Discussion I—Questions and Answers*

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Question: An area of specific interest is automation of the interface between remote sensing data and computer-assisted design. Such automation would be achieved by digitizing the interpretation and use of the remote sensing data and would apply to terrain analyses for hydrological and route-selection studies as well as to the processing of monitoring data. Related applications would include vegetation and land-use studies. Comments from the authors regarding the present state of the art in the use of digitized data and future developments in this area would be valuable.

Answer: Combining satellite imagery with digital data from other sources, such as geophysical surveys and digitized maps, allows the greatest use to be made not only of the satellite data, but also of the data available to the investigator from other sources. It is this technology, more than any other, which will bring about a general acceptance and usage of remotely sensed data in the general community.

Question: In using digitized data for computerized evaluations and processing, to what extent should regular hard-copy prints be used for comparative study?

Answer: The answer to this question is heavily dependent on application. For some investigations hard-copy prints may only be relevant in the final report, while in others they will be needed on a regular basis to test the digital and remotely sensed data against the ground truth. It is a matter that would need to be decided separately for each project and that would require consultation between the remote sensing specialist and the data user.

Question: The authors are asked to expand on their views of the geotechnical applications of remote sensing and remote data transmission. Directions in which specific industry development efforts are going that will allow a wider use of remote sensing techniques are of interest. The question is not limited to the particular topic discussed in the paper but includes any area of interest.

Answer: There are three current technical developments that will allow greater use of remote sensing techniques. These developments are more capable instrumentation, relatively low-cost image analysis systems, and procedures for integrating remotely sensed data with digitized data from other sources. These three developments will enable remote sensing to provide useful data on a broad range of applications in a cost-effective manner.

As satellite sensors become capable of routine imaging at ground resolutions of 20 m or better, and become capable of doing this in the thermal infrared and microwave frequencies, they will be able to provide data on virtually every area-based investigation. The advent of personal-computer-based image analysis systems and digital data bases will allow even relatively modest instrumentalities and companies to use remotely sensed data and to develop geographic infor-

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mation data bases for their own needs. The increased use that these developments will generate should itself overcome one of the greatest obstacles to more common use of remotely sensed data—a general lack of knowledge about its availability and capability.

Question: In order to chart further the place of remote sensing within the geotechnical industry or profession, would the authors address the question of how remote sensing specialists—and the organizations providing remote sensing data or services—interact with other organizations, such as engineering organizations, in general practice? One aspect of the question is this: what does the output look like that the remote sensing specialist in your area of application would furnish to the geotechnical engineer?

Answer: The type of output received will depend on the application. In mining applications such an output would typically include processed images, lineament maps, lineament statistics, and a number of thematic maps. In order for these data to be useful, there must be a high level of communication between the remote sensing specialist and the end user. This communication should begin in the planning of the project and continue through the data acquisition and processing. This should ensure that the final report output will be applicable to the user's needs.

Question: Can the authors summarize their views regarding the areas of remote sensing in which standardization or guideline development, or both, would be desirable or possible now or at a future date? In answering this question please keep in mind the areas within the International Association of Hydrological Sciences (IAHS) that are of interest to ASTM.

Answer: In the future it may be possible to develop a list of data sources that should be accessed for any particular application and a list of appropriate analysis techniques. However, at the moment the technology is moving very fast and much of geotechnical remote sensing technology is still experimental. In this situation there is a danger that formal lists or guidelines would bind the industry to outmoded or inappropriate techniques. A guideline about the degree of consultation to be undertaken between the end user and the remote sensing specialist could be helpful.

Question: ASTM Subcommittee D18.01 on Surface and Subsurface Reconnaissance, a subcommittee of ASTM Committee D-18 on Soil and Rock, has a direct interest in the application of remote sensing techniques. One subject related to the subcommittee's work is the ground checking of remote sensing data interpretations. Would the authors describe the requirements and procedures for ground checking within their areas of application?

Answer: In the mining industry the predictions of remote sensing information are directly tested against mining operations. However, it should be noted that remote sensing data form only one part of an investigation. It is a useful addition to more traditional tools, such as drilling, geophysics, and geological mapping. It does not replace them. Indeed one of the most important contributions that remote sensing can make is to make the work of these other tools more effective. It does this by placing these data in their real context and by optimizing site selection for further drilling and mapping. In such a program the ground checking of the remotely sensed data forms a natural part of the broader study.

Question: It appears difficult at the present time to define the quality of remote sensing data to a general user. The quality scales, for example, for Landsat imagery are well known. What further developments are envisioned within the remote sensing industry that will lead to definition of quality criteria unique to the various sensing methods and enhancement/interpretation techniques? The bottom line for consideration is this: how can a general user in need of purchasing remote sensing data and services ensure himself in advance that he will get what he wants?

Answer: The answer to this comes down to consultation. Early advice from competent experts

on the advisability of any remote sensing project is essential. Such advice can often be gained from government agencies without cost. A high level of communication with the remote sensing specialist should ensure that a general user would either get what he wanted or would realize that the technique was not appropriate to his problem.

Question: What are the selection criteria for remote sensing data to be used for geotechnical engineering purposes—for example, sensor reception frequency, scales, and resolutions? Furthermore, which different types of imagery should typically be used together to bring out the appropriate contrasts best for evaluating soil and rock conditions?

Answer: The answer to this question depends entirely on the end application. The requirements of each study will vary enormously, and we do not really have enough experience with the geotechnical applications of remote sensing to set any standard or norm. Techniques and data sources that may be used with great success in one study could be completely inappropriate in another. To repeat a theme developed elsewhere, the editors think consultation with competent professionals is the first and essential answer to this problem.