and buses operating on such roads.

5. The specific influence of pavement macrotexture in wet-weather accident models should be determined. One characteristic of pavement surfaces that should contribute to safety during wet weather is the macrotexture of pavements. Evidence indicates that high macrotexture contributes to reducing wet-weather accidents on high-speed roads, but the precise contribution of high macrotexture is unknown. Either a rational formulation that explicitly accounts for the contribution of pavement surface macrotexture or a series of carefully controlled empirical studies that permit a partitioning of the relative contributions of both microtexture and macrotexture are required.

6. Wet-weather sensors should be developed or evaluated for use in conjunction with wet-weather advisory signing. Convincing research results indicate that the performance of drivers operating at hazardous locations can be effectively modified by specific wet-weather warning and speed advisory signs. At present there appears to be no reliable wet-weather sensor that local highway agencies can use in conjunction with such signs. The development of such a sensor is highly desirable.

7. The benefits and costs of skid training should be evaluated. Skid training has been incorporated into a few driver education programs, and special courses have been set up to train commercial vehicle operators. The effectiveness of such training has not been established or identified. The potential cost-effectiveness of skid training has yet to be evaluated.

8. The importance of various perceptual cues associated with skidding should be established. To effect efficient training programs or to provide appropriate remedial aids requires an understanding of the perceptual cues used to detect skidding and maintain control of skids. Some fundamental research to fill these gaps is needed.

9. Incentives should be evaluated for maintenance of braking systems and tires. Maintenance of vehicle-braking systems and tires can have a pronounced benefit during wet-pavement conditions. Incentives for maintaining these vehicle components may be cost-effective in reducing wet-weather accidents. A variety of indicators of deteriorating wet-weather performance or the condition of brakes and tires should be evaluated.

10. The scope of cost-effectiveness models should be increased. Models of wet-weather accidents now permit investigators or decision makers to explicitly consider various options for reducing such accidents. Such models, however, are limited with regard to the types of options that can be explicitly evaluated. Evaluation of vehicle-braking systems, tire design, and education of drivers is not possible with present models.

11. Benefits and costs of skid-resistant pavement warranties should be evaluated. In general, highway agencies that have made conscientious efforts to develop systematic programs for identifying and correcting highway skidding sites have been able to effectively defend themselves against adverse litigation. These agencies must continue to improve the effectiveness of their programs. In a number of European countries, individual contractors are responsible for warranty of their construction projects. In these countries, pavement skid resistance must be held at criterion levels for a number of years; therefore, pavement surfaces susceptible to rapid deterioration cannot be used. The legal implications of such a plan should be explored thoroughly to determine whether more widespread use of construction warranties could have a significant positive effect on wet-weather safety.

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Conference Summary

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The proceedings of this conference (1, 2, 3, 4) present an overview of the current knowledge on how to prevent wet-weather accidents on highways and airfields. It is the hope of those involved in the conference that this knowledge will be used fully by those who have significant influence on the design and building of vehicles and pavements or have the responsibility of managing traffic and vehicle operators. Gaps still remain in our collective knowledge, but this does not constitute a license not to do what can be done now to reduce wet-weather accidents drastically.

This means not that dry-pavement accident rates are acceptable but that we addressed only that increment of the problem that is chargeable to pavement wetness. To eliminate that increment is an engineering problem because clearly we cannot count on drivers to change significantly because the roads are wet.

Nor would all be well if drivers did change their ways. As Segel points out (5), the variability of tire and vehicle design factors (and he might have added pavement design factors) is secondary to the variability due to operational and in-use factors. Tires wear, wheel loads change during maneuvers, brakes become unbalanced, pavements polish, puddles form, and so on. In traffic the average driver simply cannot deal with all these variables, even if he or she could recognize them and were trained to properly react to them. Drivers need all the help they can get, and this conference has shown the many ways in which significant assistance can be provided to them.

The available implementation measures fall into two broad categories: those that government agencies must apply and those that must be made available by industry and be accepted by the public. These categories are not independent of each other, because in both cases money is involved that eventually comes from the citizenry. There-

fore, trade-offs are necessary between wet-weather countermeasures and other reasonable demands for improving mobility, safety, and convenience. Thus the cost-effectiveness of measures that reduce the hazards that wet pavements present is extremely important.

In proper cost-effectiveness analysis, maintenance expenditures and the lifetime of the design or measure under consideration are taken into account. Unfortunately, this cannot always be done because government agencies must operate within a given budget and are compelled to go with the lowest bidder. Therefore, the engineering specifications for pavements must anticipate low surface courses and the length of time they will retain their skid-resistant properties over the expected life of the pavements or of the surface courses themselves. It is difficult to justify resurfacing or retexturing if the pavement is still in perfectly acceptable condition while dry. Citizens, who face an ever increasing tax burden, will show little appreciation for such resurfacing, except of course when the situation has become so bad that skidding accidents occur with deadly regularity every time it rains.

On the other hand, quite different constraints govern the design decisions of manufacturers of vehicles and components. Fortunately, the industry is now promoting safety features, at least for those improvements such as tread designs or steering geometries that do not increase vehicle or vehicle maintenance cost significantly. An improvement such as antilock brakes, however, that requires a large cost increment may have to be introduced by governmental mandate not so much because of inherent industry resistance as because of the buyer's unwillingness to foot the bill.

Some of these difficulties are caused by the inability or the unwillingness of engineers and researchers to go before the public to promote the improvements that they know can be made. The public might then insist on having those improvements made and thus encourage the allocation of the necessary funds for upgrading pavements and roadways and to add safety features to vehicles even though prices would be increased.

That we do not have all the answers yet, and certainly not the best answers, is evident from the suggestions for further research and development made by the three subcommittees. Despite the energy shortage, highway traffic is not going to decrease in the foreseeable future. Therefore, the wet-weather problems are not going to become any less pressing than they are now. Thus, our work must go on. The conference showed in a convincing manner both where we are and what we still must do. Great strides have been made since the First International Skid Prevention Conference. By the time the third conference is held, let us strive to see that all the remedies for wet-weather accidents that were presented at this conference are in full use all over the world and that we have the answers to the remaining questions and problems.

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Closing Remarks

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During the Second International Conference on Skid Prevention, we received many high-quality contributions that merit both study and reflection. Three important directions of research figured prominently in both contributions and discussions. The first deals with certain legal aspects about accidents on wet pavements, the second concerns international standardization, and the third touches on the strategy adopted by authorities responsible for reducing the number and the seriousness of those accidents.

With regard to the first point regarding skidding accidents on wet surfaces, highway engineers in some countries appear to be more and more preoccupied by the evolution of liability incurred either by contractors, civil servants privately, or highway administrations. In its report in 1975, the Committee on Slipperiness and Evenness of the Permanent International Association of Road Congresses dedicated a special chapter to this difficult and delicate subject. Without wanting to be involved in judicial problems that are outside its scope and that can vary moreover with differences in the general legislation of each country, the committee restricted its activity to outlining certain technical aspects liable to enlighten the judgments of courts.

Its point of view could be sketched like this: A skidding accident on a wet road is a complex phenomenon involving the strong interaction of many factors, the main ones being

1. Driver behavior,
2. The vehicle and its components (notably tires and suspension systems),
3. The road and its environment (and not only the pavement condition), and
4. Bad weather.

In most skidding accidents all of these factors are more or less involved, and to recognize the main factor is not easy. In other words, skid resistance is not an intrinsic property of the pavement. One cannot easily say categorically that a pavement is "abnormally slippery" and that the surface course cannot be maintained economically in a condition such that skidding is not possible. The estimation of liabilities is therefore a delicate