# Experiments in Adjustable Autonomy

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# Prototype

- Humans have meta-level control.
- Levels of robot autonomy
  - Fully autonomous
  - Goal-biased autonomy
  - Waypoints and heuristics
  - Intelligent teleoperation
  - Dormant

# The Neglect Curve

# Time Delays and Neglect

- Neglect is analogous to time delay.
  - Laptop and robot: ~0.5 seconds
  - Earth and moon: ~5 seconds
  - Earth and Mars: 45 minutes
- As the level of neglect changes, an autonomy mode must be chosen that compensates for such neglect.

- Teleoperation <----------------------> Fully autonomous
min. neglect    <----------------------->      max. neglect

# Fully autonomous

- Ideal when time delay or neglect is significant.
- Simple tasks
  - Creating local map of its surrounding environment
- Low efficiency

# Goal-Biased Autonomy

- Biased autonomous behavior ( no direct control )
- More user-specified tasks
- Better efficiency
- Lower level of acceptable neglect

# Waypoints and Heuristics

- More complicated tasks
- Improved efficiency
- More involved human operator

# Intelligent Teleoperation

- Intelligent?
  - Satisficing ( Satisfy + Suffice ) decision potentials
  - Modulated human operator command

- Most efficient
- Minimal time delay
- Minimal neglect

- Difficulties: situation awareness, etc.

# Intelligent Teleoperation
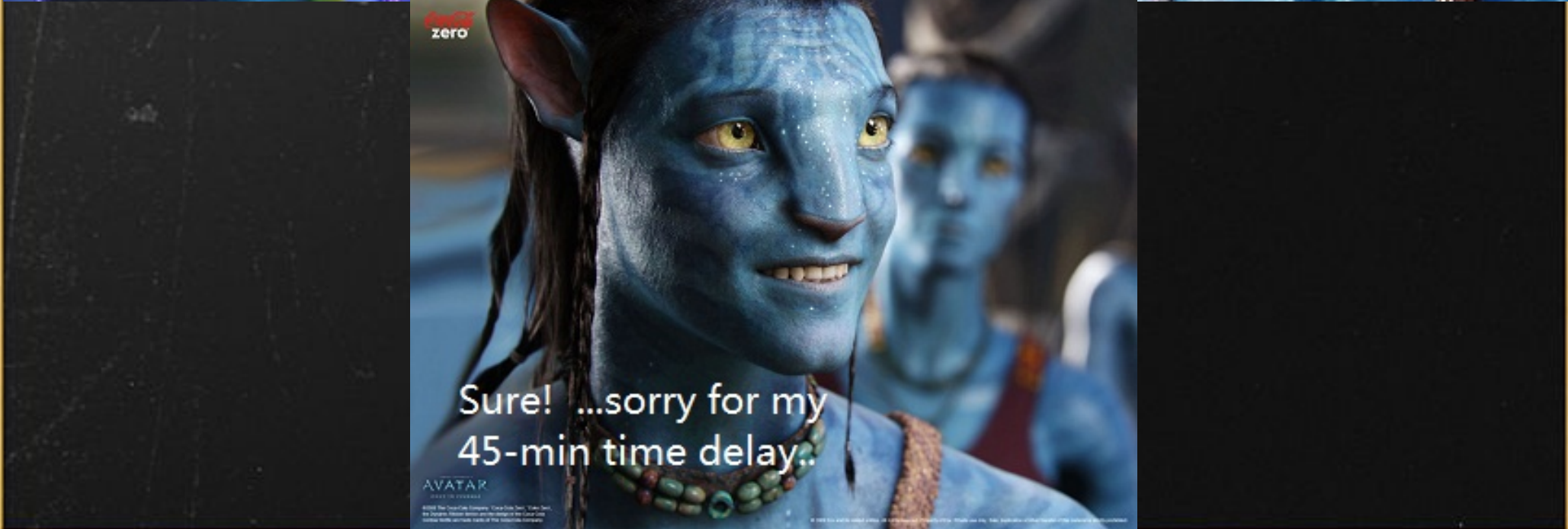
# Interfaces

- Single human operator, multiple robots
- Single robot, multiple human operators
- Multiple human operators, multiple robots

- How to design such interfaces?
  - Intuitive, easy to use
  - User-level practice and cooperation is required

# Multiple operators on a single robot

# Conclusions

- Adjustable Autonomy is an important aspect to consider when designing complex robot operating interfaces.
- Improved efficiency comparing to single autonomous mode.