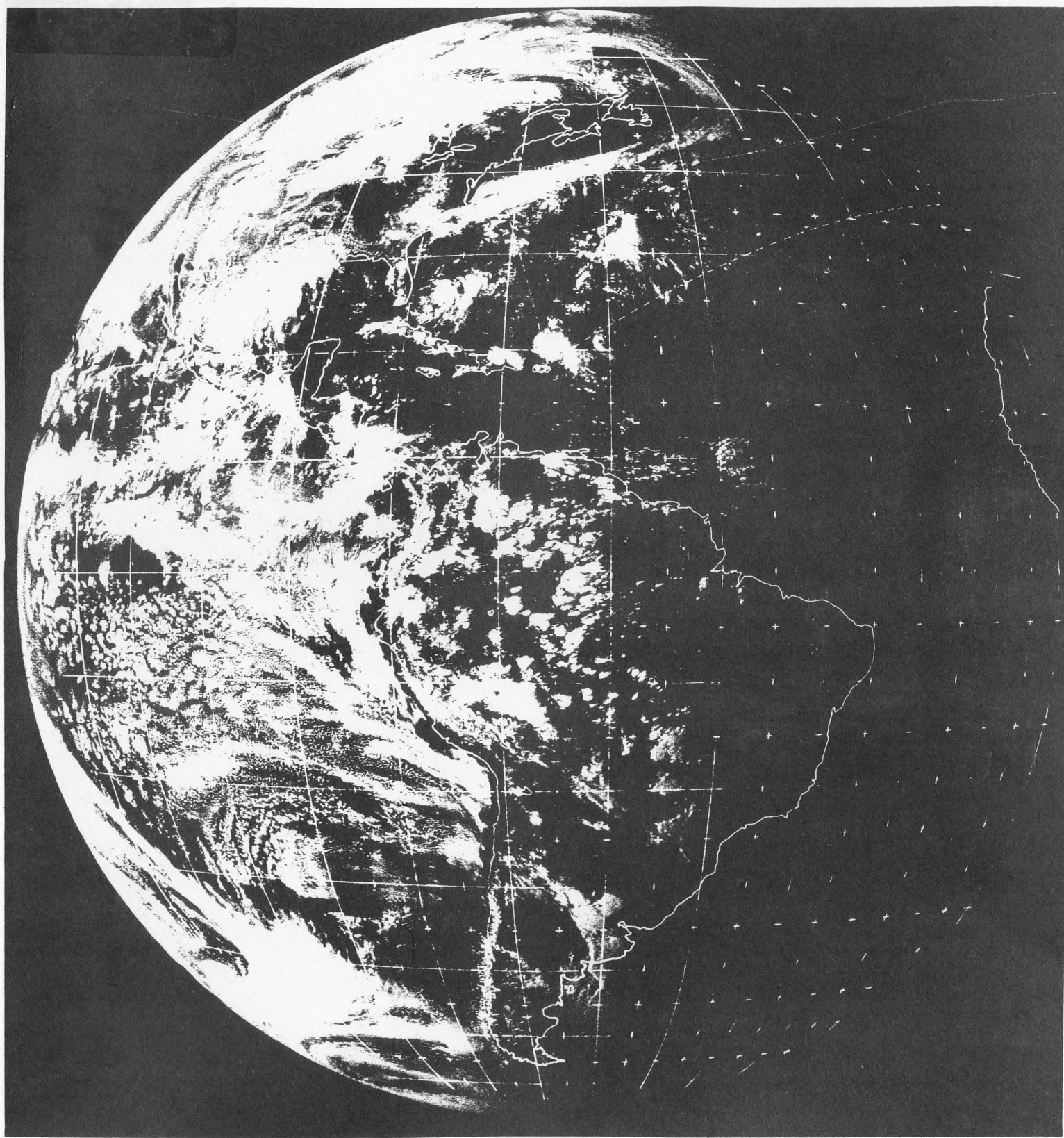


multidisciplinary studies
of the social, economic,
and political impact
resulting from recent
advances in
satellite meteorology

executive summary and
final report, volume six
space science and
engineering center
the university of wisconsin
madison, wisconsin



MULTIDISCIPLINARY STUDIES OF THE SOCIAL,
ECONOMIC AND POLITICAL IMPACT RESULTING
FROM RECENT ADVANCES IN SATELLITE METEOROLOGY

VOLUME VI

MULTIDISCIPLINARY STUDIES OF THE SOCIAL,
ECONOMIC AND POLITICAL IMPACT RESULTING
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VOLUME VI
1974

Final Report on NGL 50-002-114

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IN SATELLITE METEOROLOGY

VOLUME 6

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PREFACE

This is the final report in the six volume series produced by a most unusual, and possibly controversial, study. We set out to evaluate the impact of meteorological satellite systems on the American scene, and we believe we succeeded, at least partially, in this objective. That our findings did not support our *a priori* expectations was disconcerting, and we are grateful for the patience of our sponsors in NASA, and for the persistence of the study participants which carried the work on into the fruitful field of NOWCASTING. It is conceivable that we carried out this study too soon. The picture today seems very different.

With the completion of this study we are convinced of the great value and utility of the nation's meteorological satellite programs. In particular, we are impressed by the potential of the synchronous orbit satellites to produce quantitative data for the meteorologists and qualitative information for the public. The synchronous orbit satellites permit us to see the weather in sufficient temporal and spacial resolution so that we can at last begin to tell the public about the smaller scale phenomena which really affect man's activities. That is what NOWCASTING is all about, and it is because of this study that we are now embarked on a program to make NOWCASTING a reality.

Again I would like to thank our friends in NASA, especially Dr. Morris Tepper, for their support and encouragement. The list of participants in the study is too long to repeat here, but I thank each for his or her contributions. I would like to give special thanks to Tom Haig who provided the guidance which pulled the whole thing together.

Verner E. Suomi
June 1974

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EXECUTIVE SUMMARY

INTRODUCTION

Meteorological satellite systems are highly effective in serving the interests of the citizens of the United States of America. Additionally, the ability of meteorological satellites to serve the nation is increasing rapidly as advances in satellite technology and new scientific insights are married in comprehensive programs. This broad, extended study, "Multidisciplinary Studies of the Social, Economic, and Political Impact Resulting from Recent Advances in Satellite Meteorology" has probed deeply into important aspects of our meteorological satellite programs. From the study have emerged new insights into means of better implementing the knowledge gained from meteorological satellites for public benefit.

The overall purpose of the research was clearly stated in the original proposal: "The purpose of the proposed study is to provide a detailed analysis of the social and economic benefits of both accurate long-range weather forecasting and high-resolution weather observation, which we fully expect to attain in the next decade. These benefits are complicated by many factors. They appear in practically every sector of the economy. Many benefits appear as increased production of a commodity, but to determine the net benefit, the market characteristics of that commodity must be understood. To fully exploit the potential benefits, the nation must receive timely weather information and act on it; the probability of the national response must be evaluated."

The meteorological satellite serves as a primary source for the data that are eventually put into the hands of the user. The approach of the multidisciplinary team in this project was to begin with the user and work

back to suggest improved design and development of future satellite systems. Meteorological satellite system development should be responsive to users' needs since it is the satisfaction of these needs that justifies the system.

It was one of the purposes of our study to examine and to record the needs of the users. Users generally are not aware of the possibilities for improving weather information and therefore they do not attempt to initiate changes. In fact, there could even be some user resistance to change which has to be overcome by clearly presenting the opportunities that could be made available through the new satellite technology.

The values to be gained through user-oriented research include an improved use of our natural resources, a reduction of damage to people and buildings from disasters, an increase in economic gain in the agricultural and other sectors, a reduction in uncertainty, and a greater ease of planning for various sectors of our society.

The participating investigators undertook individual case studies to determine the nature of the impact of the weather predicting capabilities provided by the meteorological satellite program upon their area of special concern. Most investigators detailed the annual cycle of human activity in their area and identified when and how weather affected their operations. The characteristic weather effects wrought by weather variations, the type and cost (if any) of preventive measures which must be taken as a protection against adverse weather phenomena, and the benefits derived from this protection were estimated. The ways in which weather information is used in each area and the value of having short- and long-range forecasts available in an economic or social activity were also

examined.

Each of the case studies followed approximately the same outline:

1. A description of the discipline area to be considered.
2. An identification of the weather sensitive features of the activity (qualitative).
3. An identification of the functional relationships between the weather elements and the weather sensitive features.
4. The economic implications of the relationship in (3).
5. A determination of the current capabilities that can provide the function mentioned in (4) together with a distinction between those available and those used.
6. A comment on the contribution of the meteorological satellite as a capability in (5) both actual and potential.
7. An estimate of the economic implications of (6).

The work conducted verified the intuitive feeling we expressed in the original proposal:

"...interdisciplinary studies like this do not come naturally despite the urgent need to have them. On one hand the scientists and engineers who design, fabricate and fly spacecraft and evaluate the data are thoroughly familiar with what space systems do for meteorology, but they are not familiar with how these new capabilities will affect the social and economic and political aspects of society...

" On the other hand, those who are familiar with social, economic and political aspects of society know little or next to nothing about what space systems could really do to help solve these problems. The information gap for both groups prevents one from obtaining the needed customer truth..."

Throughout the program we continued to be surprised at the magnitude of the information gap, and we found that there were unarticulated needs that satellite meteorology could fulfill easily and inexpensively. Even though some users were completely unaware that meteorological satellites were even existent, not to mention any familiarity with their products and how they might be useful to their needs, it was also apparent that the "two culture" separation that existed could be bridged by undertaking detailed analysis of users' needs. From these case studies we found that there are weather sensitive parameters for about 80% of the users studied and there are substantial economic benefits to be obtained from increased weather information in the majority (70%) of the cases studied.

These case studies clearly showed that different weather parameters can be critical along the path from beginning to completion of different activities, and also that the time scale required for the user to react in a useful way varied over wide limits. From this, one could conclude that the best way to meet most user needs would not be to produce highly detailed data far in advance. To do so simply transfers the data storage and retrieval task to the user. User's needs are specific both in time and data content. Predictions of those weather parameters which affect long lead time items are needed well in advance of the weather, but when short reaction time is possible the user would actually prefer being advised at a later date. In general, large scale weather phenomena can be predicted further in advance than can smaller scale phenomena. There is a tendency for users to state their needs in terms which correspond with the theoretically achievable forecast capability, but unfortunately this is not always true. If the probable occurrence of smaller scale

phenomena could be predicted sufficiently in advance, crops could be selected at planting time to avoid loss. Put another way, it may be argued that users' needs adapt to forecast capabilities only because other forecast options have not been offered. A specific finding of our work shows that very short range information about "every day" weather as well as severe storms (hours rather than days) has significant economic value.

Still another finding of our work emphasizes the great need for what has been called the "linker." This individual must know enough about meteorology and about satellite observing systems as well as the needs of the user to be able to enhance the key information flow. We emphasize the words key information since the need for this data is obvious in the operation of a weather information service and is also critical in the design of the system. It is this latter fact which may not have been fully appreciated in the past and is in need of further application. Thus a linker is needed to interpret what could be available and to match this to the expressed needs in order that the user be able to reduce his costs and maximize the benefits.

Most of the case studies show several similar specific short term information needs and this area of weather data dissemination is clearly identified as needing additional study both to establish the impact of the requirements on the design of meteorological satellite systems, and also to project the greatest benefit to the user.

The significant findings from the many case studies and other activities are given in the following synopsis of the study volumes. The topics in each volume are defined in more detail in Appendix I through V of Volume 6.

VOLUME ONE

Water Resources Management

Nearly all water resource managers should be able to realize gains from long-range weather forecasts or from data available as a result of satellite meteorology. Areas for gain include power generation, flood damages, reduction, water quality, municipal and industrial water supply, irrigation, and navigation. Given the present advanced state of water management, gains would generally be small percentage improvements. Many would be difficult to measure; however, the small percentage gains would still be appreciable sums in the aggregate.

Some present decision processes allow for the uncertainty of future weather conditions. To the extent that this can be done, the need for long-range weather forecasts is reduced. Nevertheless, improved forecasts will reduce uncertainty and allow a narrower range of approximation. The agencies that are presently doing a good job of flow forecasting and water management will likely be the agencies best able to utilize the long-range forecasts.

There are areas of water management in which even existing weather forecasts are not used to enhance management. These include water quality management, urban storm drainage (with a few exceptions), some utilities and special water districts. Improved long-range forecasts may help to change attitudes which now inhibit use of forecasts.

Outdoor Recreation

At the present time ski resort operators, as principals in a \$1.2 billion industry, are interested in weather forecasts containing information on temperature, precipitation, and wind velocity. They favor one-day

and five-day weather forecasts and the majority currently utilize local radio and television broadcasts for weather-forecast information. The ski resort management aspects affected by weather forecasts are planning personnel numbers, ordering restaurant and ski shop supplies, planning personnel deployment, and to a lesser extent, advertising. However, nearly half the operators queried are very skeptical of present weather forecasts, even one-day predictions, and regard them as too inaccurate to be of use in their planning and management operations.

If improved weather forecasts were available, those management aspects affected nationwide would include season opening date, slope care, and number of employees. In some regions additional aspects of season closing, stocking of supplies, advertising, road and parking maintenance, and snow making would also be influenced by better weather forecasts. Improved weather forecasts would result in more flexible personnel arrangements and greater promotion of group contracts, season ticket sales and organized activities. These improved forecasts would have to include information about precipitation, temperature, humidity and wind on a one-day to one-week basis. Many respondents indicated that they would make no changes as a result of improved forecasts. They appeared to be optimistic about their ability to handle the larger crowds that might result. As most skiing occurs at weekends, the capital investment required to expand present operation might not be economical unless there was a change in the present five-day, Monday through Friday, work week.

VOLUME TWO

Horticulture Crops

Complete and precise weather information is of significance to crop production in this high value industry (tomatoes \$512 million, snap beans \$63 million, cucumbers \$51 million) because the scheduling of most operations is controlled by the weather and because the plant itself grows and responds differently under varied weather conditions. Thus weather information is a necessary factor in the majority of decisions concerning the production and marketing of each crop. Each grower tends to make maximum use of all available weather information to arrive at the best estimate of climatic conditions for the decisions that he has to make. Many growers subscribe to private weather services to obtain more detailed information on specific aspects of the weather that relate directly to their operations. Grower groups are providing funds for specialized weather forecasts and funds for research to determine the influence of certain weather patterns on crop yield and quality.

In the years ahead, the significance of precise weather information will continue to increase as agricultural enterprises become larger and more specialized. The decreasing per-unit profits, as competition becomes keener, will require managers to make more efficient use of weather information to protect the crops and to schedule operations. Improvements in communication are needed to make it possible for individual operators to obtain up-to-the-minute data to meet their specific needs.

Lettuce

Precise weather information would be of significant value to lettuce operations. A saving of \$100 per acre could be realized for lettuce

operations on organic soils of Wisconsin with precise information. The major saving would be realized for losses relating to the following weather-associated events:

1. Unexpected high temperature periods causing rapid crop maturity and producing excess quantities of lettuce that cannot be sold.
2. Sudden rain during harvesting periods so that orders cannot be filled on time or causing lettuce to be harvested dirty.
3. Heavy rains causing flooding of the fields and causing total loss of some plantings and reduced yield and quality of other plantings.
4. Rains washing pesticides from the plants.

Other weather-associated events such as frost injury and wind injury may produce significant injury but losses were not of a general concern to all growers and were restricted to only certain geographical locations or special conditions.

Peas

Weather is an extremely important variable in the growing and harvesting of peas for processing. Accurate forecasts of one day to two weeks would permit much more efficient field and processing plant operations. A more stable supply of peas would be insured and their quality would be improved. The most important weather factors are temperature, precipitation, humidity, cloud cover, radiation, and wind. Disturbances such as storms are important. Predictions are presently received from radio and television and these appear to be the most logical means for the future. Television is especially attractive because of the visual interpretation possible. Application of forecasts to small specific areas suggest that interpretation should be made on the local level. However, this should not require highly trained or

skilled people. Payment for improved weather forecasts might be agreeable to farmers and processors if they could see adequate economic benefit, and if they were convinced there was good reason the service should not be provided through state or federal taxes.

Single-Home Construction

The homebuilding industry is characterized by the following:

1. A critical path exists in which approximately one-third of home construction operations are vulnerable to adverse weather.
2. Weather losses as estimated in Milwaukee, Wisconsin suggest that something more than one percent of the total value of housing units constructed was lost due to adverse weather.
3. The industry is characterized by large numbers of small firms, local in nature and operating generally without finite long-range planning.
4. Large homebuilders tend to subcontract most of their activities; sub-contractors possess the same characteristics as the small homebuilder.
5. The bulk of the weather data and services currently available is not utilized by the majority of homebuilders.
6. Growth in prefabrication is reducing the on-site weather loss potential significantly.
7. The potential for avoidance of weather losses offered by an improved, long-range weather forecasting system necessitates long-range planning not generally found in homebuilding.

Common Carrier Trucking

The value of improved weather prediction information to common carrier

trucking is extremely small (.4% on operating expenses of \$54 million). Even if the dollar values of improved information to the sales, terminal and safety functions were known, it is highly unlikely that improved weather information would have a significant effect on common carrier's profits. In addition, it is somewhat doubtful that carriers would be willing to accept the improved forecasts as being reliable enough to determine policy changes. It would be necessary not only to provide the information in an easily usable form, but there would have to be proof that the information provided was reliable. Thus these two effects - the low dollar value and the perceived unreliability of weather information - combined with institutional factors such as the regulatory framework, labor agreements, and the unsophisticated scheduling techniques presently used, result in a very low value for improved weather prediction information. Insofar as the common carrier trucking company studied is typical of the common carrier trucking industry, it may be generalized that improved information would be of little dollar value to common carrier trucking.

Recreational Boating

We can make the following tentative statements concerning recreational boating -- a \$3 billion a year industry:

1. Boating operators would respond to improved weather forecasts by establishing better management practices and expanding their operations.
2. The public is interested in increasing its participation in recreational boating as a result of such forecasts.

3. The public and the boating operators regard information about temperature and rainfall as important in improved forecasts. Wind information is regarded as slightly less important.
4. Improved weather forecasts will not be the sole determinant of increased recreational boating participation. Such factors as the managerial aspects of lakes, the types of lakes, the personal characteristics of users, and the time of year must also be taken into consideration.

VOLUME THREE

Agriculture

Three types of benefits to agriculture are possible: quantity increases, quality improvements and reduced costs of production. We also divided crop production into general categories: field crops, vegetables, fruits, and horticulture . Our analysis clearly indicates that by far the most important benefit would be increased supply, resulting from reduced waste and more effective operations.

In the field crops it appears that the major factors contributing to supply increases are better protection from disease and insects, and to a lesser extent (except in the case of hay) reduced harvesting and shipping losses. Based on our findings, we would probably have to estimate that the supply of field crops other than hay would increase .5% to 5%, with most increases near the lower end of the range. Quality increases would also be present in field crops other than hay, but for the most part they would be insignificant. The reduction in production costs would quite likely also be insignificant.

Use of Weather Information

When agriculturally associated respondents were asked if they would be willing to help pay for some sort of continuously available forecasting system, 83% of the farmers said either they would or might help pay, compared to 67% of the lime-fertilizer dealers surveyed. Some said that it would depend upon the accuracy of the forecasts, but the response showed great interest in and strong support for such a service. All of the 257 respondents indicated that the forecasts are usually or occasionally helpful - and 60% of them usually try to plan their activities on the basis of the forecasts. Only 2.4% seldom or never plan their activities accordingly.

VOLUME FOUR

Tornado Forecasting

The operational use of satellites in tornado or severe thunderstorm detection or tracking is still in its infancy. Enough tornado cases have been studied in retrospect with satellite pictures at hand to realize the promising future that satellites have in this vital observing and warning mission. There are a number of small, erratic, and less damaging tornadoes with short tracks which probably will not be detectable from satellites. On the other hand, the familiar cloud patterns of the large family - type outbreaks, which are so damaging to large areas and cause the most fatalities, should be readily recognizable, especially as new techniques are developed and as nighttime infrared capabilities are added. In addition, a continued gain in theoretical knowledge and insight into the severe thunderstorm problem will be realized as researchers become able to compare and utilize satellite data together with conventional data in more and more cases.

VOLUME FIVE

Nowcasting in Agriculture

This survey of agricultural crops has indicated that accurate nowcasts would save crop growers and processors \$74 million each year. Nowcasts are of particular value for crops which yield perishable products and which require production practices which have to be very precise in order to insure a marketable product.

The production of these crops tends to involve a large number of specialized operations to protect the plants from climatic and biotic stresses, such as temperature and moisture extremes and various insect and disease infestations. Thus weather information is utilized constantly to maximize the effectiveness of particular operations. Production of the principal feed crops of field corn, soybeans, wheat, grain, sorghum, oats, and barley were not found to benefit directly from nowcasting information. The production of these crops involves a minimum of specialized operations during the season and little or no effort is made to protect these crops from climatic or biotic stresses during the growing period.

The results of this study should not preclude the possibility that other operations in the production of these crops may benefit from nowcasts. The data were taken from the principal growing areas for each crop and taken for those operations that appeared to provide a significant total dollar benefit. Thus, in different areas of the country, the benefits might be more or less, depending upon the specific operations required for the local production of the crop. It should be recognized also that each individual producer will be likely to vary in the use of the weather information so that savings will not be the same on each farm.

Several crops that would benefit from nowcasting information, such as cranberries, avocados and peppers, were not included in this survey because the total dollar value of these crops in the United States is not large. Nonetheless, growers of these crops would utilize nowcasting information, for these crops are subject to serious losses under particular weather conditions, protection against which could be provided with accurate weather information. The cranberry industry, for example, supports a special cooperative program with NOAA on weather information crucial to the industry.

The value of nowcasting information will increase each year as competition forces growers to become more specialized and develop larger producing units. Growers will have to make each operation in the production of a particular crop as efficient as possible. The net effect of more accurate forecasts will be more efficient production and lower cost for the consuming public.

Media Dissemination

Although television is the public's most preferred source of weather information, it fails to provide weather reports to those groups who seek the information early in the day and during the day. The result is that many people use radio most often as a source of information, yet prefer the medium of television. Radio tends to give less information, but at greater frequency than TV, and television stations give significantly less coverage to weather information on weekends, when public interest in the information increases.

The public actively seeks weather information from both radio and TV stations, usually seeking information on current conditions and short range forecasts.

Nearly all broadcast stations surveyed in this study were eager to

air severe weather bulletins quickly and often.

Bituminous Concrete Construction

Accurate weather information in a form which could be readily utilized by the bituminous construction industry would permit savings on the order of 2.5% or more of the dollar cost of the bituminous concrete operation itself, or approximately 1.3% of the gross contract costs for bituminous concrete jobs. The major savings would be realized for those losses associated primarily with precipitation in the form of rainfall. In some areas of the state of Wisconsin notably in the northern portions where morning temperatures during the early and late portions of the construction season are apt to hover around the freezing mark, temperature could also be a constraint resulting in losses. The actual losses themselves are the result of wages which have to be paid under union contract for which no work would have been performed and material losses resulting from the need to discard materials at the outset of weather occurrence.

Variations in the loss estimate would accrue from differences in hauling distances and, as a result, the amount of material which would have been on the road and would have been discarded at the outset of a weather occurrence, differences in contractor construction procedures and different union contract requirements. Other activities in bituminous concrete construction projects such as crushing granular materials, laying granular base courses, curb and gutter work, and other incidental items, are less susceptible to weather phenomenon. As a result, losses in those areas would be considerably less.

Severe Weather

The results of the study were somewhat startling, though not totally

unexpected. From our sample we found that 45% of the Dane County, Wisconsin, population was not aware of a severe thunderstorm warning. In this case this may or may not have been critical, but had the storm been extremely severe or had a tornado and flooding been associated with the storm, a large segment of the population would have been in great danger.

We found a heavy dependence on the broadcast media for the dissemination of emergency information. Though good cooperation existed between the media and emergency warning agencies, the lack of a dedicated warning system and the resultant levels of decision making left serious doubts as to the emergency effectiveness of the present system.

Our study also revealed that different groups with seemingly different responsibilities chose separate solutions to similar problems. With each group concentrating on its own immediate responsibility, primary consideration of collective, cooperative exchange of different bits of information was impossible. Needless duplication of effort as well as "tiers" of inefficiency resulted. There was no group to which "blame" can be assigned, nor was one group more responsible for system inefficiency than any other.

What this study showed us was that the real problem with the dissemination of severe weather information is not the lack of it, but the inability to transfer it in useful form to most of the general public.

NOWCASTING

Nowcasting emphasizes the recent, current and near future state of the mesoscale atmosphere. Geographic limits of a few counties or a few states and time spans of hours apply. Its objective is to provide detail sufficient to allow the user to make valid weather dependent decisions for now and the near future.

The work in Nowcasting concentrated on several separate but closely related areas during the final year of the grant. Much unique software for assembling, processing and presenting mesoscale information was developed for use on the Man-computer Interactive Data Access System (McIDAS)--a specialized computer system combined with a video image display device developed by the Space Science and Engineering Center. Experimental nowcasting programs in broadcast television format were produced plus scheduled color telecasts to the local populace via state-financed public television. A viable Nowcasting service employing a continuous presentation mode suitable for cable television was demonstrated. Integration of information from meteorological satellites, national weather radars, and conventional observations was stressed. Evaluation of the reception by users of each aspects of the service was an integral part of each area of Nowcasting activity.

It was concluded from the studies that more comprehensive weather information can be made available to the public through television. This was demonstrated for both broadcast and cable television operating modes. Data from meteorological satellites, weather radar, and more conventional sources of weather data can be combined into television weather presentations under operational conditions using a computer and its video display system. Much must yet be done to make the procedures effective and efficient. Nowcasting, from this beginning, will grow to become an essential service to the nation.

MULTIDISCIPLINARY STUDIES OF THE SOCIAL, ECONOMIC, AND
POLITICAL IMPACT RESULTING FROM RECENT ADVANCES
IN SATELLITE METEOROLOGY

VOLUME VI
NOWCASTING

I. INTRODUCTION

This is the sixth and final report of a series documenting an effort --broad in scope with novel objectives--undertaken under a NASA grant at the University of Wisconsin. At the onset of the program it was assumed that the meteorological satellite program, which represents a large portion of the United States' effort in unmanned satellites, was altering the activities of the country and its citizens in a detectable and measureable manner. Now, as we end this study, we believe the assumption was basically correct, and that society in America has been altered very significantly--and for the better--because of the meteorological satellite program. This impact, however, has not occurred in the places and in the manner which was originally anticipated. Instead, the investigators were forced to abandon preconceived notions as their investigative studies led them to discover more definitive facts about the acquisition, processing, and use of meteorological data in the United States. The dominant aspect that emerged from this program was the enormous value of meteorological satellite data to the observation, understanding, and prediction of mesoscale meteorological phenomena.

Mesoscale phenomena are those active weather phenomena of a spatial scale (meters to a few hundred kilometers), and temporal scale (less than one to several hours) too limited to be effectively and routinely detected by older types of meteorological observing networks. Mesoscale phenomena include tornados and thunderstorms as well as other severe local storms--strong winds, intensive precipitation, etc. However, the mesoscale also includes the small showers, light winds, and the variability of weather within

larger atmospheric systems which directly affect the lives of each of us. The versatility of the meteorological satellite thus makes it an effective instrument to observe the complex detail and rapid variation of mesoscale phenomena.

The total volume of atmospheric data, both observed and derived, now available on the mesoscale is considerable. As might be expected, the dissemination of information derived from these data to the public is only now becoming possible because of the limitations of existing systems, budget constraints, and the need to examine and choose among alternatives. For the nation to realize the benefits that could result from making mesoscale information readily available, effective means for producing and presenting this exceptionally perishable information in a timely, easily understood, and relatively inexpensive form to potential users must be developed, tested, and evaluated. This was the thrust of the final portion of this extended study where the means of providing mesoscale information to the user was embodied in the development and implementation of Nowcasting.

Nowcasting emphasizes the recent, current, and near future state of the mesoscale atmosphere. Geographic limits of a few counties or a few states and time spans of hours apply. Its objective is to provide detail sufficient to allow the user to make valid weather dependent decisions for now and the near future.

The work in Nowcasting concentrated on several separate but closely related areas during the final year of this grant. Much unique software for assembling, processing and presenting mesoscale information was developed for use on the Man-computer Interactive Data Access System (McIDAS)--a specialized computer system combined with a video image display device

developed by the Space Science and Engineering Center. Experimental Nowcasting programs in broadcast television format were produced plus scheduled color telecasts to the local populace via state-financed public television. A viable Nowcasting service employing a continuous presentation mode suitable for cable television was demonstrated. Integration of information from meteorological satellites, national weather radars, and conventional observations were stressed. Evaluation of the reception by users of each aspect of the service was an integral part of each area of Nowcasting activity. This report summarizes the work accomplished under the NASA grant but concentrates on the application of meteorological satellite and other environmental data to a Nowcasting service for the nation.

It will be obvious to those who read this report that we have only begun the development of the Nowcasting program. We believe, however, that we have progressed far enough to have established the feasibility and the necessity of such a program and to have clearly defined a multi-year development program leading to a comprehensive Nowcasting service.

II. BACKGROUND

The multidisciplinary design of these studies was followed throughout the period of the grant to the advantage of all concerned. This was true in both the multidisciplinary studies phase and the Nowcasting phase. The following summarizes the work carried out leading to the Nowcasting phase and the cooperative effort that was developed within the University of Wisconsin to support the Nowcasting phase of the effort. A detailed topical listing of the work performed prior to the Nowcasting phase is given in the first five parts of the Appendix which contain "Detailed Tables of Contents" for Volumes 1 through 5 of the Interim Reports.

A. Multidisciplinary Studies

These studies were conceived initially as proceeding in three phases: a data collection phase, an analysis phase, and then the preparation of reports. Looking back it is possible to identify easily the initial collection phase and the subsequent analysis period. Then, however, a second information collection phase was inserted in the program because the facts collected in the first phase deviated so widely from the preconceived notions concerning the impact of the meteorological satellite program on the community. Based upon these new facts the second data collection phase was more sharply focused than the first. During the focusing of the second data phase a new and basic program structure emerged dominated by the enormous value of meteorological satellite data to the understanding and prediction of mesoscale meteorological phenomena. Following the second data collection period the program was further refined to the concept previously defined in the Introduction as Nowcasting and a series of laboratory investigations were undertaken to test concepts which emerged in the course of analyzing the collected information. As the study drew to a close it became clear that a very substantial program previously unappreciated, at least by those performing the study, was emerging and producing new insights into the great value of meteorological satellite data and the means of realizing this enormous potential value for the nation.

The initial data collection phase was originated in a series of case studies conducted by experts in various phases of human activity in the United States. Included were experts on water resource management,

outdoor recreation, agriculture, horticulture, and the production of specific agricultural crops, plus highway construction, home construction, the trucking industry, legal aspects, and even the management of satellite programs themselves. The investigators set forth armed with questionnaires and inquiring minds to find the impact of the meteorological satellite programs on the individuals involved in these various activities. Almost without exception their efforts met with total failure when the normal response from the individual being questioned was, "What is a meteorological satellite?" It was soon apparent that the output from meteorological satellites did not impact the general public because they never saw the satellite output. It was in general consumed within the meteorological service by meteorologists and so thoroughly translated by them into information for the public that the users of the information were unaware of its source. Thus, while the impact of the meteorological satellite program has indeed been great it was not appreciated by those ultimately affected.

Confronted by this unexpected initial finding the investigators altered their approach as they pursued their data collection activities. They explained what meteorological satellite programs were to the individuals being questioned and showed examples of images from meteorological satellites--especially those from synchronous orbit satellites. The investigators were prepared to spend some time explaining the concept of a satellite, how it operated, what the images signified, how the data were processed, and so forth. However, most of the investigators were surprised to find that people not generally acquainted with satellites or satellite images had no difficulty understanding what the cloud

patterns signified, where their particular location was relative to the cloud patterns, and drawing some rather accurate conclusions about the state of the weather as revealed by the satellite images.

Discussions among the investigators then raised the possibility that meteorological satellite images were not being used to their best advantage and that presentation of the images themselves, probably accompanied by additional information, might provide a service of real significance to the public. To test this idea, motion picture loops of ATS satellite images were prepared -- some with notation, some without -- and were shown to various groups. The results of these presentations did indeed confirm the idea that the public could use meteorological satellite images very effectively and with a minimum of confusion. At this point another round of discussions among the investigators ensued and once more the data collection activities were readjusted slightly. The aim now was to gain more information about exactly what sources of weather information were used by the public, how effective they were, and to what extent it was possible for the data user to project his needs into an unknown area, plus how his needs might be better fulfilled by a different type of weather service.

At the onset of the study the emphasis, as stated in the original proposal, was "...to provide a detailed analysis of the social and economic benefits of both accurate long-range weather forecasting and high-resolution weather observations." As we learned more about the way people used weather information it became increasingly clear that long-range weather predictions were very important for planning purposes, but that the greatest need of the public, both in specialized areas and in

the general public usage of weather information, lay in accurate analysis and prediction of smaller scale, shorter term mesoscale weather phenomena. It became obvious that people used the 24-hour or longer predictions to plan, but that they made decisions based on their expectations of the weather for the next four to eight hours. As the economic implications of the usage of weather information were assessed it became very apparent that the great dollar impact lay in the decisions, not in the planning. Furthermore, the capability provided by the high resolution -- both in time and space -- data obtained from synchronous meteorological satellites provided a brand new dimension of weather observation from which mesoscale phenomena could be observed, analyzed, and perhaps with a little more work, even predicted.

In retrospect, there was nothing really new in any of these findings. Many research meteorologists working with the satellite data had come to appreciate the great value of the synchronous meteorological satellite data as a source of information for research into mesoscale phenomena. To some extent the images have been used by meteorologists in preparing local area forecasts in the normal weather service. What did emerge from the studies which was new were the very clear impressions that the public needs short term weather prediction urgently, that the meteorological satellite provides a great deal of the information necessary to satisfy the public's needs, and that the individuals have little difficulty in using the meteorological satellite images to obtain the information they want.

Because these findings led the investigators some distance from the original direction of the study, we consulted with our sponsors in NASA at some length late in 1971 and received their strong encouragement to

pursue the study further. The redirected study was to confirm the need for short term mesoscale weather information and its economic impact, and to investigate some of the concepts beginning to form in the minds of the several investigators on how to present this kind of information to the public. A second more limited set of studies were undertaken, the results of which are reported in Volume V of this series. In general, they confirmed and substantiated the earlier findings, and revealed unexpectedly high dollar values associated with accurate mesoscale weather presentations to the public.

Following the writing of Volume V of this series our attention swung from evaluation of the need for mesoscale information to the problems involved in presenting the information to the public. If one is to describe the weather as it exists at the instant and how it will exist for the next four hours, so that farmers, travelers, housewives, aviators, or whoever may decide upon their best course of action, it soon becomes obvious that the information must be presented nearly continuously, and that it must be updated at very frequent intervals. This presentation must deal with mesoscale phenomena, that is local weather, as well as the larger scale features of regional or national scope. The information content of the presentation is very high requiring the presentation be optimized for a maximum rate of information transfer to reduce the length of time which the information user must spend watching or listening to the presentation. It is easy to conceive of a national service consisting of dedicated television channels carrying continuous weather broadcasts updated perhaps every 30 minutes, but it is much harder to fit this concept into the reality of the present national weather service. Much of this report is concerned with preliminary tests which have been made

to investigate automated and semi-automated approaches to generating Nowcasting presentations.

B. Cooperative Effort in Nowcasting

The broad scope of a Nowcasting Service necessitated the enlistment of several departments of the University of Wisconsin into a cooperative, integrated effort to support Nowcasting development. In addition to the Space Science and Engineering Center, the Department of Meteorology and the University of Wisconsin - Extension Telecommunications Center played key roles at the University in a development program designed to increase the application of meteorological satellite data to real and pressing needs of the public through Nowcasting. The efforts of these groups were coordinated through an "Ad Hoc Committee on Nowcasting" composed of interested members from each organization. Representatives of the National Oceanic and Atmospheric Administration (NOAA), DOC, the National Environmental Satellite Service (NESS), NOAA, and the National Weather Service (NWS), NOAA, were particularly helpful in providing information necessary to direct the University of Wisconsin efforts toward areas compatible with current and planned national capabilities. The rationale for participation by each group is given in the following:

1. Department of Meteorology

Concurrently with the evolution of the Nowcasting concept through the Multidisciplinary Studies, the Department of Meteorology embarked on a program to develop a new constituency by cooperating in the development of a "Weathercasting" capability at the University of Wisconsin. In concert with academic programs in applied meteorology, the effort was to focus upon new methods of presenting weather and climate to public users and would involve joint efforts with other departments and centers. It would consist, in general, of an ensemble of activities designed to bring short-range weather and climate information to the user. Rather than to compete with the national agencies, the program would act as a bridge between the national agencies and the user. It would use the meteorological skills of department personnel, participants from other departments and centers, and new technological facilities for information dissemination. In an emerging climate of more actively promoting and supporting innovative services to the State of Wisconsin the program would provide an important service to the citizens of Wisconsin for "weather will always be important in human affairs." These aims fostered a natural move toward cooperative work in Nowcasting by the Department of Meteorology.

2. Telecommunications Center

Any service to the public is completely dependent upon the existence of a viable means of disseminating the service. A Nowcasting service, which must depend upon the communications media, is no exception. The University of Wisconsin is fortunate to have on its Madison campus a complete Telecommunications Center with full facilities for radio and television broadcasting. It was through the cooperation of the staff of the

University's broadcast television outlet, WHA-TV, that dissemination of a Nowcasting Service to the campus and the public was made possible.

WHA-TV became interested in Nowcasting as a result of producing an educational series of meteorological telecasts prepared and presented by a professor from the Department of Meteorology. From this evolved a desire to better serve the citizens of Wisconsin through the development and testing of innovative means for weather information dissemination. Funding was acquired for the audio and video network necessary to link the production facilities located in the Meteorology and Space Science Building to the Vilas Communication Hall, the site of the WHA-TV facility. Equipment and expertise necessary to begin both in-house and public telecasting were made available as needs become known.

3. National Agencies

Interest in a Nowcasting Service applicable on a national level emerged from the need of NOAA to meet its charter responsibilities to the nation and from discussions with representatives from NOAA, NESS, and NWS by representatives of the university. In November 1973 representatives from all three national agencies visited the campus of the university for an in-depth review of capabilities and exchange of views. At that time the needs of each agency present were stated in detail. Following the meeting and later visits to the three national agencies by representatives from the Space Science and Engineering Center and the Department of Meteorology, a draft proposal was submitted to NOAA in December 1973 by the cooperative university group.

In the draft it was proposed to develop, test, and evaluate a pilot Nowcasting Service at the University of Wisconsin. The university team

would develop techniques to present recent, current, and near future mesoscale information suitable for public dissemination media which meets most user's immediate, functional needs. Integration of geostationary and low orbit meteorological satellite data, national radar data, and conventional observations, using the latest available technology, would be stressed in developing the service. The program would employ experts in meteorology, information processing, and communication technology working in six integrated, but individually budgeted, sub-programs. Insuring compatibility of this Nowcasting Service with NOAA's mission, facilities, and personnel would be a primary goal of the program.

With the aim of developing compatible means to present mesoscale information to the public as the primary goal it was mandatory that experts from the operational agencies be consulted in order to relate our development activities to the real world. This was accomplished through the kind cooperation of NOAA. Additionally, a program begun with this stated aim can be easily expanded to examine the operational needs of NOAA.

III. NOWCASTING PROGRAM

The broad search carried out in the earlier portions of the grant led to a realization of the fact that the meteorological satellite can be of great value to the observation, understanding, and prediction of mesoscale meteorological phenomena. From this emerged the concept of Nowcasting and the development of a program to implement a Nowcasting Service. Being broad in scope, the Nowcasting program was addressed in four coordinated areas: Information Presentation Capability, Broadcast Telecasts, Continuous Telecasts, and Presentation Evaluation.

Interaction and feedback between the areas was the key to successful advancement of the program.

A. Information Presentation Capability

Meteorological data produced by sensor systems and communicated to a central location are not, a priori, meteorological information. Only after such data are processed intelligently do they become information of value to a user. It was the objective of this area of investigation to develop and test information processing and presentation techniques that would turn meteorological data into meteorological information applicable to the production of a Nowcasting Service. The integration of geostationary meteorological satellite data and national radar data with conventional data was stressed. However, all sources of meteorological satellite and national radar data with conventional data was stressed. However, all sources of meteorological data were explored and viable combinations of data and derived parameters exploited. The Man-computer Interactive Data Access System (McIDAS) -- an integrated package of selected computer and video components -- developed by the Space Science and Engineering Center was the principal information processor for NOWCASTING. Conventional facilities including weather observation equipment, national weather teletype and local weather radar were also available for use.

Presentations during the program originated from two separate but interconnected facilities: the SSEC development McIDAS and the Experimental Television Studio. Both facilities had the capability to present weather information in television compatible formats and were used in a variety of ways to produce separate or integrated presentations of innovative weather programs for telecasts and evaluation.

1. Man-computer Interactive Data Access System (McIDAS)

At the date of this report, Geostationary Satellite ATS-III was in its sixth year of operation and the first Synchronous Meteorological Satellite (SMS) was being prepared for launch. With these satellites the weather moves -- not the spacecraft -- providing the opportunity to view the weather in the time domain. Despite this opportunity, over the years it has not been possible to fully exploit this capability. It may come as a surprise that the difficulty is not too little data, but too much! Most of the data are organized in the x - y image plain -- not the time dimension. McIDAS, the Man-computer Interactive Data Access System, now filled the long-standing need to be able to treat data in the time domain in a quantitative fashion. It accomplished this by linking the flexibility, speed, and processing power of a sophisticated digital data processing system with a capability to generate, assemble, and present color video images.

The key to the power of McIDAS is that the operator of the system can see and cycle the data in a form suitable for easy and accurate interpretation. He or she can study patterns, motion, and interactions of varying scale sizes, make judgments, and then communicate exact location coordinates and instructions for processing the digital data. The same display system is used by the computer to show results and to request additional guidance. The system always has the full precision digital data to work with, so maximum accuracy is possible in any analysis.

Significantly, the McIDAS data storage, access, and display techniques developed at SSEC have applications in many areas of data processing, cloud motion data for meteorology being only one of many. An existing problem in many fields is the lack of an ability to gain efficient access to the vast

quantities of data which have been generated by modern remote sensing instruments. Referencing small subsets of these data in a fast and economical way, with accompanying observation and guidance by a human operator in an interactive mode with the system, is of considerable value. Furthermore, these benefits are not necessarily limited to a small user group. The use of standard TV components within the system assured complete access to the entire spectrum of communications technology developed in the television industry. Thus the development of McIDAS opened up the possibility of data not only being processed in real time, but disseminated in real time as well to both scientists and the public over already existing communications channels.

During the Nowcasting phase of this grant the McIDAS equipment was used to support a variety of programs in addition to Nowcasting. They included: generation of development cloud-wind sets for the GARP Data Systems Test and other users; analysis of Earth Resource Technology Satellite (ERTS) data for land use and other projects; development of techniques for estimating cloud height and rainfall; vertical mass and moisture transport; analysis of electron microscope images; analysis of images of other planets -- the most recent being Venus. Support to such a variety of programs was made possible by a strong in-being or developing hardware capability in several areas plus, as in the case of Nowcasting, specialized software to meet specific needs.

2. Experimental Television Studio

The television camera has traditionally been the means by which most visual information has been converted into a television compatible form with weather presentations being no exception. Only recently has it

been possible to convert selected weather data directly into a video presentation through the use of advanced computer systems such as McIDAS without the use of a camera. Because direct video conversion systems are still under development and are not expected to meet all data display needs for some time, plus the fact that many types of weather presentations to the public are structured to involve a personality as an integral part of the program, the capability to do experimental television studio presentations in-house was a necessary part of a Nowcasting program. In addition, the experimental studio provided the electronic capability to process and disseminate the McIDAS displays for test and evaluation purposes.

Recent technical advances in the television industry made available a broad spectrum of possible equipments for the experimental television studio which in turn compounded the problem of selecting the most effective and efficient studio cameras and accessories. Although it would have provided a complete capability, a commercial broadcast quality color video system was rejected on both the basis of cost and because it would have effectively duplicated the in-being facilities of the on-campus system of WHA-TV. A commercial broadcast quality black and white video system was rejected on the same grounds. To gain the most versatility versus cost of the investment the decision was made to procure a black and white video system similar to that commonly found in instructional settings which offers a wide variety of off-the-shelf hardware and records on 1/2 inch video tape. Although half-inch video was never made for commercial production or to create technically high-quality programs it does allow the simulation of virtually every capability of commercial broadcast systems at a fraction of the cost. We found that a complete half-inch black and white video

system could be purchased for less than the cost of a good lens for a broadcast color camera.

To gain studio production capability quickly the initial half-inch video system was leased. This proved to be a distinct advantage in that it provided experience with the video equipment in a real-time production setting which aided in determining what equipment should be purchased to fill the total production needs that could be expected to be levied on the facility.

After considerable investigation, testing, and real-time use, the basic equipment needs were defined, allowing the necessary components to be purchased and incorporated into an austere but quite functional experimental television studio. A three television camera set-up was chosen made up of two pedestal-mounted studio cameras and one tripod-mounted portable camera (Rover) for use inside and outside of the studio. The studio cameras were equipped with 5:1 zoom lens with rear-mounted zoom and focus. The portable camera, being smaller and more accessible, had no rear-mounted lens controls. Coordination between personnel operating the various equipments was via an integral inter-communications system employing individual headset-microphone combinations at each operating position. Studio lighting was provided by a selection of overhead and floor mounted spot lamps and backfill lights.

The key element in the system, the switching unit, provided a multiple input capability, a special effects generator, audio control, and a variety of preview and camera monitors. The switching unit was especially configured electronically to combine input from the experimental studio and McIDAS (in color) into a broadcast-compatible video signal.

A pair of one-half inch video tape recorders (VTR) provided the video

and audio record and playback capability. One VTR with edit capability was largely confined to studio use while the second VTR was more portable for use with the Rover camera in on-line recording. To complete the studio system, several black and white television monitors were necessary for in-studio monitoring of the production and for program presentation via a closed circuit distribution system within the building.

3. Dissemination Modes

Any video or audio presentation that is produced must reach an audience of users to be useful. The dissemination mode is determined by the purpose of the test or the audience to be served. Because of the variety of applications to which Nowcasting presentations were to be put, a variety of dissemination modes were developed and employed.

A closed circuit TV network was installed within the confines of the Meteorology and Space Science Building. Outlets and monitors were provided in the entrance lobby, lounges, and selected laboratories for routine viewing of scheduled weather presentations or for supervised evaluation of special test productions.

Access to the University audience was through a link with an in-being campus, closed circuit TV network. This network provided outlets in classrooms, lecture halls, student unions, visitor centers, and residence halls.

Through the financial and technical assistance of the University's broadcast television outlet, WHA-TV, a high quality video and audio link was installed between the Nowcasting production facilities in the Meteorology and Space Science Building and the studios of WHA-TV in the Vilas Communications Hall. This link greatly enhanced the dissemination capability for Nowcasting by providing direct access, in real time or by video tape, into the local and state-wide TV broadcast facilities of the

State of Wisconsin's Educational Communications Board.

Discussions were held with the two local cable television (CATV) companies concerning access on a test basis to their facilities. Considerable interest was shown in making available a dedicated, full time channel for a continuous Nowcasting presentation. Use of such a presentation mode was considered to be the ultimate for Nowcasting presentations but was not employed by this program. Additional development, testing, and evaluation will be necessary to successfully exploit cable television.

B. Broadcast Telecasts

Of longest standing in the video media community is commercial broadcast television. A commercial enterprise with a strong profit motive, broadcast television has only one channel into which it must funnel all of its revenue producing programs. This leaves only small segments for public service programming. To maintain its very necessary identity with a widespread potential audience it employs a considerable staff to personalize its presentations and is usually associated with a national television network. Out of this has come the tradition of presenting all programming through a personality, including the weather segments, requiring uniquely tailored, short segment, video weather presentations be provided for its use. Without the option of adjusting the available video weather presentations to match station or network input and constraints, little incentive exists for commercial broadcast television to upgrade its weather dissemination service. Therefore, visual weather presentations prepared for its use must be in video format, must be composed of short segments designed to be used as an entity or

selectively as the desires of the telecast dictate, and must be available for pick-up on a routine, scheduled basis.

Also of relatively long standing in this segment of the video community is public service broadcast television. Not as concentrated as commercial broadcast television, it is also constrained to one channel but without the profit motive. This enables it to devote more time to public service programming. Addressing a more selective audience and operating on small budgets that limit it to small staffs reduces routine use of on-camera personalities and the pressing need to maintain a station identity or trademark. Under these conditions a video weather service for use by public service television would consist of tailored segments but of greater length and increased variety than those for use by commercial broadcast television. Today public service television broadcasts little weather information. The opportunity to use routinely prepared, professional video weather presentations should greatly increase its weather dissemination services to the public.

It was with the needs, capabilities, and potential of broadcast television in mind that the Nowcasting effort was first explored. Cooperative, interagency, discussions held early in 1973 between members of the Department of Meteorology and the Space Science and Engineering Center resulted in a decision to demonstrate the viability of the of the Nowcasting concept in a broadcast television mode using the facilities of the Experimental Television Studio which was being assembled by SSEC. The first development and test vehicle was a one month University course in synoptic meteorology held in May 1974 and telecast over closed circuit facilities in the Space Science and Engineering Building. The course was designed to train meteorology

students in real-time weather analysis and prediction under the guidance of a professor highly interested in the field and to give them first-hand experience in television weather presentation. Additionally, it was to demonstrate the feasibility of producing an operational weather presentation, to aid in the selection of optimum equipments for weather presentations, and provide an outlet for innovative work in weather presentation content, format and application.

The students were assigned to work in teams on four hour shifts to simulate operational conditions in a working weather station. Guidance was provided by the instructor on the use of graphic materials and program content but each team was given considerable flexibility in its presentations to encourage innovative approaches. The Experimental Television Studio production crew had several student members who had majored in television production insuring a professional atmosphere for the televised weather presentations. All productions were carried out in a format similar to that used in broadcast television weather presentation employing four to seven minute telecast segments.

Several significant findings emerged from the course. All concerned were impressed with the dedicated effort required by both the meteorological and production personnel to produce scheduled, operational weather presentations and by the large number of man-hours necessary to maintain a schedule of several daily telecasts. The only break in the daily presentations was over Sunday but even that caused continuity problems for the meteorological students. The lack of speaking experience on the part of the meteorology students came to be a serious deficiency curtailing possible attempts at new, innovative presentation formats and styles. This deficiency carried over into the audience reaction where the

viewers concentrated on the production capability and presentation ability while largely ignoring attempts at new meteorological applications. This was a strong indication of the need for the best professional production in any weather presentation in order that the meteorological information not be ignored by the viewer. The many students in the course made it a prime opportunity for student learning but their lack of consistency in style, view point, meteorological experience, and prediction accuracy helped to degrade viewer attention. Overall, the development and testing of new formats was not as great as anticipated. The tight operational schedule and lack of student experience caused the participants to continue tried and true modes in which they had confidence. With productions being live, with no rehearsal, any last minute change in the weather content or an innovation in format caused considerable difficulty. At the end of the course the general consensus was that even with all its difficulties, it had been a successful learning experience. Sufficient knowledge on equipment needs and use had been gained. Experience in producing weather presentations had been accumulated and a number of students were now confident that they could continue such a program.

Following a review of the results from the course the decision was made to continue the program through the summer and into the fall. It would be produced by interested students employing the same basic format as the first course. This consisted of live talent appearing on camera only at the beginning and ending of a five to eight minute weather presentation. The length was tailored to match the viewing habits of the available audience who were mobile as they walked past the TV monitors placed at several locations in the Meteorology and Space Science Building and on the University campus. The presentation emphasized graphic visual

aids employing back-lighted "cels" or viewgraphs in color made from multiple layers of acetate with rub-on lettering used for readability. A set of standardized base maps was used as well as most standard meteorological symbols and notations. The order and content of each presentation was influenced by the current weather situation but generally consisted of weather on the national scale followed by weather on a mid-west scale, a state scale, and the local scale. The presentations addressed weather pertinent to the day showing current and predicted conditions. Special interest items such as time lapse weather photography were inserted from 35mm color slides or 16mm film. The successful use of the limited sequences available illustrated the need for an extensive library of weather photographs. The schedule of the presentations varied according to the weather situation and available personnel. As many as three separate telecasts plus two live updates were made daily with special interest users being assisted as necessary. Particular attention was given to advisories aimed at boater safety on Madison's lakes. Before the presentations were concluded in November 1973 some McIDAS displays of meteorological satellite images and weather observations and analyses were used in near real-time as well as live telecasts of local weather radar displays.

The continuation of the weather presentation program did not reveal any startling new information but it did reinforce the findings from the first course. The need for such programs is real with this being graphically indicated by the well-stated questions and comments of the viewers when they had a special need for information. Such requests became more frequent as the viewers became more aware of the scope of available weather information. A shortage of staff again limited development to mostly tried and true

approaches. The ability of an electronic data access and display system to aid the forecaster in his presentations became evident very quickly. This knowledge was one basis for shifting emphasis to supporting a television broadcast weather program reaching the public.

In cooperation with the University affiliate of the Public Broadcast System, WHA-TV, a new approach to presenting weather information to the public through broadcast television was scheduled for initiation in October 1973. High-quality video links were installed connecting the facilities of WHA-TV with the Experimental Television Studio and McIDAS. These video links were designed to feed computer processed and displayed meteorological information from McIDAS and live local weather radar displays from the Experimental Studio into the control center of WHA-TV. There it would be available for use by the meteorologist from the Department of Meteorology, the same professor who initiated and supervised the first presentation course just described, in his presentation of the new weather show.

The television weather presentation was designed to use a combination of manually prepared graphics and McIDAS prepared image displays, along with studio input, to fill a five to nine minute time slot. The aim was to provide not only the best possible weather information to the viewers in an effective format and in pleasing color but also to increase their knowledge concerning the weather and its effects. The show was scheduled as the concluding segment of a hosted, one-half hour, current events telecast titled "Target - The City" to be shown from 6:30 pm to 7:00 pm, Monday through Thursday, throughout the telecasting season.

During the initial telecasts in early October 1973 the design was to introduce and use massive amounts of McIDAS produced displays -- live or

video taped by WHA-TV just prior to broadcast time. Sequences of current geostationary meteorological satellite images incorporating hand-drawn grids and annotation inserted by the computer were attempted. A variety of weather parameter displays, parameter analysis displays, and their combination spanning most of the day were used. Live local weather radar in real-time was included. Color enhancement of the McIDAS displays was undertaken. All possible capability and resources were brought to bear.

Although sound in theory, the weather presentation design did not perform as planned under the stress generated by daily operational telecasts. In retrospect, it was simply a case of "too much, too soon." Under maximum development, the McIDAS had only reached a semi-operational status a day or so prior to its use to support the weather show. Neither the meteorologist presenting the show nor the meteorologist and production personnel providing support had had an opportunity to become at all familiar with McIDAS and its capabilities. No formats had been selected and tested either for style or quantity. No test display sequences had been possible. Color enhancements of the images had been arbitrarily pre-selected and were untried. The compatibility of the McIDAS output signal with the broadcast station was untested. The meteorologist on the show had little experience in using such a new and innovative information source and image preparation capability.

Considering the variety of obstacles to be overcome, the public service weather telecast was quite successful in getting its information to its audience. Still under development, McIDAS experienced several lengthy periods of downtime during the fall and winter thereby eliminating any McIDAS input to the weather show during those periods. This required the meteorologist to fall back on his manually prepared graphics which, al-

though quite effective, took many man-hours to prepare. Additional informational segments were also used as well as time lapse photography of weather systems.

Most effectively used of the McIDAS produced products were the real-time ATS III geostationary meteorological satellite images. They provided the nationwide, detailed picture of where the clouds associated with the nation's current weather systems were located plus the changes with time of the cloud location, coverage, and brightness -- an information capability available from no other source. The ability of McIDAS to expand any selected portion of a satellite image and to align standard or expanded images in a coherent sequence of cloud changes with time gave the meteorologist the option of concentrating the viewer's attention on the most pertinent weather developments influencing the viewer's area of interest in the near future. In the case of the evening telecast time scheduled here, the viewer could be shown developments in the cloudiness to near sundown -- one or two hours before broadcast time.

The ability of McIDAS to substitute color selected by the meteorologist for any of the 64 gray levels of the satellite image was particularly useful in making satellite images more informative and viewer attracting. With the weather show being telecasted in full color it was desirable to use this capability to the fullest but with always the constraint in mind that many in the audience were viewing the program on black and white television sets. One effective color approach used was to flow smoothly from deep blue into light blue, into silver, into white as the black to white levels of the image were addressed. This caused the clouds to appear light silver (or gray) to white depending upon their recorded brightness. Brightness areas of particular interest were assigned bold colors for emphasis to

attract viewer attention. A wide range of color combinations were available as desired.

Of prime importance in presenting any meteorological information in pictorial form is to have the viewer fully knowledgeable as to the frame of reference of the display. In the case of satellite images the viewer must be able to orient himself geographically to the point where he or she feels comfortable (located in the picture) or the transfer of desired weather information will be severely curtailed. This was accomplished for the weather telecasts by keying a colored grid in geostationary satellite projection onto the McIDAS produced and displayed satellite image using the camera and switching capability of the Experimental Studio. The ability to place such grids directly on satellite images internally within McIDAS had not yet been fully developed.

The use of local Department of Meteorology radar displays was effective, particularly during periods of strong convective activity in the Madison area. Of note was the occasion where a damaging thunderstorm system moved across the city during the late afternoon with the threat of more to come later in the evening. By video taping a sequence of the storm's progress, as depicted by the continuous radar echo display, for viewing on the evening show, followed immediately on the show by the current radar echo picture telecast live-from the Experimental Studio, the meteorologist was able to both inform the audience of what had occurred and to reassure them that no further severe activity was eminent. This was accomplished by showing that the current position of the afternoon storm was far to the northeast and that no echos were visible to the southwest of the city, the direction from which the previous storm had come. In this case it was too late in the day for visual satellite

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The use of local Department of Meteorology radar displays was effective, particularly during periods of strong convective activity in the Madison area. Of note was the occasion where a damaging thunderstorm system moved across the city during the late afternoon with the threat of more to come later in the evening. By video taping a sequence of the storm's progress, as depicted by the continuous radar echo display, for viewing on the evening show, followed immediately on the show by the current radar echo picture telecast live from the Experimental Studio, the meteorologist was able to both inform the audience of what had occurred and to reassure them that no further severe activity was eminent. This was accomplished by showing that the current position of the afternoon storm was far to the northeast and that no echos were visible to the southwest of the city, the direction from which the previous storm had come. In this case it was too late in the day for visual satellite

pictures to confirm the lack of additional activity making the radar the vital information source. The need for the ability to select and combine information rapidly was demonstrated here and in many other situations during the months of weather telecasting.

An evaluation program to assess the public service weather telecasts was undertaken. Results from the evaluation were not as comprehensive as desired as only 4 to 5 percent of the potential audience viewed the program "Target - The City". Because the weather show was the concluding segment of this serious attempt to address the activity of the city -- a somewhat unique place for a broad appeal type of presentation -- it did not attract a large audience. It is interesting to note, however, that the name of the meteorologist presenting the weather show became almost a household word in the city before the end of the program series. This was due in part to the engaging and infectious personality of the presenter but also because of the innovative approach to weather presentation used and the use of presentations not to be seen elsewhere on local commercial television.

Overall, the public service weather telecast proved the technical feasibility of the Nowcasting concept as applied to broadcast television and provided experience in using McIDAS, the other display facilities, and the video transmission systems. It also emphasized the gains to be achieved in weather information dissemination from automatically prepared and distributed video displays, not only in the information content itself but also in the time compression. The time compression in data display and application now permits the mesoscale features of the weather to be captured and used by the meteorologist and their

information content passed to the public while there is still time to influence the decision making process and appropriate action be taken.

C. Continuous Telecasts

The most recent addition to the video media community and its fastest growing member is cable television. Multi-channel, cable television has a continuous appetite for large quantities of video presentations and a small budget and staff with which to obtain or produce them. In most cases it must, by law, provide channels for public service telecasting which it can only fill from very low cost sources. This makes cable television a natural for dissemination of a continuous weather service routinely prepared by an outside professional organization. Cable television, being relatively new, is not incumbered by any tradition of personalities on camera or other programming restrictions that would limit the format of a weather service video presentation. Under these conditions cable television requires a full, continuous weather service that will always be available to potential users during its many hours of operation. The continuous presentation can, however, be structured by the originating organization to pass all desired weather information visually, with audio support, in a routine, largely automated video mode.

Any design of a visual weather presentation for dissemination through the video media must consider the media capabilities and constraints and the goals, facilities, and personnel of the originating organization. Operationally, however, the weather situation to be presented and the potential users should play the dominant role in the routine choice of content, selection of displays, use of automation, and the frequency and extent of updates. Of particular interest would be providing a frequency

of update to match rapidly changing mesoscale phenomena in the form of severe local storms. The availability of weather radar data every 100 seconds, meteorological satellite data as often as every 15 minutes, and synoptic data every hour makes updating every 15 to 30 minutes possible. Only through maximum automation and preparation could updates of this frequency be done at a reasonable cost with available personnel and only through a continuous weather service telecast on cable television could the capability be completely and effectively exploited to the benefit of a considerable segment of the nation.

In this portion of the Nowcasting effort the aim was to develop and test the techniques to ultimately be used by a working meteorologist or field forecaster in using and disseminating continuous weather information in video format. With maximum automated assistance from his facilities, and instant access to a library of proven video displays the field forecaster would concentrate on forecasting the weather and keeping the public informed about what was happening and what to expect in the future. We began development of families and sequences of video information displays, tailored to particular weather situations or information sets, that would allow the forecaster to assimilate quickly the variety of meteorological information reaching him and to react appropriately. By the time the forecaster using such a capability would reach his decision on what actions to take in any particular weather situation he would be able to automatically assemble from his display library proven video information display families that tell the public via television what the forecaster knows and needs to inform them about. In addition to the families of displays, we briefly addressed display scenarios, largely automated, of what combinations and

sequences of information displays best tell the forecaster's story via the video media community, be it a continuous weather service for cable television or tailored segments for use by public and commercial broadcasters.

A continuous weather service telecast for use by cable television could be presented in a number of ways. One possible format would be a three to ten minute weather presentation telecast live while being video taped for immediately replay. The same telecast material would then be repeated from the video tape several times before a new, live updated telecast was again presented and video taped. The length of a presentation, the number of times it is repeated, and the frequency of its update would be dictated by the particular weather situation, geographic area, and the user's needs. Each presentation could contain national, regional, and local; past, recent, current, near future weather conditions as desired by the producer of the presentation. This format was developed and tested during the new, unexplored capabilities of McIDAS as influenced by the development of the system described previously.

Following the beginning of McIDAS operations in October 1973 the development of a series of continuous weather service telecasts was begun with the telecasts to be shown in-house. The first of the series of continuous telecasts of weather information was done in real-time to simulate operational conditions and used the current ATS III geostationary satellite images, the live local radar, and current surface observations. The telecast cycle was tailored to the most likely transit pattern of the audience and to available information. A new updated telecast cycle was originated every 30 minutes composed of four segments of 7 1/2 minutes each with the choice of 30 minute and 7 1/2 minute periods considered a

viable first estimate. Each of the four segments contained six minutes of McIDAS input with appropriate audio commentary and 1 1/2 minutes of input originating in the Experimental Studio, also with appropriate commentary. In the first segment of the 30 minute cycle the McIDAS portion was telecast live and at the same time recorded on video tape for replay during the remaining three segments of the cycle. The Experimental Studio input was produced live in all segments to provide the time necessary to rewind the video tape containing the McIDAS input for reshowing. To make the most effective use of available data the telecast cycles began at 20 minutes and 50 minutes past the hour allowing the use of the current hour's state weather at 20 minutes past and the hour's regional (mid-west) weather at 50 minutes apart. ATS III images were used in the next cycle after their receipt on the real-time link with the receiving site. Radar data was inserted as appropriate.

Because of the concentrated effort required to produce a Nowcasting test it was necessary to use short bursts of high effort over relatively short periods of time to attain the goal of proving Nowcasting a viable service to the public. The first series of tests was telecast continuously for three to four hours per afternoon over a period of several days. Image generation and display sequence commands were input manually to McIDAS via teletype keyboard by the meteorologist preparing and presenting the continuous telecast. The displays were shown in shades of gray to gain experience first in that media and because no color viewing facilities existed in the building. A minimum staff of one meteorologist and one television production person, with only occasional assistance from another production person, was employed during the actual telecasts to simulate operational personnel restraints -- in retrospect, a very ambitious undertaking.

The six minute McIDAS produced portion of the telecast opened with several seconds of preset blank display leading into an introductory display giving the term Nowcasting and the current date. The national weather picture was then introduced through the display of the current ATS III satellite picture with a national and state outline grid inserted into the image from a camera in the Experimental Studio. Frontal location and pressure center information were then added to the satellite image in the next display using the line creation and alphanumeric capability of McIDAS. To illustrate the development of cloud systems up to the telecast time, a series of the eight most recent ATS III images were expanded in scale (blownup), 1/4 the original television image filled the display screen, and geographically aligned causing earth features to remain almost stationary with the motion of the cloud systems predominating. This sequence of satellite images was shown as an image loop at rates of 1 to 6 frames per second as desired by the meteorologist.

The sequence of satellite images was followed by concentration on reported surface weather parameters received and ingested by McIDAS in real-time from the "Service A" weather teletype circuit. First displayed was a five frame sequence of the afternoon's reported weather on a regional scale, the mid-west, followed by a display of reported surface wind reports, combined with a contoured representation of the current temperature pattern, for the state of Wisconsin. A five frame hourly sequence of the clouds and weather reported over Wisconsin during the afternoon completed the information on recent and current weather and led to a presentation of the local forecast.

A time cross-section display format was used to give the forecast out to six hours with cloud and weather symbols depicted in the first

display, winds in the second display, and temperature and chill factor combined in the third. Support to building personnel preparing to drive in the occasionally harsh Wisconsin winter conditions was provided by showing a television frame outlining the Wisconsin road network alternately with a frame displaying the current weather and wind conditions to the same scale. The segment was closed using a display announcing the continuous nature of the NOWCASTING service.

Introductory and amplifying audio commentary was inserted during the McIDAS sequence of displays by the meteorologist. This was accomplished while also commanding McIDAS to change displays. The audio was designed to highlight the video information by selected comments without the necessity to present in a continuous monologue the information displayed in video format. Commentary was also added to the live telecasts from the Experimental Studio between McIDAS produced segments.

Following completion of a McIDAS segment the impression of information currentness imparted was maintained by switching immediately to a live, preset television camera in the Experimental Studio viewing portions of the campus and the weather occurring there from the 14th floor studio window. A clock and an alphanumeric display of the current local weather were also located in the camera's field of view. As the weather situation dictated, the local radar display monitor was inserted following the outdoor shot via another live, preset camera. A third preset camera provided the option of adding an additional display to the others. The studio segment closed with the campus view with the video taped McIDAS segment being retelecast following the rewinding of the video tape during the live 1 1/2 minute studio segment.

The first series of continuous weather service telecasts proved that weather information could be provided continually in real-time through use of computer-generated video displays. It was also very enlightening as to what must be done in order to make such a video weather service viable for operational use. It demonstrated the absolute necessity for a high degree of automation in preparing and displaying video images. It also demonstrated that under the pressure of a real-time operation, complete pre-planning is essential, equipment must be reliable, and support personnel must be well trained. Additionally, production procedures must be developed and followed to insure a professional presentation with presentation formats and color enhancements developed and tested well before their implementation. It indicated the meteorologist must have the capability to interact with the data in real-time to gain the information and prepare the displays necessary to tell the weather story as it develops. Because of the need for frequent, rapid, updating, the time required for McIDAS to generate a display must be tightly constrained. Internal gridding of satellite and radar images must be done by McIDAS if it is to be accomplished accurately and quickly.

In the follow-on series of continuous weather service telecasts many of the lessons learned in the beginning series were put to use. The development of scheduled, computer controlled, display generation capability coupled with a computer scheduled and executed display sequencer began to alleviate the pressure on the meteorologist and allowed him to concentrate on changing weather conditions. The scheduler allowed pre-planned programs to be constructed prior to the

beginning of a continuous telecast. The sequencer permitted individual displays and sequences to be manipulated accurately under computer control including the order, rate, and content of sequences and the automatic incorporation of preset image enhancements. The sequencer also insured precise time control on presentations, essential to a professional, operational presentation.

As more experience was gained the need for further investigation into presentation formats and the use of color enhancements became apparent and was undertaken. Progress was made in those areas, including better means of accessing color for displays, but required careful, step-by-step development. Optimization of McIDAS operations was a continuing program in the Center adding to the Nowcasting capability. Programs for computer gridding of satellite and radar images were begun. Ways of providing media access to Nowcasting video information and its reception by the ultimate users were addressed on a general level.

The concept of a continuous telecast providing up-to-date weather information at the fingertips of users embraces a broad spectrum of activity. In this beginning study we developed and demonstrated a capability to produce the necessary weather information and present it in a video format in a simulated operational mode. Much must yet be done to make the procedures efficient and effective. We feel, however, that Nowcasting can grow from this beginning to become an essential service to the nation.

D. Presentation Evaluation

The beginning stage of the Nowcasting development program undertaken under this grant required reliance on formative methods of evaluation. Selected areas of development were examined as they were produced and presented and the results fed-back to the developer. During the introductory broadcast television course the student's efforts were reviewed almost daily by means of questionnaires completed by residents of the building and the impressions gained used to enhance the content and style of the program. Effective feed-back was difficult to obtain in many cases because the viewers were frequently critical of both meteorological and production staff mistakes which tended to cloud the development questions being asked. Viewers most often commented on the technical competence and polish of the presentations while almost totally overlooking new production concepts or the quality of meteorology being conveyed. This finding of the critical need for a highly professional approach and execution of weather presentations to provide a non-disruptive vehicle for information transfer influenced all further development efforts and evaluation procedures.

The acquisition of a portable video tape playback capability added to the ability to evaluate Nowcasting developments. In one instance this capability was used to investigate the impact of a single, presumably first time, exposure to a Nowcasting weather information presentation to an audience located outside the city. The objective of the study was to investigate the assumption, basic to the Nowcasting program, that meteorological and technical development in concert offer weather information and presentation methods of greater value than now available and that

users will chose the new development if given the choice. A before - after design was used in the study where respondents self-administered a first-wave questionnaire preceding introduction to a Nowcasting presentation and a second-wave questionnaire following exposure to a Nowcasting presentation. A formative evaluation with 38 respondents, the study results indicated that the assumption of user choice of new developments was valid and that users could be influenced toward recognition and appreciation of a different and innovative method of processing and presenting current weather information. Details of this study are presented in Appendix VI.

During initial development of the continuous telecast capability a rigorous evaluation program was not undertaken. Until a basic standardized format and the ability to present alternative displays was established, effort was concentrated on assessing the mechanics of a continuous, operational, presentation, the basic information to be used, and the demands placed on the meteorologist presenting the telecast in real-time. It was found that a careful selection of materials and presentation methods was necessary for any measure of success and that additional experimentation would be required before implementation of an extensive evaluation study.

An extensive evaluation of the Nowcasting effort in Public Broadcast System television was undertaken. Addressed was the impact of the weather segment of WHA-TV presentation "Target - The City" on the citizens of the city of Madison. Face-to-face, in-depth, interviews of persons residing at randomly selected addresses in the city were carried out over a period of several days using an extensive and comprehensive questionnaire.

The questionnaire addressed the acquisition and use of weather information and knowledge of weather phenomena as well as the reactions of persons who had watched "Target - The City" -- 4 to 5 percent of the sample.

The limited number of persons viewing the WHA-TV weather segments reduced the measurable impact of the Nowcasting input which was a prime goal of the evaluation. The study did, however, detail potential audience views and preferences concerning the availability and use of weather information considered essential to the continued development of a Nowcasting Program.

IV. CONCLUSIONS

More comprehensive weather information can be made available to the public through television. This was demonstrated for both broadcast and cable television operating modes. Data from meteorological satellites, weather radar, and more conventional sources of weather data were combined into television weather presentations under operational conditions using a computer and its video display system. Much must yet be done to make the procedures effective and efficient. Nowcasting, from this beginning, will grow to become an essential service to the nation.

APPENDIX I

MULTIDISCIPLINARY STUDIES OF THE SOCIAL, ECONOMIC AND
POLITICAL IMPACT RESULTING FROM RECENT ADVANCES
IN SATELLITE METEOROLOGY

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APPENDIX II

MULTIDISCIPLINARY STUDIES OF THE SOCIAL, ECONOMIC AND
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APPENDIX VI

AN EXPLORATORY STUDY OF THE EFFECTS OF NOWCASTING ON CURRENT USE
AND PREFERENCE OF WEATHER INFORMATION

This study represents a preliminary inquiry into the impact of a single, first-time exposure to a Nowcasting presentation of weather information. Nowcasting emphasizes the relationships between the recent, current and near future mesoscale state of the atmosphere. Geographic limits of one or a few states and time limits of hours apply. The format is intended to provide detail and content sufficient to allow the user to make valid weather dependent decisions for the present and into the immediate future. Nowcasting concepts and processes are being developed and tested with the aid of a Man-computer Interactive Data Access System (McIDAS), developed by the Space Science and Engineering Center, which rapidly processes relevant and useful meteorological data and displays processed mesoscale information in a comprehensible and timely form.

The primary objective of this study was to determine whether Nowcasting offers weather information of greater utility, and, that given the choice, the Nowcasting format will be preferred by users.

This study was designed to evaluate:

1. User comparisons of Nowcasting presentation and present commercial broadcast TV weather reports.
2. The influence of the Nowcasting presentation on user preferences for (a) source for weather information, (b) types of weather forecast information, and (c) weather condition information items.

DESIGN

A before-after design was incorporated in this study. Respondents self-administered a first-wave questionnaire preceding introduction to

a Nowcasting presentation, and a second-wave questionnaire following exposure to the Nowcasting presentation.

The Nowcasting presentation was comprised of the following:

1. An 8-minute videotaped weather presentation about conditions prevailing during a 4-hour period of the day preceding this study followed during the talk by a 4-minute tape giving a 3-hour period of weather for the same day this study was conducted, plus a forecast for the projected hour of the presentation.
2. A brief explanation of the development of the Nowcasting concept and of technological complexities which may be up McIDAS. This explanatory accounting, which took the form of a 35-minute talk by Dr. Kenneth G. Bauer, was strictly not a part of the Nowcasting videotape instrument. However, its influence on respondents cannot be discounted. The magnitude of its separate effect is not determinable from the data collected.

SAMPLE

Of 45 first-wave and 47 second-wave questionnaires returned, 7 and 9 questionnaires, respectively, contained either missing data or insufficient respondent identification for paired analysis. As a result, 38 respondents remained to constitute the sample (N=38) for this study.

The nature of sampling procedures warrants consideration of implications concerning the reliability and validity of findings. Respondents were persons who elected to attend a talk about a development program for the collection and presentation of weather information. Consequently, the composition of the sample can be described as:

- (1) Self-selected respondents, and plausibly entertaining positive expectations of the merits of an innovation (McIDAS) in weathercasting.
- (2) Respondents interested in meteorology and plausibly pre-disposed to favorable views and concerns about meteorological phenomena¹.

¹Frequency tabulation shows that 28 respondents are both majoring in a science or engineering subject and have completed a course in meteorology or climatology; 5 are science or engineering majors only; and 2 have completed a course in meteorology or climatology only. (Respondents were students and teachers at Northern Illinois University, De Kalb, Illinois.)

- (3) Relatively qualified judges of the meteorological aspects of the presentations.

Factors (1) and (2) above may well constitute a conjoint influence which skews the data in a direction favoring McIDAS. Presumably scientists and meteorologists tend to be less critical of developments and presentations in their own or related areas. Factor (3) above, on the other hand, can be an argument for knowledgeable as opposed to uninformed judgement.

Recognizing these considerations, we advise caution in interpreting findings. For this reason we have avoided tests of statistical significance, and have stated our findings in the form of descriptive statistics.

RESULTS AND DISCUSSION

Television and radio were reported by nearly two-thirds of respondents as media they currently most often relied on for weather information, as shown in Table 1. More importantly perhaps, almost 29 per cent reported reliance on NWS weather reports available on FM broadcasting (which requires special or more sophisticated receivers) and via telephone service. Asked where they would prefer to obtain weather information ², nearly 90 per cent of respondents indicated TV. Between the first and second questionnaires, TV (existing VHF-UHF) gained 31.6 per cent or better than 75 per cent margin increase, and Cable TV gained 13.1 per cent which represents a margin increase of nearly 500 per cent. These gains, coupled with substantial losses in other source categories, seems to indicate that the Nowcasting presentation influenced respondents' opinions concerning the effectiveness of the television media. Presumably, current use of the NWS FM radio broadcasts and telephone service are for

² Asked in the second-wave questionnaires after exposure to the Nowcasting presentation.

TABLE 1.

Percentage of Respondents' Current Use of
and Preference for Mass Media as Sources
of Weather Information

MASS MEDIA	News-papers	Maga-zines	Radio	TV	CATV	NWS*
<u>Current Use</u> (N=38)	2.6	00.0	23.7	42.1	2.7	28.9
<u>Preferred</u> (N=38)	00.0	00.0	2.6	73.7	15.8	7.9

* Refers to National Weather Service weather reports available on FM broadcasting and via telephone service.

reasons of convenience and functional utility not presently available on TV, CATV and commercial radio broadcasts.

Table 2 shows percentages of frequency respondents indicated as their preference for types of weather forecast information when restricted to two and then three choices (the latter introduced after the Nowcasting presentation). The notable finding here is an increase of 59.2 percentage points from 4 per cent of respondents preferring 'Next 2 to 4 hours' forecast information in the first-wave questionnaire to 63.2 per cent following exposure to the Nowcasting presentation.³ Sex, marital status, and education variables showed greater within-category differences, but we would hesitate to conclude that any of these demographic variables is a good predictor of preference for Nowcasting-type forecasts because their distributions are skewed. Also, in the case of education there are no distinctive levels to speak of. Every unit in the sample is at least a recipient of some college education.

Single and married persons show significantly different preferences (Table 2). Married persons display more of a preference for weekend weather forecast information. This is expected. Presumably married persons, especially those with families, are less independent than single persons and largely confine their activities/outings with spouses and children to weekends.

Table 2 also shows that the 'Next Day' forecast is preferred by a far greater proportion of respondents than any other type of forecast. Conceivably the 'Next Day' forecast represents a basic informational need, presumably for planning purposes.

³It should be noted, however, that after exposure respondents were given an additional (3rd) choice, which 63.2 per cent represents.

TABLE 2.

Percentage of Respondents' Preference for Types of Weather Forecast Information Under Limited Choice Conditions by Sex, Age, Marital Status, Education, and Occupation.

Type of Weather Forecast Information	Next Day			Same Day			Overnight			Weekend			Next 2 to 4 hours			n=
	2	3	2	3	2	3	2	3	2	3	2	3	2	3		
SEX																
Male	44.1	----	25.0	----	4.4	5.9	22.1	14.7	4.4	67.7	34					
Female	50.0	----	----	----	25.0	50.0	25.0	25.0	----	25.0	4					
All (N=38)	44.7	----	22.3	----	6.6	10.5	22.4	15.8	4.0	63.2	38					
AGE																
Under 20	46.9	----	18.8	----	3.1	12.5	21.9	18.8	9.4	62.5	16					
21 to 25	43.8	----	25.0	----	12.5	12.5	18.8	12.5	----	62.5	16					
26 and Over	41.7	----	25.0	----	----	----	33.3	16.7	----	66.7	6					
All (N=38)	44.7	----	22.3	----	6.6	10.5	22.4	15.8	4.0	53.2	38					
MARITAL																
Single	45.5	----	21.2	----	7.5	12.1	21.2	12.1	4.5	66.7	33					
Married	40.0	----	30.0	----	----	----	30.0	40.0	----	40.0	5					
All (N=38)	44.7	----	22.3	----	6.6	10.5	22.4	15.8	4.0	63.2	38					
EDUCATION**																
College + +	89.0	----	51.6	----	15.4	18.7	33.0	14.3	11.0	59.3	20					
College - +	100	----	----	----	----	----	100	100	----	----	1					
College + -	100	----	12.5	----	----	----	75.0	----	12.5	87.5	5					
College - -	100	----	25.0	----	----	----	75.0	25.0	----	75.0	3					
Grad + +	37.5	----	25.0	----	6.3	----	31.3	25.0	----	62.5	8					
All (N=38)	44.7	----	22.3	----	6.6	10.5	22.4	15.8	4.0	63.2	38					
OCCUPATION																
Student	45.6	----	20.6	----	7.3	11.8	22.1	14.7	4.4	61.8	34					
Teacher	33.3	----	50.0	----	----	----	16.7	33.3	----	66.7	3					
All (N=38)	44.7	----	22.3	----	6.6	10.5	22.4	15.8	4.0	63.2	38					

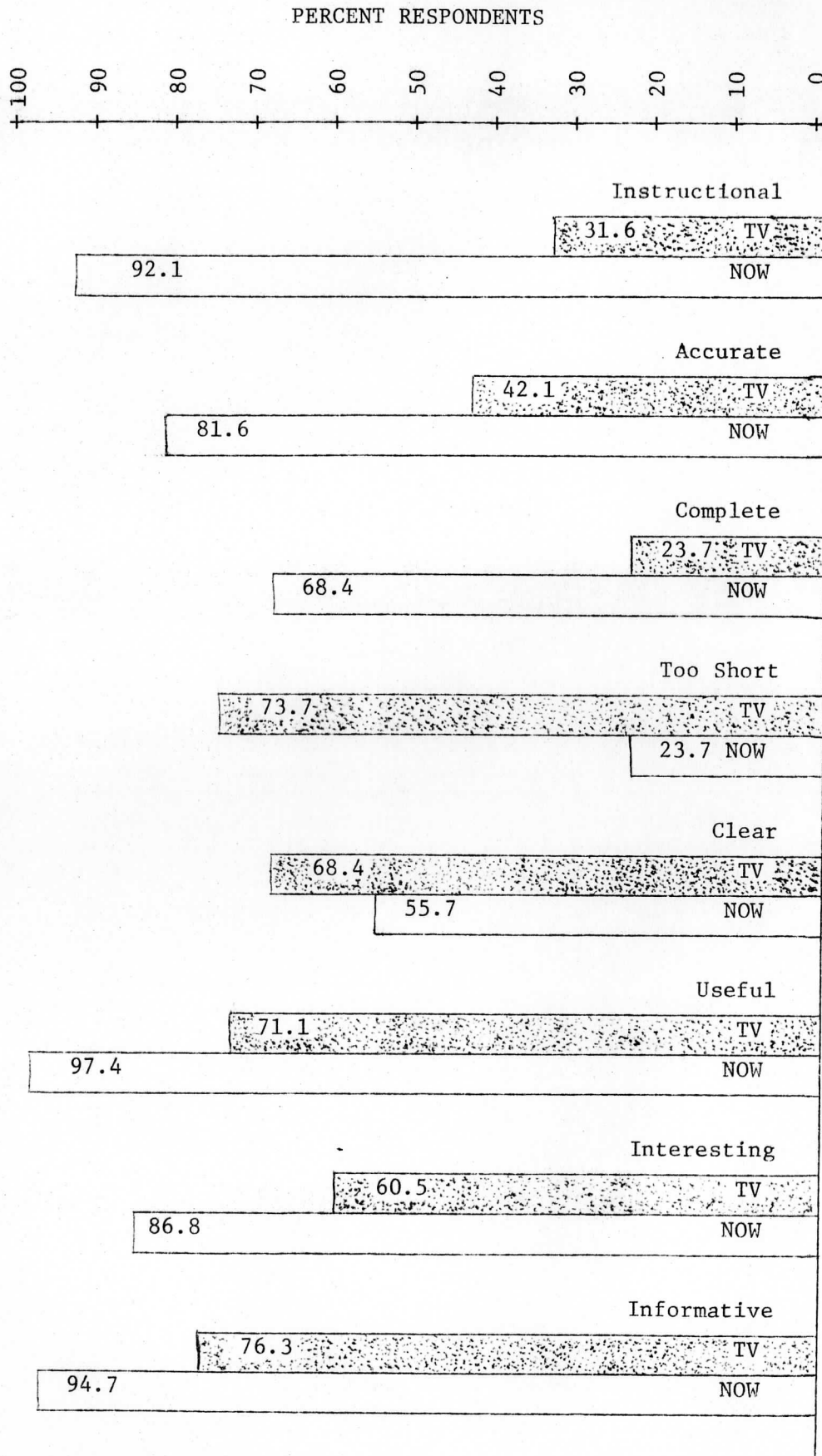
* Refers to preferential choice of 2 types of weather forecast information and to 3 types in the second wave of questionnaires. Thus column under "3" indicates the additional type desired.
 ** (+) and (-) signs respectively refer to (yes) and (no) science/engineering major, and to (have completed) and (have not completed) a meteorology or climatology course. Thus, for example, "College +-" refers to college students majoring in a science or engineering subject, and who have not ever completed a course in meteorology or climatology.

Figure 1 illustrates respondents' comparative ratings of TV weather reports and Nowcasting on a number of attribute dimensions. Respondents judged the Nowcasting weather presentation superior to the weather reports they usually viewed on television.

Also, the Nowcasting presentation was considered somewhat less clear than TV weather presentations, and definitely much longer. These findings indicate to us that the subjects' response to these attributes included consideration of the talk (by Dr. Bauer) rather than only the videotape. The Nowcasting presentation was also judged as more complete than TV weather reports. We raise the possibility of a confounding effect of the talk on judgements of the videotape presentation. This argument is supported by the finding that 92.1 per cent of respondents thought the Nowcasting presentation was highly instructional, while only 31.6 per cent could credit the same for TV weather shows.

A majority of respondents indicated the weather parameters of greatest interest to be temperature, wind speed and direction, and precipitation; cloud cover, humidity, and barometric pressure formed, as it were, a cluster of second preferences; and chill factor and pollution index a third preference pair (Table 3). Frost warning information was negligibly preferred.

When an additional information item was allowed, and after respondents had been exposed to the Nowcasting presentation, cloud cover was included in the four-item, first preference cluster. The combination of increased availability and exposure to Nowcasting also had the effect of clarifying preference among weather condition information items, even though preference by rank order did not change substantially. One might also infer from the data that humidity, barometric pressure, and cloud cover information items are interchangeably important, possibly depending on



RATINGS ON ATTRIBUTE DIMENSIONS OF TV AND NOWCASTING

Figure 1.

Comparative Ratings of Respondents on Attribute Dimensions of TV and Nowcasting

TABLE 3.

Rank and Percent of Preference for Weather Condition

Information Items Under Limited Choice Conditions.*

<u>Rank Preference 4-Item Choice</u>	<u>Weather Condition Information Items</u>	<u>Percent Respondents 4-Item Choice</u>	<u>Percent Respondents 5-Item Choice</u>	<u>Rank Preference 5-Item Choice</u>
1	Temperature	97.4	97.4	1
2	Wind Speed/Direction	73.7	89.5	2
2	Precipitation	73.7	84.2	3
4	Cloud Cover	50.0	79.0	4
4	Humidity	50.0	52.6	5
6	Barometric Pressure	31.6	44.7	6
7	Chill Factor	10.5	21.1	7
7	Pollution Index	10.5	13.2	8
9	Frost Warning	2.6	5.3	9

(N=38)

* Respondents were asked to state their preference for 4 of weather condition information items listed in the first-wave questionnaire before they were introduced to the Nowcasting presentation, and subsequently for 5 items from the same list (in the second-wave questionnaire) after the presentation.

geographical location or region, the season, or user perceptions of his own needs and purposes.

CONCLUSION

These findings lend plausibility to the assumption that meteorology and technological development in concert offer weather information and forms of presentation of greater utility value than hitherto is the case, and that given the choice this type of information will be preferred by users.

The Nowcasting presentation used in this study had the effect on influencing users toward recognition and appreciation of a different method of processing and presenting meteorological information. The perception of greater potential and expectation for more diversified weather information among respondents can be attributed to the Nowcasting presentation experience.

Although we qualify the extents of conclusiveness and reliability of the data in recognition of the limited and special sample, this study nevertheless underscores the importance and usefulness for continuing research and development of Nowcasting concepts.