



COMMUNICATION DELAYS IN CISELUNAR SPACE: RESULTS FROM A LAB STUDY EXAMINING EIHSSO AND TEAM RISKS

Lauren Landon¹, Tina Holden², Satyajit Upasani¹, Nikole Moody³, Tyler Duke¹, Josh Mosonyi⁴, Jessica J. Marquez⁵, John Karasinski⁵, Millennia Young⁶, Emma Lyon³, Jennifer Miller³, Mercedes Jorge³, & Suzanne Bell⁶

¹KBR; ²Leidos; ³JESTech; ⁴Aegis; ⁵NASA Ames; ⁶NASA JSC



Results

For study background and methods, please see our sister IWS presentation by Holden et al., 2026

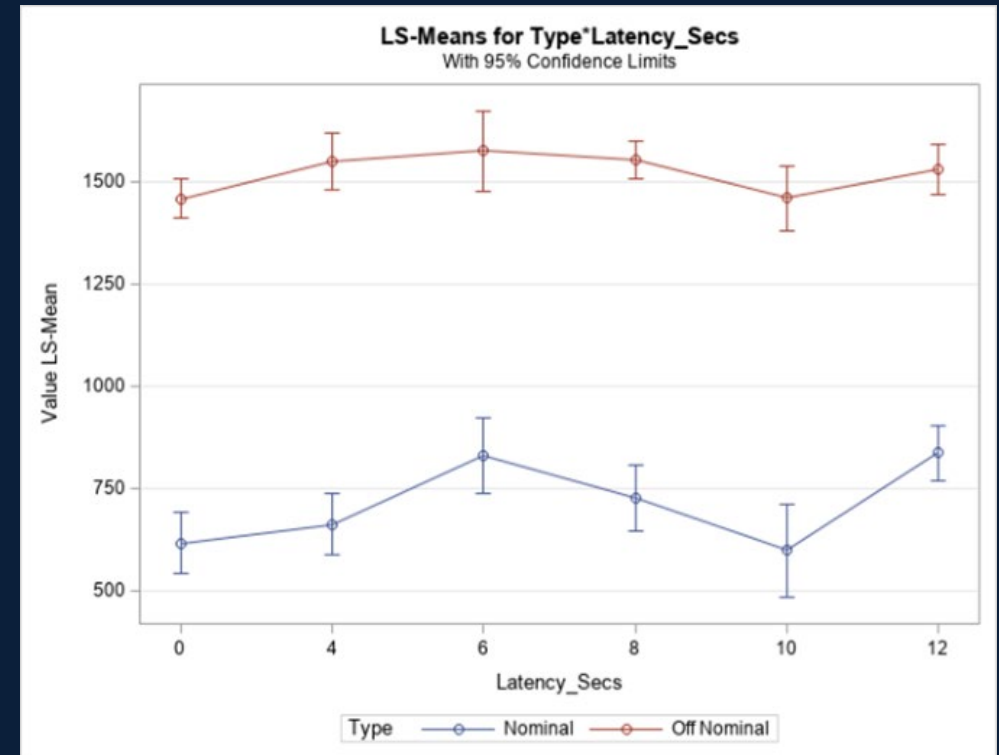


EIHSO Outcomes

Earth independent human-systems operations

Task Completion Time (team)

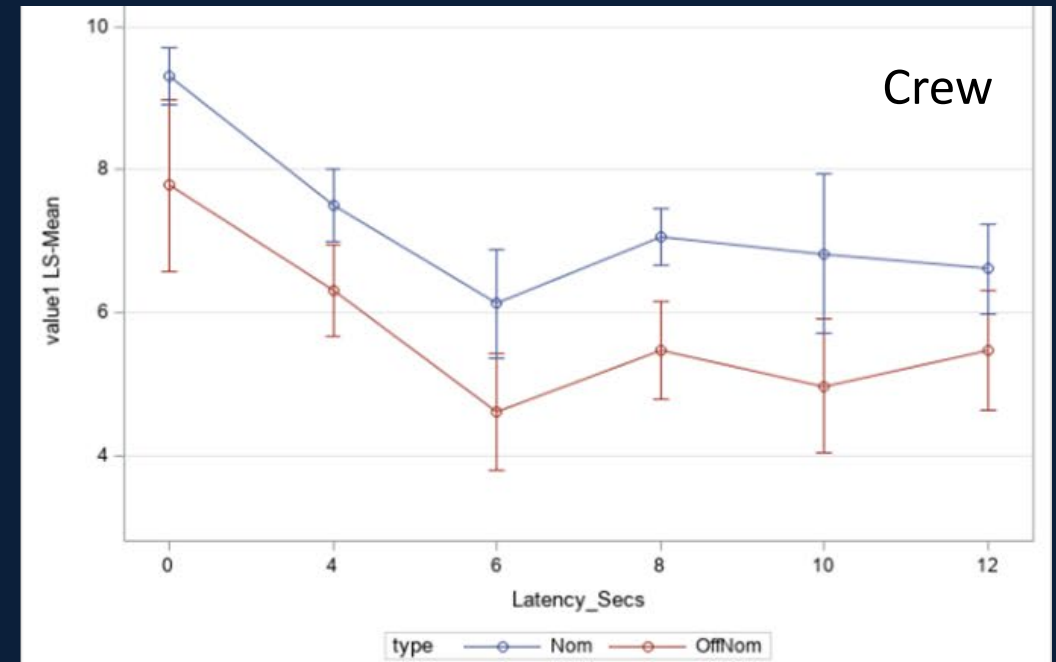
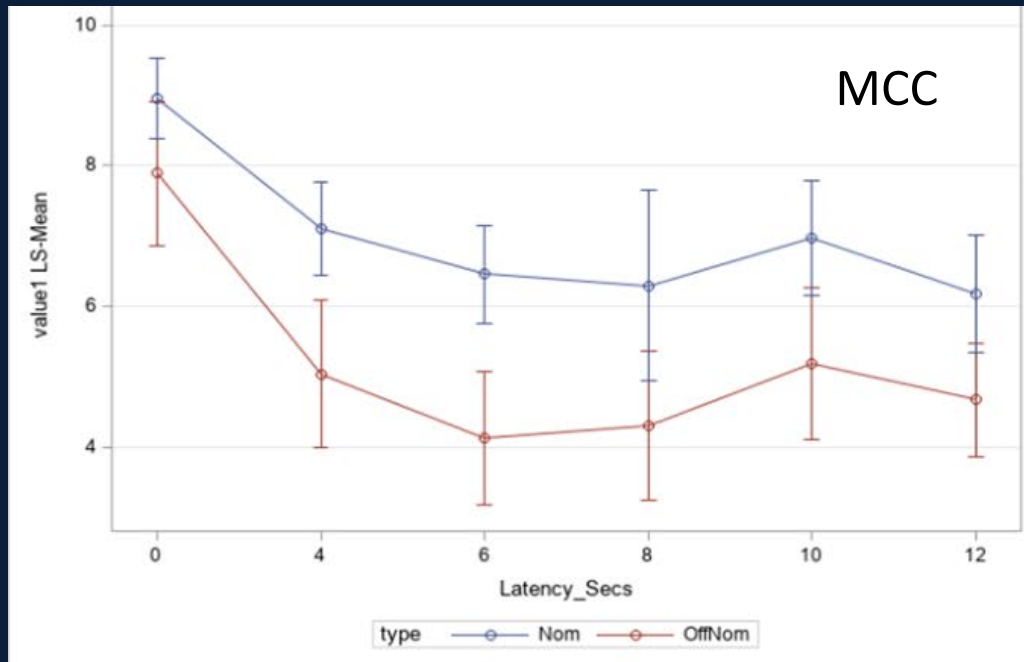
- Nominal task
 - Task time higher under delay vs 0s*
 - High task time in 6s - perhaps learning effects due to incomplete counterbalancing.
 - Communication strategies and use of texting may have helped reduce task time in higher delay conditions
- Off-Nominal task
 - Lack of significant effects due to task time boundary



Operational Acceptability Rating

(1 Totally Unacceptable – 10 Totally Acceptable)

- Delayed tasks are less acceptable
- Lowest ratings (5-6) still considered borderline acceptable

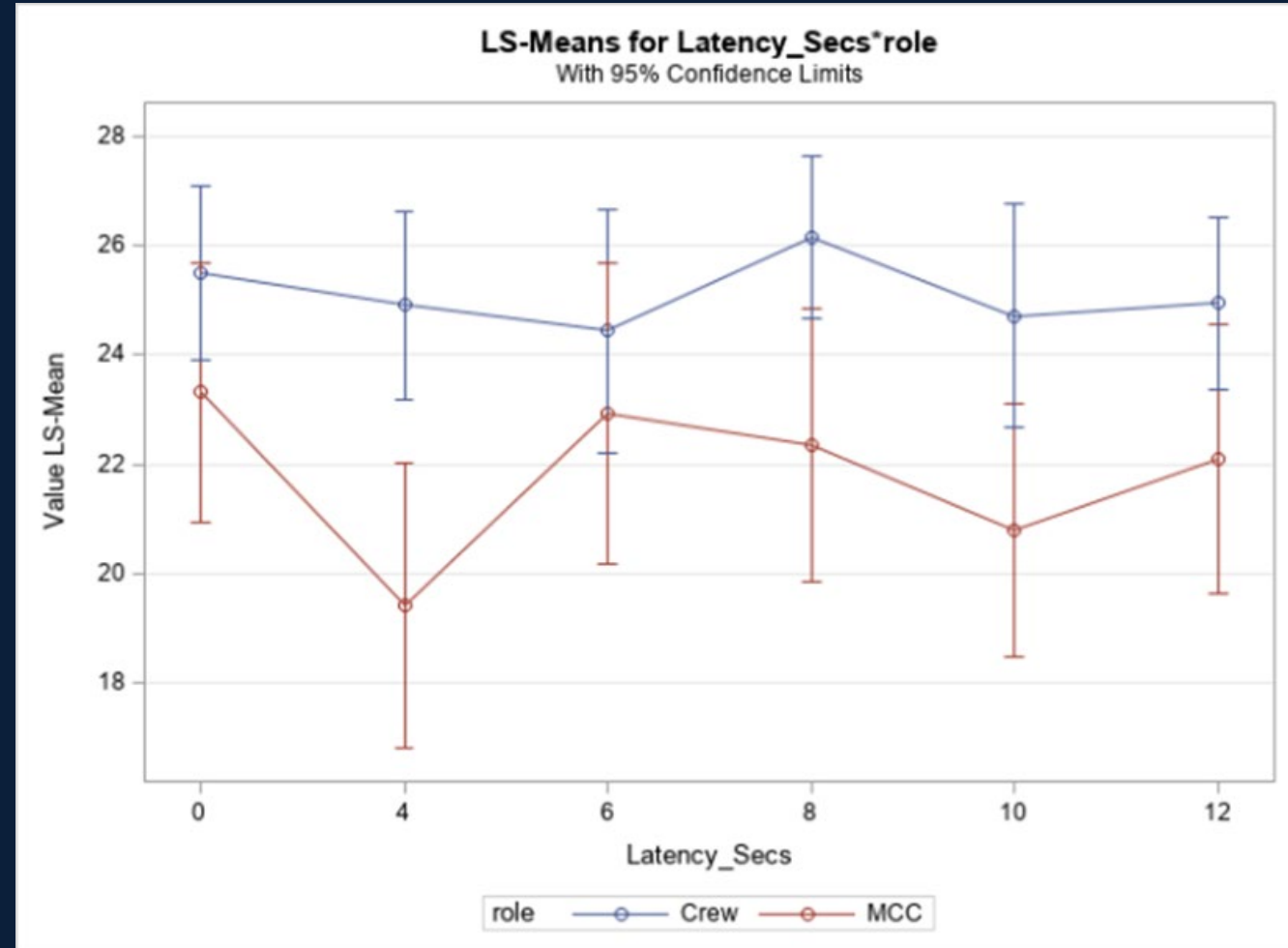


NASA Modified System Usability Scale

(NMSUS: 0-Low to 100-High;
Rating for overall session)

- MCC rated usability lower than Crew
- Delay not significant

MCC



✦ Workload and SA



- NASA Task Load Index (TLX) - post-task
 - Minimal impact of delay on Cognitive Workload
 - Off-nominal task workload was higher than nominal for all 6 TLX scales
- Bedford Workload Scale – post-session
 - Minimal impact of delay on Cognitive Workload
- Situation Awareness – post-task
 - No impact of delay on SA
 - Off-nominal tasks provided less SA



Behavioral Health Outcomes

★ Frustration

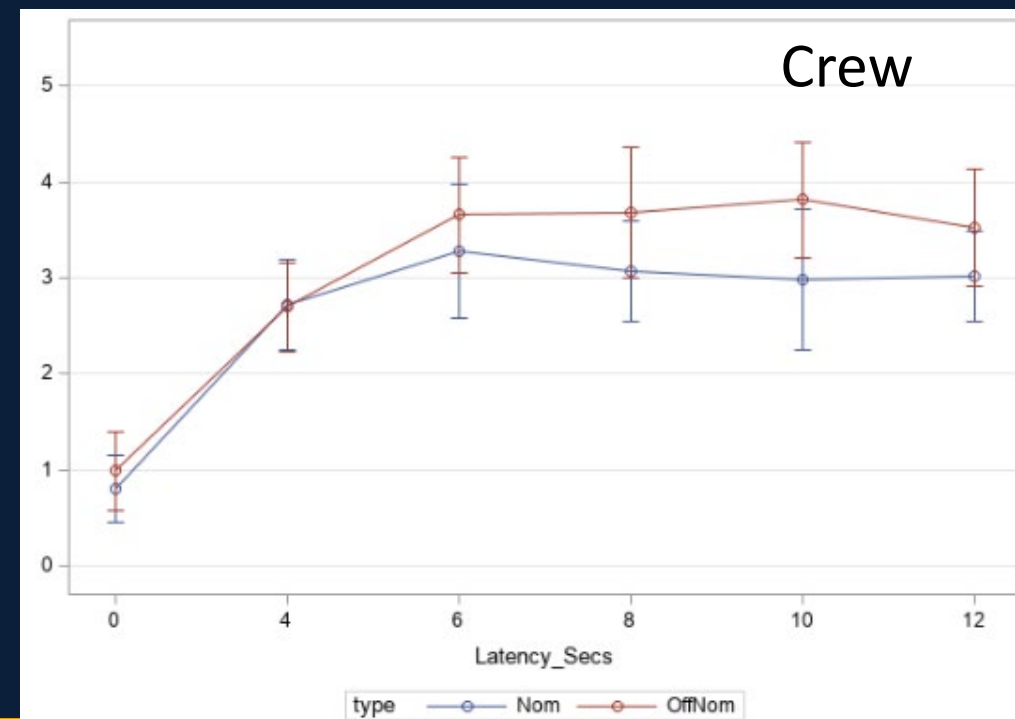
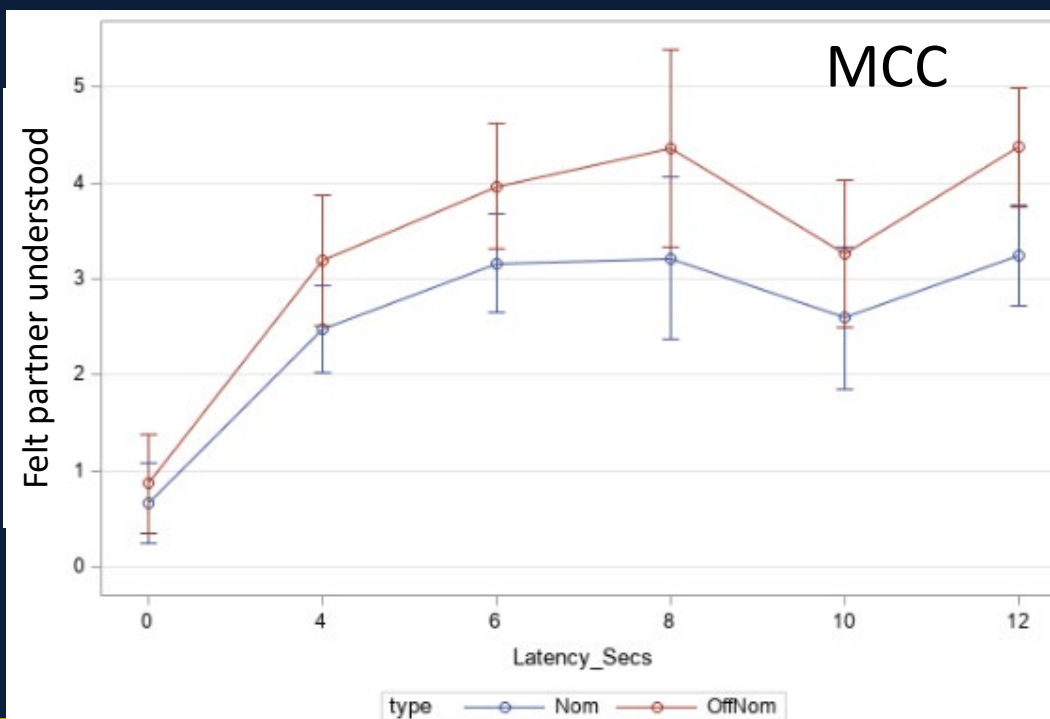


- With latency: 2-way interaction of task by role, task by delay
- With task type: off-nominal more frustrating
- With partner: 2-way interaction of task by role, delay by role

Moderate

Low to moderate

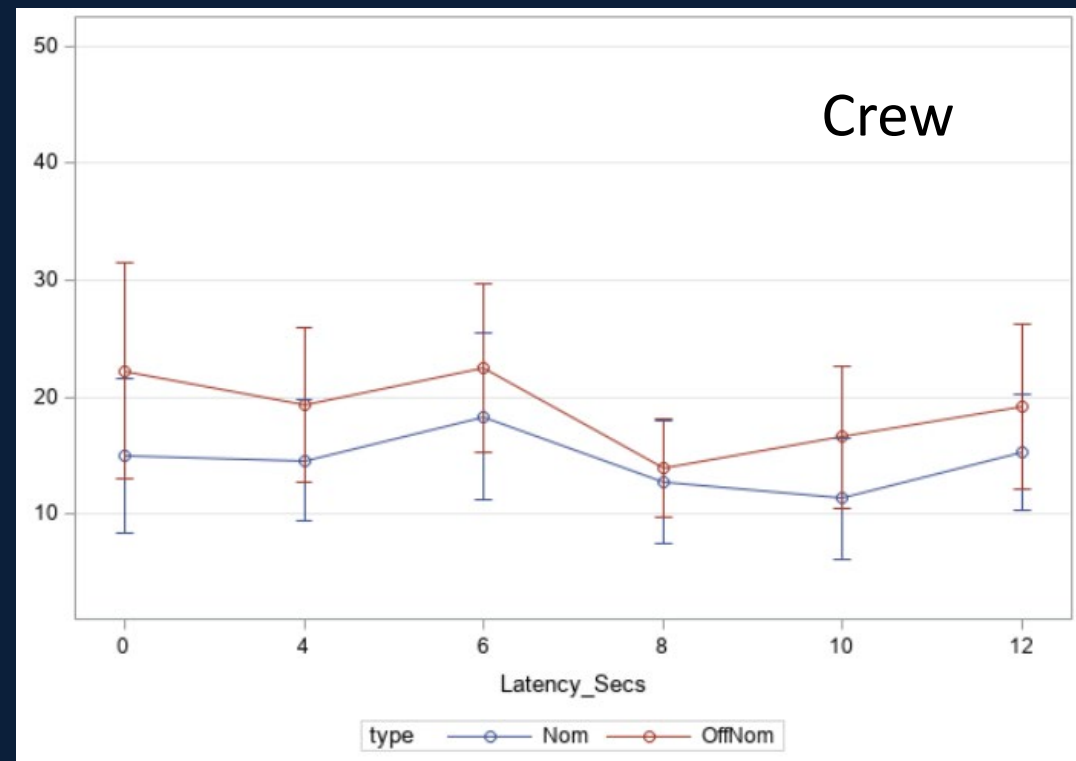
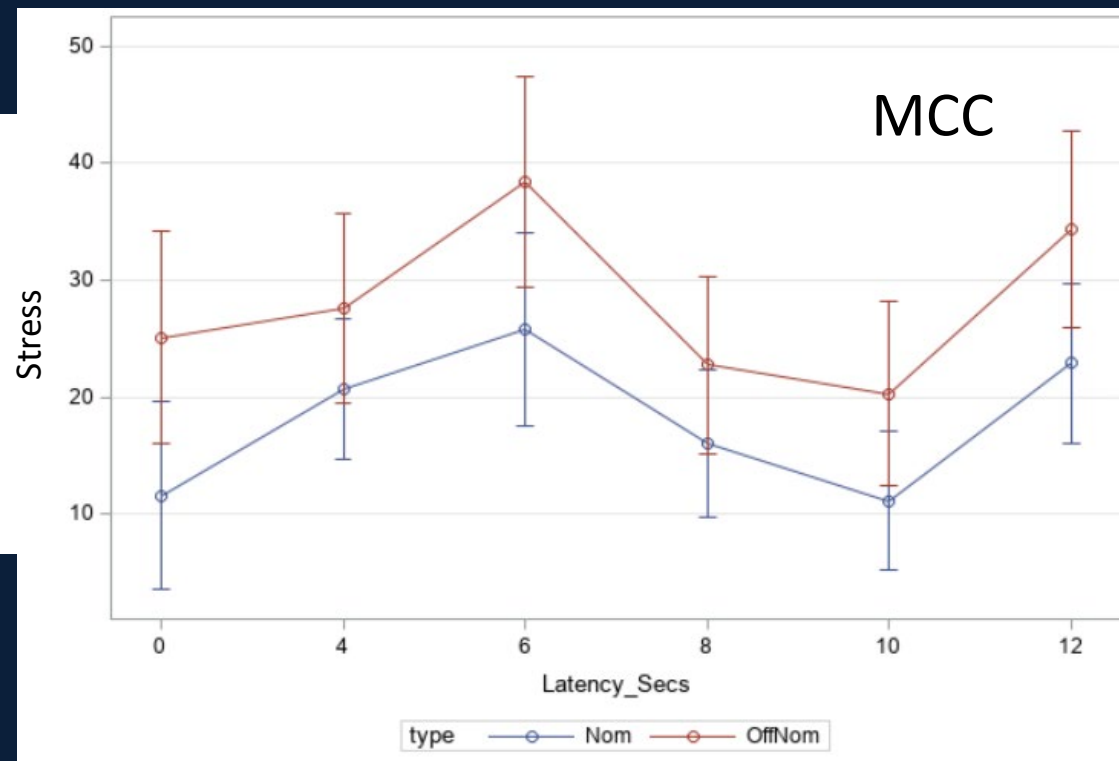
Low



Stress



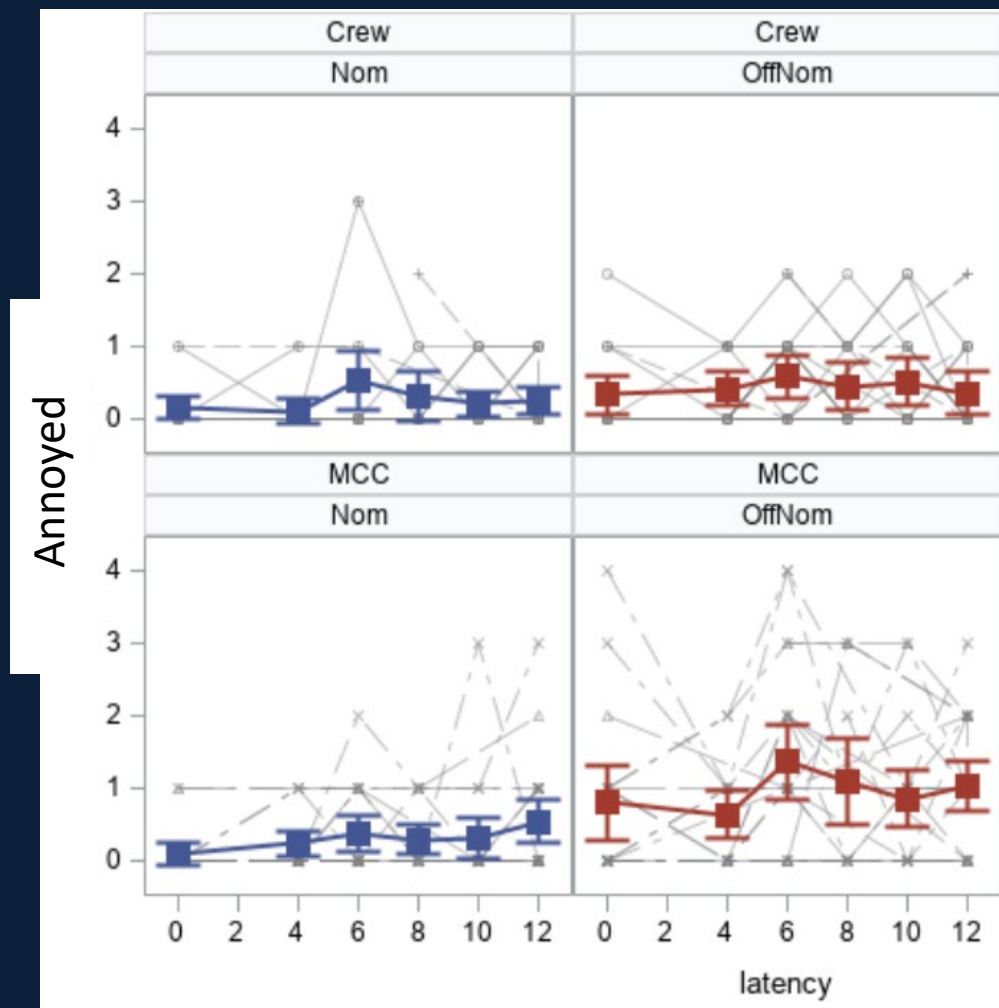
- Delayed, off-nominal, MCC -> more stressful
- Sig. 2-way interaction for task by role



Mood



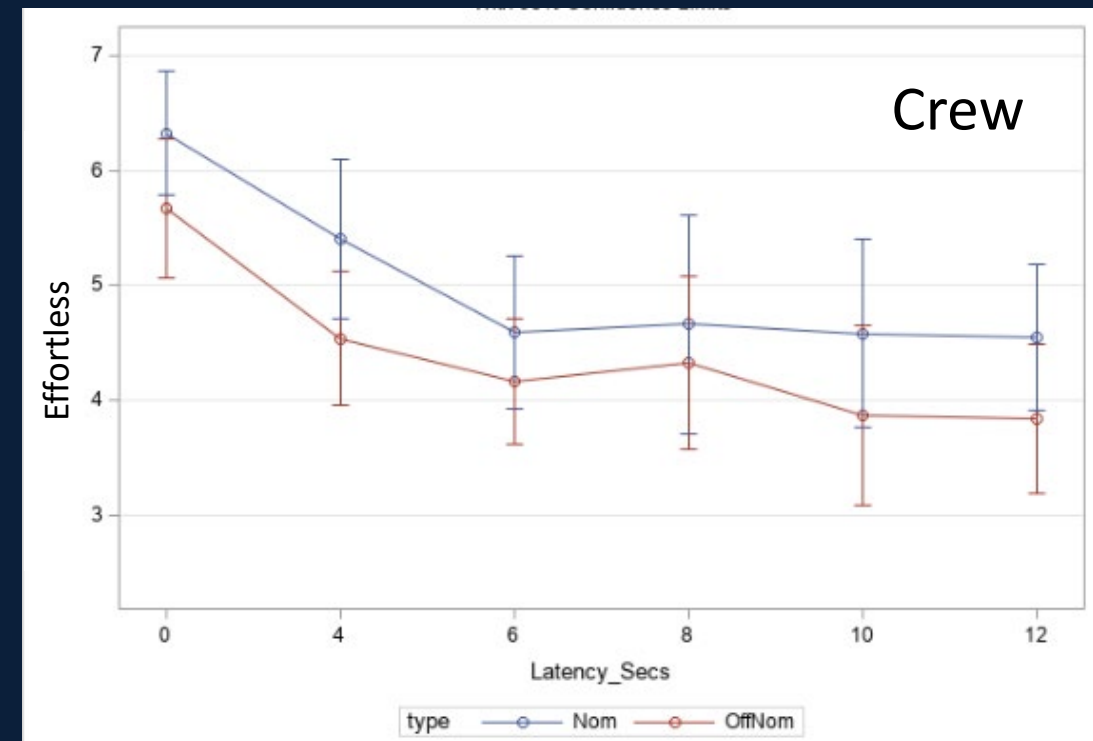
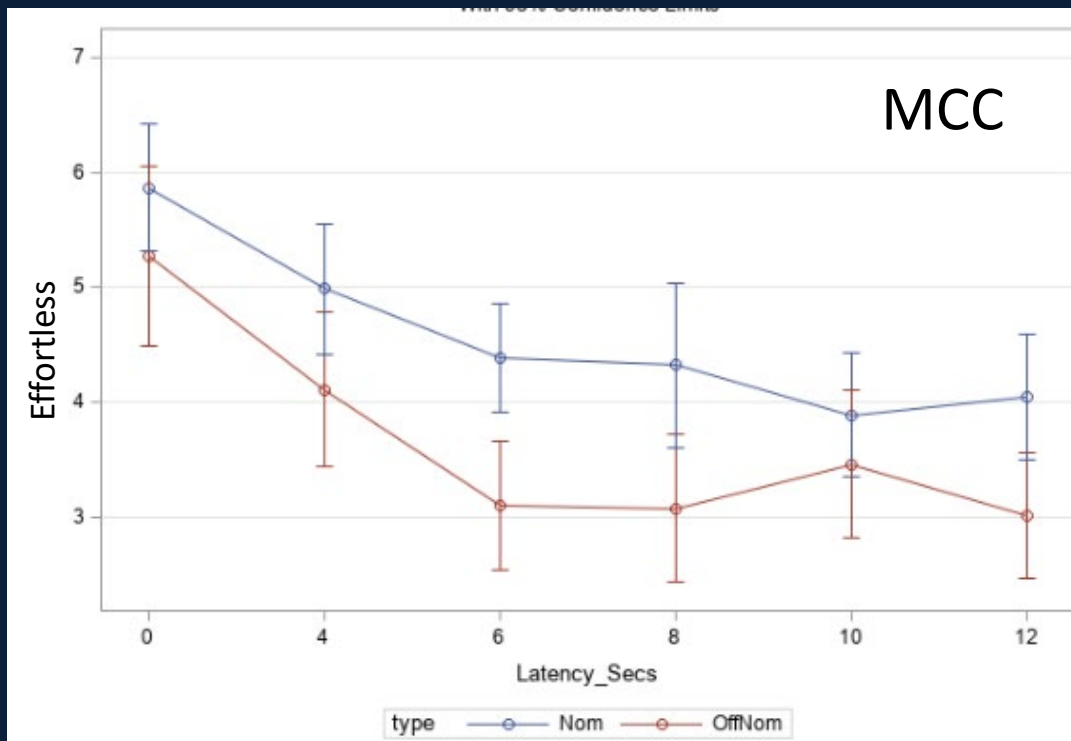
- More negative mood, less positive mood for off-nominal, MCC
- Delay had little effect (except proud)
- Generally, low levels of mood



Comm Quality



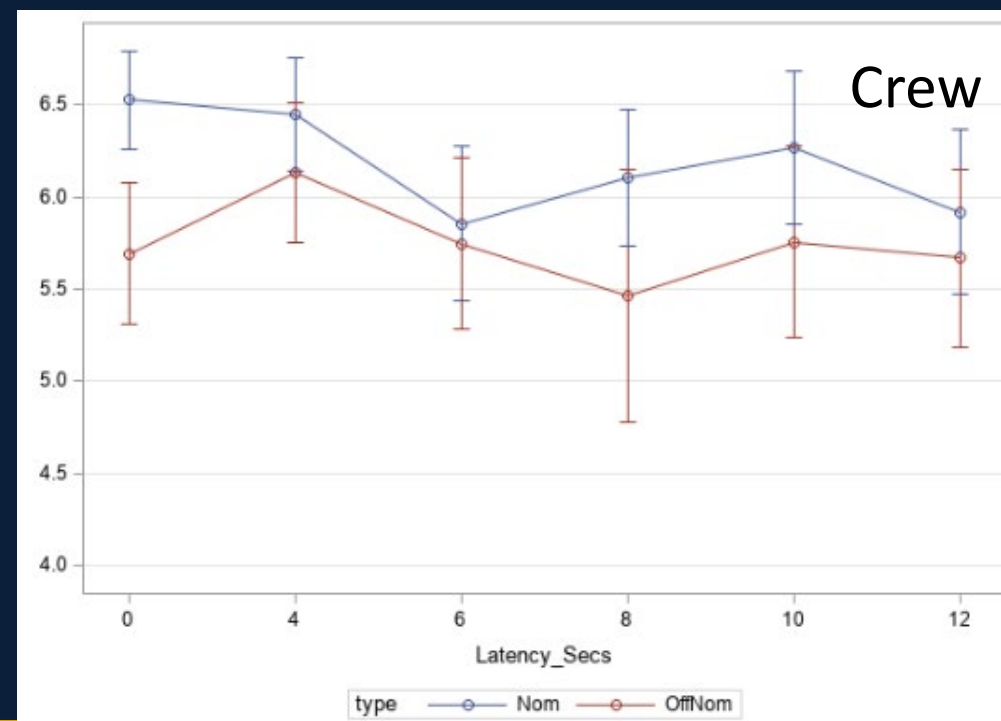
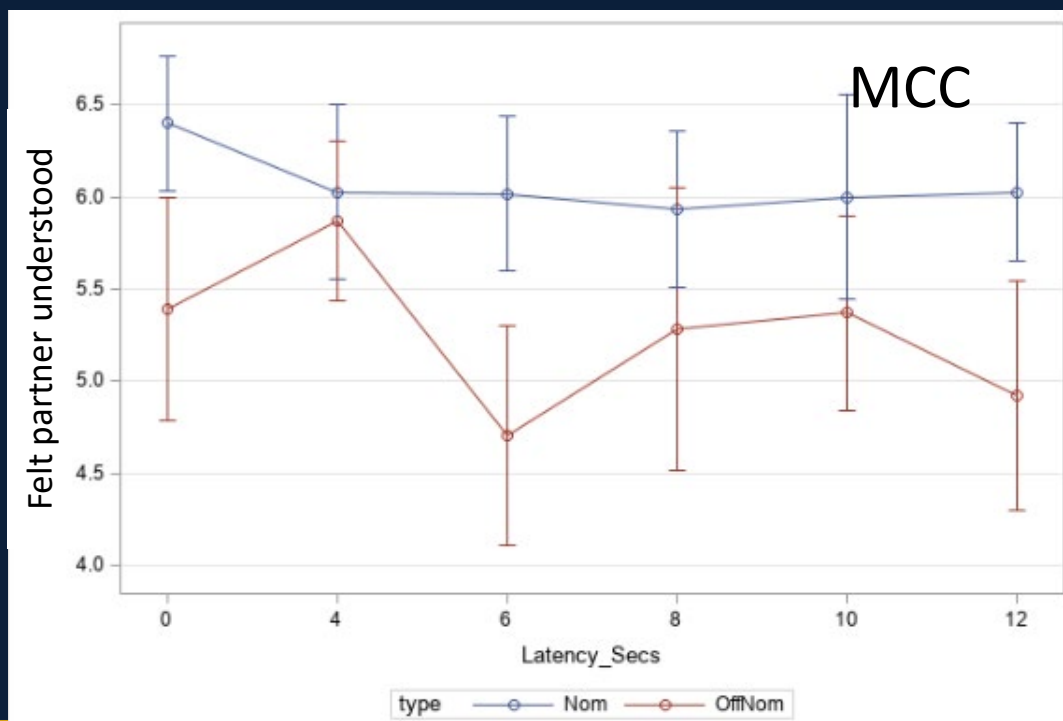
- Delayed, off-nominal, and MCC (with stale data) conditions are:
 - Less effortless and less efficient
 - More complicated and more disjointed



★ Connection



- Subject understood partner less in off-nominal and MCC (sig. 2-way)
- Felt partner understood them less in off-nominal, under delay, and for MCC (sig. 3-way interaction)
- Enjoyed conversation with partner less in off-nominal, delay



Autonomy

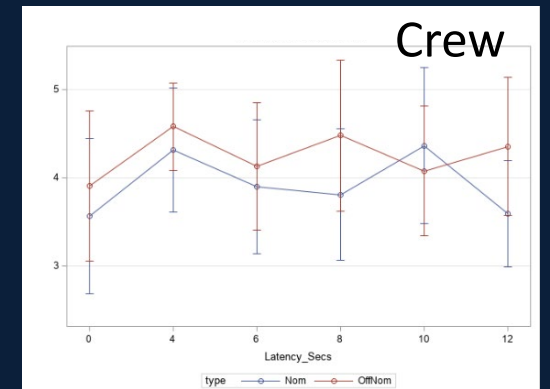
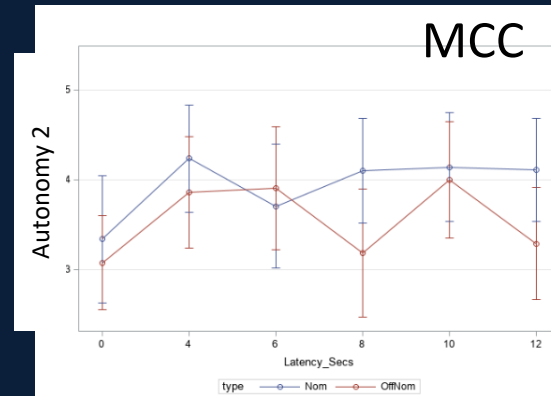
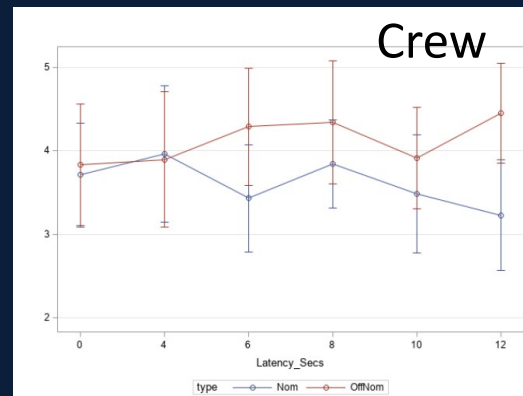
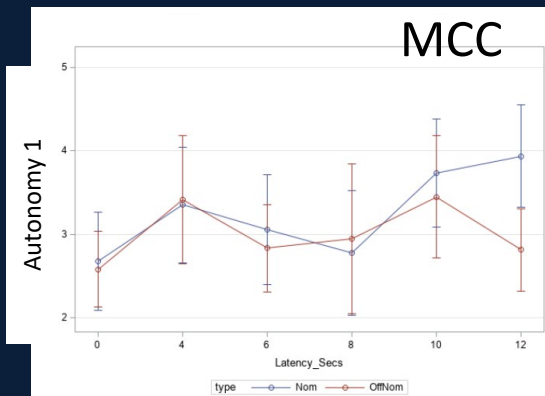


Crew felt greater independence during delayed, off-nominal tasks

- Significant 3-way interaction

...and freedom and independence in how the task was completed

- Significant 3-way interaction



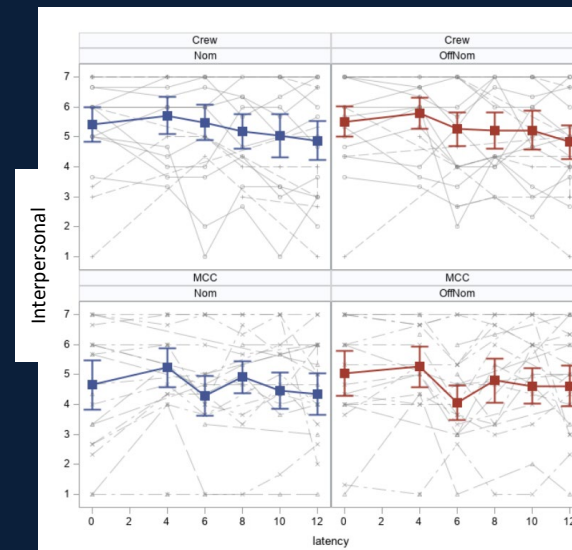
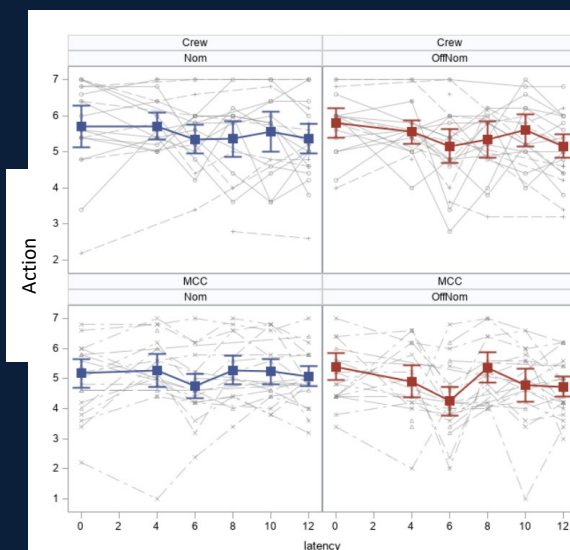
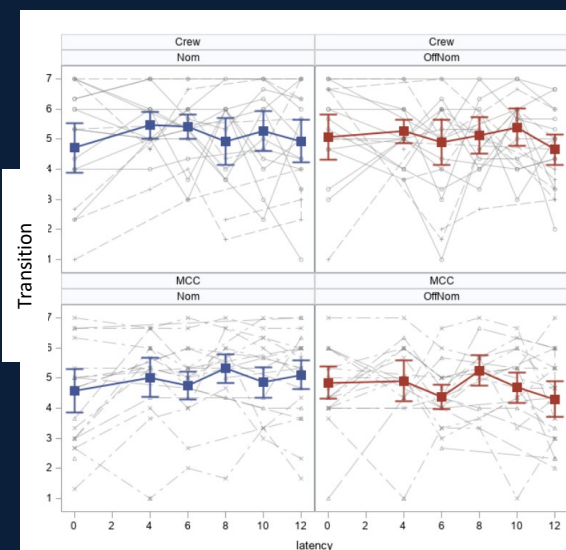


Team Outcomes

Team Processes



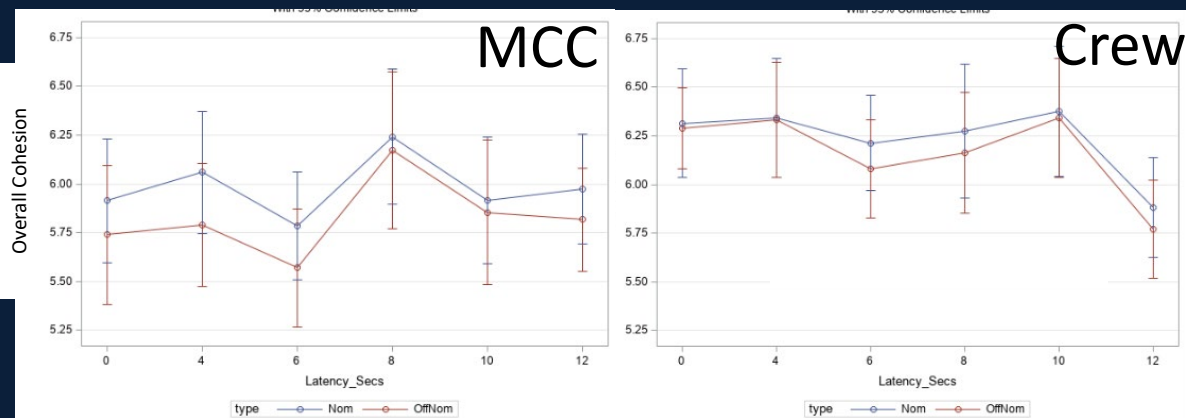
- Under delayed, off-nominal conditions: (sig 2-way: task*delay)
 - Worse at transition processes
 - Worse at action processes
- Delay worsened interpersonal processes



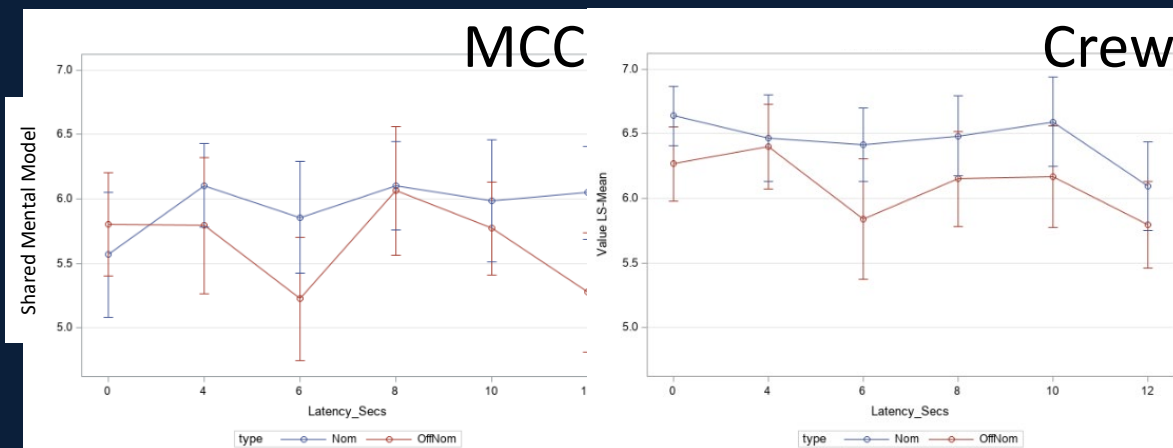
★ Cohesion, SMM



- MCC reported lower overall cohesion in delayed conditions (2-way delay*role)



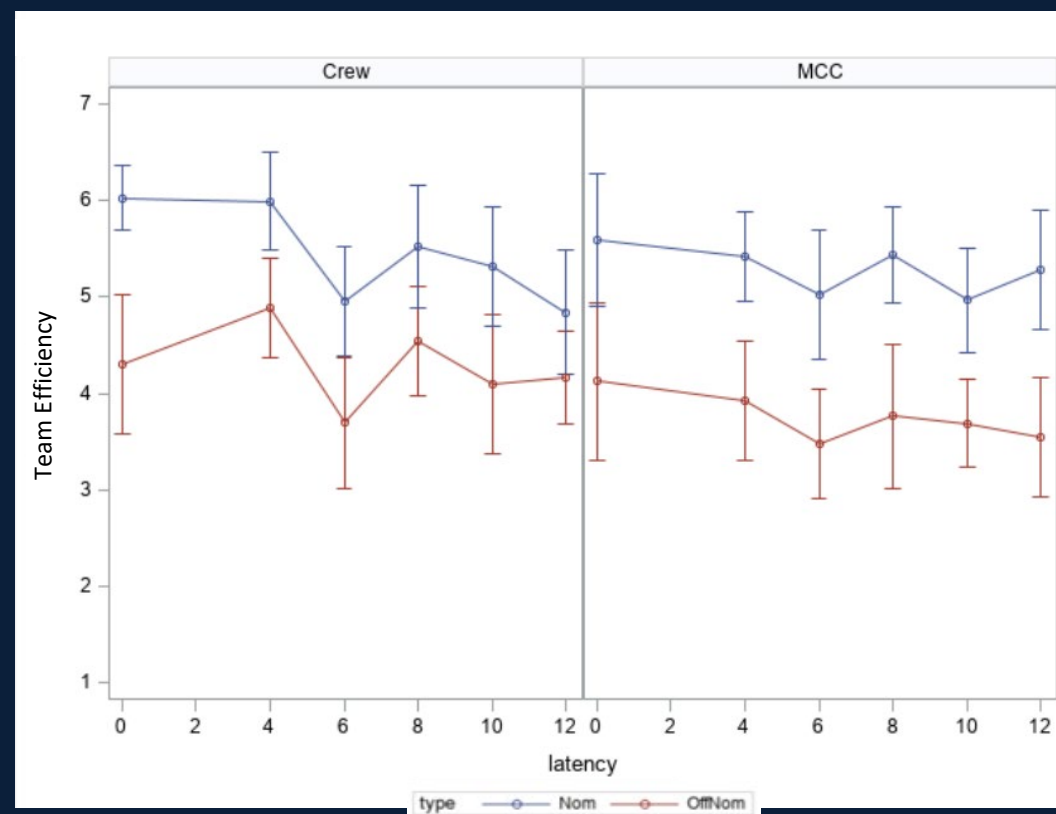
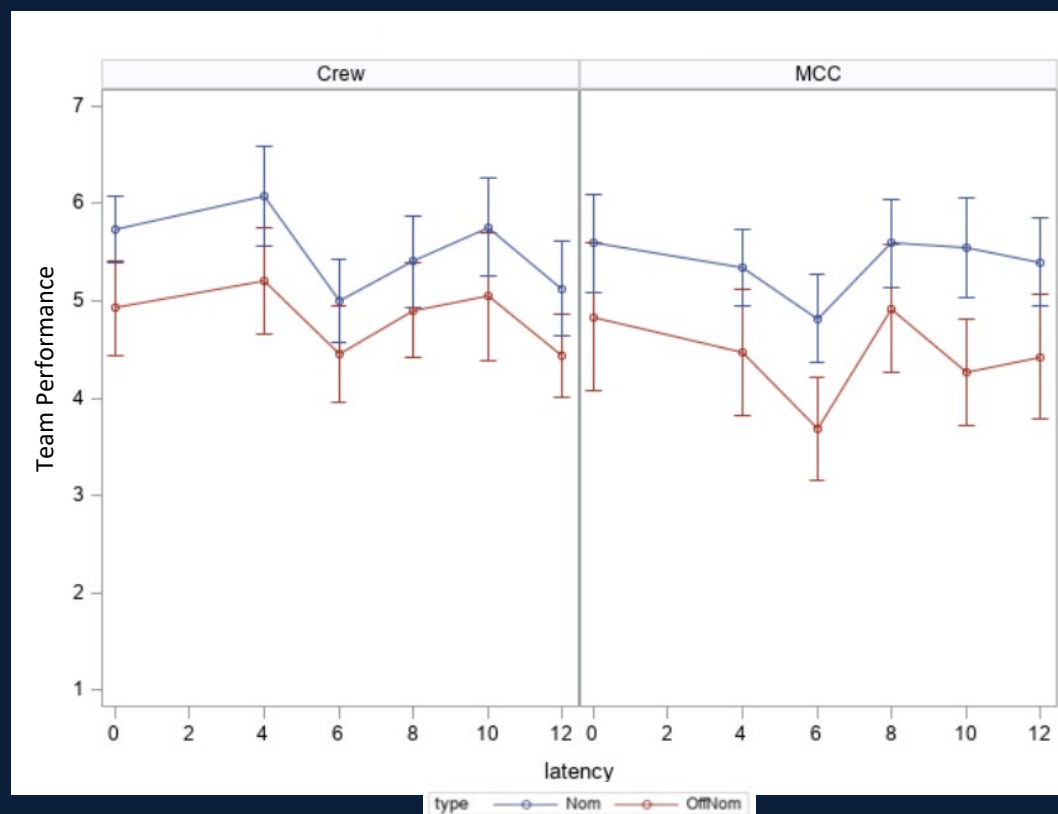
- MCC reported reduced shared mental models under delayed, off-nominal conditions (3-way)



Team Performance



- Lower self-rated performance and efficiency under delay and during off-nominal tasks





Wrap-up

Conclusions



- Indications of increasing negative impacts at longer delays and in off-nominal situations; over time these could increase risk
- Negative impacts may be balanced by participant ability to cope with the delays through experience, practice, and countermeasures

INFORMS:

Future Artemis-like comm
delay research



Artemis mission risk posture
and countermeasures



NASA Standards such that
training and task design
should institute comm delay



Recommendations



- Task design
 - Support greater autonomy and reduce the need for real-time communication
 - Procedure design that does not require step-by-step interaction
 - Use of automated alerts and reminders for key steps and procedures
- Comm Training
 - Train with structured, best practice, comm protocols - “Gateway calling...,” “over,” “pausing”
 - Conduct pre-task briefings to set expectations and agree on comm strategies
 - Leverage wait times to plan next communication and/or problem-solve
- Repeat partner assignments whenever possible
- Mitigate stress and frustration by providing teammate video, pre-task comm planning, and stress management training
- Technology design
 - Have a texting capability and/or use real-time transcription tools so messages are in writing and can be referred to as needed
 - Provide an integrated communication platform that combines audio, video, texting and shared task views

Questions?



Lauren Landon | lauren.landon@nasa.gov



Tina Holden | kritina.l.holden@nasa.gov

