

University of Arkansas Microelectronics-Photonics Graduate Program

PhD Candidacy Exam – March 2004

Photonics Area of Emphasis Exam

PROBLEM TO BE SOLVED

A space probe is to be launched to explore the Oort cloud, a swarm of icy bodies on the outer reaches of the solar system. They are of particular interest to scientists since they contain materials left over from the creation of the planets - including Earth.

Due to the extreme distances involved, radio communication may not be adequate so there is a desire to investigate the use of laser communication. The distances involved will range from 30 - 120 astronomical units (AU), and it is anticipated that a 12 kg, 70 W radio transmitter would be able to send back around 180 bits per second (bps) at 30 AU and only 11 bps at 120 AU.

You are the CTO of a company interested in bidding to be the primary contractor to the government on this task. Your job is to investigate the idea of using digital laser communication over the same range, within the same constraints of 12 kg total mass for all components (transmit and receive) and 70 W of available electrical power.

YOUR DELIVERABLE

Your task is to write an internal proposal for your corporate officers describing your approach to this issue. Be sure you address all of the following:

Current State-of-the-Art - What is already being done in this area by other researchers, companies and governmental institutions? The current state-of-the-art for both the science and the implementation should be described, making use of diverse resources such as science literature, journals, conference proceedings, the internet, patents or other sources of existing public knowledge. Be sure to cite all references used.

Your Proposed Solution - Describe in detail your solution to this problem, including both the scientific/engineering basis and method of applying this to a workable solution. You must provide specifications and preliminary design for the units both on the spacecraft and on (or near) Earth. Estimate the performance expected, along with a list of potential benefits and problems. Calculate the expected rate that data will be able to be passed back and forth between the ground and the spacecraft, taking into account all factors that influence the rate and availability of data transmission/reception by this method. Pay particular attention to pointing requirements for both stations in terms of what is required and how it will be achieved.

Testing and Qualification - Describe a set of tests and demonstrations that you will use to demonstrate the effectiveness of your approach. These should include tests that show that the systems can work as intended and can survive the conditions that they will be subjected to.

Cost Analysis - Perform a cost analysis that includes, at least, acquisition of raw materials, labor rates, costs per operation, testing and qualification, etc. You may exclude from your analysis possible additional costs in such infrastructure areas as human resources, facilities engineering, janitorial and grounds, upper level management, etc. You must include all direct fabrication costs, both startup and continuing; and you must discuss explicitly space and personnel requirements to set up a stand-alone product line. Generic per process costs for various manufacturing methods can be used, as long as they are rationally applied. You should plan on manufacturing enough units for testing, qualification and two completely operational units for the spacecraft (one will fly and one will be a backup) and a set of whatever ground units you require. Minimizing costs are less important than obtaining suitable system performance, but infinite money is not available. Be reasonable, and clearly justify the major performance/cost tradeoffs you choose.

Intellectual Property - List all IP sources that were consulted while formulating the answer, and include the full list of examined documents as an appendix to this exam. (The full list will not be counted as part of the 15-page limit.) From this list, identify the three that are the most significant threats to the IP you have created in your solution.