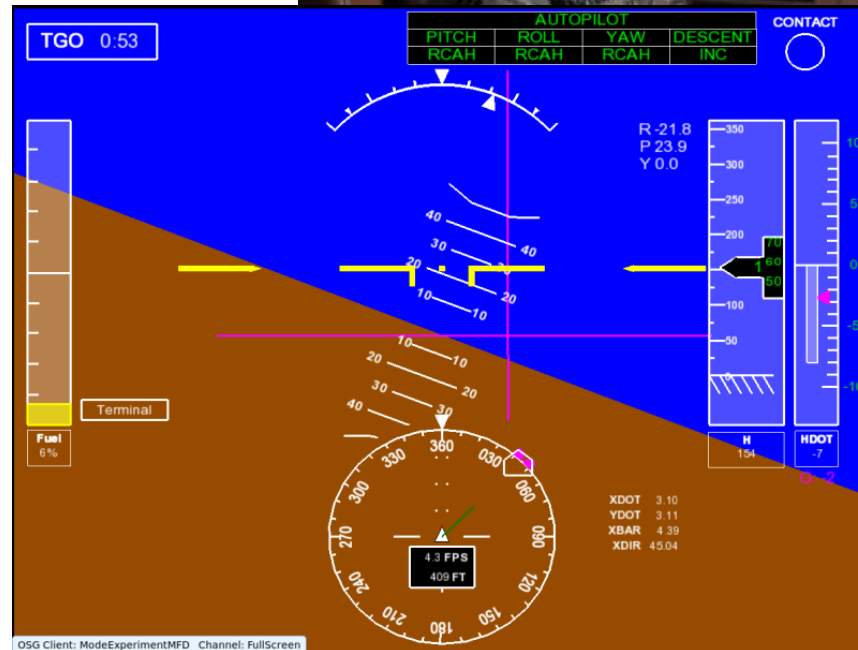


Scenario Time (sec)

- Required Callouts
- Correctly Made Callouts

Future Applications

- Piloted Aircraft
- Supervisory Control
- Remotely Operated Robotics
- Real-time Analysis Tools



List of Acronyms

- **ASR:** Automatic Speech Recognition
- **EVA:** Extravehicular Activity
- **ISS:** International Space Station
- **LOA:** Level of Automation
- **RMSE:** Root Mean Square Error
- **SA:** Situational Awareness
- **SAFER:** Simplified Aid for Extravehicular Activity (EVA) Rescue

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Forthcoming: Duda, K.R., Prasov, Z., et. Al (2015) *IEEE Aerospace Conference*