MIT
Dept of Aeronautics and Astronautics
Qualifying Exam   Jan. 2012

Humans and Automation

This is a design question in which you will be asked to consider the human factors issues involved in a combined manual/automatic spacecraft docking. You will be expected to show knowledge of the key human factors issues and to suggest designs consistent with these principles. If you are not certain of any particular aspect of the problem make an assumption and state your assumption.

The task is to design a system to safely dock a large unmanned cargo vessel (like the Progress) to a large manned spacecraft (like the ISS). The primary system should be automatic, and receive inputs from the ground (via radar) and from the two vehicles (via laser range finding and attitude indicators on both vehicles). The manual monitoring of the docking will be from the ISS, by astronauts observing the approaching cargo vehicle visually and monitoring instruments of your design. The control of the approaching vehicle can be altered by turning on and off (but not otherwise adjusting the thrust) of several reaction control jets.

Consider the following factors in the design. A complete design is not expected, but you may be asked about your approach to any of these factors.

What monitoring tasks will be assumed by the astronauts and by the ground during fully automatic docking? What displays will be presented? What alarms should be provided? What are the key instruments which should be displayed to the operator(s), and how should they be arranged relative to each other and to operator controls? What limits on control authority should be observed? What kinds of integrated displays or object oriented displays might be employed?

What are the optical markings which will be of use during docking – whether automatic or manual? How does the background come into play?

During manual docking, what loops should be closed in order to permit control with high accuracy and low workload? What should be the relationship between the astronaut's effector (e.g. joy stick) and the cargo vehicle motion? (Consider the order of the basic, unaugmented system and the requirements it would place on the operator(s), as well as the ways in which the manual tasks could be made easier.)

If the monitoring/manual control task would benefit from the use of more than one astronaut operator how should the tasks be divided? How could you determine if the workload level was acceptable? What considerations apply to the choice of automatic vs. manual operations?

During automated docking what precautions should be taken to avoid mode confusion or misoperation by the human operator. What should the monitor be shown about the automated actions and states?