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IVAM Annual - 1975

An Annual Report

on

Innovative Video Applications in Meteorology (IVAM)

Contract 5-35156

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Submitted to:

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I. INTRODUCTION

This report is submitted to the National Oceanic and Atmospheric Administration (NOAA) in partial fulfillment of Task H, Article I of Contract No. 5-35156. The purposes of this report are to present a comprehensive review of the work performed under the contract from 1 August 1974 to 1 May 1975, a period of nine months, and to describe the work to be undertaken in the future.

The work presented was performed by members of the staff of the Space Science and Engineering Center and other members of the University of Wisconsin-Madison campus. For ease of reference the program was informally titled "Innovative Video Applications in Meteorology" and the acronym, IVAM, is used throughout the report.

The purpose of the IVAM program is stated succinctly in the contract statement of work and is quoted here:

The Problem

The National Oceanic and Atmospheric Administration would achieve a significant gain in keeping the public advised of changing weather conditions if effective, automated methods of delivering video segments of weather information to TV outlets could be devised. Although this is known to be a technologically possible accomplishment, the methods needed to make it economically feasible have not been developed.

Solution

The National Weather Service and the National Environmental Satellite Service jointly undertake the funding of a study to develop a state-of-the-art capability to efficiently deliver quality video presentations of weather information to the public at acceptable cost.

Study Objective

This study will be directed toward the development of formats and techniques designed to maximize the effectiveness of the TV presentation of weather information to the public. Program content and organization will be addressed, as well as the conceptual design of the communications methods and systems that would allow the presentations to be economically delivered from NOAA sources to various redistribution terminals. The objectives of the study are to develop techniques and formats that are characterized by:

- High information content in an interesting and understandable presentation.

- A maximum employment of automated presentation formatting, in order to keep staffing levels reasonable.

- The maximum utilization of existing or planned NOAA facilities. methodologies, and communications systems.

- Modest NOAA implementation costs and modest-to-low cost for media, public, or private acquisition.

- Quality and utility coefficients that generate media and public enthusiasm and demand.

The IVAM program is organized in five major tasks, and is based on an anticipated three year development period. The correspondence of the five major tasks to the ten tasks specified in the contract work statement is indicated by the lettered task designation in parentheses which refer to the work statement. The overall program plan and schedule by major task is as follows:

Task 1 - Software Development (Tasks E,J)

This is the major development effort in the IVAM program. If the objectives as described by NOAA above are to be achieved, the software system must be as efficient and as flexible as the state-of-the-art allows. Early in the program we conducted a series of very thorough, and very critical reviews of several possible routes we could have pursued. We chose to start at the very beginning, and to defer any actual software development until we had produced a sound software system concept which we were confident could support a development program capable of meeting the NOAA objectives. We believe we have achieved our initial goal and the software system concept document is attached to this report as Appendix A. This task is about 30% completed at this time with the completion of the concept document and with the existing McIDAS software which we can draw upon for specific operation programs.

Task 2 - Presentation Content Studies (Tasks A,B)

In a series of related studies we have established a logical basis for the content of automated weather TV presentations. Variables considered include the needs for specific weather information by different classes of viewers; changes in these needs because of season, time of day, weather situation, and location; constraints imposed by information availability, characteristics of the TV media, and costs; and considerations of viewer acceptance, presentation credibility, and aesthetics. This task is approximately 85% completed at this time. Further work will consist of re-evaluation of conclusions after evaluations of presentations have been performed and results tabulated under Task 4.

Task 3 - Hardware Concept Studies (Tasks E,F)

Two related studies under this task are included in this report, Section IV "Hardware System Study" and Section V "Output Distribution Study". At this stage of the program, study of the hardware required to implement IVAM has been limited to exploring concepts in conjunction with the software study. We have allowed the hardware study to progress just far enough to establish system feasibility and to provide guidance to the software concept development. We have resisted going further into detailed specifications to avoid becoming locked-in on existing hardware in a rapidly changing field, and to avoid establishing unnecessary hardware constraints on the software development. This task is about 15% completed and will continue at a moderate level of effort until the last phase of the program when implementation hardware specifications are to be prepared.

Task 4 - Program Test and Evaluation (Task C)

It will not be possible to test many aspects of the IVAM system until the software is in an advanced stage of development. However, it is possible to investigate some of the information transfer and aesthetic aspects and some media interface problems using motion picture film and video tapes generated by McIDAS and by manual art production. Two such test presentations have been produced and partially evaluated at this time. Copies of the test presentations on video tape are being delivered to NOAA with this report. Since we are still using the presentations to investigate specific questions, the report in Section VI "Program Test and Evaluation" is incomplete, but some very useful results are presented. This task is about 5% completed and will move into a relatively large scale effort by the middle of next year.

Task 5 - Final Program Development (Tasks D,I)

This task will start only after NOAA is satisfied that the implementation of IVAM is feasible, and that when implemented, IVAM will meet the NOAA objectives. This is the wrap-up effort when software development is stopped, configuration control is imposed, detailed interfacing with AFOS is accomplished, hardware specifications are completed, final documentation is prepared, etc. We anticipate starting this task in 1977.

2. PRESENTATION CONTENTS STUDIES

2.1 Approach

The purpose of this study area is to determine the contents of the IVAM TV weather presentations. Several approaches were considered, such as cataloging the present TV weather shows into several categories, based on style, station network, geographic location, etc. or defining a few basic TV presentation formats based solely on weather data available.

Instead, a more general approach was chosen which was to study the needs for weather information by various user groups, identify the parameters of those needs, then determine the constraints on a TV presentation based on limits of data available and limits inherent to the TV media. These requirements, approached from both the user's and the producer's standpoint, were then combined into a series of matrix charts, further refined by combining various parameters, until a set of units exist, described in terms of all the parameters. These basic units are called segments, and by defining a scenario of segments, one can define a complete TV presentation.

2.2 User Group Studies

A series of intensive library searches were performed to determine the needs of various users. The users were sorted into three major groups, with subgroups, as shown in Table 2-1.

TABLE 2-1 - USER GROUPS

General Public
- Recreation
- Health & Convenience
- Pollution
- Personal Transportation

Industry
- General Construction
- Concrete Laying
- Utilities
- Manufacturing, Retailing and Transportation

Agriculture
- Filed Preparation
- Planting
- Spraying
- Growing
- Harvesting

The user's needs were defined in terms of weather parameter and season. Some items not strictly weather elements but highly weather dependent (depth of frost, degree days) are included as weather parameters because of their importance. The weather parameters identified in the needs study are:

TABLE 2-2 WEATHER PARAMETERS

Temperature	Dew Point/ Fog
Degree Days	Snow Cover
Frost	Sunny/Cloud Drying Conditions
Soil Temperature	Wind
Depth of Frost	Barometric Pressure
Precipitation	Dry/Wet Spells
Relative Humidity	Severe Weather

The studies showed a seasonal dependence on needs relating to the user activity and geographic location. For instance, frost is of concern during the gardening season, but not of strong interest in northern states in winter. However, frost is of concern in southern states even in "winter." Defining "season" was approached from a strictly needs standpoint. Transitions are important to users, a winter-spring, spring-summer, etc. approach was tried. However these transitions still vary for different parts of the country. Certainly, calendar dates are not a reliable basis for defining season.

Suomi,and others, have used climatic seasonal changes as a definition of season. The method applies well here and is used for definition of season throughout the study. The important climatic changes are first frost, last frost, ground freeze and ground thaw. These transition points are significant for virtually all user groups. While they at first seem to be mostly of agricultural interest, they apply to larger segments of the population in relationship to pollen count (allergies), fishing, hunting, camping, home gardening, etc. They further allow for large differences in climate for various geographical locations, i.e., San Diego never experiences winter as defined here. The seasons are defined as:

Spring - Ground thaw until last spring frost

Summer - Last spring frost until first fall frost

Fall - First fall frost until ground freeze

Winter - Ground freeze until ground thaw

The user needs study results are consolidated into three study reports General Public, Industry and Agriculture, followed by Table 2-3 which is the composite matrix of needs by user group, season, and weather parameter.

Constraints, involving media, timing, and scale are discussed after Table 2-3.

GENERAL PUBLIC NEEDS - RECREATION

Outdoor recreational activities are heavily reliant on the weather for their success, either because they capitalize on some particular weather event for their performance (how can one ski without snow?) or because the activity can be extremely unpleasant without the right environment (as, for instance, going to the beach in subfreezing temperatures). Despite the paramount importance of weather, there have been few scientifically sound studies done on the subject. This lack may be because everyone has directly experienced outdoor recreation in some aspect and feels that he "knows" what role weather plays in his recreation. This subjective knowledge may not be a good guide to what is actually true. Reactions vary widely as to what weather is pleasant and what is unpleasant. Weather too cold for some is invigorating for others, the latter being more inclined to use the day as an excuse for some form of exercise. Nonetheless, it is possible to treat the matter statistically and to average out individual attitudes. Paul (16) has, for example, looked at the attendence figures for various park facilities under various weather conditions and has been able to conclude that only 10% of the people will use the beach if temperatures fall below 19 degrees C. Where available, this sort of data has been used in this report. Hopefully, more such studies will be done in the future.

SUMMER OUTDOOR RECREATION

Summer activities considered here have a fairly wide range: from the more solitary activities of hunting and fishing to the public use of park facilities for sports, swimming, touring, and picnicing. Weather factors which were considered range from the particular needs of the activity concerned (tracking animals is harder or easier depending on wind, precipitation, etc.) to the general conditions under which most people find it feasible to be out-of-doors. Also, the importance of weather severity varies according to the activity. Only the worst conditions will stop many hunters, relatively little discouragement is enough to cancel a picnic or a trip to the beach.

Also considered were dangers or inconveniences to persons who are outside, such as forest fires and insects. If fire dangers are high, people should be aware of this before they enter a wooded area. Similarly, an otherwise ideal outdoor setting can be unpleasant if long term weather conditions have been conducive to mosquito breeding.

Temperature and precipitation are the two most important variables in recreational activities. Mild temperatures are conducive to good fishing (5), while warm temperatures above 22°C encourage swimming and beach activities. Warm temperatures have their disadvantages too: insects such as mosquitoes like warm humid air especially at night (12), and hot daytime maxima dry out wood and increase the danger of forest fires(11). Cool temperatures, on the other hand, tend to preserve animal scents and increase hunting prospects(14). Not surprisingly, below normal temperatures over an extended period in summer have a definite depressing effect on the tourist trade (9).

Perhaps the most unpleasant event that can normally occur to a recreational activity is rain. Sports events may be cancelled (10), race tracks closed (2), picnics and park sports forgotten (16), and general tourist trade and camping discouraged if wet weather continues for an extended period (18,19). Pools and puddles of standing water also increase insect breeding (12).

Relative humidity also plays an important role. While high humidity makes swimming, park and beach use more inviting, active sports are discouraged (16). High moisture also increases hunting prospects by preserving animal scents (14). Low relative humidity can increase forest fire danger (11).

One should also mention fog,which is a menace to boating (1) and ruinous to scenic views (18).

Except in boating, generally low wind speeds are desirable in summer, especially for fishing, sports, and beach use (16,18). Even in boating, sudden squalls or heavy winds can be dangerous (1). Wind speeds, directions, and durations are another factor determining the actual forest fire threat on any given day (11).

Sunshine is an important variable in a few activities, the most important being beach use and swimming (16). Lack of sunshine over a period of a week or more also depresses tourist trade (18).

WINTER OUTDOOR RECREATION

Winter activities are more limited than in summer and are mainly dependent on conditions of the snow and ice. These include skiing, skating, snowmobiling, ice fishing, and ice boating. Among the most weather sensitive of these is skiing. Taking place in hilly or mountainous areas, the weather there usually varies appreciably from residential areas, thus increasing the need for pertinent weather data. Although artificial snow-making has decreased, the skiers' dependence on proper snow conditions, such snow-making has weather criteria of its own, including proper conditions of temperature and humidity.

One winter hazard is included here, that being the threat of avalanches. This is a very real threat in the mountainous areas of the West, against which the skier is not always adequately forewarned.

In winter, an optimal range of subreezing temperatures is necessary, both to preserve the quality of snow for skiing (8) and snowmobiling (17), or to allow freezing of ice (4) and artificial snow-making (6). Temperatures too low can lead to dangerous icing of the ski slopes (8). Alternate freezing and thawing constitutes another danger to ice fisherman and snowmobilers since such fluctuations weaken ice and create large cracks (4).

Besides the obvious advantage of snow cover to skiing and snowmobiling (8,17), snow aids in tracking animals for hunting (3). Rain in winter is seldom a welcome event; it hurts snow conditions (8) and can increase the danger of avalanches (13). High relative humidities are also undesirable since they prevent artificial snow-making and help make a day raw and damp -- weather particularly uninviting to a skier (7).

High winds are known to cause closing of chair lifts and ski tows (15), to discourage snow-making (7), and to cause drifting and packing of snow, a factor in avalanches (13).

GENERAL PUBLIC - HEALTH AND CONVENIENCE

Certain weather conditions have a definite effect on the comfort or health of the human body. These effects fall into two general categories: those to which a normal, healthy body may be subjected, as in heat stroke or discomfort from humidity, and those which a person suffering from some disability or ailment may find harmful (e.g. the effect of cold air outbreaks on asthma patients). There is little doubt that adequate warning to persons especially vulnerable to certain kinds of weather would be generally beneficial to public health.

Temperature has been shown to have a effect on human health. Falling temperatures or cold winter outbreaks of arctic air have been associated with a range of public health problems from arthritis and heart ailments to glaucoma and asthma. Warm air, especially with humid air, correlates well with congestive heart disease, heat stroke, glaucoma, and tuberculosis (21,31). A number of interesting studies have found that reaction times are slowed in the warm, humid sector of cyclones with an unmistakable rise in the factory and motor vehicle accident rate.

Of course, temperature is associated with less severe and more mundane matters. No one would dress without some consideration of what clothing would be warm or cool enough, although often such a basic decision is guess-work that is later regretted. There do exist, however, definite quantitative guides to adequate clothing (29). Home heating is another every day factor which could be estimated over the season for the benefit of those who are keeping track of their fuel bills (21).

Periods of warm, humid weather especially in the spring or early summer play a large role in the size of the insect population (27). While not commonly harmful, large numbers of mosquitoes are certainly an example of a nuisance to be avoided.

Health problems due to actual rain or snowfall are not serious; however, high relative humidities can cause scar pains, besides being plainly uncom-fortable (21,31). Very low relative humidities in winter have been related to the spread of influenza while fog in combination with cooling has been correlated with bronchitis and arthritis (31). Insects are encouraged by puddles and pools of stagnant rain water (27).

High winds may cause structural damage (32), or endanger large vehicles on highways (as a crosswind). Crosswinds on highways combined with loose snow can seriously hamper or stop traffic entirely. Wind speed is also an important factor in deciding about appropriate clothes (29). Low wind speeds have been sited as a factor in the spread of influenza. (31)

Sun angle, visibility, and cloudiness, while not crucial factors in human health, all enter into the problem of sunburns (21). Bright sunlight can also encourage glaucoma (31).

Radiation, in addition to temperature and wind, is an important factor in determining adequate clothing (29).

POLLUTION

Because of its importance, air pollution is considered as a separate topic in Table 2-1. The concern of the public with pollution falls into two general areas; damage to materials and dangers to health.

Air pollution is estimated to cause 2 to 12 billion dollars damage a year to materials, much of which is private property (23). Such damage can take many forms from deterioration of paint to corrosion of building metallic objects, and damage or death to plants and trees.

Health effects from air pollution are becoming increasingly serious. In addition to episodic stagnation of air masses, trapping industrial pollutants in a small area, there are daily problems associated with traffic which releases carbonmonoxide and other gases. Such pollutants are more dangerous to certain groups of individuals such as the very young and old, and those with chronic respiratory problems.

Either of the above problems associated with air pollution could be ameliorated by adequate warning on days when damaging effects were anticipated.

Temperature, by increasing chemical reaction rates, increases damage to materials due to pollution. Temperature inversions, are also a problem because they trap harmful gases and particulates close to the surface (23, 24, 25, 26).

High soil moisture, dew, and high relative humidities are all conducive to pollution damage and poor air quality (23).

Wind speed, direction, and duration are crucial factors in determining the spread or dispersion of pollution, an especially important factor during periods of peak traffic (8 AM and 5 PM) (23, 24, 25, 26).

GENERAL PUBLIC - PERSONAL TRANSPORTATION

Weather is frequently the sole or contributing cause to many motor vehicle accidents, sometimes due to the fact that the motorist has not been warned of possible dangers such as slippery spots on the road. Either snow, rain, or fog may increase the accident rate (22,30). Subfreezing temperatures at the road surface can form dangerous icy spots. Frost may also be a threat to safety when deposited on infrequently traveled roads (28,30). Timely weather data, tailored to the peculiarities of the local situation, could do much to improve road safety.

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INDUSTRY

The desire for improved weather information by business and utilities is evidenced by the increase in hiring of meteorological consultants or even full-time meteorologists by industry. Industrial fuel usage, generally considered in the past as primarily an economic element, has recently taken on new meaning in terms of energy conservation and a greater economic consideration than before.

Survey of the literature suggests dividing industrial meteorological concerns into three broad areas; construction, utilities, and general commercial needs. Separate categories for construction and utilities are used because these two industries are especially weather sensitive and both are very large operations, involving billions of dollars through the U.S.

INDUSTRY - CONSTRUCTION AND CONCRETE LAYING

The construction industry is a general term which covers a host of operations from the initial surveying and site preparation to the laying of concrete, carpentry, masonry, roofing and painting, ending with fencing and light installation (1). Also included under construction is road building and laying of utility lines. Each of these operators has its own particular weather sensitivity, but for the purpose of this study it seems sufficient to generalize, with the exception of concrete laying which has an especially complicated relation and sensitivity to the elements. Three types of weather information are needed for construction work: forecasts for day to day planning of work, forecasting to insure the timely delivery of materials, and warnings of adverse weather that might occur suddenly during the course of a day (26).

It is estimated that the construction industry alone amounts to nearly 10% of the U.S. gross national product and that 45% of the construction expenditures are in weather sensitive areas. In fact, weather is among the three most important causes of delays (2). It is estimated that 500 million to 1 billion dollars or more could be saved annually if efficient use of current weather information could be maintained (36). Columns 1 and 2 of Table 2-1 show where these losses may be incurred with regard to concrete and general construction operations respectively.

Most forms of precipitation are harmful to construction projects, especially rain, sleet, dense fog, high relative humidities, and heavy snow (1,27,32). Rain, for instance,can wash out or ruin concrete (3, 12, 13). Even very dry conditions are not ideal since concrete that drys too quickly weakens the material. Construction firms are generally well aware of these factors and feel the need for special information, if in fact they have not already hired a meteorological consultant (3).

High wind speeds (greater than 20 mph) create numerous problems for both construction and utility work. Wind gusts can make work with structural steel impossible (32, 1) and can weaken fuel consumption (6,18).

Although there is a general need for timely weather information during all parts of the day, such data is most useful at two particular times: from 6 to 7 AM and from 2 to 3 PM, when construction operations are beginning or ending (1).

Generally both very warm and very cold temperatures are inimical to construction operations (1,32). In particular, concrete laying is a sensitive operation in that both excessive heat or freezing weakens the freshly laid mixture and operations must be cancelled or redone if such temperatures occur (3,12,13). Bricklaying is also halted in subfreezing temperatures (34). Long periods of mild weather, especially in the spring, however, can be advantageous for the economy by encouraging housing starts early in the year (27). Such an effect could be amplified if such mild spells could be foretold in advance.

INDUSTRY - UTILITIES

Two sorts of utilities were surveyed: fuel and electric companies. Both types are quite vulnerable to slight changes in the weather. Home heating, for instance, begins when outside temperature fall below 65°C and for each 2°C below 65°C, 3 kilowatt hours per day are needed for each 1000 ft^2 of floor area. It is not surprising therefore, that utilities would pay up to $1500 per day for a perfect forecast (5). Temperature is a prime consideration in such forecasts, which may be either short or long term (one day or several days); however, other factors such as solar radiation, cloudiness, wind (which may account for up to 30% of the meteorological variability of the load) and precipitation may also affect the load. It is economically important that fuel distributors and electric companies have the capacity to handle the day's demand without having a wasteful over-supply. Further, severe weather may impede fuel deliveries or knock down electrical lines (19).

Weather information is generally designed not for the astronomical day, but for the "gas day", from 7 AM to 7 AM (6). Continuous updating of 24 and 48 hour forecasts are needed every three hours during the day (30).

For utilities, temperature is the primary factor in determining fuel and electrical consumption (11, 5, 15, 18). Because of the problems connected with the storage of energy, the proper forecasting of very cold weather lasting 4 or more days is very important. Utilities are also concerned with the problems of pollution when their smokestack effluents are trapped by inversions (19).

Temperature is a primary factor in river and reservior management in that snowmelt and runoff is directly dependent on this parameter (28).

For utilities, precipitation and relative humidity are not as important as temperature in determining electrical and fuel consumption, but nonetheless, should be taken into account (15). Precipitation may also be a factor in pollution damage from utility smokestack and cooling tower effluents. Rain falling through smokestack plumes may pick up a high acidity which will damage surrounding vegetation and pollute the groundwater (20). Cooling tower evaporation may lead to condensation and dense fog on days with high relative humidities, thus constituting a danger to nearby highway travel (20). Snow or storms may also damage electrical wires (15) or affect fuel deliveries (5).

Precipitation is the single-most important factor in river and reservoir management and flood control. Quantitative rainfall estimate, intensities, durations, type, coverage, motion of rain storms, and distribution of rain and snow are vital needs, along with a knowledge of soil moisture and evaporation (18,28).

While clouds and sunshine are not as vital as the preceeding factors, they nevertheless figure into a number of operations. Cloud cover can, for instance, increase fuel consumption, but most importantly, it can affect electrical use since cloud heights, amounts, thicknesses, and visibilities all determine how much more electrical lighting is used (6, 11, 18, 15).

INDUSTRIAL - MANUFACTURING, RETAINING, AND TRANSPORTATION

The interests represented in this section are extremely varied; chemical companies, chocolate manufacturers, snow removal contractors, department stores, distributors, merchants, bakeries, water navigation (for large cargo ships), land transportation, etc., all have needs for varied and complex sorts of weather data which have been shown to have direct economic value in these interests (5). For example, retail trade sales and the weather type (good or bad for shopping)fluctuations move in the same direction (better sales with better weather) four times more frequently than in the opposite direction (better sales, worse weather) (21). Furthermore, sales after stormy periods do not seem to make up for the slack sales during bad weather. This finding makes it apparent that weather has great economic value to the retailer. Sales are most vulnerable when mornings are wet, discouraging the potential customer from leaving home at all, and dropping trade by up to 15% off the normal. Duration of the rain is also significant, with sales progressively falling as duration increases. Snow can have a similar effect with the added twist that suburban trade drops more drastically than that within the city or within the residential neighborhood.(25) Snow had widespread effects (5) especially on truckers, food distributors, newspapers, and street clearing crews, who need at least four hours notice for impending storms (11).

Temperature effects on general industrial and commercial needs are varied and numerous. Consumption of beer (23, 29), retail sales (22), breadbaking (26), manufacturing of precision machinery parts (34), ship navigation problems with icing (33), pollution control (11), and distribution of all kinds of foods and seasonal clothing (5, 25, 21, 34) depend on optimum temperatures which are neither too warm nor too cold. Many distributors have found it to their economic advantage to stock their products according to the national distribution of the weather (25).

In addition to the obvious problems connected with navigation of merchant ships (correct routing of ships around storms and high waves can save millions of dollars world wide in time and cargo) (33), strong crosswinds can threaten trucks and other large vehicles (37) as well as tall structures with limited tolerance to wind load (31). Wind speeds and directions are also instrumental in spreading or dispersing noxious pollutants from industry and traffic (8, 9, 4, 7).

Those interests represented on Table 2-1 can only be said to provide a sampling of possible meteorological needs; many more have only begun to be discovered and met by the existing meteorological know-how.

An additional factor to be considered in this area is the effect of pollution on industry. While actual construction is not affected greatly by pollutants, utilities have to worry about pollution they may generate in the course of their operations (19). The physical plant of many industries, as well as their materials, may also be adversely affected by pollution combined with certain weather conditions. Paint, metals, and masonry have a much shorter lifetime when various gases such as SO_2 and various flourides can combine with available moisture in the air to form corrosive chemicals that destroy the appearance or substance of common building materials. It is estimated that 2 to 12 billion dollars damage per year is made on materials in the U.S., many of these materials being associated with commercial and industrial interests (7).

Of course, the ultimate solution to this problem will depend on air quality control; however, until then industry must be aware of pollutant conditions against which they might guard if given adequate warning. Gaseous pollutants can cause virtually no damage when the moisture in the air is low; on days with higher relative humidities, industiries could protect vulnerable equipment from the high moisture content through the use of special storage or dehumidified areas. High relative humidities have a different range of effects on the storage of chemicals (5), and rust or corrosion potential (34). This is particularly important where air pollutants are high (11). Plentiful sunshine can also induce more retail trade (22, 32). Finally, movie producers and aerial photographers are examples of trades that are highly dependent on natural lighting conditions (5).

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AGRICULTURAL

To farmers and other agriculturists, the close relationship between their enterprise and the weather is a very constant one. By the same token, the influence of weather on crops and other aspects of agribusiness is fairly common knowledge around the world. All meteorological elements are important to agriculture, from simple temperature and rainfall to solar radiation and the complex relations of evapotranspiration (Landsberg 1961)[1]. Historically, man's concern with weather and crops goes back to Biblical times and before. No doubt the prehistoric change from nomadic to "settled" cultures depended to a large degree on, among other things, a suitable agregation of weather factors (Seddon 1967).

Coming up to present times, a tremendous amount of technical interest has been shown in the field of agrometeorology. For example, Wang and Barger (1962) published a formidable bibliography of this field with 10,762 entries, acknowledging nonetheless that in many areas the titles do not represent an exhaustive list. Furthermore,the entries date back only to the beginning of the century. In addition, hand and computer searches of recent literature carried out this paper indicate that there has been an extremely large contribution to the agrometeorlogical literature since 1962.

On a national level, the Department of Commerce and the USDA cooperated in the development of a plan for a national agricultural weather service (US Department of Commerce - USDA 1967). Since many of their arguments, particularly the focus, rationale and objectives, are consistent with those of IVAM, a discussion is presented here of various aspects of the federal plan (hereafter, cited by page reference).

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[1] References cited are listed alphabetically in the end bibliography.

In the forward, Coordinator Robert M. White points out that the plan "focuses on the need for providing specialized weather services to farmers and other agribusiness interests."

As part of its rationale, the report states, "Weather is the most significant variable explaining year-to-year fluctuations in... yield..," and "Less-than-optimum growing conditions for 79 of the principal crops... [are estimated to]...reduce farm income by an average of $1.6 billion per year" (Page 1).

As an objective, "Weather support to agriculture should be designed to contribute to user decisions which will minimize losses resulting from adverse weather conditions and will improve the yield and quality of agricultural products through effective cultivation, processing and marketing procedures and control of pest and diseases" (Page 2). An additional parameter to the foregoing area is that, "Producers in particular require more than strictly meteorological information; they require detailed and specialized assistance in the determination of the implications of forecast conditions to their immediate operations" (Page 14). A moderate, well-planned and scientifically-based system of advisories would indeed be a useful and necessary adjunct to an effective agrometeorlogical program.

For emphasis, at this point it seems appropriate to quote from a report (Tibbitts and Meier 1969) which will be used extensively to document the tabular presentation accompanying this paper. The report, extensive and detailed, is a carefully worked out investigation of the significance of accurate weather predictions to the management of a representative list of specific horticultural crops. The authors state:

> Complete and precise weather information is of significance to crop production 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. (Page 36)

As a key part of the method of the federal plan, "The total user population..[was divided]...into a number of categories and subcategories. For each of these groups, weather-sensitive operational decisions were identified, and for each of these decisions the necessary weather information inputs were determined." (Page 5)

A follow-up report (U.S. Dept. Comm. 1971) shows that in certain selected areas of the U.S., the existing Agricultural Weather Service "effectively meets the needs of agricultural interests within existing technical capabilities" (Page 27). The balance of the report describes a proposed improvement of the service by implementation of a phased program to provide coverage to all currently unserviced areas.

Less-than-optim growing conditions for 79 crops reduce farm income by well over $1 billion per year (U.S. Dept. Comm. - USDA 1967). Much if not all of this reduction is due to weather factors and some of it could not be prevented even if weather forecasting methods for agrometeorology were, in fact, perfect.

The value in improved forecasts to agriculture lies not so much in warnings of severe weather, but in information that will improve the efficiency of a farming operation. A grower's response to accurate, specific information on expected weather can be in the form of effective decision-making, leading to cost savings or improved return; whereas in the event of impending severe weather the most a grower can do is get livestock, machinery or men in from the field, secure shed doors, or in certain cases, begin a forced harvest or work up soil to reduce loss by wind.

A farmer may vary some of his operations within a given time block to accommodate vagaries of weather, but extreme delay can be costly, and once committed to an operation, such as planting, he must face subsequent weather elements as they appear. For example, in a study using the parameters of soil temperature and autumn sowing of wheat in England, the variety Capelle, it has been found, should not be sown earlier than 10 days after soil temperature at a 4 inch depth first falls below 55°F, nor later than 45 days after the same point. Failure to plant in this period will result, on the average, in a yield reduction of 2 cwt. per acre per week.(Stansfield 1970) Hence, an accurate prediction and reporting of soil temperatures would be of economic benefit to English wheat farmers. At the same time, forecasts of rainfall would be helpful so that the farmers would be able to plan for wheat planting within the optimum soil temperature time period.

This same line of reasoning can be applied to crops grown in the U.S., although the details regarding specific temperature, number of days, and so on, will vary. The farmer will be capable of making the decisions applying to his crops or livestock, assuming he is provided accurate weather information and pertinent advisories.

The liaison person needed to supply these pertinent advisories is the agrometeorologist. More will be said about this aspect of the program later in this section.

Crop Values

The federal weather plan (U.S. Dept. Comm. - USDA 1967) defines highly weather-sensitive crops as those "for which growth, disease and pest control, and productivity are closely associated with one or more elements of the weather; and for which the farmer, given an accurate forecast of unfavorable weather, can take protective, preventive or corrective action or given a forecast of favorable weather, can take position action (plant, spray, harvest)" (Page 24).

On the basis of this definition, the following crops were considered the most weather-sensitive: vegetables, fruits and nuts, cotton, tobacco, peanuts, Irish potatoes and hay (Page 24).

Looking at estimates of some crop values that could indeed be affected by accurate, timely weather forecasts, Dancer and Tibbits (1972) reproduce a USDA table for crops whose value, at more than $24 billion, represents over 92 per cent of total U.S. crop value for the 1970-71 season. (See Table 1) By a search of the literature and a series of personal interviews with crop and production experts in many sections of the country, they arrived at several sets of figures that approximated the savings in dollars that could be realized by improved forecasts of various weather elements for the crops listed in Table 1.

The operations that were affected included:

(4) Seedbed preparation, planting

(1) Spraying (air, ground, insect, weed, disease control)

(2) Protection of certain crops from high or low temperature extremes

(3) Harvesting, combining, processing

(The numbers indicate ranking in estimated dollar value of savings accrued from improved forecasts).

The total crop value of improved forecasting on a nationwide basis was estimated to be over $74 million. Within the short-forecast-period parameters of their study, Dancer and Tibbits were not able to establish direct savings from improved forecasts for several main crops, including field corn, soybeans, wheat and oats. These crops, of relatively low value on a per-acre basis, are grown on a large scale in this country and around the world, and do not lend themselves to high-cost weather-preventive actions such as intensive irrigation, frost-fighting, etc. However, on a longer-term forecast basis, especially at planting, spraying and harvest periods, the literature does infer benefits to these crops from improved forecasting. Because of the large acreage devoted to these crops, the $74 million dollar figure cited alone would no doubt begin to approach the $1 billion figure of the 1967 federal weather report.

According to the federal Plan for a National Agricultural Weather Service, first priority should be assigned to the forecasting of precipitation, its occurrence, timing and amount. Next is evaporation, with emphasis on measurement and accuracy of forecasts. Other factors in order of the importance assigned by those writers are temperatures, inversions, wind and dew (Page 28).

In another paper (Hill 1972), where the National Weather Service is shown to be moving even more in the direction of providing specific forecasts for agricultural and other particular users, it is suggested that the following weather information, added to the present forecast format and given to television meteorologists, would be useful to farm as well as urban viewers; an extended outlook, wind speed information, the average daily soil temperature at a 4 inch depth under sod, a drying index, a livestock temperature index, and a dew forecast for the next morning.

In their report, Dancer and Tibbits decided that the following weather elements were most pertinent: precipitation (intensity, duration); wind (direction, velocity); cloud cover; critical low temperature (time, duration); critical high temperature (rate and time of change); dew point, and air temperatures.

Production Value and the Principal Growing Areas for the Major Economic Crops Grown in the United States. 1970-1971 Growing Season. (USDA Crop Report).

Crop	Production (millions of tons)	Value (millions of dollars)	Growing Area (Principal states)
Field Corn	155.0	5890	Iowa, Ill., Ind.
Soybeans	35.1	3465	Ill., Iowa, Ind.
Hay	131.0	3333	Cal., Wis., N.Y.
Wheat	49.2	2168	Kan., Daks., Wash.
Cotton	7.0	1679	Cal., Texas, Miss.
Tobacco	0.9	1368	N. Car., Ky., S. Car.
Sorghum Grain	25.1	926	Texas, Kan., Nebr.
Citrus*	11.3	670	Fla., Cal., Texas
Potatoes	15.8	626	Idaho, Cal., Maine
Oats	14.0	638	Minn., Daks., Wis.
Tomatoes	5.8	444	Cal., Ohio, Ind.
Barley	11.1	443	Daks., Minn., Cal.
Rice	4.2	440	Texas, Ark., La.
Sugar Beets	26.9	414	Cal., Idaho, Colo.
Peanuts	1.5	406	Ga., Ala., N. Car.
Grapes	4.0	372	Cal., N.Y., Mich.
Apples	3.1	308	Wash., N.Y., Mich.
Lettuce	2.3	272	Cal., Ariz., N.M.
Peaches	1.4	173	Cal., S. Car., Ga.
Processed Vegetables**	3.2	161	Wis., Ore., Minn., N.Y., Md
TOTAL	507.8	24,096	

* Includes oranges, grapefruits, and lemons.

** Includes green peas, snap beans, and sweet corn.

Temperature, Air

In a complex study by Guise (1969), high-predictive-value regressions on wheat yields were found for the influence of the following weather elements: pre-planting temperatures, harvest temperatures, planting rainfall, and growth period rainfall. Wang and Suomi (1958) found that warm and cold spells, rather than merely mean temperatures, are important parameters for all crops. Puffer and Turrell (1967), in discussing frost protection in citrus, feel that important parameters are freezing, frost, dewpoint, temperature inversion and cold air drift.

The heat-unit system is in use with many crops; Decker (1967) gives a useful review of the topic, as do other workers, so this paper will not attempt more than a brief summary (from Decker): growth generally begins for many plants when several consecutive days with maximum temperatures above 40°F occur. For other plants, grown usually under warmer conditions or planted later in the season, the threshold temperature appears to be near 50°F, or, for some (e.g., cucumbers) even 60°. Cereals and forage crops tend to fall in the 40° category; crops such as corn, sorghum and soybeans in the 50° group.

Temperature, Soil

The effect of soil temperature has already been introduced in regard to Capelle wheat (Stansfield 1970). With peanuts, soil temperature is considered ideal for spring planting after the mean temperature at a depth of 10 cm has exceeded 18°C for at least 10 days (Yao 1973).

As one of the bases for his system of "crop prediction without weather forecasts," previously mentioned, Wang (1967) reports that the effects of soil temperatures on the subterranean ears of sweet corn in the early seedling stage determine the number of days required for maturity.

Precipitation; Drying Index; Evaporation

The influence of rainfall is commonly known to be of great importance on crops and is well documented by a representative study of irrigation practices (Veitch and Forrester 1973). Rainfall variations account for appreciable portions of the variability in irrigation water demands. Current rainfall is usually relevant, particularly in summer and fall. In summer, rainfall of the previous month has its least influence. Spring temperature variations also contribute to demand at that season. Hence, accurate rainfall predictions will be of decision-making help to the increasing number of irrigators in the country.

In other farm operations, such as haying and combining, rainfall forecasts are essential (Tibbitts and Meier 1969; Dancer and Tibbitts 1972; Heger 1973). The prediction of dry spells and wet spells is of even greater importance, according to some investigators (Wang and Suomi 1958; Taylor 1967).

As previously mentioned, Hill (1972) suggests adding a drying index to the present agricultural weather forecasts to aid in decision-making.

Wind: Speed, Direction, Duration

Because of its influence on many farming operations, wind is another of the main parameters to consider (Dancer and Tibbits 1972; Felch 1973; Hill 1972; Hooker 1972; Stock 1971; Tibbits and Meier 1969).

Apple harvest, grain combining and other harvest operations are more successful if they can be carried out before rather than after windstorms, assuming the crop is otherwise ready to harvest. Sprinkler irrigation is adversely affected by wind velocities over 5 mph; wind forecasts help irrigators plan their field schedules. Scores of many disease alerts can be influenced by accurate forecasts. Hot, drying winds are a positive influence on haying, although they have a harmful effect on the growth of hay crops and other farm plants. Wind forecasts enable a grower with sandy soil types to work up the soil prior to the arrival of high wind to prevent soil erosion and the killing off of young seedlings by the blowing soil particles.

Solar Radiation: Cloud Cover

These two parameters, although related to drying and evaporation, have important effects of their own, some of which are sensitive to forecast efforts and others that are not. In the latter category is the fact that the quality and intensity of solar radiation have a direct influence on the dry matter composition of various crops, most notably, the Irish potato.[2]

This phenomenon is essentially a constant for a given region, and accounts, for example, for the slightly better processing quality of potatoes grown in Idaho compared to those from Wisconsin.

On the other hand, net solar radiation, which should be susceptible to forecasting, has an influence on air turbulence in the plant microclimate which in turn can adversely affect the spray pattern of small-droplet-size pesticide sprays (Johnstone, et al. 1974).

Multiple Parameters

Although not all of their factors lend themselves to our prediction, or decision making, many models are appearing in the literature that depend on complex agrometeorological approaches. As an example, the abstract of a Russian paper (Korobov and Bugera 1972) reports on the multiple interaction of several weather elements with cereal yields: rainfall of August and

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[2] Source - personal discussion with M. Grosskop of American Potato Co.

September, sum of minus temperatures in the frost period, number of days with thaw, depth in mm to which the land is thoroughly soaked in March, rainfall in the spring - summer period, time for the beginning of vegetation to shooting, number of days from swelling to full ripening, number of days with dry winds, and rainy days in the harvest period. The authors claim that the rate of yield increase is thus determined on the basis of the appropriate rate of increase of the factors investigated.

IMPROVED TECHNOLOGY

An increasingly larger segment of the literature reflects satellite technology, such as Nagarajan (1973), "Satellite television cloud photography as a possible tool to forecast plant disease spread."

Simultaneously, a continuing improvement is being made in the sophistication and efficiency of weather forecasting instruments and procedures (Wang 1972), so that the weather prediction capability asked for or implied in the foregoing discussion are now, or soon should be, available.

AGROMETEOROLOGISTS - LIAISON SPECIALISTS

Up until the present time, meteorologists with a little training or background in agriculture - or often with no such training - have been assigned weather bureau offices where weather forecasts have been prepared for farming communities (U.S. Dept. of Commerce 1967, 1971). That such a program has been only marginally effective no doubt prompted the article title, "Agriculture-the Forgotten User of the Forecast" (Hill 1972), which has already been discussed in this paper.

The two U.S. Department of Commerce publications cited above (1967, 1971) discuss in some detail the requirement for trained agrometeorologists who will be equally capable and "at home" in interpreting weather data for agriculturalists (and vice versa). Such persons are indeed being trained at Land Grant Colleges and elsewhere to fill the need for agricultural forecasters (Page 31).

DISCUSSION AND SUMMARY

The problem of improving agricultural operations by expanding and refining meteorological capabilities is of concern in the "established" nations as well as the "upcoming" nations of the world, and a great deal of agrometeorological activity is going on in all those places. The interchange of agrometeorological technology, in terms of both "software" and "hardware" inputs, is enabling the production of systems that are indeed improving the planning and production efficiency of agriculturalists around the world.

In regard to basic approach, a forecaster individually or as a team, must, as Wang (1967) says, "first be well acquainted with the past history of his crop in a given locality and enivornment, and especially the relationship between them..[Then] the current crop and environmental data...should be analyzed" (Page 398).

This basic approach requires the close cooperation of agricultural and meteorological specialists, or better yet, the training of technicians with a good grounding in all areas of the combined field .

The following weather elements or forecast parameters are of greatest importance for the agricultural phase of IVAM:

Precipitation:	Occurrence, timing amount
Evaporation:	Amount, "drying index."
Temperature:	High, low, duration; critical levels.
Wind:	Velocity, direction, duration
Dew and dewpoint.	
Degree days.	
Soil Temperature	
Soil moisture	

Others (possible of greater importance in certain situations): solar radiation, cloud cover, storms.

The following crops are considered to be most weather-sensitive: vegetables, fruits and nuts, cotton, tobacco, peanuts, Irish potatoes and hay. All crops, at one phase or another of their growth cycle, can benefit from timely, accurate weather forecasts coupled with agricultural advisories. The twenty most valuable crops or crop categories in the USA are summarized in Table 1, page 7.

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Table 2-3 Weather, Parameter, Season, User

WEATHER PARAMETERS	RECREATION FALL, SPRING & SUMMER	RECREATION WINTER			
TEMPERATURE					
Current	Mild T good for fishing Water T too warm or too cold discourages fishing (5) T & RH determine possibility of forest fires(11) Good hunting scents depend on low temperature (14)	Important for skiing conditions (8) For making snow T _ 28°F (6)			
Low for Day		T _ 28°F needed for ice skating rink flooding (4) Low temp causing icing bad for skiing (8)			
High for Day	Swimming comfort needs max. T 22°C(16) Beach area needs 19°C. More use of parks & outdoor sports in warm, not hot weather (16, 19)				
Duration of Current Ranges	Periods of warm humid temp with some fluctuations encourage insect formation (12) Low summer temp for extended periods discourages use of resorts (9)	Prolonged high temperatures can run skiing (8) (1 day) Prolonged low temp. increase use of snowmobile (17)			
Inversions					
Degree Days					

Table 2-3 cont'd Weather, Parameter, Season, User

WEATHER PARAMETERS	RECREATION FALL, SPRING & SUMMER	RECREATION WINTER			
FROST					
Time of Arrival					
Lowest Temp. Duration					
Ground Freeze or Thaw		Thawing & freezing dangerous to ice fisherman (4)			
Depth of Frost in Ground					
PRECIPITATION					
Form(Rain Drizzle, etc.)	Park use, tennis, sports beach use, swimming discouraged by rain (16) Also picnicing.	Rain or freezing rain can ruin snow cover (8) An inch or more of rain can lubricate snow layers in preparation for an avalanche (13)			
Quantity	Pools of rainwater encourage insect formation (12) Baseball games may be cancelled due to wet field (10)	An inch or more of rain can lubricate snow layers in preparation for an avalanche (13)			

Table 2-3 cont'd   Weather, Parameter, Season, User

Time of Arrival	RECREATION FALL, SPRING & SUMMER	RECREATION WINTER			
Duration	1 hr. precip. probabilities needed by racetrack operators, stadiums(2) Rainy spells discourage	Rain or freezing rain can ruin snow cover (8).			
RELATIVE HUMIDITY	High RH encourages, park beach & swimming use(16) High RH discourages golf & other sports (10) RH Affects forest fires(11) High RH gives good hunting scents(14)	RH $\leq$ 61% for artificial snow making (6) Raw damp weather discourages skiing (15)			
DEWPOINT (Dew, Fog)	Fog dangerous to boating (1) High visibility needed for scenic areas(18)				
DRY SPELLS (Wet Spells)	Wet spells discourage tourists (18)				
SNOW, SNOW COVER	Snow cover useful for tracking in hunting (3)	Important to skiing (8) & snowmobiling (17)			
SOIL MOISTURE					

Table 2-3 cont'd Weather, Parameter, Season, User

WEATHER PARAMETERS	RECREATION FALL, SPRING & WINTER	RECREATION WINTER			
SOIL TEMPERATURE					
Drying Conditions Evaporation					
WIND					
Speed	Light winds for fishing (5) Low winds encourage outdoor sports(16), used beaches(18) Winds need for boating navigation (1)	Needed for ice boating. Important for artificial snow making (7)			
Direction	Wind speed, direction & duration determine rate of forest fire spread (11)	Wind direction & speed determines snow deposition- a factor in avalanches(13)			
Duration		High winds discourage skiing (15) chairlifts close for high winds).			
CLOUD COVER	Cloudy weather discourages tourists (18)				
Amount	↓				
Duration	↓				

Table 2-3 cont'd Weather, Parameter, Season, User

WEATHER PARAMETERS	RECREATION FALL, SPRING & SUMMER	RECREATION WINTER			
Barametric Pressure Change	Falling p bad for fishing Rising p good (5)				
SOLAR RADIATION	High sunshine encourages swimming, beach use, sports (16)				

Table 2-3 cont'd Weather, Parameter, Season, User

WEATHER PARAMETERS	PUBLIC NEEDS HEALTH & CONVENIENCE SPRING	PUBLIC NEEDS HEALTH & CONVENIENCE SUMMER	PUBLIC NEEDS HEALTH & CONVENIENCE FALL	PUBLIC NEEDS HEALTH & CONVENIENCE WINTER	PUBLIC NEEDS POLLUTION WINTER, SPRING, SUMMER & FALL
TEMPERATURE					
Current	Warm humid cyclonic air associated with car accidents & suicides(2)(12). Also Summer, Fall, Winter Falling T., moist-- (12) (Also Fall, Summer, Spring)	Air conditioning needed For T _ 25°C(2). Also Spring & Fall Tuberculosis encouraged by warm humid weather (12)	Home heating needed for mean daily temp _ 18°C (2) Also Winter, Spring	Breathing very cold air carries heavy burden on heart-lung system (2) Temp. a factor in type of clothes to be worn (10) (Also Fall, Summer, Spring)	High T encourages pollution damage to plants and materials (4)
Low for Day					
High for Day	High T & RH dangerous congestive heart disease (2) Also Summer, Fall	Heat Stress (Function of T, Wind, RH) source of heat stroke, death (1,2) High T a comfort factor (12)			
Duration of Current Ranges	Periods of warm, humid temperatures, with fluctuations encourage insect breeding (8) ⟵	Very warm days associated with glaucoma (12) ⟷	Arrival of first cold outbreak causes asthma attack to rise (2) (12) ⟶	Large T changes can cause blood clotting(2) Very cold days assoc. with glaucoma(12) Strong cooling--heart attacks (12)	
Inversions					Inversion causes increase in pollution (4,5, 6,7)
Degree Days					

Table 2-3 cont'd Weather, Parameter, Season, User

WEATHER PARAMETERS	PUBLIC NEEDS HEALTH & CONVENIENCE SPRING	PUBLIC NEEDS HEALTH & CONVENIENCE SUMMER	PUBLIC NEEDS HEALTH & CONVENIENCE FALL	PUBLIC NEEDS HEALTH & CONVENIENCE WINTER	PUBLIC NEEDS POLLUTION WINTER, SPRING, SUMMER & FALL
FROST					
Time of Arrival	Frost can be a danger to vehicles on sparsely traveled roads (11) Also, Fall, Winter				
Lowest Temp. Duration					
Ground Freeze or Thaw					
Depth of Frost in Ground					
PRECIPITATION			Rain washes out pollens which affect hay fever (2)		
Form (Rain Drizzle, etc.)	Rain associated with 12.5% of car accidents (3) (9)				
Quantity	Pools of water left from rain encourage insect breeding (8)				

Table 2-3 cont'd Weather, Parameter, Season, User

Time of Arrival	PUBLIC NEEDS HEALTH & CONVENIENCE SPRING	PUBLIC NEEDS HEALTH & CONVENIENCE SUMMER	PUBLIC NEEDS HEALTH & CONVENIENCE FALL	PUBLIC NEEDS HEALTH & CONVENIENCE WINTER	PUBLIC NEEDS POLLUTION WINTER, SPRING, SUMMER & & FALL
Duration	Pools of water left from rain encourage insect breeding (8)		Rain washes out pollens which affect hay fever (2)		
RELATIVE HUMIDITY	Moist air, falling T. encourages arthritis	High RH causes scar pains(2) See also pressure change Humid wx a factor in tuberculosis(12) High RH a comfort factor (12)		RH 50% encourages influenza (12) See T, High for Day above.	High RH encourages pollution damages plants & animals(4)
DEWPOINT (Dew, Fog)	Fog hazardous to car trans. Associated with 2.5% of car accidents (3)(9)			Fog associated with bronchitis & cooling (12)	Dew can encourage pollution damage (4)
DRY SPELLS (Wet Spells)					
SNOW, SNOW COVER	Snow associated with 6.1% of car accidents (3) Also Fall, Winter				
SOIL MOISTURE	Variable dryness and Wetness of road surface leads to slippery spots (9)				High soil moisture encourages pollution damage (4)

Table 2-3 Weather Parameter, Season, User
Numbers refer to bibliographic entries

WEATHER PARAMETERS	INUDSTRY-GENERAL CONSTRUC. WINTER, SPRING, SUMMER & FALL	INDUSTRY-CONCRETE LAYING WINTER, SPRING, SUMMER & FALL	INDUSTRY - UTILITIES WINTER, SPRING, SUMMER & FALL	INDUSTRY & COMMERCE-GENERAL WINTER, SPRING, SUMMER & FALL
TEMPERATURE Current			Electrical and fuel consumption depends mainly on ave. daily T. (11,5,15,18)	For every 1°F change, consumption of beer changes 1.1%(23,29) High T encourage plant pollution and materials damage(11) Retail sales can be partly estimated from T at noon (22) Optimum T, RH needed for breadbaking & storage of yeast, flour(26) Variations in T affect tolerances & dimensions in precision machinery plant (34)
Low for Day	T _ 32°F somewhat harmful T _ 10°F very harmful (1,32)	Freezing weakens concrete (3,12)		Temperature conducive to icing important to merchant ships (33)
High for Day	T _ 90°F harmful (1)	Excessive heat weakens concrete (3,13)		Warm, sunny weather affects candy manuf. & distributors (5). Manmade textiles less tolerant of warm T, RH, during weaving (25)
Duration of Current Ranges	Mild Spring weather increases housing starts (27)		Very cold weather very important to utilities, esp. 4 days (6) Temp. trends needed for river management (28)	Heat wave prediction useful to merchants trying to sell summer merchandise(5)(25). Winter coat sales in Sept proportional to Sept. mean temp. (21)
Inversions			Inversion may trap pollution from fuel driven electrical generators (19)	Inversions trap pollutants and increase pollution damage (8,9,4,7)
Degree Days			Degree days a primary factor in fuel consumption (11,5)	Sales of air conditioners related to degree days (25)

Table 2-3 cont'd Weather, Parameter, Season, User

WEATHER PARAMETERS	PUBLIC NEEDS HEALTH & CONVENIENCE SPRING	PUBLIC NEEDS HEALTH & CONVENIENCE SUMMER	PUBLIC NEEDS HEALTH & CONVENIENCE FALL	PUBLIC NEEDS HEALTH & CONVENIENCE WINTER	PUBLIC NEEDS POLLUTION WINTER, SPRING, SUMMER FALL
SOIL TEMPERATURE	Road stc temperature below freezing dangerous (9) Also Fall (11) Winter				
Drying Conditions Evaporation					
WIND					
Speed	Strong crosswinds across highways endanger large vehicles with high center of gravity (9) →			Wind speed a factor in what sort of clothes to be worn (10) Also Summer, Fall, Spring	NO, SO, EO & other gases spread by wind. Dangerous to materials & health (esp. at peak traffic hrs 8AM - 5PM (4,5,6,7)
Direction					
Duration				Low wind speeds encourage influenza (see R.H.) (12)	
CLOUD COVER		Cloudiness a factor in sunburn potential (2)			
Amount					
Duration					

Table 2-3 cont'd Weather, Parameter, Season, User

WEATHER PARAMETERS	PUBLIC NEEDS HEALTH & CONVENIENCE SPRING	PUBLIC NEEDS HEALTH & CONVENIENCE SUMMER	PUBLIC NEEDS HEALTH & CONVENIENCE FALL	PUBLIC NEEDS HEALTH & CONVENIENCE WINTER	PUBLIC NEEDS POLLUTION WINTER, SPRING, SUMMER & FALL
Barametric Pressure Change					
SOLAR RADIATION	Sunny days worsens glaucoma (12)	Sun angle, visibility & cloudiness determines sunburn potential (2)		Radiation a factor in what kinds of clothes to wear (10) Also Fall, Summer, Spring)	

Table 2-3 cont'd Weather, Parameter, Season, User

WEATHER PARAMETERS	INDUSTRY-GENERAL CONSTRUCT. - WINTER, SPRING SUMMER & FALL	INDUSTRY - CONCRETE LAYING WINTER, SPRING, SUMMER & FALL	INDUSTRY - UTILITIES WINTER, SPRING, SUMMER & FALL	INDUSTRY & COMMERCE-GENERAL WINTER, SPRING, SUMMER & FALL	
FROST					
Time of Arrival	Bricks cannot be laid in freezing temp.(34)	Frost harmful to concrete (3,12)		Freezing wx necessitates use of insulation for shipping of some products (34)	
Lowest Temp. Duration			See temperature duration above		
Ground Freeze or Thaw	Ground freeze harmful (1) Earthmoving difficult below 15°F (17)				
Depth of Frost in Ground					
PRECIPITATION			Precip. affects electrical consumption (15)	Retail sales can be partly estimated from forecast precip.(22)	
Form(Rain Drizzle, etc.)	Rain, sleet harmful Freezing rain somewhat harmful (1)				
Quantity		Rain can wash out, delay or ruin concrete (3,12,13)	Type, amount, coverage, duration, intensity needed for river management (28) (18) Rain falling through smokestack plumes may damager vegetation & increase activity of ground water (20)	Amount of snow forecast needed by clearance crews, newspapers, distributors, truckers, dept.stores, bakery chains (5)	

Table 2-3 cont'd Weather, Parameter, Season, User

Time of Arrival	INDUSTRY-GENERAL CONSTRUC. WINTER, SPRING, SUMMER & FALL	INDUSTRY - CONCRETE LAYING WINTER, SPRING, SUMMER & FALL	INUDSTRY - UTILITIES WINTER, SPRING, SUMMER & FALL	INDUSTRY & COMMERCE-GENERAL WINTER, SPRING, SUMMER & FALL	
Duration	Rain, sleet harmful Freezing rain somewhat harmful (1)	Rain can wash out, delay or ruin concrete (3,12,13)	Type, amount, coverage, duration, intensity needed for river management (28)(18)	Duration of precip. affects amount of retail sales (25)	
RELATIVE HUMIDITY	THI 777 harmful (1)		RH affects fuel consumption & electrical needs (30)(6) Cooling towers may reduce visibility if RH is high (20)	High RH encourages plant & materials damage from pollution(11) High RH causes storage problems of chemicals, metals (5,34), drying operations.	
DEWPOINT (Dew, Fog)	Fog, dense is harmful (1) (32)			Dew can encourage pollution damage to materials (7) Fog hampers navigation of ships (33)	
DRY SPELLS (Wet Spells)			Needed for river management (28)	Wet spell-prediction useful to merchants (5)	
SNOW, SNOW COVER	Snow generally harmful (1) Housing starts cut by snow in Spring (27)		Snow can affect fuel deliveries (5)	Snow clearance crews need info. 4 hrs before storm(11) Retail sales can be partly estimated from snow depth (22)	
SOIL MOISTURE	Important to road construction (35)		Needed for river management (28)	High soil moisture encourages pollution damage (11)	

Table 2-3 cont'd Weather, Parameter, Season, User

WEATHER PARAMETERS	INDUSTRY-GENERAL CONSTRUC. - WINTER, SPRING SUMMER, FALL	INDUSTRY - CONCRETE LAYING WINTER, SPRING, SUMMER & FALL	INDUSTRY-UTILITIES WINTER, SPRING, SUMMER & FALL	INDUSTRY & COMMERCE-GENERAL WINTER, SPRING, SUMMER &FALL	
SOIL TEMPERATURE	See Ground freeze or thaw				
Drying Conditions Evaporation	Excessive drying harmful (1)	Excessive drying can harm concrete (3,12,13)	Evaporation needed for river management (28)		
WIND					
Speed	Winds 20mph harmful 35mph very harmful(32)	Wind can dry out and weaken concrete (3,12,13)	High winds increase fuel consumption (6) (18)	NO, SO & CO & other gaseous pollutants are spread by wind. Dangerous to materials & health(esp. at peak traffic hours-8AM-5PM (8,9,4,7) Navigation of Ships (33)	
Direction				Strong crosswinds across highways endanger large vehicles with high center of gravity(37) Navigation of Ships (33)	
Duration				Maximum wind gust for crane operators, off-shore oil rigs(5) wind load on structures (31) Navigation of Ships (33)	
CLOUD COVER			Cover affects fuel & electric consumption (6,11) (18)	Movie producers, aerial photographers need info(5)	
Amount			↓	↓	
Duration			↓	↓	

Table 2-3 cont'd Weather, Parameter, Season, User

WEATHER PARAMETERS	INDUSTRY-GENERAL CONSTRUC. - WINTER, SPRING SUMMER FALL	INDUSTRY - CONCRETE LAYING WINTER, SPRING, SUMMER & FALL	INDUSTRY - UTILITIES WINTER, SPRING, SUMMER & FALL	INDUSTRY & COMMERCE-GENERAL WINTER, SPRING, SUMMER & FALL	
Barametric Pressure Change					
SOLAR RADIATION			Insulation can affect electrical consumption (15,18)	See Cloud Cover. See High T. Retail sales can be partly estimated from % sunshine predicted (22) (32)	

Table 2-3 cont'd Weather, Parameter, Season, User

WEATHER PARAMETERS	AGRICULTURAL FIELD PREPARATION				AGRICULTURAL PLANTING				AGRICULTURAL SPRAYING				AGRICULTURAL GROWING SEASON				AGRICULTURAL HARVESTING			
TEMPERATURE	W	SP	S	F	W	SP	S	F	W	SP	S	F	W	SP	S	F	W	SP	S	F
Current	18	50,15, 18	18	50,18	18	18	50, 18	18		17,19, 25	17, 19 25	50, 7 17,19,25	6,18,23	X 6,17, 18,53 64	X 2,17, 18,46 60	7,2,17 16,46, 60	18	X 16,17 18	X 2,16 17,18 46,60	X 2,15 17,18 26,46 60
Low for Day	18	50, X 15,18	18	50, X 18	50,18	X, 18	50, X 18	X, 18		X, 17, 19, 25	X,17 19,25	50, 7, X 17,19,22	6,18,23	X,6,17 18,53 64	X, 2, 17,18, 46,60	X,2,17 18,46, 60	50, 18	50,X 16,17 18	50,7 X,2, 16,17 18,26 60	X, 2, 15,17, 18,26, 46,60
High for Day	18	15,18			18	X,18	X,18	X,18		X,17, 19,25	X,17 19,25	50, 7, X 17,19,22	6,18,23	50, X, 6,17, 18,53 64	X, 2, 17,18, 46,60	X,2,17 18,46, 60	50, 18	50, 7 X,16, 17,18	X,2, 16,17 18,46 60	X,2, 15,17, 18,26 46,60
Duration of Current Ranges	18	15,18	18	18	50,18	X,18	X,18	X,18		X,17,19 25	X,17 19,25	50, 7, X 17,19,22	6,18,23	X,6,17 18,53 64	X,2, 17,18, 46,60	50,7,X 2,17,18 46,60	18	50, X 16,17 18	X,2, 16,17 18,46 60	X, 2 15,17, 18,26 46,60
Inversions										X	X	50, 7,X	36							
Degree Days						X	X							50,7 X, 9	X, 9	X, 9			X, 9	X, 9

X denotes requirements by agricultural consultant

Table 2-3 cont'd Weather, Parameter, Season, User

WEATHER PARAMETERS	AGRICULTURAL FIELD PREPARATION				AGRICULTURAL PLANTING				AGRICULTURAL SPRAYING				AGRICULTURAL GROWING SEASON				AGRICULTURAL HARVESTING			
	W	SP	S	F	W	SP	S	F	W	SP	S	F	W	SP	S	F	W	SP	W	F
FROST																				
Time of Arrival	.50	50	50			X, 61							36,44	7, X	7, X	X, 44	50		X	X
Lowest Temp. Duration	50	50	50			X, 61							36,44	7, X	7, X	X, 44	50		50, 7 X	X
Ground Freeze or Thaw		X		X		X								23		X				X
Depth of Frost in Ground		X																		
PRECIPITATION																				
Form(Rain Drizzle, etc.)	X			X	X	7, X	X	X		50, X	50, X	7, X	7, X	7, X	7, X	7, X			X	X
Quantity	18	50,X 18, 21	X,18, 23	18,21 23	18	X, 15, 18	X, 18, 53	X, 18 23		X, 17, 18,25, 30,42	X,17, 18,25 30,42	7, X 17,18 22	7, X, 6,17,18 38, 62	50, X 6,17, 18,23, 38,53 62,64	X, 2 6,11, 15,17 18,23 38,53 60	X, 2,17 18,38, 60	18	17,18	X,2,17 18,32 60	X, 2, 17,18, 23,26, 32,60

X denotes requirements by agricultural consultant

Table 2-3 cont'd Weather, Parameter, Season, User

Time of Arrival	AGRICULTURAL FIELD PREPARATION				AGRICULTURAL PLANTING				AGRICULTURAL SPRAYING				AGRICULTURAL GROWING SEASON				AGRICULTURAL HARVESTING			
	W	SP	S	F	W	SP	S	F	W	SP	S	F	W	SP	S	F	W	SP	S	F
Duration	50,7									X,18, 25,30, 42	X,18 25,30 42	7,X,18 22	X,18	7,X,18	X,18	7,X,18	18	16,17 18	2,16 17,18 32,60	X above refs.
RELATIVE HUMIDITY	18	18	18	18	18	X,18	X,18	18	18	X,18, 25,30 42	X,18 25,30 42	7,X,18 22	X,18	7,X,18	X,18	7,X,18	18	7,X, 18	X,18	X,18
DEWPOINT (Dew, Fog)		X				X	X			7,X	X	7,X	18,36	X,18	X,18	X,18	18	18	X,18	X,18
DRY SPELLS (Wet Spells)	18	X,18 21	18	18,21		X,18	X,18		13	7,X,18	7,X,18	7,X,18	18	7,X,18 23	7,X,11 18,23	X,7,18	18	7,X, 16,18	X,16, 18,21	X 18, 21 23
SNOW, SNOW COVER	X	X			50								X	X						X
SOIL MOISTURE		X	X	X		X	X	X		X	X	X	X	X 23	X,46, 60	X,46, 60		X	X,46, 60	X,46 60

X denotes requirements by agricultural consultant

Table 2-3 cont'd   Weather, Parameter, Season, User

WEATHER PARAMETERS	AGRICULTURAL FIELD PREPARATION				AGRICULTURAL PLANTING				AGRICULTURAL SPRAYING				AGRICULTURAL GROWING SEASON				AGRICULTURAL HARVESTING			
	W	SP	S	F	W	SP	S	F	W	SP	S	F	W	SP	S	F	W	SP	S	F
SOIL TEMPERATURE	18	18	18	18	18	X,18,56 63	X,18	18,45		X			18	X,18 56,63	X,18	18			18	X,18
Drying Conditions Evaporation		X	X	X		X	X	X		X	X		18	X,18	X,18	X,18	18	18	X,18	X,18
WIND																				
Speed	18	X,18	X,18	X,18	18	X,18	X,18	18	18	X,17, 18,19	X,17, 18,19	X,17, 18,19	18	50, X 17,18 64	X,46 60	X,46 60	18	X,17 18	X, 2, 17,18, 46,60	X,2, 17,18 46,60
Direction	18	X,18	X,18	X,18	18	X,18	X,18	18	18	X,17, 18,19	X,17,18 19	X,17, 18,19	18	X,17, 18,64	X,46 60	X,46, 60	18	X,17, 18	X,2,17 18,46 60	X,2,17 18,46, 60
Duration	18	X,18	X,18	X,18	18	X,18	X,18	18	18	X,17, 18,19	X, 17, 18,19	X,17, 18,19	18	X,17, 18,64	X,46 60	X,46, 60	18	X,17 18	X,2,17 18,46 60	X,2, 17,18 46,60
CLOUD COVER																				
Amount		X	X	X		X	X	X		X	X	X	50	50,X	50,X	50, X	50	50	50,X	50, X
Duration		X	X	X		X	X	X		X	X	X	50	50,X	50,X	50,X	50	50	50,X	50,X

X denotes requirements by agricultural consultant

Table 2-3 cont'd Weather, Parameter, Season, User

WEATHER PARAMETERS	AGRICULTURAL FIELD PREPARATION				AGRICULTURAL PLANTING				AGRICULTURAL SPRAYING				AGRICULTURAL GROWING SEASON				AGRICULTURAL HARVESTING			
	W	SP	S	F	W	SP	S	F	W	SP	S	F	W	SP	S	F	W	SP	S	F
Barametric Pressure Change		X	X	X		X	X			X	X	X		X	X	X			X	X
SOLAR RADIATION										20	20			X	X				X	

X denotes requirements by agricultural consultant

2.3 Media Constraints

IVAM concepts were discussed with different sections of the television industry to identify a basic framework defining programming requirements. The conferences involved people within the main offices of the major networks, government regulating agencies and local stations. A survey from the AMS Weathercaster Convention in Denver this spring and current literature on the media were reviewed. Three types of television media require separate consideration:

1. Commercial Broadcast Television
2. Public Broadcast Television
3. Cable Television

Commercial Broadcast Television

Commercial television has been in existence for roughly 25 years. Its remarkable growth and impact on society quickly overshadowed most of radio and the print media. The motivating force in this nearly exponential growth is free enterprise. Advertisements consume about 25% of daytime television and about 13% of prime time. While this compares favorably with other media, program content is determined by the commercial needs of the industry, not the public interest. Entertainment and sports comprise 75-90% of the total commercial television offering, with public service accounting for just 2-1/2%. The remaining percentage is divided among news and wide variety of other programs. (11)

Commercial broadcast television presents two nearly opposing views on needs for weather information. The general opinion held by the three major networks is negative to changes in weather information presently provided.(8,10 &12) IVAM concepts were considered, but suggestions for <u>any changes</u> were met with resistance. In general, the network officials liked the idea of IVAM but felt it must be handled locally. However, each network said they would distribute IVAM if the other networks were using it. The thrust for getting IVAM implemented into the networks is through a "grass roots" need expressed by the public and local affiliate stations. This need exists now, and was stated definitely by those interviewed; however we believe that its full impact will not be felt until there is a clear demonstration of how IVAM would improve existing weather information systems. For instance, satellite pictures now distributed by networks are of poor quality, but are delivered because affiliate stations use them. This has set the standard for "improved" weather information, and the networks will not demand more until they see that an improved service is possible. (8, 10 & 12)

Local affiliates have a very different attitude. They want weather data better in quality, better in timeliness, and more specific to the locale.

Affiliates display differing weather information requirements. The three Madison network outlets have the following opinions:

Station 1 — Weather is part of the news program, but receives only summary coverage with emphasis on "newsy" weather. They would prefer a completely prepared 1-2 minute format and would use it on their news without any changes. If the audio is acceptable to them, they would use it as received. (1)

Station 2 — They definitely want their own audio and "personality" in the program. They also want a choice of formats so they can be different from other local stations. (3)

Station 3 — This station has a professional meteorologist and wants IVAM data in segments so it can be presented with a varied program format leaving max imum options for professional meteorological expression. The IVAM concept is highly desirable to this station since their meteorologist presently spends 3-4 hours per day in graphics preparation. (15)

At the AMS Weathercaster Convention in Denver this spring the IVAM program was described and an opinion questionnaire circulated. IVAM concepts were enthusiastically received as great improvements in providing timely data and saving time in the preparation of graphics. Most weathercasters said they would use short (30-60 second) segments of weather updates during regular daily programming breaks. (4)

Results from a study of stations conducted by SSEC provide some general guidelines:

1. None of the stations present weather information outside their news blocks. The locally generated news blocks were the 6 PM and 10 PM segments and less frequently at noon. Networks supplied news and weather at breakfast time. When asked about plans for increasing program lengths or the number of presentations, an overwhelming majority said they had none.

2. Calculations based on a segment of the total sample indicate the mean program length for selected Midwest stations is 3.3 minutes, the median is 3.5 minutes and the standard deviation is 1.156 minutes. These figures suggest a program of 2.5 to 4.5 minutes, three or more times per day, as required IVAM output. Commercial broadcasters may not balk at more frequent and more lengthy weather presentations, but presently available data and manpower cannot support greather weather coverage. Most stations said they would "consider" greater frequency and length if IVAM products were available.

Public Television

This form of broadcasting originated out of a general feeling of inadequacy over commercial television's programming in the public interest. The PB System relies primarily on foundation grants and, more recently, government subsidy and is free of commercial broadcasting pressures for advertising revenue.

Public television stations as a rule do not have daily news teams; however ,there are notable exceptions. Most PB Stations do not compete with the networks or local stations with news area due to the expense. Commercial stations provide this service because of public service requirements and sponsor desire to advertise.

Public broadcasting lacks the stereotyped news telecast format found in most commercial stations. Lacking this right format, PBS can exercise greater flexibility in the use of IVAM information.(14)

The PBS is most responsive to requests of its affiliate stations. The IVAM products will be distributed on PBS when it is requested by a number of stations. For example, the Aviation Weather Show, produced weekly on PBS, is very well received. While it is aimed at aviators, its large following by non-aviators is attributed to its clear, thorough presentations of high quality graphics. (5)

The PBS has less rigid programming schedules than the commercial networks, and often has 1-2 minute spots to be filled. These spots are filled now with fillers like musical interludes. On some days public television even has 5-15 minute time spots open. These voids could contain IVAM programming. For longer periods, tutorial weather presentations would be welcomed. (14)

For PBS, with more program time available (on the average) than commercial television, greater coverage of weather information is possible. Studies show the public's television attention span lasts about 20 minutes, so 5-15 minute weather shows may be feasible. (14) Further, public television does not promote the "personality" weatherperson, allowing a longer show with less concern for devices like chromakey and cuts.

Cable Television

Cable television began as community antenna television (CATV) and provided service by cable to areas unable to receive conventional broadcast signals. Since then, cable has grown into a very large business, servicing rural communities as well as cities. The ability to receive the broadcast is now assured and the importation of programs from other areas is the real attraction. The Federal Communication Commission, which initially refused to regulate cable, has changed its mind. This decision forced cable television businessmen out of the cable installing business and into the broadcast business. Requirements for local origination of programs, provision for access by the public and limitations on importation has complicated the situation. The impetus for three tiered regulation (federal, state and local) is the realization of cable television's potential to provide greatly expanded public service communication.

This has created concern among cablecasters. While the cost of production equipment and staff is an important concern, it is really another problem to fill a channel with locally originated programs from the start to the end of the broadcast day. This feat is accomplished by commercial network affiliates only with the help of extensive network programming. This is the reason we see stock market alphanumerics, screens filled with news teletype output, and whole "weather" channels devoted to 20 second scans of weather dials. One solution is "netting" or interconnecting various cable companies for mutually shared programming. This subject will be discussed further in the IVAM distribution section on cable netting.

Our experience in preliminary discussions with local cable operators indicates a genuine willingness to experiment with new presentations of weather data and willingness to commit a full-time channel to weathercasting. This presents perhaps the greatest opportunity for the ultimate weather presentation format; a continuous, dedicated 24-hour service. Utilization of such a channel is the IVAM challenge. Cable TV can reach more varied segments of the population more often than the broadcast media. Given the conservative projections that 60% of the American public will have cable service in the next 15 years, the full service potential of cable TV becomes a major communications opportunity. Warning systems incorporated into some cable companies in severe storm areas of the South has led to increased subscribership.

Specific methods for covering cable needs will be presented in the formation of segments section.

DISCUSSION

Significant differences in requirements are posed by each of the media alternatives. Three important examples of these are evident when considering presentations of weather information on commercial television

1. The use of weather "personalities" requires the IVAM product to be prepared so that both voice and image of the weathercaster can be placed in the foreground by relatively simple techniques (chromakey or camera insert) available at most stations. The IVAM graphics must be a significant improvement over the locally generated visual aids now in use, but this objectives is easy to achieve.
2. By making the same video package available to all commercial stations in a market area, there would be little to distinguish one weather show from another. Broadcasters will "individualize" the segments through selective videotaping, and by adding some locally generated visual aids, but one can expect that weathercasters will seek a greater element of control over initial segment development.
3. The question of credibility, or accuracy, is also important, for this would be one of the criteria used by the broadcaster to decide in favor of implementation. Believability is dependent upon the original source and timeliness of the data, the speed of the processing, analysis and packaging of the data, and the quality and style of delivery. High standards must be constantly maintained in all these areas. Frequency of presentations also affects this issue because credibility may be seen as a function of frequency.

Public television also challenges our weather presentation program. Some of the major issues are:

1. Public broadcasting stations have not established a weather broadcast schedule to the extent that commercial stations have. One can expect considerable experimentation by the PBS stations in the use of the IVAM product and a serious attempt by these stations to identify and meet the weather needs of their particular audiences. Requests for reporting of weather parameters not normally used by the commercial stations can be expected.
2. The PBS audience is small, select and dedicated, PBS programming does not attract the same audience as does commercial station programming. However, polls have shown that when regular programming of materials of general interest in provided PBS stations do capture a large segment of the market.

Problems presented by the cable television industry include:

1. Rural areas will be the last to be completely cabled. Exclusion of this service jeopardizes achieving the goal of reaching one of the largest single groups of weather information users. The financial health, and therefore the audience expansion rate, of the cable TV industry has been affected by opposition from broadcasters and by severe government regulation. There is no doubt that cable TV will continue to grow, but the rate of growth is dependent upon factors not under the immediate control of the cable TV industry.
2. Timeliness and quality of the cable TV weather presentation are important to establishing credibility. It is not true that standards for cable TV can be lower than for broadcast TV simply because cable TV stations are willing to use almost any material.

CONCLUSIONS

Development of weather presentations for delivery on commercial television requires that considerations be given to the following factors:

1. Segments must be of superior technical quality, to meet network broadcast standards.
2. Segments must be new, innovative and interesting packages.
3. Materials must stress local weather within the station viewer area.
4. Segments must consist of individually useful blocks, which can be assembled to make up presentations ranging from 2.5 to 4.5 minutes in length.
5. A choice of subject matter and formats is desired so that stations can have different weather programs in format, style and emphasis. The choice should allow chromakey, cuts between station weather-caster and weather video and segments at several scales and for various specific audiences served by the stations.
6. Segments must be timely and accurate.
7. Segments must be provided to meet present station schedules of breakfast, lunch and dinner times plus the 2200-2300 news slot. Shorter update segments at frequent intervals are desired.

For Public/Broadcast TV:

1. Segments must be of superior quality, meeting commercial network broadcast standards.
2. Segments must consist of the latest, most comprehensive data available to ensure maximum accuracy and usefulness.
3. Segment construction must be flexible, allowing feedback and modification according to area user need.

4. Educational and informational programs, devoted to urban, rural and business/industry needs are needed for both regular daily programming and for seasonal, severe weather, and other occasional use.

Cable television's potential emerges as the most challenging and probably the most effective of the three media discussed. The use of a complete 24-hour channel for weather information allows development of a completely automated computer video presentation. This is the only way to deal effectively with some of the many different special information requirements in real time. Here, too, we do not have to overcome established conventions, but can set out to create a new service. Some of the factors involved in delivery of weather information via cable include the following:

1. Segments must be of superior video quality, meeting commercial network broadcast standards.
2. Segments must consist of the latest, most comprehensive data available to ensure maximum accuracy and usefulness.
3. Segments must consider the total picture, fully utilizing each block according to critical and useful times for specific viewers.
4. Production of regularly scheduled educational blocks must be considered to provide users with the means to apply specialized weather information and to establish credibility of the service.

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2.4 Presentation Format Study

While time and space scales could be considered separately, the development and motion of weather systems and weather phenomena define a general time-space relationship. The 1972 ICAS report, The National Research Effort on Improved Weather Description and Prediction for Social and Economic Purposes, describes five space scales: 1 mile, 1-100 miles, 100-1000 miles, 1000-4000 miles and >4000 miles, labeled microscale, mesoscale, macroscale, continental and hemispheric - global respectively. Five time scales are defined as 0-1 hr, 1-6 hr, 6-24 hr, 24-72 hr, and 72 hr - 1 month. These scales were slightly modified by our group to provide some overlap and to be aligned with more recent AMS definitions of time and space scales. Further, from the ICAS report, space-time relationships are defined with isopleth's indicating most intense weather information needs in the 1-6 hr and 1-150 mile range. The time-space scales used for this study are defined and labeled as follows:

SPACE	TIME	NAME
<5 miles	0-1 hr	Microscale
1-150 miles	1-6 hr	Mesoscale
100-1000 miles	3-18 hr	Subsynoptic
1000-4000 miles	12-72 hr	Synoptic
>4000 miles	>48 hrs	Hemispheric-global

Program needs vary during a 24 hour day the study found, and depend on data available, audience group and media. Four time groups are defined as:

Midnight - 6 AM	4 PM - Midnight
6 AM - 4 PM	24 hour continuous

The midnight - 6 AM group serves mainly the industrial needs where minimum report-to-work notice times are required; trucks are loaded for fuel oil, highway maintenance, etc. or for frost and freeze threats to agricultural crops.

The 6 AM - 4 PM time groups covers many general public needs, housewives, transportation, and agricultural planning.

The 4 PM - Midnight time group reaches the largest population group where weekend plans, travel, recreation, etc. are being considered.

The 24 hour continuous is designed for cable television where a dedicated weather channel is used. The audience group there is largely urban; a large variety of weather data can be provided as the audience group is better defined. It is the most rapidly changing audience at this point with the growth of cable television.

Efforts to define TV audiences in terms of weather needs were frustrating. TV audiences are categorized by age, sex, religion, income group, mental attitude, etc., but not by any topic relating to weather. Several urban/rural group combinations were considered but simplified to a basic urban/rural consideration.

Time and space scale information were applied to the information of Table 2-3, with the results represented by Table 2-4.

Another matrix is needed, where the needed segments as shown in Table 2-4 are further described in terms of audience group, time-of-day of presentation, and media used. This final step then provides a list of all possible program segments, based on the needs <u>and</u> the constraints. To avoid the confusing format of showing the entire array of segments in a table, the data were punched on cards and a listing is included as Appendix B of this report.

Table 2-4 Time/Space Scales of Interest by User/Weather Parameter

WEATHER	GENERAL PUBLIC: RECREATION				HEALTH & CONVENIENCE				POLLUTION				PERSONAL TRANSPORTATION							
	W	SP	S	F	W	SP	S	F	W	SP	S	F	W	SP	S	F	W	SP	S	F
TEMPERATURE																				
Current	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4												
Low for Day	3,4	3,4	3,4	3,4	3,4															
High for Day	3,4	3;4	3,4	3,4		3,4	3,4	3,4		3,4	3,4	3,4								
Duration of Current Range	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4								
Inversions									3,4	3,4	3,4	3,4								
Degree Days					4	4	4	4												
FROST													2,3	2,3		2,3				
Time of Arrival													2,3	2,3		2,3				
Lowest Temp. Duration													2,3	2,3		2,3				
SOIL TEMPERATURE																				
Ground Freeze or Thaw	3,4																			
Depth of Frost in Ground	4,5																			
PRECIPITATION																				
Form(Rain, Drizzle, etc.)	2, 3,4	2,3,4	2,3,4	2,3,4	2, 3,4	2,3,4	2,3,4	2,3,4		2,3,4	2,3,4	2,3,4	2 3,4	2,3,4	2,3,4	2, 3,4				
Quantity	2 3,4	2,3,4	2,3,4	2,3,4	2 3,4	2,3,4	2,3,4	2,3,4		2,3,4	2,3,4	2,3,4	2 3,4	2,3,4	2,3,4	2 3,4				
Time of Arrival	2 3,4	2,3,4	2,3,4	2,3,4	2 3,4	2,3,4	2,3,4	2,3,4		2,3,4	2,3,4	2,3,4	2,3,4	2,3,4	2,3,4	2,3,4				
Duration	2 3,4	2,3,4	2,3,4	2,3,4	2 3,4	2,3,4	2,3,4	2,3,4		2,3,4	2,3,4	2,3,4	2,3,4	2,3,4	2,3,4	2,3,4				
RELATIVE HUMIDITY					3,4	3,4	3,4	3,4		3,4	3,4	3,4								
DEWPOINT (Dew, Fog)	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3		2,3	2,3	2,3	2,3	2,3	2,3	2,3				

1-microscale, 2-macroscale, 3-subsynoptic, 4-synoptic, 5-hemispheric

Table 2-4 cont'd Time/Space Scales of Interest by User/Weather Parameter
GENERAL PUBLIC

WEATHER PARAMETERS	RECREATION				HEALTH & CONVENIENCE				POLLUTION				PERSONAL TRANSPORTATION							
	W	SP	S	F	W	SP	S	F	W	SP	S	F	W	SP	S	F	W	SP	W	F
DRY SPELLS (WET SPELLS)																				
SNOW COVER	3,4	3,4		3,4	3,4	3,4		3,4					3,4	3,4		3,4				
SOIL MOISTURE													3,4	3,4		3,4				
SOLAR RADIATION vs. CLOUDS	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4												
DRYING CONDITIONS EVAPORATION																				
WIND	3,4	3,4	3,4	3,4					3,4	3,4	3,4	3,4	3,4	3,4		3,4				
SEVERE WEATHER	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3				

1-microscale, 2-macroscale, 3-subsynoptic, 4-synoptic, 5-hemispheric

Table 2-4 cont'd Time/Space Scales of Interest by User/Weather Parameter

WEATHER PARAMETERS	INDUSTRY: GENERAL CONSTRUCTION W	SP	S	F	CONCRETE LAYING W	SP	S	F	UTILITIES W	SP	S	F	MANUFACTURING W	SP	S	F	RETAILING W	SP	S	F
TEMPERATURE																				
Current									3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4
Low for Day	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4												
High for Day			3,4				3,4							3,4	3,4	3,4				
Duration of Current Range		3,4							3,4	3,4	3,4	3,4							3,4	3,4
Inversions									3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4				
Degree Days									3,4	3,4	3,4	3,4						3,4	3,4	3,4
FROST	1,3				1,3	1,3		1,3					1,3	1,3		1,3				
Time of Arrival													1,3	1,3		1,3				
Lowest Temp. Duration					1,3	1,3	1,3	1,3					1,3	1,3		1,3				
SOIL TEMPERATURE					3,4	3,4	3,4	3,4												
Ground Freeze or Thaw	3,4				3,4	3,4		3,4												
Depth of Frost in Ground	4,5																			
PRECIPITATION																				
Form(Rain, Drizzle, etc.)	2, 3,4,	2,3,4	2,3,4	2,3,4		2,3,4	2,3,4	2,3,4		2,3,4	2,3,4	2,3,4					2,3, 4	2,3,4	2,3,4	2,3,4
Quantity	2 3,4	2,3,4	2,3,4	2,3,4		2,3,4	2,3,4	2,3,4		2,3,4	2,3,4	2,3,4					2,3, 4	2,3,4	2,3,4	2,3,4
Time of Arrival	2 3,4	2,3,4	2,3,4	2,3,4		2,3,4	2,3,4	2,3,4		2,3,4	2,3,4	2,3,4					2,3, 4	2,3,4	2,3,4	2,3,4
Duration	2 3,4	2,3,4	2,3,4	2,3,4		2,3,4	2,3,4	2,3,4		2,3,4	2,3,4	2,3,4					2,3, 4	2,3,4	2,3,4	2,3,4
RELATIVE HUMIDITY						3,4	3,4	3,4	3,4	3,4	3,4	3,4								
DEWPOINT (Dew,Fog)	2,3	2,3	2,3	2,3									2,3	2,3	2,3	2,3				

1-microscale, 2-macroscale, 3-subsynoptic, 4-synoptic, 5-hemispheric

Table 2-4 cont'd Time/Space Scales of Interest by User/Weather Parameter

WEATHER PARAMETERS	INDUSTRY: GENERAL CONSTRUCTION W	SP	S	F	CONCRETE LAYING W	SP	S	F	UTILITIES W	SP	S	F	MANUFACTURING W	SP	S	F	RETAILING W	SP	W	F
DRY SPELLS (WET SPELLS)									4,5	4,5	4,5	4,5					4,5	4,5	4,5	4,5
SNOW COVER	3,4	3,4							3,4				3,4	3,4			3,4	3,4		
SOIL MOISTURE		2,3	2,3	2,3						2,3	2,3	2,3		2,3	2,3	2,3				
SOLAR RADIATION vs. CLOUDS									3	3	3	3	3	3	3	3	3	3	3	3
DRYING CONDITIONS EVAPORATION		3	3	3		3	3	3		3	3	3								
WIND	3,4	3,4	3,4	3,4		3,4	3,4	3,4	3,4	3,4		3,4	3,4	3,4	3,4	3,4				
SEVERE WEATHER	2,3	2,3	2,3	2,3		2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3

1-microscale, 2-macroscale, 3-subsynoptic, 4-synoptic, 5-hemispheric

Table 2-4 cont'd Time/Space Scales of Interest by User/Weather Parameter

TRANSPORTATION

WEATHER PARAMETERS	MARITIME				COMM. TRUCK															
	W	SP	S	F	W	SP	S	F	W	SP	S	F	W	SP	S	F	W	SP	S	F
TEMPERATURE																				
Current																				
Low for Day	4	4		4																
High for Day																				
Duration of Current Range																				
Inversions																				
Degree Days																				
FROST	3	3		3																
Time of Arrival	3	3		3																
Lowest Temp. Duration	3	3		3																
SOIL TEMPERATURE																				
Ground Freeze or Thaw																				
Depth of Frost in Ground																				
PRECIPITATION																				
Form(Rain, Drizzle, etc.)					2,3		2,3	2,3												
Quantity					2,3		2,3	2,3												
Time of Arrival					2,3		2,3	2,3												
Duration					2,3		2,3	2,3												
RELATIVE HUMIDITY																				
DEWPOINT (Dew,Fog)		3	3	3																

1-microscale, 2-macroscale, 3-subsynoptic, 4-synoptic, 5-hemispheric

Table 2-4 cont'd Time/Space Scales of Interest by User/Weather Parameter

TRANSPORTATION

WEATHER PARAMETERS	MARITIME				COMM. TRUCK															
	W	SP	S	F	W	SP	S	F	W	SP	S	F	W	SP	S	F	W	SP	W	F
DRY SPELLS (WET SPELLS)																				
SNOW COVER						3,4		3,4												
SOIL MOISTURE																				
SOLAR RADIATION vs. CLOUDS																				
DRYING CONDI-TIONS EVAPORATION																				
WIND		3,4	3,4	3,4	3,4	3,4	3,4	3,4												
SEVERE WEATHER	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3												

1-microscale, 2-macroscale, 3-subsynoptic, 4-synoptic, 5-hemispheric

Table 2-4 cont'd Time/Space Scales of Interest by User/Weather Parameter

AGRICULTURE

WEATHER PARAMETERS	FIELD PREPARATION				PLANTING				SPRAYING				GROWING				HARVESTING			
	W	SP	S	F	W	SP	S	F	W	SP	S	F	W	SP	S	F	W	SP	S	F
TEMPERATURE	1,2,3	1,2,3	1,2,3	1,2,3.	1,2,3	1,2,3,	1,2,3	1,2,3,	1,2,3	1,2,3	1,2,3	1,2,3,	1,2,3	1,2,3,	1,2,3	1,2,3,	1,2,3	1,2,3,	1,2,3	1,2,3,
Current	1,2,3	1,2,3	1,2,3	1,2,3		1,2,3	1,2,3	1,2,3		1,2,3	1,2,3	1,2,3		1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3,
Low for Day	1,2,3	1,2,3	1,2,3	1,2,3		1,2,3	1,2,3	1,2,3		1,2,3	1,2,3	1,2,3		1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
High for Day	1,2,3	1,2,3			1,2,3	1,2,3	1,2,3	1,2,3		1,2,3	1,2,3	1,2,3		1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
Duration of Current Range	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3		1,2,3	1,2,3	1,2,3		1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
Inversions										1,2,3	1,2,3	1,2,3								
Degree Days						2,3,4	2,3,4							2,3,4	2,3,4	2,3,4			2,3,4	2,3,4
FROST Time of Arrival		1,2,3	1,2,3			1,2,3				1,2,3				1,2,3	1,2 3	1,2 3			1,2 3	1,2 3
Lowest Temp. Duration		1,2,3	1,2,3			1,2,3				1,2,3				1,2,3	1,2,3	1,2,3			1,2,3	1,2,3
SOIL TEMPERATURE	3,4	3,4	3,4	3,4		3,4	3,4	3,4		3,4				3,4	3,4	3,4			3,4	3,4
Ground Freeze or Thaw		3,4		3,4		3,4														
Depth of Frost in Ground		4,5																		
PRECIPITATION	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3
Form(Rain, Drizzle, etc.)	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3			2,3	2,3
Quantity	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3		2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3
Time of Arrival		2,3	2,3	2,3		2,3	2,3	2,3		2,3	2,3	2,3		2,3	2,3	2,3	2,3	2,3	2,3	2,3
Duration		2,3	2,3	2,3		2,3	2,3	2,3		2,3	2,3	2,3		2,3	2,3	2,3	2,3	2,3	2,3	2,3
RELATIVE HUMIDITY	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3
DEWPOINT (Dew,Fog)		1,2				1,2	1,2			1,2	1,2	1,2		1,2	1,2	1,2	1,2	1,2	1,2	1,2

1-microscale, 2-macroscale, 3-subsynoptic, 4-synoptic, 5-hemispheric

Table 2-4 cont'd   Time/Space Scales of Interest by User/Weather Parameter

AGRICULTURE

WEATHER PARAMETERS	FIELD PREPARATION				PLANTING				SPRAYING				GROWING				HARVESTING			
	W	SP	S	F	W	SP	S	F	W	SP	S	F	W	SP	S	F	W	SP	W	F
DRY SPELLS (WET SPELLS)						4,5	4,5													
SNOW COVER	3,4	3,4							3,4					3,4						3,4
SOIL MOISTURE		2,3	2,3	2,3		2,3	2,3	2,3		2,3	2,3	2,3		2,3	2,3	2,3		2,3	2,3	2,3
SOLAR RADIATION vs. CLOUDS										3	3			3	3				3	
DRYING CONDITIONS EVAPORATION		3	3	3		3	3	3		3	3	3		3	3	3		3	3	3
WIND	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4	3,4
SEVERE WEATHER	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3	2,3

1-microscale, 2-macroscale, 3-subsynoptic, 4-synoptic, 5-hemispheric

Using a simple sort routine, a presentation may be specified simply by selecting the choice of user, media, season, time of day, etc. What such a sort provides is not a uniquely defined presentation, but a "menu" list from which a weathercaster may choose the segments he feels best suit the meteorological situation.

The present list totals 483 separate segments. This number will be reduced by a factor of four or five, as the segment formats are developed into image sequences. Lack of distinction between segments for different times of day, similar user needs, etc., will decrease the list to below one hundred.

2.5 Emergency Needs

Emergency situations can be defined as those in which danger is threatened to life, health, or property. The thrust of this discussion deals with emergency situations related to weather, although the same considerations may apply to other disaster threats such as chemical leaks, large fires, etc. Our concern is one of preventing or minimizing loss rather than one of survival after occurrence.

BACKGROUND

A warning system, like any communication system, can be thought of as a general system of information flow as in Figure 2-1.

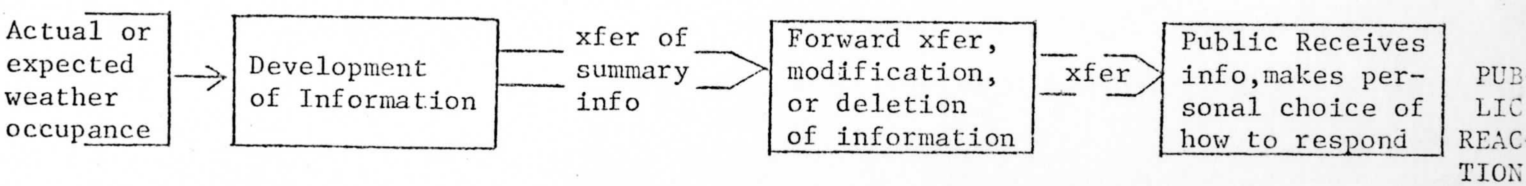


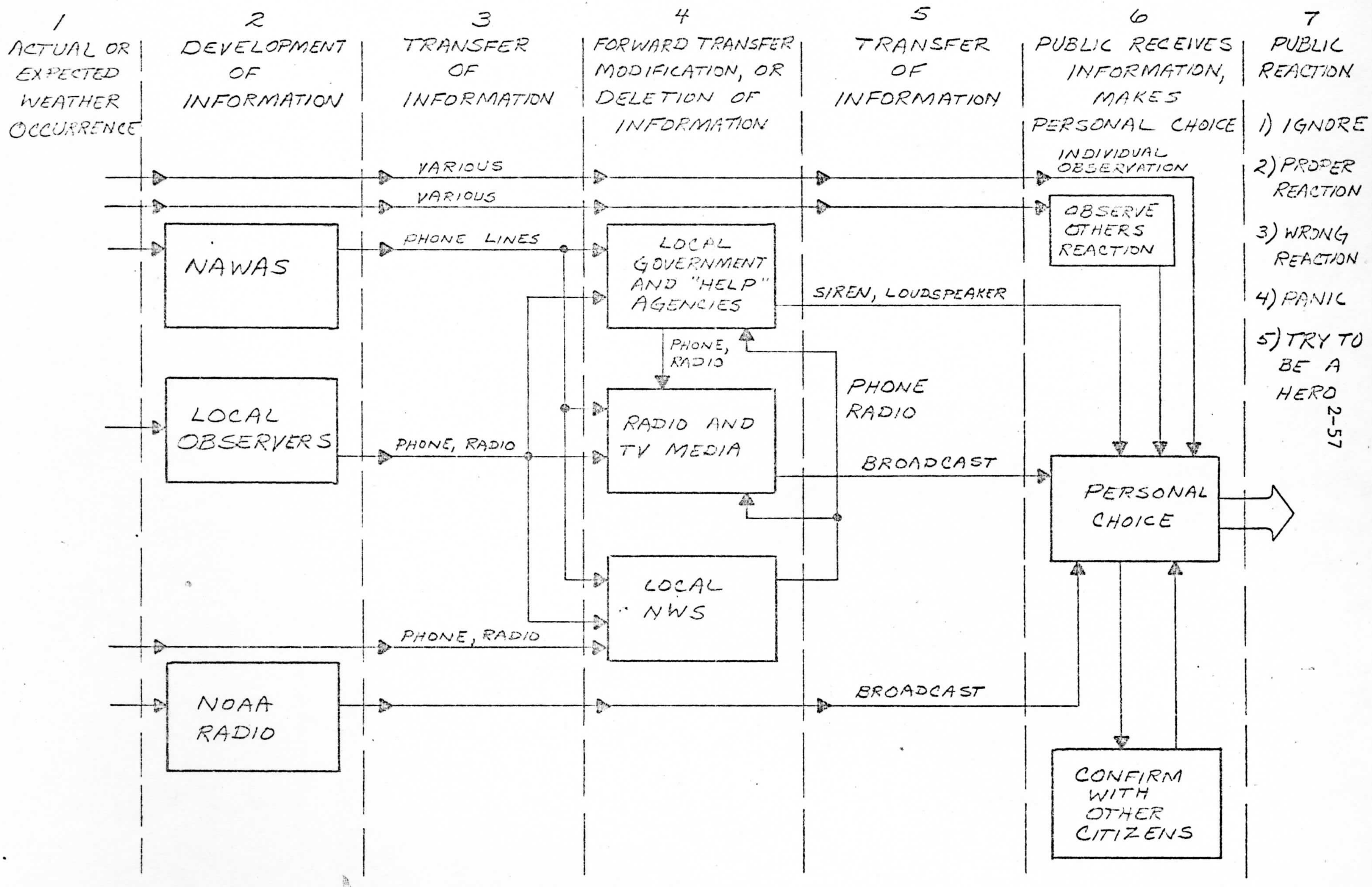
FIGURE 2-1 - GENERAL INFORMATION FLOW DIAGRAM

The seven elements are all necessary for the system to work, but how well it works is not controlled, since the system has no feedback. This diagram fairly well describes the present warning system. It may be well to review the general advantage and disadvantages of the elements.

Figure 2-2 shows the same system, but with greater detail. Column 2 is the first point of analysis, i.e., a decision point for determining that an emergency situation exists. Of the five paths of information, two are of high integrity, NAWAS and NOAA radio. A third one, local observers, may or may not be reliable, depending on individual training and the specific situation. Value of the warning of any of the three depends on (1) technical competence of observer, (2) source information available and analytical capability of the organization, (3) timeliness of observation, and (4) local specificity of the observation.

Column 3 of the diagram labeled "Transfer of Info" appears unimportant but is critical for two reasons, reliability and bandwidth. The two media used are limited to voice transmission (or voice rate). Warning information often lacks in completeness because of limits on transmission capacity. Further, reliability of phone communication is low during severe weather situations since phone lines are highly susceptible to storm damage. CB radio communication is more reliable in a storm but the channels are often over used during such times, and must compete with lightening interference too.

Successful communication through the Column 2 region reaches the local NWS, local agencies, or the media. Each of these three elements have the ability to modify the message as they see fit. The task of all three is to reach the public with the warning information as effectively as possible.



DETAILED INFORMATION FLOW DIAGRAM

FIGURE 2-2

The four avenues of communication are SIREN, LOUDSPEAKER, RADIO BROADCAST, and TELEVISION BROADCAST. While telephone is also possible, its inefficiency in reaching a significant part of the public rules out its utility.

The siren signal reaches a relatively large percent of the population, and could be considered reliable in the sense of liklihood to operate. However, the information content of a siren signal is very low. Further, it causes confusion and misunderstanding. (1) Overuse and misuse of the siren causes a "wolf-wolf syndrome" where the sound no longer commands attention because of its familiarity. Message coding be varying blasts of the siren is generally not understood by the public.

The loudspeaker generally consists of a mobile unit mounted on an automobile which is driven about the area, giving a voice message. To be effective, a message must contain complete information of what, when, where, who, etc. A message sufficiently long to cover the necessary materials takes time approaching a minute. Problems here are:

(a) Peoples attention must be atracted prior to the message (i.e., give enough time to come out of the house or office to hear)

(b) Driving must be slow enough to complete message before driving out of hearing range

(c) Only practical for densely populated areas

(d) May be safety risk for personnel in mobile unit.

The radio and TV media are the most effective means of contacting the public. Reliability of commercial broadcast is high and television offers great capacity for information transmittal. Loss of electrical power by the consumer is no longer a serious problem with the increasing use of battery operated radio and TV. The problem is one of limited information; again only voice rate information is available from NWS to the media. Technical terminology often confuses the station employees and the urgency of a message may not be apparent to them.[2] The message may become confusing if the station tries to modify it. Instructional messages are usually too brief, based on time constraints at voice rates.

The local NWS office has no means of reaching the public directly, except through phone answering. Their major function is to provide accurate up date information to the local government agencies and media. A serious problem is that of workload in the local office. The local NWS office is staffed for a full workload for normal weather; severe weather increases the amount of work dramatically. The further complication is that the work being done and decisions being made during severe weather periods are much more important but must be done with less data, in less time, by an overworked staff.[2] An effective warning system must not burden a system already working at or near capacity with nominal weather.[2]

The last two columns of Figure 2 deal with the public response to an emergency. The individual has six bases of information from which to make a choice. In the face of conflicting evidence, his choice is based on the credibility or completeness of the various messages. Individual observations, other's reactions, and confirmation of other citizens is generally a non-reason for taking specific action. Such inputs provide an emotion for action and are not usually a good base of judgment. The sound of a siren generally serves no more than the function of an attention getter. Its real function is to alert people to then tune into the media. The loud speaker method has already been discussed, leaving radio and TV. The NOAA radio will be a great improvement for communication of instruction and information, but still lacking is the ability to convey a picture. The public must be able to maintain a choice, but the lines of communication must provide a credibility and confidence so as to create correct priority in the mind of the individual.

PUBLIC NEEDS FOR EMERGENCY WARNING

The public needs warning and instruction that is:

- unmistakebly clear in content
- timely
- specific to locale
- authoritative

The message of emergency warning must have a clearly understandable terminology. There are numerous references to the watch/warning confusion in the literature. The Agnes Floods study(2) states"..It's (NWS) credibility is sure to slip if it speaks to the public in codes or symbols. Time is too short for translations. NACOA strongly recommends that NOAA review its battery of warnings to develop improved ways of communications warning information." Reporting the status or expected condition is not sufficient information upon which to act. The public must have a clearly defined instruction of what to do.

In the Agnes Floods, less than 10% of the news media in the stricken areas had access to the latest forecasts and warnings (2). The problem was one of the NWS not having time to keep up with the weather events and to communicate them to the media. Automation of relaying the information is certainly to be considered.

The general public's needs are greatest for weather forecasts within a six hour/100 mile scale for normal weather (3). When severe weather occurs, the interest within this scale is intensified. Certainly the mesoscale and even the microscale, is important. In the Agnes Floods "...hurricane and weather systems responsible for extremely heavy precipitation.. were...

smaller...than the effective resolution of the models." Radar, aircraft, and satellite observations were not available for analysis. Availability of such "pictoral" information is technically feasible; such capability must be developed.

The Agnes Flood study (2) states "Where public authorities exercised a strong command and control initiative, the response tended to be excellent. Where people had to make their own decisions or improvise, the response was as varied as human nature. When radio or TV announcers conveyed a sense of the seriousness of the risks the public became more responsive. The report further states "...accountability for warning delivery is fragmented to the point where no agency has the responsibility." It is the opinion of the report that NWS must see that the proper message reaches the public. "Releasing a forecast to the media is only one and sometimes a minor part of the whole system." The potential for IVAM to effectively reach the public is a powerful tool for meeting the needs of emergency warning.

Ivam's Role in Emergency Warnings

The two avenues of NWS reaching the public directly with emergency information are the NOAA weather radio (4) and IVAM. Both systems must be used, for they offer complimentary and distinctly different capabilities.

The NOAA weather radio is expected to serve as the primary warning device. It provides an automatic turn-on capability which is implemented in the home on a voluntary basis. The ultimate limit on the NOAA radio, however, is the voice rate of information transfer. It could be likened to listening to an instructor who has no blackboard or visual aids. There is a distinct disadvantage compared to an instructor who uses good topical visual aids.

IVAM provides the visual aids which can be used with or without the "instructor", or voice channel. The National Cable Television Association (NCTA) has made several studies of ways in which cable TV can provide emergency warning service to subscriber (6). In fact, subscribership of cable service has shown a marked increase where emergency warning service is available (7). Many communities have, or are developing, plans in which the local emergency operating center uses the free access channel. Special IVAM emergency sequences can be used on that channel which complement those in use on the regular weather channel.

On broadcast TV, timely visual information is hardly ever available for emergency coverage. Periodic IVAM updates, along with standard formatted instructional messages can be available as needed.

The generation of specific TV presentation segments for emergencies by warning does not pose a special problem for IVAM. Severe weather segments are just one more type of segment. The problem which needs further study is how to bring local emergency service authorities into the weather telecast. Since this does not involve generation of TV images by IVAM, we do not consider this problem to be of direct concern to the program.

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4. The Use of Telecommunications to Warn the General Public, January 13, 1975.

5. National Policy for the Use of Telecommunications to Warn the General Public, OTP, January 13, 1975.

6. Cable TV and Engineering Services, Hazel S. Dyson, National Cable Television Association, Nov. 6, 1974.

7. Interview with Delmar Ports, Vice-President, NCTA, March 4, 1975.

3.0 Software

This section will detail the process that the software development has followed during the first nine months. After some guiding concepts have been introduced, it will describe several important decisions which have guided subsequent software design. The salient features of the resulting design are then presented together with the implications for hardware design and costs. Then, an overview of the major software document which appears as Appendix A will be given.

IVAM is to be an automated system capable of generating a wide variety of video images based upon meteorological input data. These images must be acceptable to both the broadcast media and the viewing public.

The optimum system for providing this service is one that includes within its scope the full range of foreseeable software needs through the following stages of the program:

1) software development
2) hardware design
3) initial field testing
4) full national implementation
5) continuing evolution due to the availability of new information and changing media needs.

Thus we can state that the goal of the software design is to provide a sound conceptual framework within which to implement a system which:

1) is hardware independent
2) is flexible enough to allow extensive modification during development as new transformations and display techniques are tested
3) can be easily tailored to different locals, seasons, and user groups
4) is capable of demonstrating the full range of reasonable options and clearly defines several levels of capability and the costs associated with each.
5) can be scoped to include a wide or narrow set of options as desired
6) assures an orderly transition onto the implementation hardware
7) provides NWS several ways IVAM can be interfaced or integrated with AFOS while postponing the point at which this decision must be made.

Since the software design is to be optimized for the solution of the IVAM problems. Certain points must be made with reference to the subject of efficiency. Software people tend to think of efficiency in terms of minimizing execution time, conserving core, and conserving disk space; but the essence of these concerns is saving money. An efficient system is one that conserves expensive resources. In the data processing field the state-of-the-art is changing very rapidly. One must not accept the old criteria for efficiency without question. Instead we should try to preduct the costs of system components will compare in the future, i.e., which will be the critical resources.

There is strong evidence to suggest that both CPU time and core space, the traditional "critical resources", will no longer cost enough to justify an effort to conserve them. This means that all the lessons of past system development experience must be reevaluated to see if they still hold, especially for the IVAM design which includes the specification of hardware which will be bought in quantity. Initial procurement and installation costs are high, and changes which must be made after the system is in the field can be very expensive. Therefore, it is true economy to minimize the machine dependent part of the software and to make later modification easy even if traditional "efficiency" rules are stretched. The costs of the software development are incurred only once, no matter how many copies of the system are made. A software design which preserves hardware options is more efficient in the long run than one that conserves CPU and memory now.

3.1 Alternative Approaches

With these thoughts in mind we sought to identify the several alternative approaches to the software design. The first step was to examine past experience and existing software to see what lessons had been learned and how much could be applied. Past software development done at Space Science has assumed the presence of a man in the process. This procedure provides a very effective division of labor. The man decides what the computer should do and the computer does it. In order to automate this process it is necessary to identify exactly what it is the man provides to see what the computer must do to replace him. In addition to invoking the sequence of operations, he selects the data and provides the knowledge about what parameters each operation requires. On the other hand, automating the McIDAS system is not sufficient because McIDAS is a research tool used by meteorologists who are grateful to be able to visualize their data and quite willing to adjust to the aesthetic deficiencies of the image, whereas both the media and the public are not so accommodating. While the two systems might seem quite close in intent, it was decided that the flexibility required of the IVAM system was not simply an aspect of the problem. It was the problem! These observations were then organized and presented to management in the form of three alternative design approaches.

The three approaches represent three levels of emphasis on generality and on short term versus long term results. Their purpose was to identify a policy issue and to invite management's participation in the decision. The three options were:

1. Process Flow System
2. Subroutine System
3. Integrated System

<u>Process Flow</u>

The first approach is based on the following visualization of the IVAM process (Fig. 3-1).

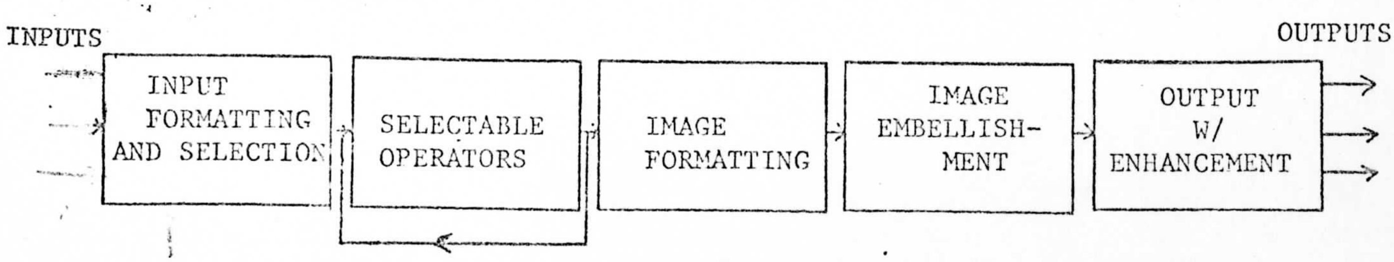


Fig. 3-1

Input data enters at the left and is processed step by step until the final image is created. For each image that is desired a separate program can be written to generate it. That program may actually invoke the execution of other programs to accomplish each processing step. The sequence of programs is presented to the host operating system as a sequence of system control statements and it has complete control of their execution. A scenario then would be specified as a longer sequence of control statements and handled the same way.

This approach provides a number of advantages:

1. Since each program sequence accomplishes all of the steps in the process flow, it provides immediate products and visible signs of progress.
2. With small modifications existing, software could be applied directly.
3. Host operating system takes care of all sequencing.
4. It is based on FORTRAN so seemingly machine independent.

On the other hand, a number of disadvantages can also be identified:

1. This approach obscures its dependence on the machine used to develop it. The FORTRAN programs are necessarily permeated with code that assumes a particular data format and the existence of certain kinds of mass storage and specialized image generation hardware. Also FORTRAN differs slightly from machine to machine,particularly with small computers.
2. It provides only the minimum flexibility.
3. System problems are repeatedly solved in different ways throughout.
4. FORTRAN programs must always allocate storage for the maximum amount of data they ever expect to handle.
5. Any generality must be achieved independently in each part of the system, i.e., there is no single approach to the problem of generality.

6. There is no ability to take advantage of future hardware developments. This system is based on programs and there is no provision for breaking up programs easily.
7. It is easy to ignore the problems of implementation such as tailoring the system to different geographic locals, times of day, and user groups.
8. There is no provision for dealing with contingencies such as missing data.

This is a quick way of providing a minimal solution to a well defined problem. IVAM is not well defined.

<u>Subroutine Approach</u>

The second approach is more modular and breaks up all processing steps into FORTRAN subroutines. A completely separate system then translates specifications into a sequence of processing steps and generates a control program which calls all of the appropriate subroutines with the appropriate parameters. This control program is then collected (a machine language block containing the code for all the subroutines is formed).

The advantages of this approach are:

1. It is quick to produce results although not as quick as the first option.
2. Each subroutine is defined only once in the system whereas the first alternative might easily have a number of programs containing code to accomplish the same result.
3. It does recognize and generalize the problem of data and parameter passing between subroutines.
4. It still can be mainly FORTRAN based.

The disadvantages of the Subroutine Approach are:

1. Many of the subroutine functions such as assigning colors are not particularly amenable to a FORTRAN approach.
2. It still has to allocate the maximum amount of storage these subroutines expect to encounter.
3. Each subroutine has to do its own I/O.

4. It requires core for the whole collected program at once.

5. The fact that the processing steps are collected into a program means that there is no way to intervene in its execution once it has started. There is no way to execute the first few steps at one time, suspend the program, and continue later.

Integrated System

The final alternative was to consider all of the software problems the system faces and to come up with a single unified approach for addressing all of them. Rather than relying completely on the host machine for its execution, this system would oversee the scheduling and execution of all IVAM code. The need for generality would be recognized as permeating the system. Thus, although different parts of the problem might be generalized in different ways, the system would provide a common set of tools for use throughout.

The advantages of an integrated system are compelling:

1. It addresses the full problem while many solutions can be postponed, the ability of the system to deal with them is never foreclosed.

2. The result is extremely flexible.

3. It allows new features to be added and others deleted with relative ease.

4. Any of the hardware or performance specifications of the system can change without requiring a costly overhaul of the system.

5. It allows the question about what is feasible to be answered definitively. A lesser capability can be simulated with the general system and, once its sufficiency has been completely demonstrated, it can be precisely defined and optimally implemented.

6. Several such options could be simulated.

7. Thus, it maximizes the depth of experimentation while preserving the ability to optimize costs and performance later.

However, there are two disadvantages, one real and one apparent:

1. This approach does postpone visible results until the support system is implemented.

2. The overhead would seem to degrade performance. It will be shown later that this is not true.

In presenting these alternatives, we did point out that IVAM is under greater pressure for generality or ease of change than most systems because:

1. Final acceptance of the system by the media and the public is based on aesthetic rather than practical judgement.

2. Many crucial aspects of the system are not specified. The software tasks are actually proceeding in parallel with software design. In fact the final specification of the system awaits confirmed acceptance of its products.

3. Customer needs are likely to evolve after the system is implemented. New stations and programs will be created. Any given station may seek to change its formats from time to time. New user groups may be identified or make their needs known. Ironically, if IVAM is well received, these problems are guaranteed.

4. The final interface to AFOS cannot be fixed at this time.

5. The future development,and therefore needs and capabilities of the cable operators cannot be predicted at this time.

6. IVAM must be machine independent in order to preserve hardware options.

7. It must be independent of hardware configuration as well, e.g., it cannot assume an analog disk or colorizer.

8. Hardware configurations and capabilities are changing very rapidly at this time.

3.2 Fundamental Design Decisions

On the strength of these arguments the decision was made to pursue the Integrated System Approach. As we investigated this approach further we were led to make a number of extremely important design decisions:

1. There will be two stages in system development: development and implementation.

2. The design will be completely modular.

3. A descriptive as opposed to procedural language will be used to define scenarios.

4. Distinctions between processing steps and image elements will be preserved as long as possible.

5. The final step of filling in the pixel by pixel detail should be postponed as long as possible and then isolated in a separate module.

6. A basic net structure will be used to implement as much of the system as possible.

Each of these decisions, which when taken together, describes much of what is unique about the IVAM software concept, is described in further detail:

Decision 1

During the development of the software, the system should provide a wide variety of imaging options. At this stage the system is a tool for discovering the most effective visual results. Once this determination is made the goal changes. The optimal hardware configuration can be chosen and the software can be constrained to the minimal subset required. The general system agreeably assists with its own lobotomy. Discarded options and development aids are simply omitted by deleting software modules.

In fact, our suspicion is that this step will never be taken. First of all, the complexity of IVAM's task may require an irreducible minimum of generality which will also allow a richer product at no extra cost. Even more important, there are almost no examples of significant systems which do not continue to evolve as long as they are used. Even if the pace is only one change a year, the ease of making that change and the liklihood of its disturbing the rest of the system are important design concerns. Thus, we believe that when the decisions are made as to what to include in the implementation software set, most of the development aids will remain as insurance against our inability to anticipate future needs and whims. Furthermore, it may be that the system is implemented at one level of capability but the option of later augmenting it is to be kept open.

Decision 2

The second decision was to make the system completely modular, i.e., to break all of the processes down into their component subprocesses as far as possible. The function of the system then is to support the execution of modules. This means that it must:

1. translate scenario specifications into a sequence of modules
2. determine the next module to be executed
3. invoke the execution of a module
4. pass parameters to the module
5. get input data for the module
6. store output data generated by the module
7. keep track of the location of stored results
8. coordinate the accumulation of images for several scenarios simultaneously.

The supporting system must itself be modular in order to isolate machine dependencies and thus to facilitate the bootstrapping of the system onto another machine. By keeping the machine dependent modules to a minimum and defining the rest of the system in terms of them, it should be possible to transfer the system to a new machine simply by implementing those modules.

In addition to providing all of the advantages of generality, the modular approach also allows the developers to:

1. Maintain clean interfaces between programmers. Each programmer implements a module at a time.

2. Debug their programs easily because they work on small processing steps. Also, the operation of a module, its inputs and outputs, can be easily traced by the system. It is worth noting that the presence of a system for debugging is of extreme importance given the tendency to underestimate the importance of that function.

3. Make timing studies on the use and speed of the various modules to determine system bottlenecks.

4. Consider the application of parallel processing (separate computers) to eliminate bottlenecks.

5. Further consider reducing some heavily trafficked modules with simple mechanical functions or hardwired electronics.

6. Separate processing steps so accumulation, alteration, or transmission of images or preimage data can be accomplished at any stage.

7. Maintain options on AFOS interface. IVAM modules may be attractive to AFOS before the two systems are integrated. Different levels of control as well as resource and capability sharing are available because IVAM maintains and clearly isolates many of the possible interfaces for its own generality.

Decision 3

The system for specifying scenarios must be descriptive rather than procedural. A descriptive language describes the desired results. It says nothing about the procedures required to accomplish the result and nothing about the order in which they must be executed. A procedural language, on the other hand, details the step by step process for accomplishing the result but communicates nothing about what the result is. Only programmer comments on the final output do that.

The importance of this distinction is that a scenario specifies the order of the output presentation, but cares not at all what order the system finds convenient to accomplish the processing as long as the results are ready when the scenario is to be shown. Thus the order of execution depends on:

(a) What data is available. The 12:00 a.m. Service-A temperatures cannot be computed at 11:45. The data is not in. However, the system should not hang up waiting for that data. It should move on to another task and return when the data is available.

(b) What segments are already completed for other scenarios. If the results already exist there is no reason to repeat the processing.

(c) What storage is available. There may be no room to store completed digital images but other processes producing less output can proceed until the space is free.

(d) What segments have priority because their presentation time is closest.

The goal is a system that never waits. If it is possible to insure that all processing resources are being used fruitfully at all times, then a minimum hardware configuration can be chosen. It also is worth noting there is no concern that the translation of scenarios be an efficient process. This translation does not have to be done very often.

Decision 4

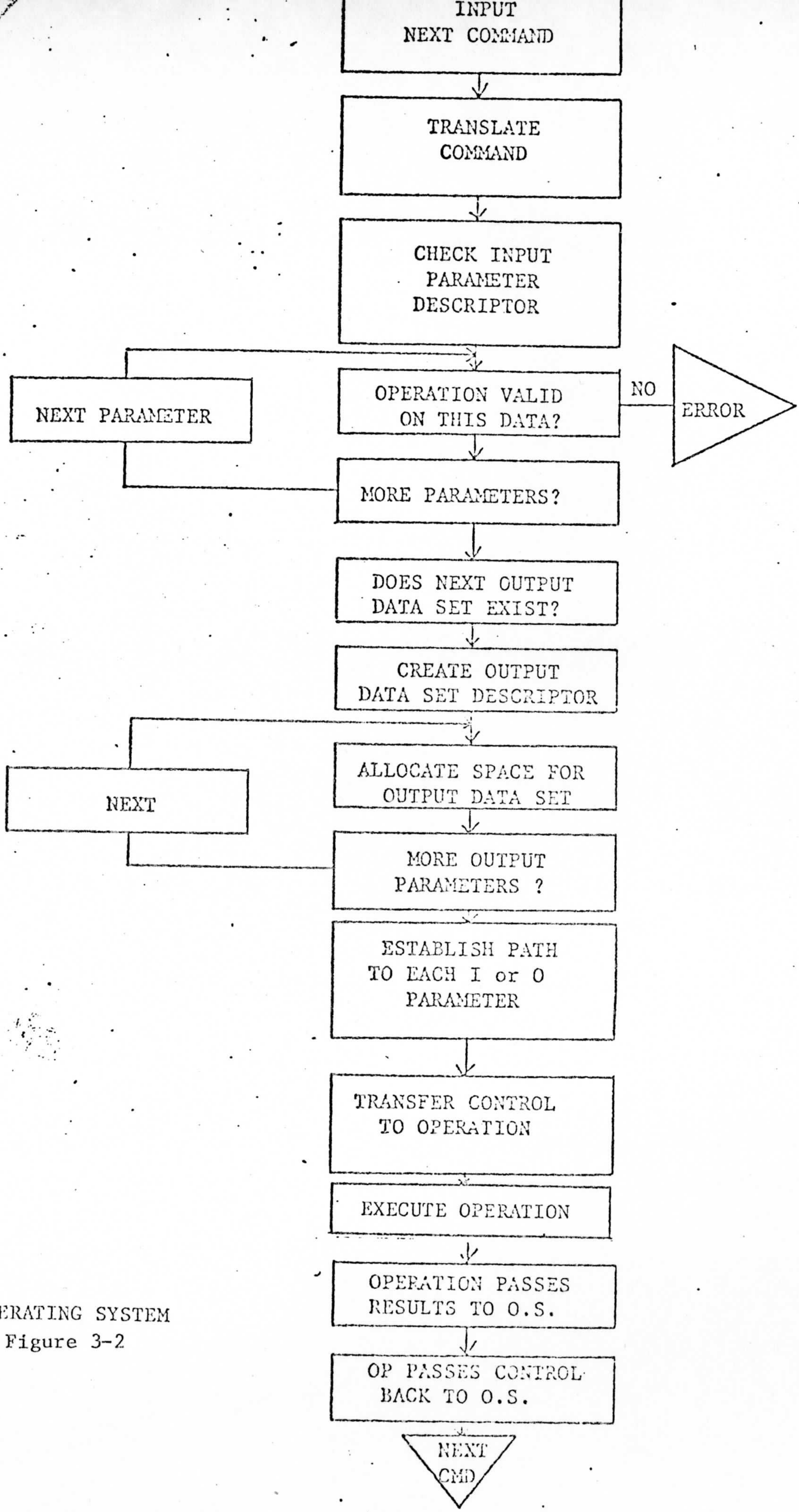
The system should preserve the distinctions between different image elements as separate data sets as long as possible. The processing of image elements is represented in Fig. 3-2. Each horizontal line represents the processing steps necessary to produce one image element. The benefits of maintaining these distinctions are:

1. The processing of each image element is independent of the others.

2. Changing one of the elements does not require changing any of the others.

3. Therefore the elements required to produce a family of images differing only in details can be accumulated. It may be found that accumulating image elements is the most efficient way of conserving storage.

4. The greatest range of alternative imaging techniques can then be applied to a given set of data.



OPERATING SYSTEM
Figure 3-2

Decision 5

The step filling in the pixel by pixel detail should be postponed as long as possible for the following reasons:

1. At this point in the processing, the amount of data to be stored increases by an order of magnitude.

2. The amount of processing required to accomplish this represents a very likely bottleneck for the system.

3. It is a completely mechanical process which could be delegated to separate and perhaps multiple processors and perhaps even hardwired.

4. It is a crucial point where all distinctions within the image are irretrievably lost. Afterwards the result is just an image, all reference to its elements and their placement is difficult to recover.

The data construct called the Scan Topology was created to isolate this step. It is the last point where all of the information about the image is available. It will be mentioned again within the software report and in the hardware studies report. Its isolation quite conceivably will have an important impact on the system, hardware costs and therefore on the feasibility of IVAM. It also suggests a way that a color display might be added to AFOS at some point at a relatively modest cost. The identification of this possibility is an important result of the modular design.

Decision 6

We have created a basic system building block which we call a "net". The nets are general structures which are used to define the specialized structures required for the various system functions. Here are the most important of these structures:

1. Descriptor Nets

   (a) Contain all of the information associated with an image
   (b) Are both the specification of what has been done and what remains to be done to generate the image.
   (c) Are therefore an extremely general way to pass parameters which are not handed directly from one process to the next, but left in the descriptor where the system can find them when it wants to pass them to the next module. It is important to realize that this method means that the generation of an image can be suspended and resumed without upsetting the parameters. Thus the transfer of control and the passing of parameters really occur at different times.

2. Structure Nets

   (a) Are the basic means of finding data in the system.
   (b) Accomplish the descriptor search needed to find parameters and data pointers.
   (c) Follow these pointers to files on mass storage
   (d) Are capable of finding particular elements in formatted data sets.
   (e) Free the processing modules from all machine and configuration dependence. Traversing the Structure Net actually invokes the machine dependent modules

3. Semantic Nets

   (a) The agreement among colors
   (b) The contacts between domains
   (c) Dependencies among processes
   (d) The definition of general image formats
   (e) Groupings of data and parameters to allow macro statements

3.3 Hardware Requirements

After one pass through the design process was made, it was realized that software considerations might influence hardware design as much as the reverse. Therefore an in-house document was written describing what hardware would be desirable from a software point of view.

A distinction was made between separable and dependent processes. A process is dependent on another if it cannot be executed until the completion of the other. Two processes are separable if neither depends on the output of the other. However, either or both can be dependent on

We, therefore, recommended that parallel processing be considered for the final implementation. In particular:

1. I/O should be delegated to a separate processor.

2. The controlling system should be a separate processor so system overhead is accomplished in parallel with system execution and therefore does not slow its execution.

3. Additional processors should be used to break any other system bottlenecks especially in filling in the Scan Topology.

In addition, it was recommended that all video storage be digital or at least capable of the color fidelity of digital, because in this way color encoding is absolutely secure. Furthermore, partial animation can be achieved by changing color assignments dynamically.

It was also pointed out that the number of bits used to represent a pixel determines the number of different colors and intensities of color that can be present in any single image.

Finally, the precipitous drop in both CPU and semiconductor memory prices was noted.

3.4 Software Concept Document

The software concept document included as Appendix A to this report represents a significant effort. It presents, in software terms, the detailed concepts that will guide system development. The document is divided into three major sections: Concepts, Language, and Systems.

The Concepts Section identifies the major software problems confronted by the software design and presents the theme of the chosen approach. It introduces the terms that will be important throughout the document and defines them in terms of their function.

The Language Section is designed to provide a sense of what the basic mechanisms of IVAM processing will be. These are presented with sample IVAM statements to suggest how the language capability of the system will allow us to use them with great flexibility and generality. Certain problem areas which will require considerable effort and whose solutions will be organized into subsystems within the IVAM system are discussed. The first such problem is data selection. The system has to be generalized so that in each geographic location the date sources and geographic boundaries can be grouped and referred to by name. General methods also have to be established for creating texture and assigning color. A general method of defining image formats and inserting data into them must also be developed. Particular formats and particular textures will be used to define a vocabulary of animated area weather symbols. Other formats will define a variety of graphs and alphanumeric tables.

The Language Section also includes examples of how a series of statements in the IVAM language can be controlled or qualified.

The system section describes the system utilities required to implement the capabilities described in both documents. These include the general tools to support any such system, i.e., resource management, mass storage access, interrupting processing, etc. These will be provided by the operating system of the host machine. The most significant section here describes the implementation of the nets from which the generality of the system derives. The implementation and use of the Descriptor Nets, Structure Nets, and Semantic Nets are also described. Then the function of the language passes and the fact that the meaning of words can depend on the context in which they appear are presented, together with the constructs which support this capability. The macro feature of the language is mentioned in this context. Finally, an elaborate example is constructed using familiar Service-A data. It is hoped that this example will clarify the complex concepts in the system.

Summary

The software approach is unique in several respects. First it addresses the optimization of the entire project rather than ignoring the interaction of the software with the evaluation studies, hardware development, and the step by step process of the final implementation. We believe that by the end of the project, it is this approach that is cost effective, and that it will produce the best product. The fact that the interfaces of the system to its inputs and outputs can remain flexible is extremely important, especially because these are usually the first things to be fixed. The software described can definitely accomplish the stated goals of the IVAM system. It can also adjust easily to the several forces that will dictate its final form.

With the nets, in particular, it was felt that it was important first to indicate the places they would be useful and later to detail their precise function and implementation.

4. HARDWARE CONCEPT STUDY

4.1 STUDY OBJECTIVES

IVAM is an ambitious program in which the software and hardware designs required to implement a never-before-attempted system are being developed simultaneously. The goal of the IVAM program is a fully automatic video presentation system which is optimally interfaced with the National Weather System and the Automation of Field Observation System (AFOS) on one hand, and with the several TV media on the other. Optimal interfacing must satisfy important considerations of economy, efficiency, reliability, and acceptability by the public. During the first year of the program it has become increasingly clear that the total system approach of the IVAM program is absolutely essential if the program objectives are to be met. There is a tendency, which has been evident in other system developments, to determine a hardware design early in the program; and to force software to conform, or worse, to compensate for the shortcomings of the prematurely determined hardware configuration. For IVAM such a course would be disasterous for several reasons:

(1) It is clear that there are several sets of hardware that could be assembled now that would implement IVAM, but probably not optimally. Available video hardware design is advanced in concept and capability; it is in the software area that significant innovation is required. Since IVAM is a total system development program, the hardware design must await the software developments.

(2) AFOS, the basic data distribution system in the NWS, is itself still being developed. The overall concepts of AFOS are quite firm, but one must expect significant changes in hardware

and software configurations as AFOS is refined and implemented. The interface with AFOS is of great importance to IVAM and must not be frozen too soon.

(3) As later discussions in this report indicate, a major determinate of IVAM hardware design is the interface with the using media. Considerable progress has been made in developing the parameters of this interface, but much remains to be done. It is not likely that this interface will be fully understood until fairly extensive tests of IVAM have been completed and evaluated.

(4) The electronics industry is starting what appears will be the greatest period of change in data processing equipment since computers first appeared. Already the production of microprocessors has drastically altered the cost balances between processing, moving, and storing data. It is easy to predict further changes during the next several years, but the exact capabilities of the new equipment are not clear yet.

During the first nine months of the IVAM program the hardware concept study has been held to a small effort, limited for the most part to contacts with electronics industry members, some limited engineering studies, and internal conferences. During the conferences we developed and discussed alternative configurations with the intent of impacting the software concept formulation process. One objective was to explore hardware-software relationships as early in the developmental process as possible, and to continue this interaction so as to maintain generality rather than to settle on limited concepts too soon. A second objective was to avoid developing a system which is permanently shaped by the equipment upon which it is developed. The computer at the heart of the McIDAS, which will be used to develop and test IVAM, and the video display section of McIDAS, must be used with care to develop, but not to determine, the IVAM system.

4.2 HARDWARE REQUIREMENTS

This section on IVAM hardware requirements is organized by an arbitrary set of general tasks which approximate the data flow. The report organization does not necessarily signify that hardware subsystems would be similarly organized.

1. Input

The IVAM hardware must be capable of injesting the entire data content of the NWS National Digital Circuit (NDC), SMS/GOES satellite image sectors from the NESS Central Data Distribution System (CDDS), single images and image sequences from a local video tape or film file, and manual inputs from the local forecaster or operator. The Input task contains several interesting aspects which should be considered further:

a. Decoding Conigraphic data from the NDC

In AFOS the conigraphic data are decoded by digitally generating x and y deflections which drive the write gun of an analog scan converter to paint the curve segment on a physical reference screen. When the graphic has been fully developed, it is raster scanned by the read gun of the scan converter to refresh a video display. This technique is not appropriate for IVAM because of the lack of precision inherent in the analog scan converter. It is not possible to generate a set of images by this process which will not jump around the video screen when shown in sequence.

In IVAM, a software concept (data construct) called "Scan Topology" will be used to organize all graphic image information immediately after the information is generated. This same data construct will organize decoded conigraphic data so that it can be read out in raster format. Scan Topology specifies the image elements by words which contain address locators which permit rapid scan of the random access memory in which the words are stored to produce a skeleton of the final image with the image elements in proper order for raster scan. In a second step, the image is "fleshed-out" by filling fields between the image elements. The performance of the Scan Topology data construct is similar to that of a digital scan converter, but it does not require a fixed memory grid of full TV frame dimensions. That is, data are generated by raster line, but compactly within the line without the redundant field-filling pixels being present. Instead, the TV pixel location for image elements is designated in the stored word address. The advantages of the Scan Topology approach are many: 1) the memory size is smaller; 2) data at curve or area intersections are retained fully; 3) total data store is not limited to a single TV frame; 4) many different output images can be read from the stored data depending upon the image read rules employed.

The hardware required to implement the Scan Topology data construct can be: 1) a part of a general purpose computer; 2) an auxiliary RAM peripheral to a general purpose computer; 3) a microprocessor with RAM; or 4) a special purpose hardwired "digital scan converter." At this point the choice need not be made, and we can wait for the developments of the electronic industry to determine the optimum choice. In the interim, the development of the Scan Topology software can continue without prejudicing the final hardware decision. Also the Scan Topology software data construct could be integrated into AFOS to replace or augment the present analog scan converter, and to increase the flexibility and fidelity of the AFOS displays. A more complete description of the Scan Topology data construct is contained in Appendix A to this report.

b. Input Data Storage

The AFOS program is already developing the software and hardware to intercept, select, error check, and store the data from the NDC. We have assumed that the IVAM system would never be installed except at a WSFO with an AFOS installation. The IVAM program may or may not include its own data input section, but if not then it must interface with the AFOS data storage design. At present the address and retrieval schemes of AFOS and IVAM are quite different and these must be brought into coincidence, or separate digital disks for data storage must be provided. These alternatives are discussed further below.

c. Input Image Storage

In addition to the NDC data IVAM will use satellite images, single pictures and picture sequences. SSEC is now building a digital data storage and playback system designed to interface with the CDDS sectorizer line and to output still or sequenced images in standard TV format. This initial device uses a digital disk recorder, but it is likely that solid state digital storage can replace the disk recorder within two years at equivalent or lower cost. This type of equipment will meet the IVAM requirement fully.

Equipment for automatic retrieval of 35 mm slides and 16 mm movie sequences are in use by many TV stations at present and pose no design problem. However, these devices do represent a sizable maintenance workload, and it may be that a video magnetic tape cassette library will be more efficient and more economical. The automatic cassette library equipment now available is not satisfactory because of time base error, and high maintenance requirements, but significant improvements are expected during the next two years.

2. Processor

The basic processor for IVAM can be a standard small computer, or a set of interrelated microprocessors, or a combination of both. If a single computer is used it should meet the following criteria:

a. 16, 24, or 32 bit word length

b. 32,000 word memory minimum, 164,000 word maximum

c. floating point

d. byte addressing

e. disk operating system

f. multi-programming

g. numeric language (FORTRAN preferred)

The efficiency of the system would be improved if the computer also had memory-to-memory data transfer and parallel processing capabilities.

A set of interrelated microprocessors is an intriguing concept which is not yet fully developed. The total system capability using microprocessors should meet the cirteria listed above for the single computer. With the exception of very large scale operations there has been little experience with multi-processor systems, but the field is growing very rapidly. The combination of a small general purpose computer which controls several specific function microprocessors operating in parallel may be preferred alternative. This approach offers great system flexibility and operating efficiency. It may also offer cost savings and the easiest way to interface with AFOS if one considers using the AFOS applications computer as the controller.

3. Assembler and Output Storage

The assembly function is a hard one to pin down at this stage of system development. It is analogous to a railroad marshalling yard where individual cars are switched and shunted until trains are assembled with the proper cargoes in the proper order. The marshalling yard consists of a large number of short-term storage tracks, means for moving cars from track to track, a few larger train assembly tracks connected to the main line, and a control center. The IVAM assembler will have short term digital storage of from 100 to 500 TV frames, larger scale segment or presentation digital storage into which frames are transferred and out of which a TV presentation can be read, and a controlling computer programmed with scenario generating software. Several possible arrangements of these elements are discussed more fully below.

If one considers a five minute presentation as a suitable IVAM output, it is necessary to assemble a total if 9000 TV frames. Many of these frames will be repeated or repeated with minor changes. Based on test presentations which we have prepared, the number of basically different images required for a five-minute presentation is approximately 90 and the number of overlays or image segments required to modify and animate these basic images is about 200. It appears to be possible to provide the 9000 frame presentation from 80 to 100 basic frames to which are added detail overlays or substitutions during assembly to produce from 250 to 500 frames which are repeated and sequenced to produce the five minute presentation.

4. Output

To interface with broadcast and cable TV media capabilities and schedules we must output full presentations or segments in the following formats:

a. A complete weather presentation of five or six minutes repeated five or four times to make a 30 minute program block updated each half hour. This service would be only slightly less acceptable if the responsibility for recording and repeating the presentations were left with the cable TV station. Either audio background or computer generated audio track is desired. This is the basic format for Cable TV.

b. Weather presentation segments designed for use by a weathercaster at a broadcast TV station or network. Segments must be complete in themselves, one minute or less in length, aesthetically related so that presentations from one to six minutes can be assembled by the weathercaster. Segments must be transmitted at hour and half hour blank periods for network distribution, and can be sent at other times for local stations.

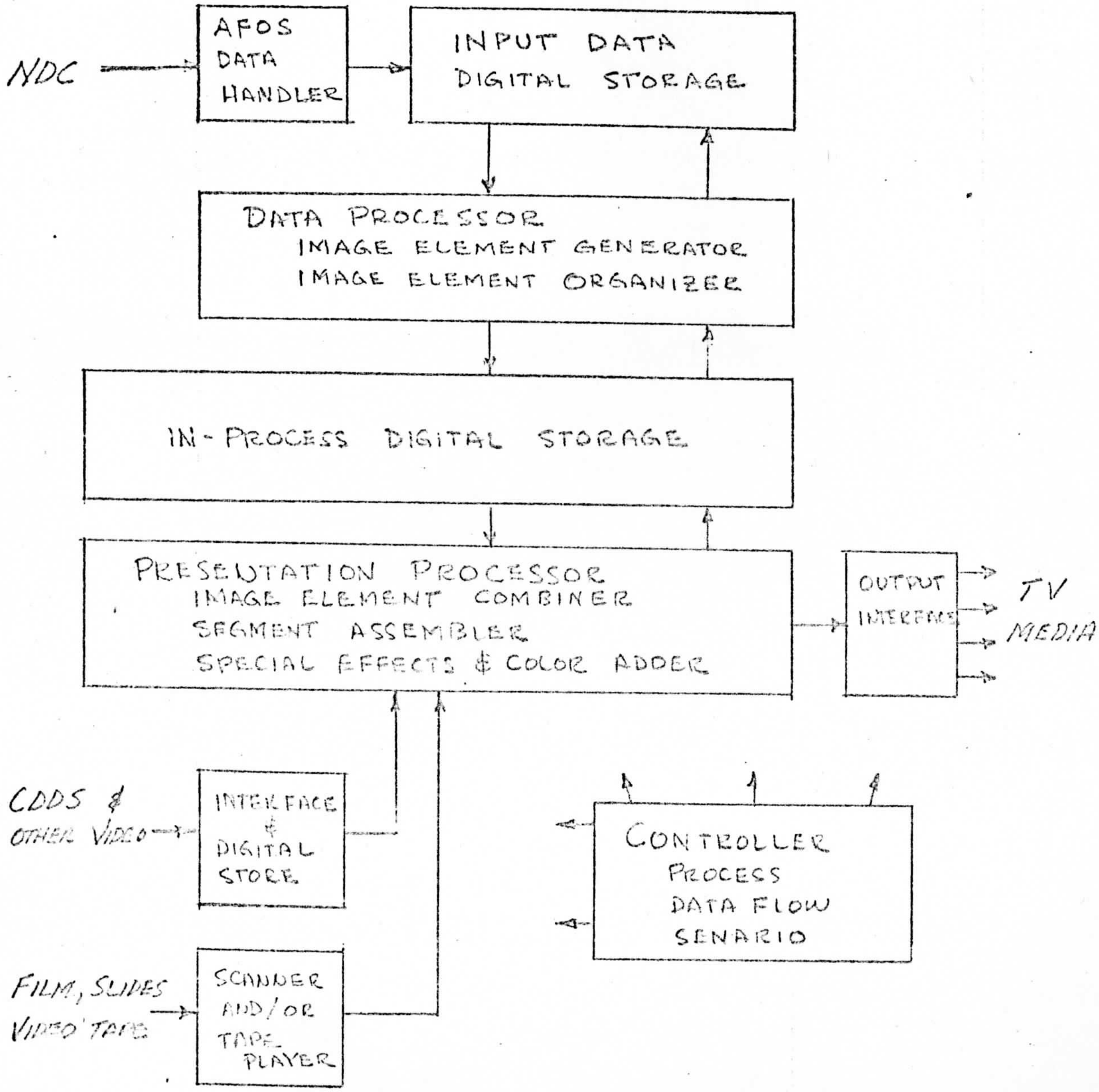
c. Weather background and educational segments from five seconds to five or six minutes in length to be stored and sent out"on demand". Educational and commercial broadcast stations and cable stations all requested this service.

d. 15 second to one minute "stand alone" weather up-date presentations for broadcast stations which will not require a weathercaster. Either audio background or computer generated audio track is required.

To provide these output formats it is clear that provisions must be made for continuous output, precisely scheduled outputs, and output on-demand. None of these present any particular difficulty from a hardware standpoint.

4.3 ALTERNATIVE CONCEPTS

Figure 4-1 is a basic IVAM functional block diagram. It could be drawn many other ways, and will be altered to illustrate the more significant hardware concept options. To keep the number of alternatives to be considered to a minimum, it is convenient to consider them in two groups; input and processor options, and storage and output options. There are three significantly different options in each group which when taken



IVAM BASIC FUNCTION BLOCK DIAGRAM

FIGURE 4-1

together could make up nine alternative systems. In addition, each of these nine alternatives can be considered using either a central data processor (one computer) or multiple processors (several microprocessors).

Input-Processor Alternatives

1. Minimum AFOS Interface

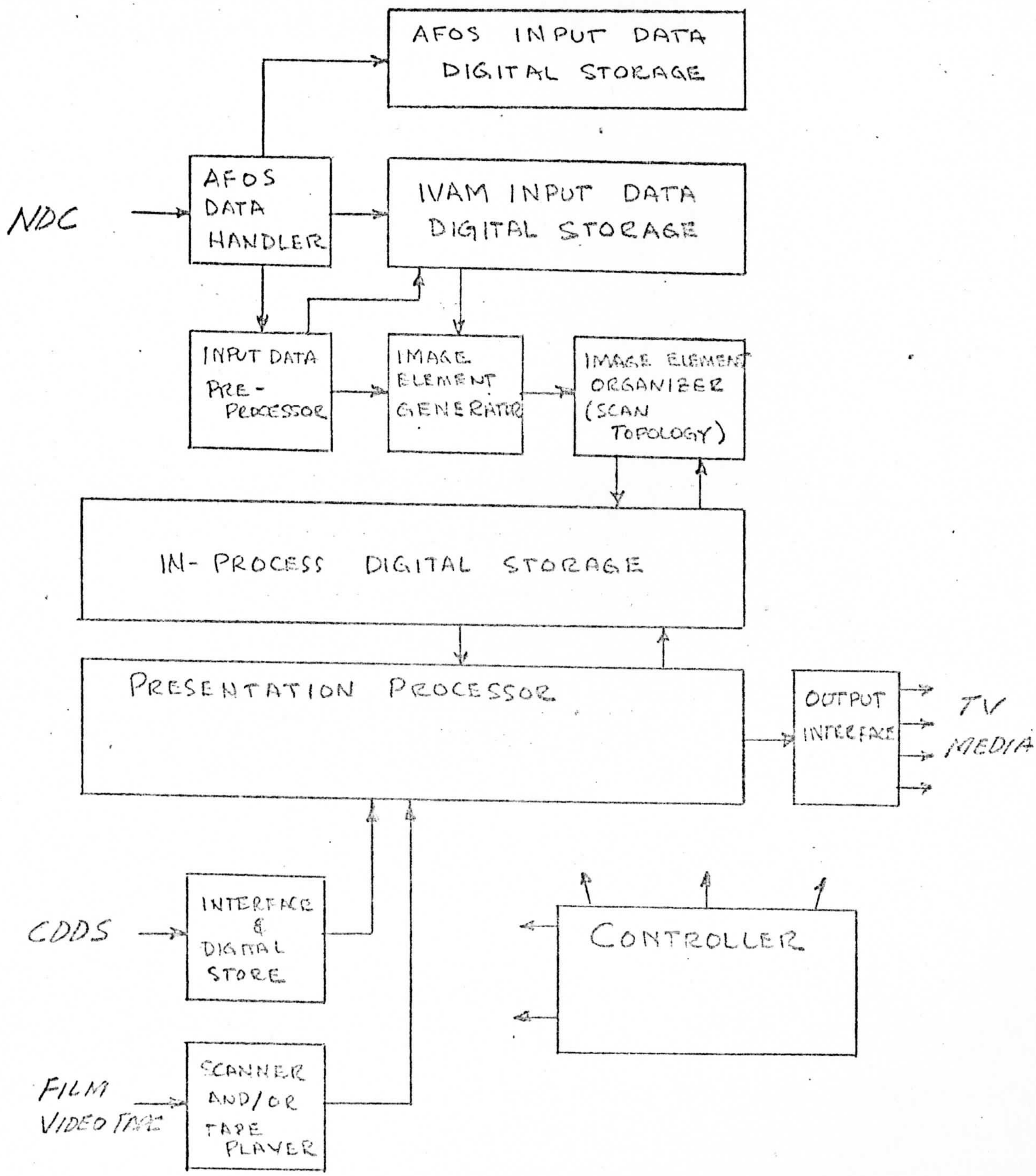
Figure 4-2 illustrates a "stand alone" IVAM which simply parallels the output from the AFOS data handler and does all its own data storage, processing and controlling. There is little to recommend this alternative except minimum mutual interference between AFOS and IVAM. This approach would probably not be the least-cost alternative and could result in two systems so different in hardware that maintenance and operating manpower would be excessive.

2. Partial AFOS Integration

The alternative illustrated in Figure 4-3 uses the AFOS input data processing and storage system entirely, and uses the AFOS applications computer as the overall system controller. This approach would require some modification to the AFOS data preprocessing and storage software, but we believe that the present AFOS hardware design capability would not be exceeded. Similarly, the additional task of controlling the IVAM system is a small additional load for the AFOS applications computer (estimated to be less than 2% of CPU cycles) and could be incorporated with relatively minor changes required to the AFOS software.

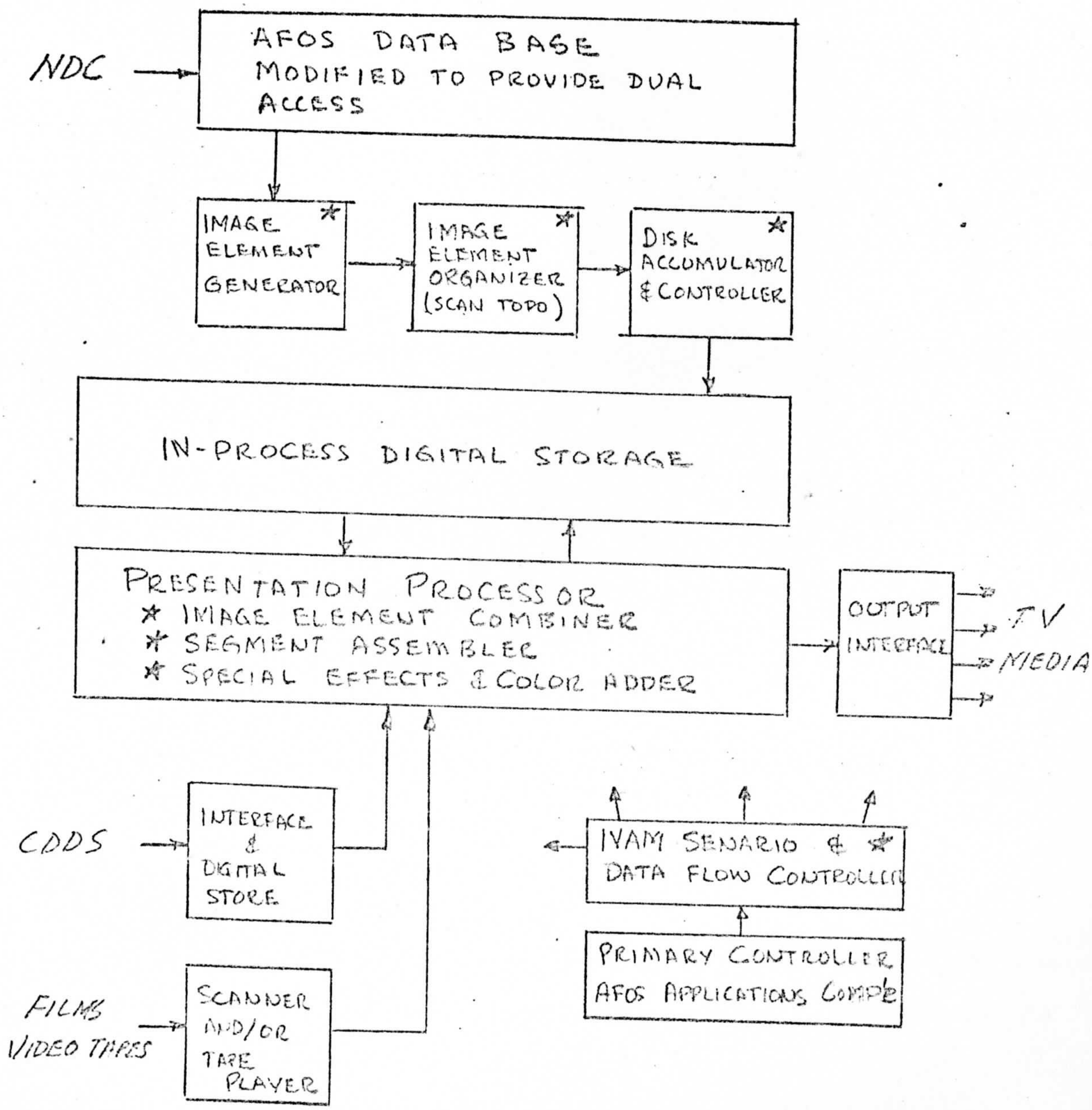
All of the functions shown starred could be performed by a second computer, probably identical to the AFOS Applications Computer, or by seven microprocessors. The multiple microprocessor approach appears to be more attractive at this time because:

a. Total system cost could be much less, depending upon future costs of microprocessors,



MINIMUM AFOS INTERFACE

FIGURE 4-2



PARTIAL AFOS INTEGRATION

FIGURE 4-3

b. IVAM implementation could be accomplished in a series of relatively low cost increments,

c. Each added increment would benefit AFOS by providing improved displays and greater flexibility to the forecaster,

d. Maintenance costs could be reduced since the system would consist of several identical microprocessors with entire unit replacement being practical,

e. Multiprocessor operation would provide higher through-put rates,

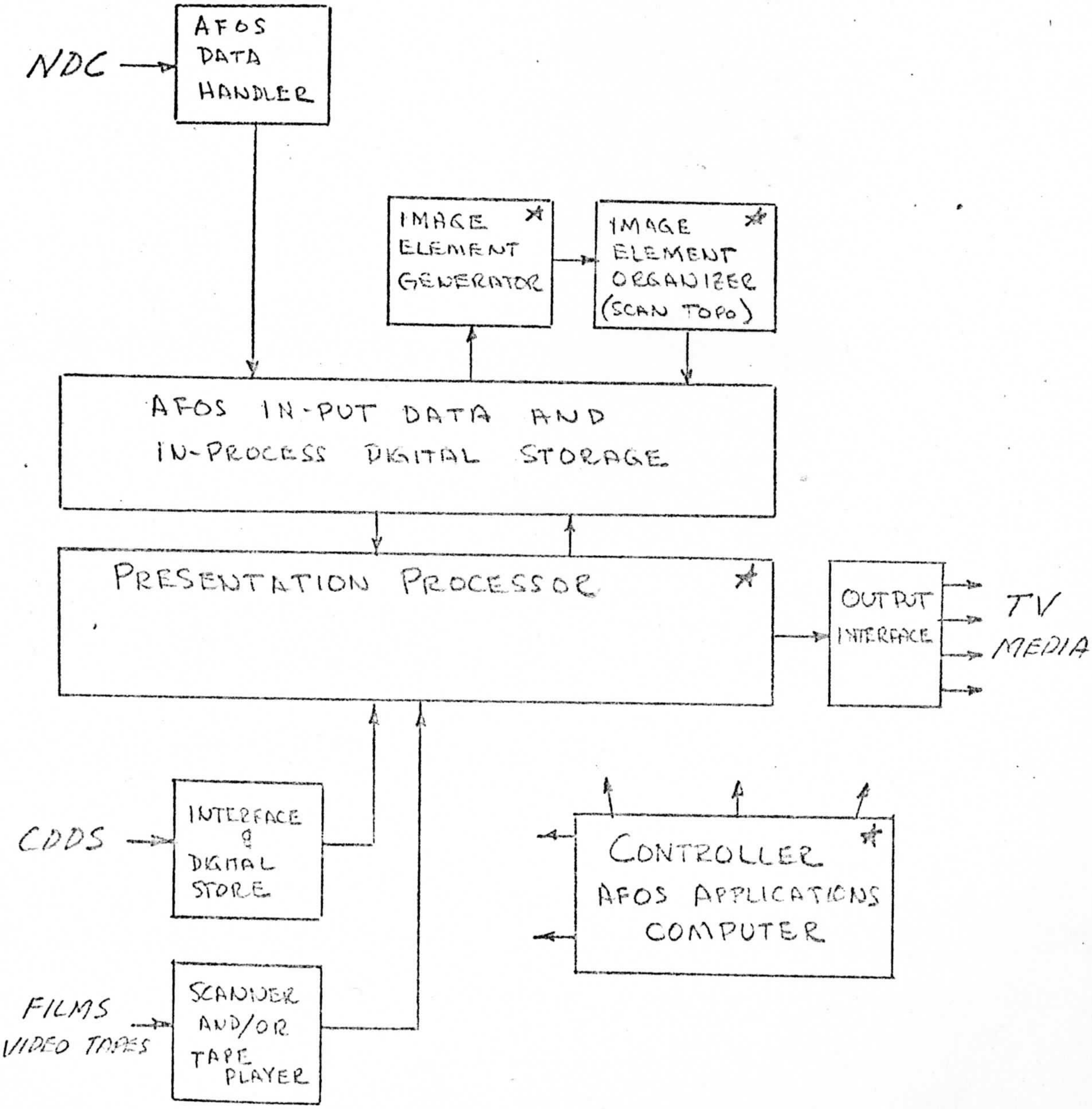
f. System up-date would be less costly because component blocks are smaller.

3. Complete Integration with AFOS

In Figure 4-4 IVAM is shown completely integrated into AFOS. Those functions shown starred could be performed by the AFOS applications computer (which would require a larger computer and a complete new software package) or by multiple microprocessors. The AFOS digital data storage would have to be expanded and a more complex data transfer controller capable of controlling both IVAM and AFOS data movements would be required. This alternative would probably be most attractive if AFOS and IVAM were being implemented simultaneously. However, since AFOS will be placed in the field first, the impact of this approach on AFOS would be very severe. Actual equipment costs for this alternative would probably not be significantly different from the partial integration alternative

Storage-Output Alternatives

The basic function block diagram, Figure 4-1, illustrates the IVAM system with sufficient storage capacity for complete presentations. Despite the expected advances in digital data storage devices it probably is not practical to expect to be able to store 9000 complete TV frames in



COMPLETE INTEGRATION WITH AFOS

FIGURE 4-4

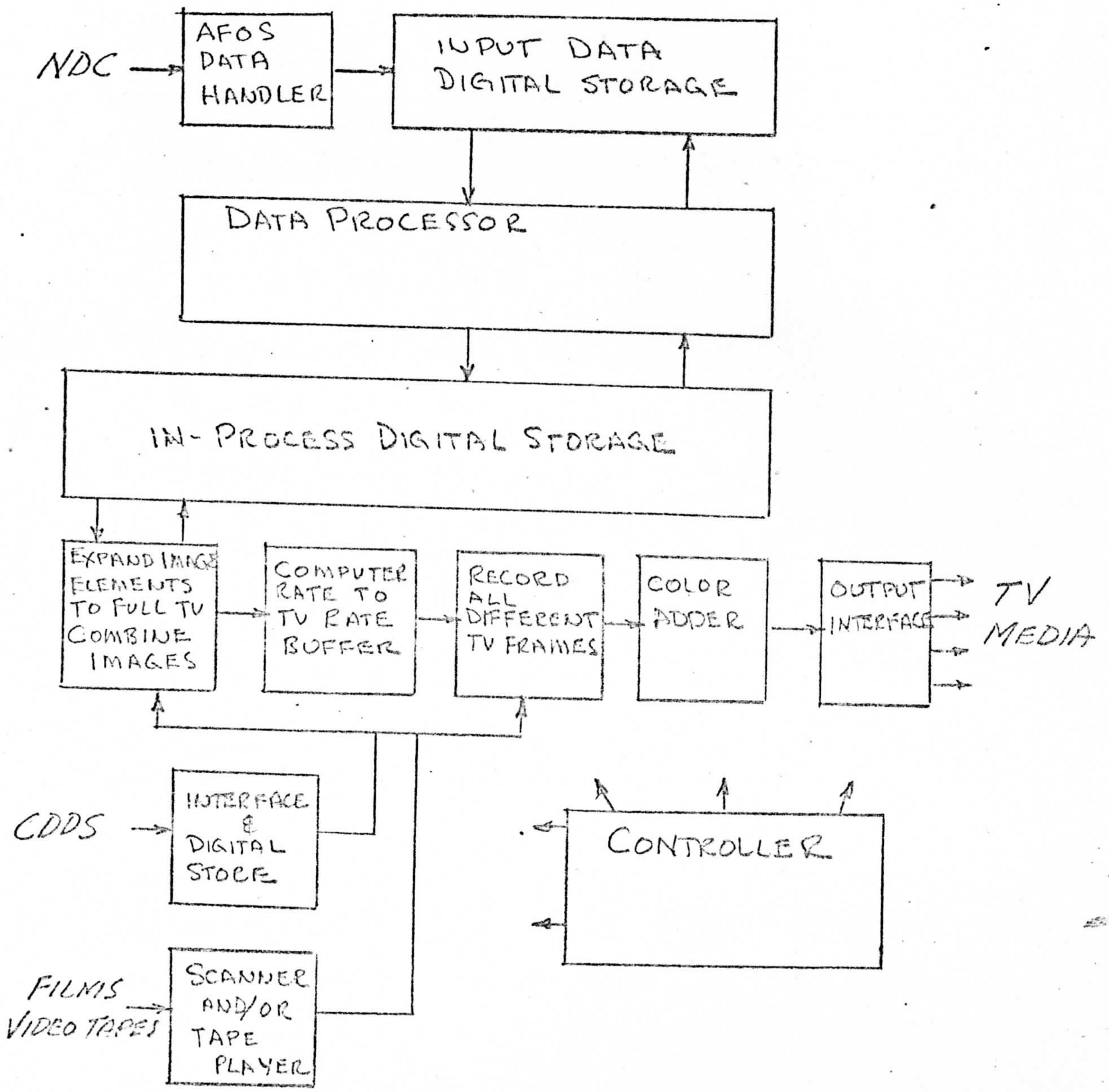
solid state memories or even on digital disks. It is very possible to store this five minute TV presentation on video tape, but tape recorders are relatively high maintenance devices and require frequent operator attention.

The storage output problem is difficult because at the output of the system both the data rate (TV rate) and the data volume (all frames present and complete) are maximum. The problem becomes easier if the images can be stored earlier in the process chain where rates are lower (computer rates) and volume is less (only different images, only basic images, or perhaps only image elements). The alternatives below consider three possible solutions to the storage output problem.

1. Storage of All Different Frames

As was noted earlier, there is a very high rate of redundancy in the 9000 TV frames. If only the different frames in a five minute presentation were stored, a reduction in storage requirement by a factor of 25 to 35 could be realized. The problem then is to program the readout system to repeat images in the correct order and the correct number of times to make up the full presentation. In this approach from 250 to 500 TV frames would have to be recorded. This can be done in recorders which operate at TV rates or at computer rates.

Consider first using a TV rate recorder, this option is shown in Figure 4-5. Image elements organized by Scan Topology are stored in the inprocess store, then fleshed-out and recorded in the TV rate recorder. If an analog recorder, like the one used in McIDAS, is used it will be necessary to load the TV frames in the order they will be read out in the final presentation because the time required to move read heads precludes random disk access at TV rates. This is a serious limitation



STORAGE OF ALL DIFFERENT FRAMES

FIGURE 4-5

because it precludes generating several different presentations from the same set of basic images and greatly complicates updating by adding images. Since 250 to 500 TV frames would have to be stored in this option, it is probably not possible at reasonable costs to provide a storage device which allows random access.

If the TV frames were stored on computer-rate digital disks the situation is even worse. The position of the rate compensating buffer moves to the right and a problem of maintaining TV rate output is introduced. The requirement for ordering the images in the recorder remains the same.

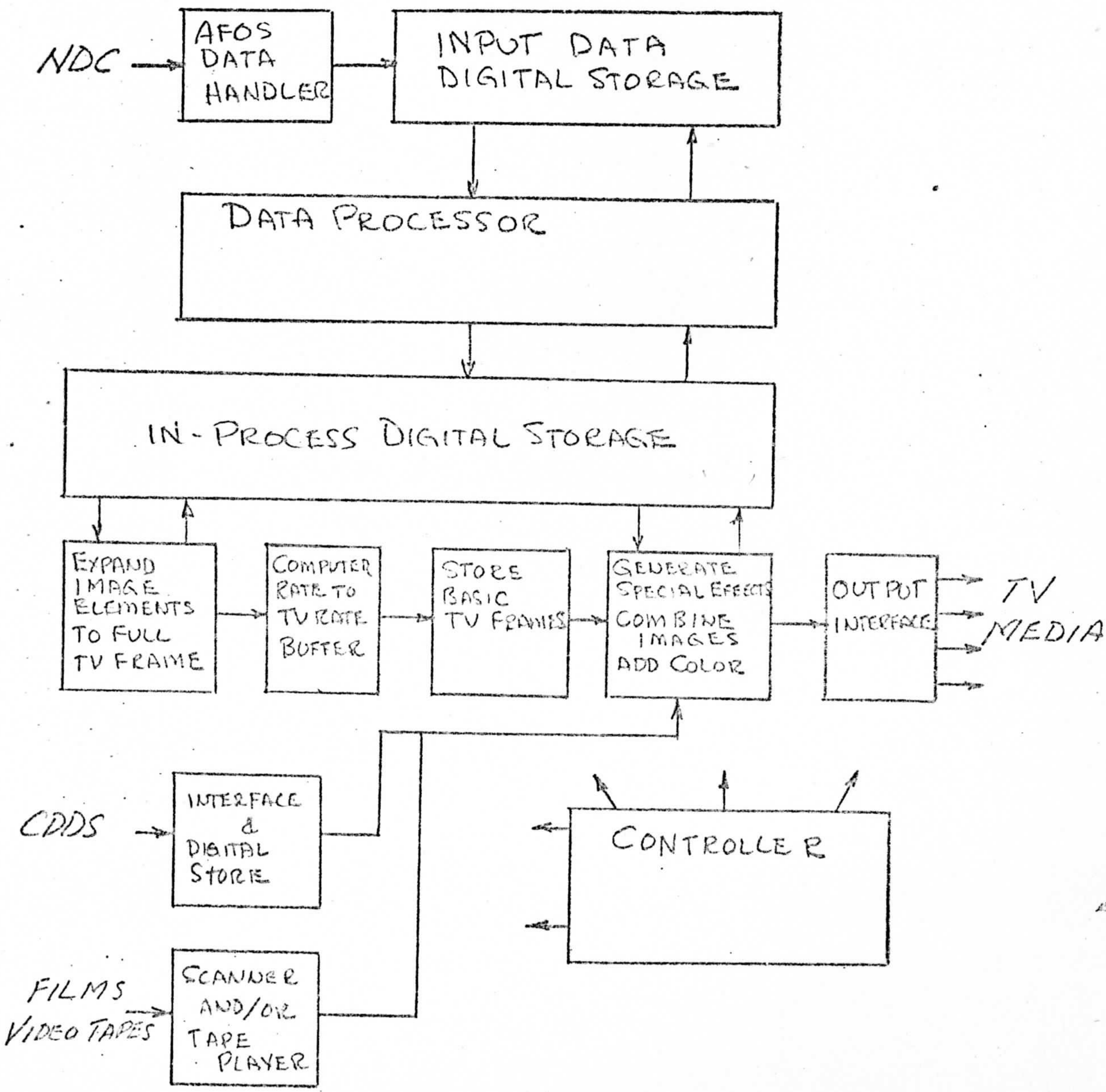
2. Basic Image Storage

If only basic images are stored, the storage requirement drops to fewer than 100 frames, but some of the image formation tasks such as overlaying, adding alphanumerics and animated inserts would have to be stored or be generated in real time at TV rates. Figure 4-6 illustrates alternative. In this option the frame storage requirement is smaller, but still probably not small enough to be met by a random access store. The need for random access is reduced, and a dual head analog recorder might provide sufficiently rapid access for most purposes. The generation of alphanumerics in real time is no problem since equipment to do this is available now. Whether grids and other graphical overlays and animated segments of images could be generated in real time or whether storage would have to be provided for these and other special effects requires further study.

This alternative is marginal and deserves further consideration.

3. Image Element Storage

The images that require storage are all graphics, either reproduced from conigraphic coded data from the NDC or generated by IVAM. When organized



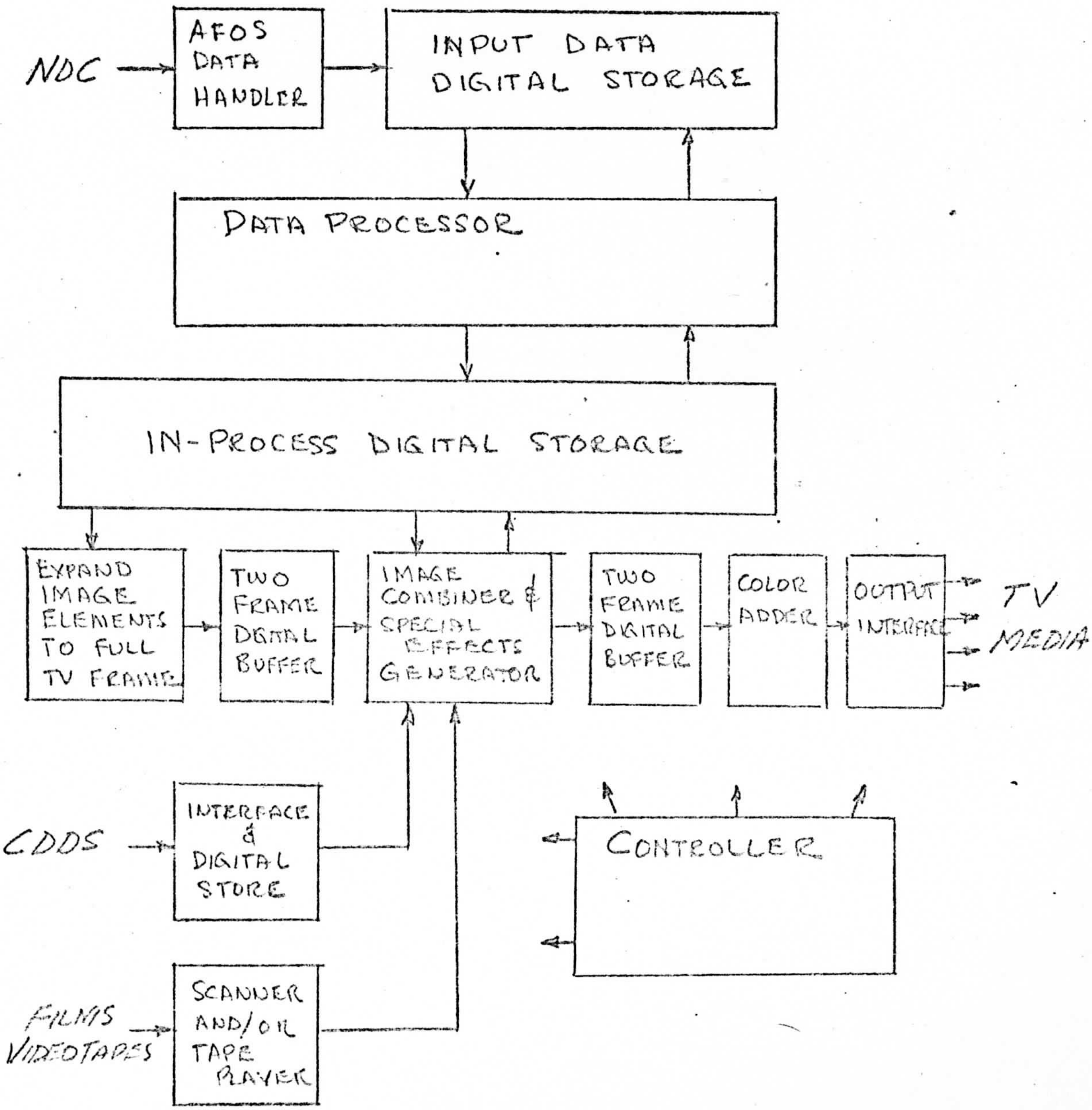
STORAGE OF BASIC IMAGES

FIGURE 4-6

by the Scan Topology data construct the number of bits required to describe the most complicated graphic image which we believe is likely to be required is less than one tenth of the bits for a full TV frame at four bits per pixel. These image skeletons must be stored in the in-process storage disks (about 16 megabits required which is a part of a small computer peripheral disk). While we have not yet demonstrated that it is possible to do so, we believe we can readout the scan topology image skeleton, expand each line to full TV frame format and pass the image to an image combiner at close to real time TV rates. We actually have at least six TV frame periods (200 ms) to complete this process since the least number of times any frame will be repeated in the final sequence is six. If we are able to meet or exceed the 200 ms processing rate, and this appears to be an easy task, it would be possible to configure the system as shown in Figure 4-7.

With this alternative, a graphical image skeleton is processed through a microprocessor to produce a fleshed-out full TV frame which is collected in one part of a two-frame solid state buffer. When the image is complete, it is read out at TV rate synchronized with the input from the satellite image digital disk or video tape library and combined with these TV frames as required. Alphanumerics and special effects are added at the same time. The combined image is stored in one part of a two frame solid state buffer from which it is repeated as many times as necessary to make up the output presentation. Color is added by look-up tables, as in McIDAS, and the signal is converted to standard TV analog format at the output interface.

Properly synchronized, the system could function with only one frame in each buffer, but with two frames in each buffer it is possible to combine two graphical images with the pictorial images, and it is possible to provide horizontal or vertical "wipes" of information onto background frames,



STORAGE OF IMAGE ELEMENTS

FIGURE 4-7

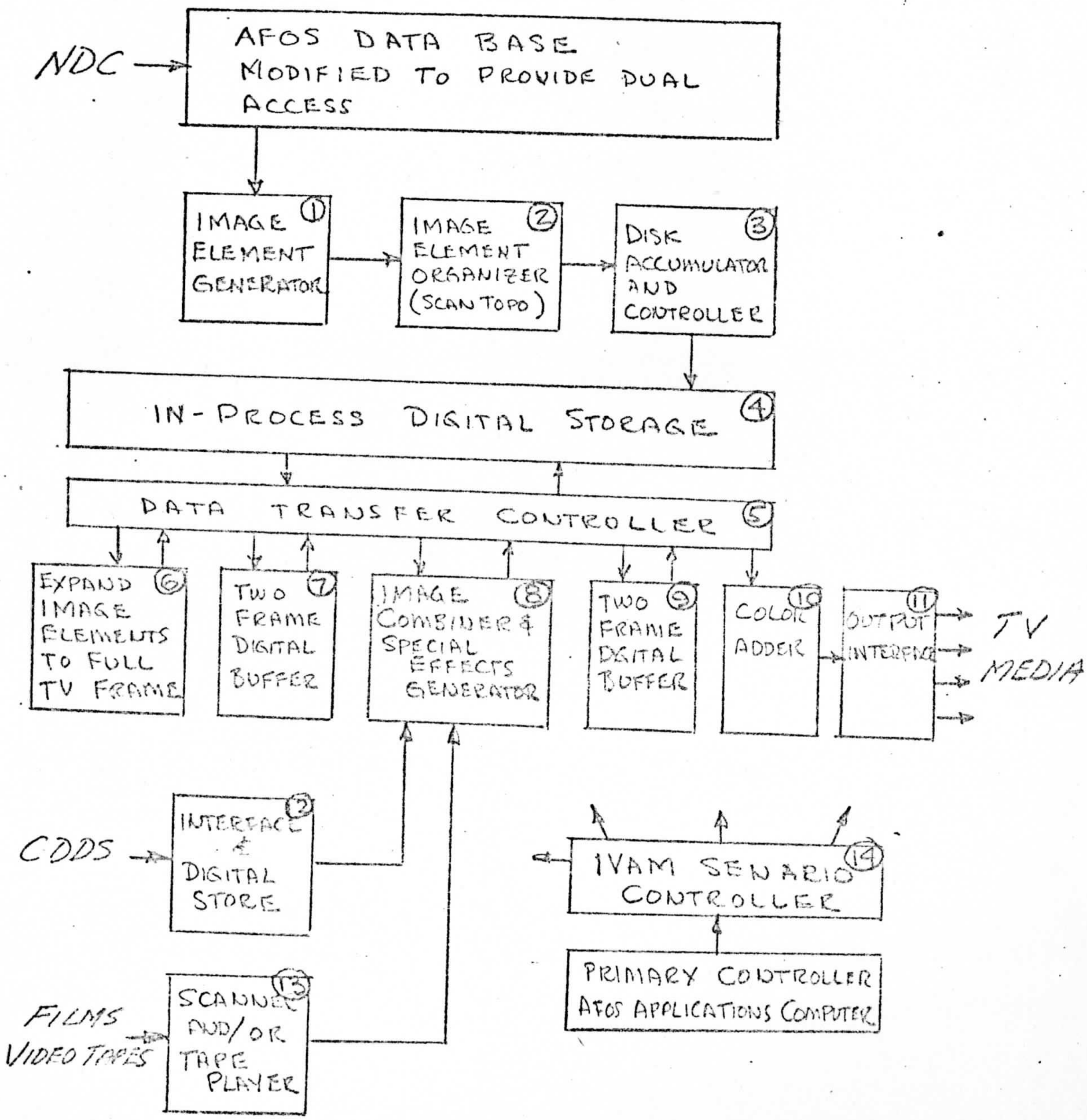
scintillation, and other simple animations.

Of the three output alternatives this is much the most attractive at this time.

4.4 SUMMARY AND COST ESTIMATE

Of the alternatives so far considered the most attractive system configuration is partial integration with AFOS in the Input-Processor-Controller functions (Figure 4-3) and Image Element Storage (Figure 4-7). When these concepts are combined the system configuration is as shown in Figure 4-8.

It is not possible to provide firm cost figures at this time; however, it may be helpful to tabulate costs of the configuration in Figure 4-8 if it were to be built now, and then to adjust these based on expected technological changes between 1975 and 1978. Each of the function blocks in Figure 4-8 is numbered, and in the table below a possible equipment listing with current costs is provided for each function block. One should use this table with great caution - the system design has not been fully developed, and all functions have not been demonstrated. The purpose of this tabulation and cost estimate is to provide a rough system size and cost perspective only. Estimated costs are based on current retail single item prices including connecting cabling, etc. It is reasonable to expect lower costs when larger quantities are purchased. Also, savings to be realized by multiple use of components when assembled in a total system have not been considered. Hardware design and software development costs are not included.



IVAM - POSSIBLE SYSTEM CONFIGURATION

FIGURE 4-8

TABLE 4-1

POSSIBLE IVAM SYSTEM IMPLEMENTATION

(Item numbers refer to function blocks in Figure 4-8)

Item	Possible Configurations	Present Cost (Upper limit)
1.	Mini-computer (microprocessor plus ROM's, RAM's, etc.) equivalent to PDP-11/45	$ 24,000
2.	Microprocessor, equivalent to PDP-LS1-11	5,500
3.	Microprocessor, equivalent to PDP-LS1-11	5,500
4.	Small digital disk equivalent to CDC 9427 (10 megabytes)	5,400
5.	Microprocessor, equivalent to PDP-LS1-11	5,500
6.	Microprocessor, equivalent to PDP-LS1-11	5,500
7.	2.5 megabit solid state RAM configured for two-frame independent input/output	12,500
8.	Mini-computer plus alphanumeric generator and special effects generator	32,000
9.	Same as item 7	12.500
10.	Three section look-up tables equivalent to those in McIDAS	2,000
11.	Standard D/A converter, Modems	2,000
12.	Video-looper which is currently being developed by SSEC	19,000
13.	3/4 inch cassette video recorder with computer control interface	15,000
14.	Microprocessor equivalent to PDP-LS1-11	5,500
	Current Cost of System	$151,900

If the cost per function of data processing equipment follows anticipated trends, and if further IVAM system development produces the system simplification which we anticipate, it is reasonable to project the system installation cost at less than $100,000 each when procured in multi-unit quantities.

5. OUTPUT DISTRIBUTION STUDY

5.1 INTRODUCTION

Perhaps the reason the distribution of the IVAM output appears to be a big problem is because none of the parts of the distribution system are under the control of NOAA. For political, budgetary, and business reasons it is most unlikely that NOAA will ever operatre its own television distribution system on a national scale. If the IVAM output is to reach the broadcast and cable TV stations it must get there via facilities furnished by the broadcast and cable TV industries. With that fact as a starting point we have studied :he TV industries to develop feasible concepts for the distribution of the IVAM presentations.

We have learned that distribution of the IVAM output to the network affiliated broadcast stations and to most independent broadcast stations is practival using existing facilities and at very small additional cost. Some local and regional capabilities exist for distribution to most cable TV stations must await installation of additional facilities.

This section of the report reviews some of the pertinent aspects of the television industries; especially those concerning video distribution systems and how they are used. Some more exotic distribution concepts are examined and found wanting, and finally, practical concepts for both national and regional distributions are presented.

5.2 EXISTING DISTRIBUTION FACILITIES

Broadcast Television

Four major video distribution networks feed affiliate stations on a nationwide scale; CBS, NBC, ABC, and PBS. For the most part, distribution of PBS programming is handled like that for the three commerical networks and is considered the same in this report, with exceptions noted (1,2,3).

Most programming for the three commercial networks orginates in New York City; the PBS programming generally originates in Washington, D.C. and all network can originate from Washington. Most network transmission is via facilities owned by AT&T and leased to the networks. Each of the three commerical networks pay AT&T about $12 Million per year for 24-hr a day service. This service is a one-way service, it allows a feed of information from New York or Washington out to the stations only.

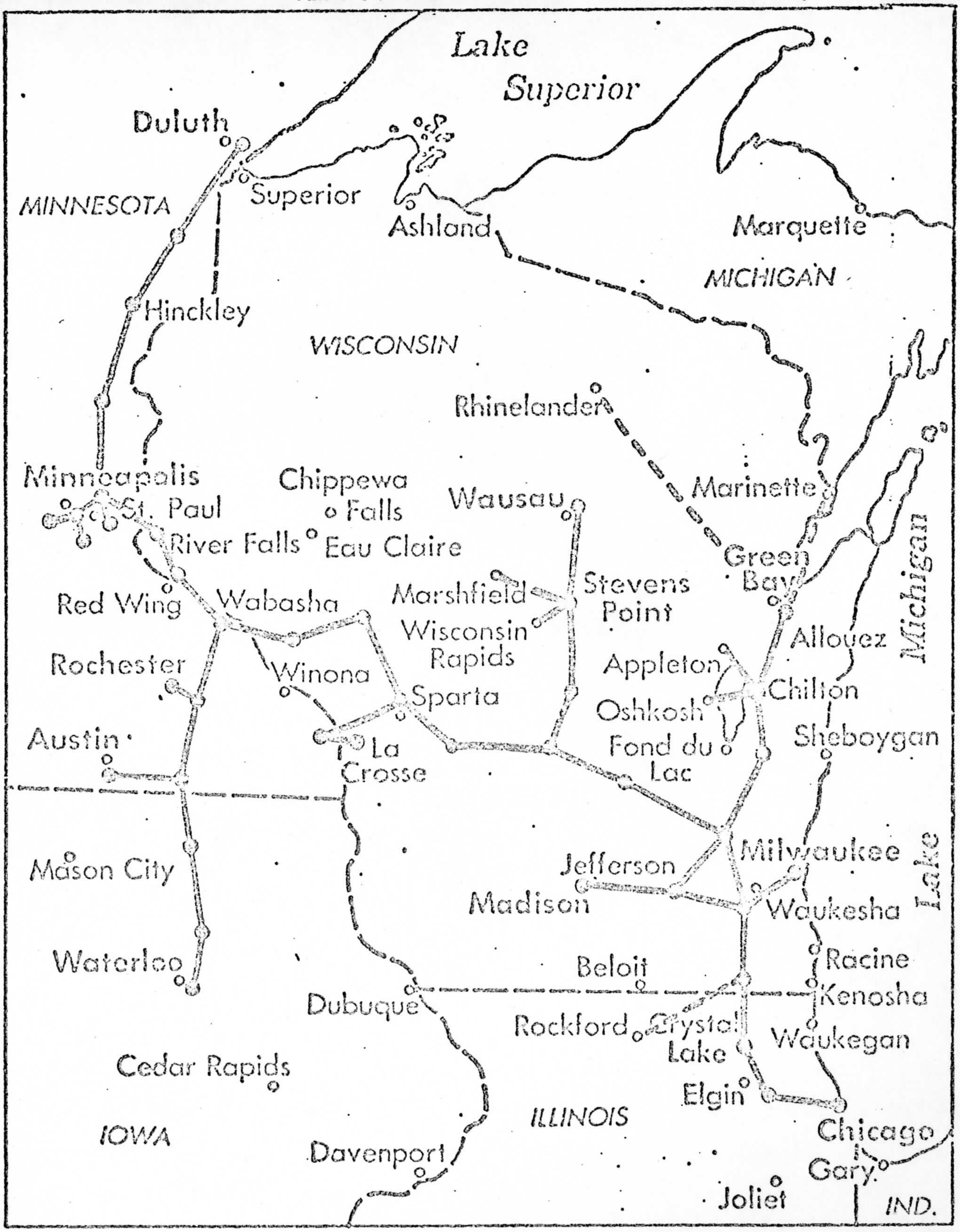
To feed information from locations other than New York or Washington requires use of one of the 3 types of part-time service provided by AT&T. One type builds the channel for a special event and takes it down each time. This service, used on an occasional basis, costs 75¢ per hour per mile plus set-up costs. Another service, provided to TVN (Television News Service) but available to anyone with the need (and funds) is based on one hour per day, costing $18/mile/month. Actually AT&T sets up and takes down the equipment every day also so that it can be used for other services. A third service provides 10 hr/day at a cost of $40/mile/month. This is used by the regular networks and the Hughes Sports Network for special events originating outside New York or Washington, (1).

AT&T provides about 20,000 miles of "dedicated" interconnection. While this interconnection is leased as uni-directional, much of it can be used for transmission in the opposite direction (under a separate lease agreement of course). In studying the network's distribution maps it appears that the networks are routed so that in a few cases two networks are feeding over the same path but in opposite directions. In addition to the dedicated interconnection there is unspecified mileage of part-time lines and back-up links which are used in case of failure of the primary network links.

A small but growing number of independent relay companies are forming in different parts of the country. They have developed as competition for AT&T links to reduce cost to the networks and local stations. For example, a Milwaukee owned company, Midwestern Relay Company, provides service for all four networks to Wisconsin, Minnesota, Western Iowa, and Northern Illinois. A physical routing map is shown in Figure 5-1. Typical of most independent relay companies, Midwestern offers bi-directional service and special channels at rates much lower than AT&T. The networks have encouraged the development of independents and their continued formation is likely unless AT&T reduces rates by a large factor and for a long period. They are of interest to IVAM for they provide additional flexibility in the future transmission of video data on a local and regional scale.

Cable Television

Cable television, being a reltively new industry, does not have established methods of distribution as does broadcast television. In fact, the entire subject of distribution for cable television is in a state of rapid change within the industry at this time (4). Cable television stations across the country share the problem of finding sufficient program material to fill their allotted channels with interesting subject matter. Origination of many hours of programming from the local stations is impossible because of demands on equipment, studio space, talent, and funds. The cable stations have begun to look to each other for the sharing of programs, and interconnection, "netting", is being established.



MIDWESTERN RELAY SYSTEM

Figure 5-1

Netting takes place at local and regional scales and national nets are being planned. Local interconnection is relative inexpensive for companies with adjoining territories and easy if the interconnection is done within one governmental jurisdiction. Interconnection between different communities or regions requires a more organized plan since it involves the policies of more than one governmental authority. In spite of difficulties, cable systems have installed a large amount of netting throughout the country connecting both large and small companies.

The netting of cable companies is in response to a need for more and more diverse programming, so in some cases cable networks have developed around the independent broadcast television stations, because of the broadcast station's greater capability to generate programs (4). If cable companies continue to interconnect with broadcast independents, a very powerful new communication network will grow, which can easily include a dedicated weather channel.

The number of local cable TV interconnections is nearly as numerous and as varied as are the Cable TV stations themselves, for example:

WGN feeds a cable network to the large Chicago and northern Indiana area. A large cable network in Kansas City serves over one million people, reaching into Kansas, Idaho, S. Dakota, and Nebraska. Johnson City, Texas is served by 12 interconnected cable companies. Sterling Communications of New York City servies 70,000 subscribers for major events in Madison Square Garden. It also has interconnection with independent channels 5, 9 and 11 of NYC. The statewide Pennsylvania Cable Operators is largely state funded, in a combination of cable and educational broadcast TV. They use state-owned fire watch towers for microwave relay antenna mounts.

Obviously, the development of Cable TV nets is a new part of a very young industry. As these nets grow and mature they will provide increasing opportunities for distribution of IVAM presentations.

In addition to the various local and regional nets, there are some very positive forces at work for organized, national setting. The CSAE (Cable Satellite Access Entity) is a national organization of 80 májor cable systems established to study an organized approach to national cable network interconnection. They have sponsored a four part study conducted by Booz, Allen, and Hamilton which covered (5,6):

a) Availability of programs, netting, fee policies, etc.

b) Business format of organization, amoritization, cash flow, etc.

c) Engineering - applications problems, using equipment within state-of-the-art

d) Regulations - national, regional, local

The outcome of the study provides a practical plan for a nation-wide cable interconnection via satellite. Tradeoffs consider low cost receivers vs. high cost spacecraft or higher cost receivers and low cost spacecraft. The detailed report has not been released outside the CSAB group, but it has received high acceptance within the group.

Another consortium comprised of PBS stations (5) is planning to develop a second network, using some cable to provide them:

a) higher sound fidelity (with stereo)

b) higher picture fidelity

c) higher transmission reliability. Presently, AT&T can "dump" a PBS broadcast without warning if the channel is needed to support a commercial broadcast.

Studies about the future of Cable TV have reached widely varying conclusions depending upon who sponsored the study. Parallels can be recognized in the similar arguments made about broadcast television twenty years ago. The facts are that the Cable TV industry has met and passed the initial challenges of government regulation, public acceptance and capital financing. The biggest problems remaining are program generation and distribution. Local distribution house to house is progressing. The 629 cable systems in 1974 already pass 11 million homes (7) (cables can reach about 1/6 of the U.S. population). Technology may improve the physical cable laying methods and reduce the cost at rural service. The other problem, distribution between stations, will also be solved by the application of technology and the investment of capital in ground and satellite communication systems.

Other Distribution Facilities

Television News (TVN) is a private news service with 73 subscribers who receive capsule video news for one hour each day. Some of the subscribers are also commercial network affiliates. The data is transmitted via AT&T at present, but is being converted to satellite relay via TELSTAR. TVN expects to be using ESTAR by summer 1975 (8,9). The TVN data is regionalized serially into six segments. After satellite operation is underway, expansion of programming is expected to include commercially sponsored films, etc., as the major networks do now. Low cost receive stations are being developed for the TVN application and they will, of course, be applicable to cable network relay reception.

In addition to the increase in satellite communication, new land based communication networks are developing which will compete with AT&T. Data Transmission Company has proposed a switched system for digital data transmission at voice rates, but may handle video rate data as well. Microwave Communications, Inc. has proposed a point to point (closed circuit) interconnection system which could deliver television signals to areas servicing 75% of the nation's population (10). Clearly the possibilities of interconnection are very real, and are improving.

Summary

Established networks for broadcast TV and the new capabilities being built by companies which intend to compete with AT&T provide a surplus of data handling capability. As a result, we can expect rates to decline and it will become easier to interest networks in public service program distribution.

The Cable TV industry has demonstrated continuing growth during an unprecedented period of high capital cost and consumer depression despite strenuous opposition from the broadcast TV industry and regulation bordering on harassment by local, state and federal government. The vitality of Cable TV cannot be doubted, and continuing growth appears to be inevitable.

Cable TV nets are appearing locally and are being consolidated on regional and national scales. It is safe to predict that the capacity for IVAM program distribution via Cable TV is being planned, or even being built now and will be ready when we are.

5.3 NETWORK PROGRAMMING FORMAT

The feed of programs on a commercial network follows a pattern of minor modification about a basic daily framework. All four networks follow the same basic pattern. There are a great number of short time periods, 30 to 90 seconds, during which no signal is transmitted, and there are occasional periods of 1/2 hour or longer which are not assigned to programming. Table 5-1 shows the "blank" feed periods for the four networks during a typical week in Fall of 1974. The basic structure of blank periods is identified by the network as in Table 5-2, several months in advance, but is subject to minor modifications with a few days notice to affiliate stations. Typical changes may be to use a blank spot to preview a program or feed commercials and other material "lost" in earlier transmission; however, the networks rarely use these blank spots. The PBS transmission is much less structured and nearly every day has some 2 to 5 or 10 minute open spots where music interludes are used at local stations.

Each commercial network feeds a 1/2 hr of news late every afternoon which can be edited and used in the local evening news as affiliate stations see fit. The present satellite sequence used on television is fed as part of the network news 1/2 hr feed. In an interview with CBS news, we learned that the satellite film loop was supposed to be carried by bus from Suitland to New York, where it is used by the networks. Since it often missed the bus, the networks have hired a courier to see that it is delivered in time for the various network feeds. CBS also mentioned that there were plans to provide a video feed from the World Weather Building to the networks (11).

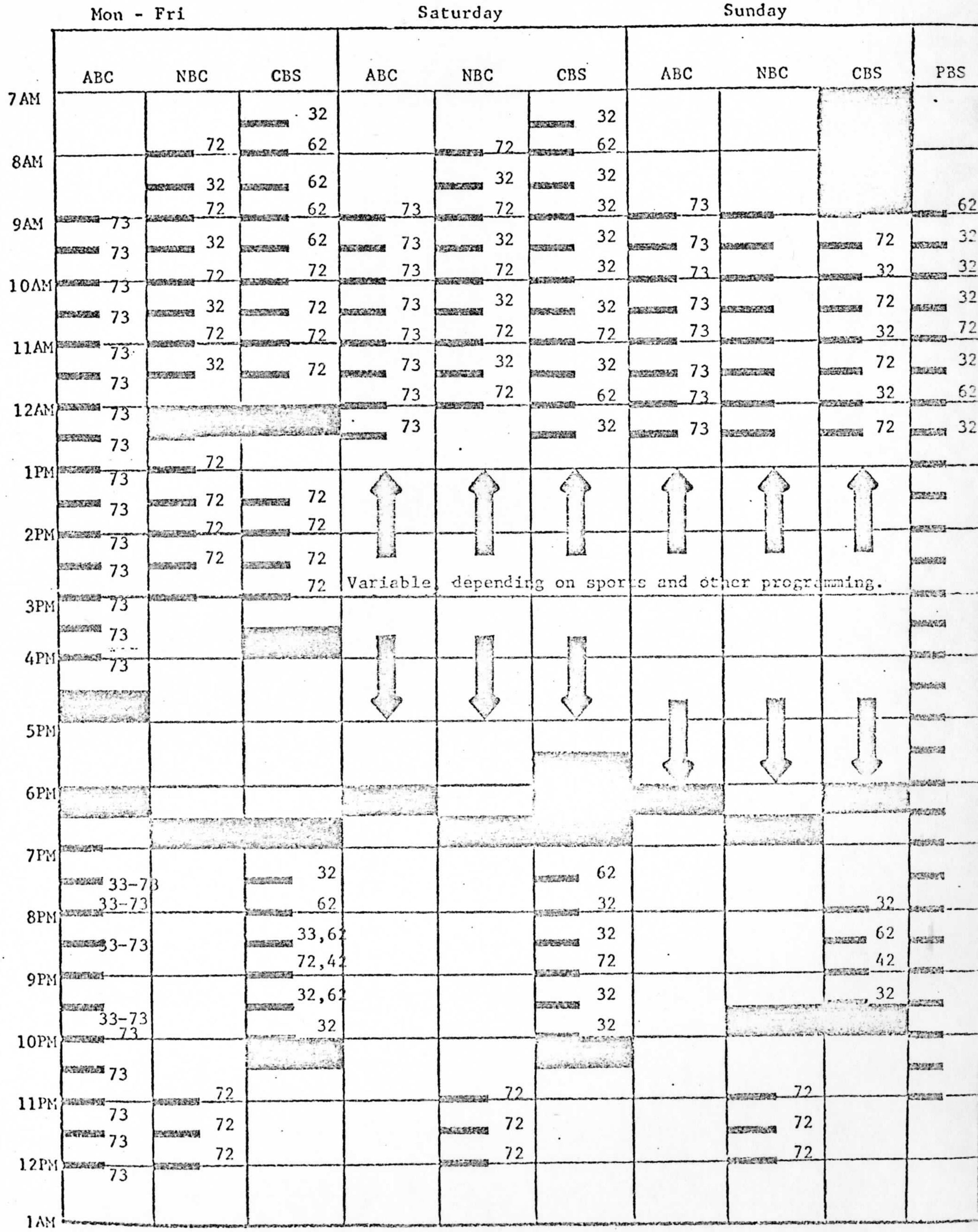


Table 5-1
Open Network Feed Times for Typical Week

CBS STATION BREAKS–FALL 1974

	7:00	7:30	8:00	8:30	9:00	9:30	10:00	10:30–11:00
SUN	(LOCAL)	APPLE'S WAY	32	62	KOJAK 32	62	MANNIX 42	32 (LOCAL)
MON	CBS EVENING NEWS OR LOCAL	(LOCAL)	GUNSMOKE 32	62	MAUDE 32	RHODA 62	MEDICAL CENTER 10 (a) 32	32
TUE	CBS EVENING NEWS OR LOCAL	(LOCAL)	GOOD TIMES 32	M*A*S*H 32	HAWAII FIVE-O 32	62	BARNABY JONES 10 (a) 32	32
WED	CBS EVENING NEWS OR LOCAL	(LOCAL)	SONS AND DAUGHTERS 32	62	CANNON 32	62	MANHUNTER 10 (a) 32	32
THU	CBS EVENING NEWS OR LOCAL	(LOCAL)	THE WALTONS 32	62	THE CBS THURSDAY NIGHT MOVIES 62	42	62	32
FRI	CBS EVENING NEWS OR LOCAL	(LOCAL)	PLANET OF THE APES 32	62	THE CBS FRIDAY NIGHT MOVIES 62	42	62	32
SAT	CBS EVENING NEWS OR LOCAL	(LOCAL)	ALL IN THE FAMILY 62	PAUL SAND IN FRIENDS AND LOVERS 32	THE MARY TYLER MOORE SHOW 32	THE BOB NEWHART SHOW 62	THE CAROL BURNETT SHOW 10 (a) 32	32

(a) To provide time for stations to promote local news shows, the start of these programs is delayed 10 seconds.

Revised June 26, 1974

5.4 POSSIBLE DISTRIBUTION METHODS

Broadcast TV

Four methods have been studied for transfer of IVAM weather data from the NWS to local stations. Both sides of the "interface" were considered; distribution within NWS, and within the media to the consumer. The approaches studied are:

a) Transmit at low data rate and reconstruct at station.

b) Transmit at TV rates via satellite or auxiliary network.

c) Insert into network feed blanks at New York or Washington.

d) Insert at regional nodes in the networks.

a. Transmission at Low Data Rate

There are a large number of schemes for slow-scan TV, and line-at-a-time transmission which have been investigated and some show real promise for the future. The best of these are:

(1) Slow-scan transmitted via telephone circuit. In principle it is completely feasible to transmit high quality video via narrow band lines and to reconstruct it at the receiving end. Using rather elaborate equipment, high quality slow-scan TV has been demonstrated several times. There are at least four companies now marketing moderate cost equipment for slow-scan transmission. After investigating the best of these we have concluded that to obtain broadcast quality consistently at the receiving end requires an investment of at least $40,000 at this time.

It is reasonable to expect that new technology will reduce costs of digital transmission and receiving equipment which can assure high quality images. We estimate that the receiving terminal costs can be expected to drop to about $25,000 in three to five years. At that time the combined cost of equipment and line rental falls into the marginally acceptable range for broadcast stations and probably into the fully acceptable range for regional distribution to local cable TV nets. The data rate is so low (4 to 6 minutes per TV frame an phone links) that it is not obvious how adequate IVAM service could be provided via this alternative. Nevertheless, slow-scan digital transmission may be the best answer for some applications and we intend to continue to study this option.

(2) Multiplexed TV. The standard broadcast TV signal does not completely fill its alloted channel bandwidth. It is technically feasible to multiplex a slow-scan video channel with the standard TV signal and to receive both without mutual interference. Special equipment at both transmitting and receiving ends of the link are required and the cost of these is not well defined at this time. Experiments with this technique are being conducted and we can expect that the limitations and advantages will be identified better during the next year or two.

(3) Transmission during TV frame retrace. In England, the BBC Commercial Service is broadcasting a signal with its normal TV program which is decoded and accumulated by a relatively inexpensive ($150) add-on to a home TV set, and which can present single frames of alphanumeric information upon request. This program, called CEEFAX, is the first practical use of the otherwise unused time interval between TV frames called the retrace period. In United States TV format the retrace period is equiavlent to the time required to transmit 17 TV lines. This period is used now to send grey scale and color calibration information but it is entirely feasible technically to consider sending at least 10 lines of video during this period and to

build up full TV frames at the receiving end. At 10 lines per TV frame it would take less than two seconds to send one IVAM frame. This data rate is much better than the slow-scan option offers, and there is no addition transmission line cost. The commercial potential for this technique, as demonstrated in England, is so large that it is doubtful that the capability would be available for weather information if it were installed in the U.S. However it is an attractive concept and deserved further consideration.

b. Special Weather Net

While studying the existing communications facilities in the U.S. we were impressed by the large number of "spare" lines which can be found at any time of normal operations. We attempted to construct a separate video net from these spare lines with the idea that perhaps a reliable public service capability could be identified which could carry IVAM presentations at no cost to the government and at no additional cost to the facilities operators. We are convinced that such an attempt is futile because of deeply intrenched FCC and other government regulations which would forbid it, and because of adamant opposition by the carriers. It is not practical to consider paying for such a net since it would cost about $12,000,000 per year. We saw no reason to believe that new facilities, such as satellites, would change this picture.

c. Insertion into Existing Network Blanks at New York or Washington

As seen in Table 5-1, a network may have on the order of twenty blank spots during a typical day, each open from 32 to 72 seconds, providing the potential for ten to twenty minutes of information to be fed. Since the IVAM programming is designed in segments from a few seconds to 1 minute in length it is feasible to fit such information into the blanks, and to record the segments at the using stations to make up complete presentations. In addition there are several half hour open periods each day, usually between 1500 and 1900. Also, the time between 0100 and 0700 is almost completely open and continuously available except for maintenance down time which is not frequent. The programming in all networks provides ample unused available time to distribute IVAM presentations on a timely basis. This is true even for the pre- and post-prime time newscasts.

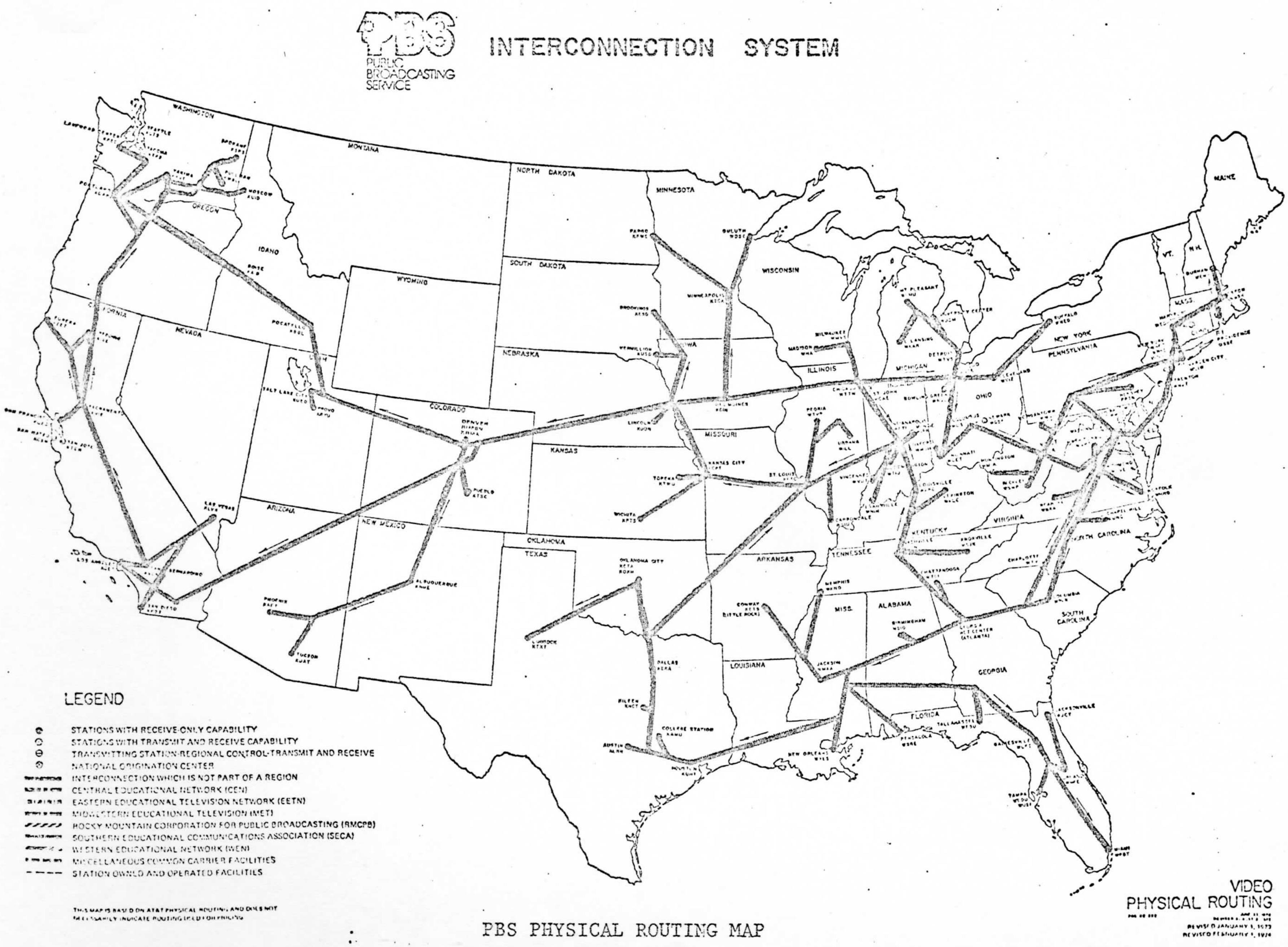
To use this network free time, there must be a video tape recorder available to store the segments at each station. In our discussions with local TV stations, we learned that normally recorders are occupied with local commercial message playbacks. Most stations have two recorders which are played alternately for the convenience of the engineer. However, given priority to tape the IVAM presentation feed, the engineer can "stack" the commercials on one recorder to free up the other. At most stations no additional equipment would be needed, but a change in procedure would be required. This does not appear to be a problem.

The distribution of national scale IVAM data from a central feed in New York or Washington does not appear to pose a serious problem. The necessary facilities, equipment and techniques already exist and the service can be provided at no additional equipment cost to the government networks, or local stations. There may be some additional cost to the local stations for engineer's time to man the recorders to intercept the IVAM segments.

d. Insertion at Regional/Local Network Nodes

While providing IVAM presentations on the national scale is a worthwhile goal in itself, the major value of IVAM is to provide current information on the local scale. We discussed local distribution at great length with affiliated and independent stations and with the large networks. From these discussions a feasible plan has been developed to feed network affiliated stations (12).

Most commercials originated by the networks are distributed nationally, but there are some which are distributed regionally, such as snowmobile ads, soap commericals narrated in regional accents, certain beer ads, etc. To accomodate these commercials the networks have developed techniques for originating distribution at points along their network paths so that the area of interest is the only one served. For example, suppose a Coors beer ad is to be shown during a particular commercial program slot, but only in the Rocky Mountain and Northwest areas. The commercial will probably be made up in New York and is then sent before program time to those stations which are located "up-stream" on the network from the area of interest. When the programmed commercial slot time arrives the prerecorded commercial is originated by the up-stream station. Stations located down stream on the network from the area of interest, but still up-stream from, say California, are instructed to use local programming during the commercial intended for California viewers. In principal, any network station can break the net and act as an originating point for all stations down stream from that point. Some stations are better equipped for this service then are others. All of these network control and switching functions are performed by network and station people; AT&T is not involved in any way. No additional network charges are incurred in this kind of operation.



PBS PHYSICAL ROUTING MAP

Figure 5-2

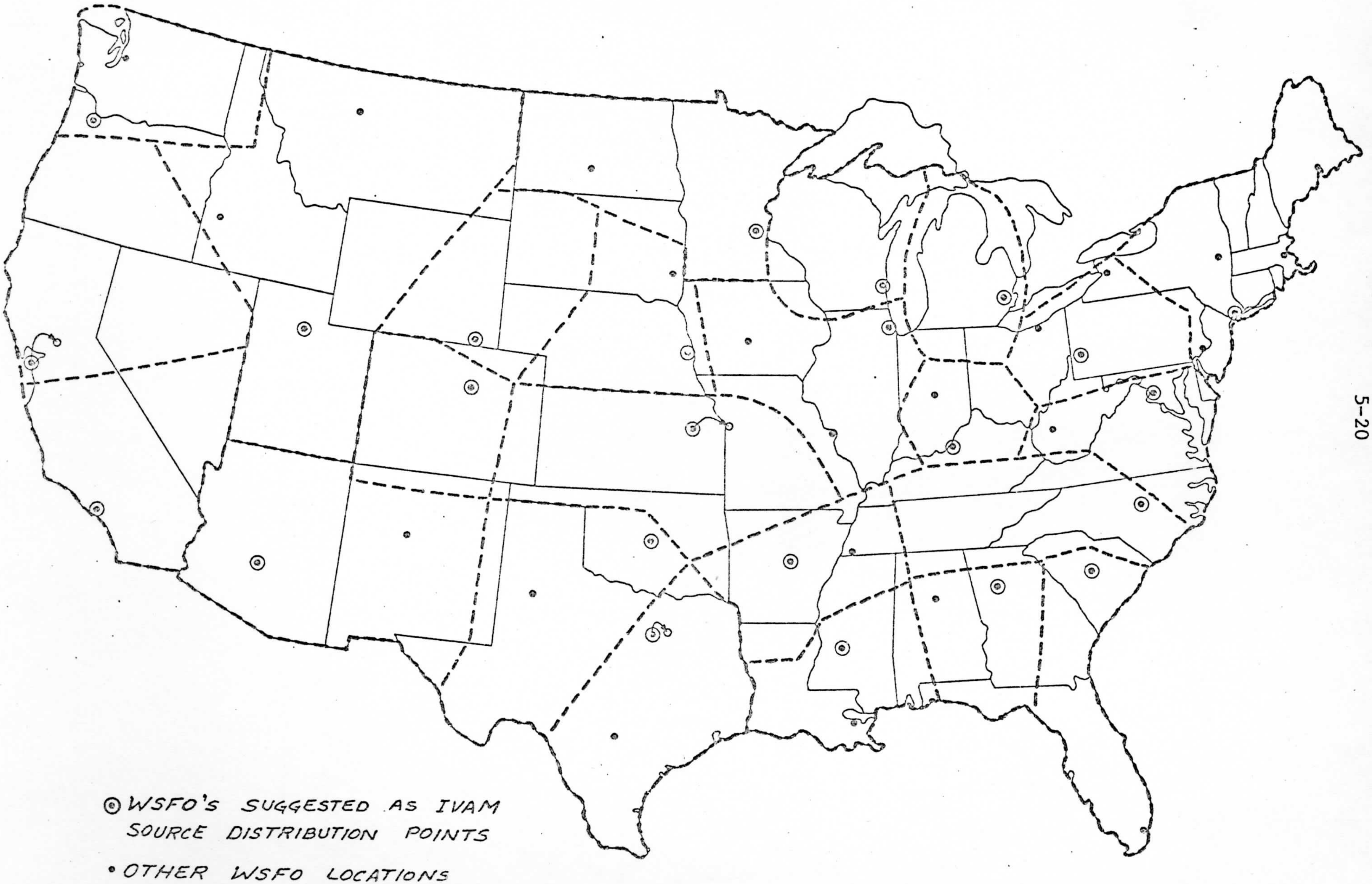
Commercials or other program materials (political announcements for example) which are to be distributed regionally may be originated live at the up-stream station, but they are usually sent to the station at the end of the daily news feed and are recorded for replay at the designated time.

The potential for feeding IVAM presentations on a local, or at least small-region basis to network affiliate stations exists and has been amply demonstrated. The next question was whether the four network distribution lines and the location of National Weather Service Forecast Officer (WSFO's) coincided sufficiently well to make up-stream regional IVAM distribution feasible. We requested net routing maps from the four networks and encountered a security problem. It seems that the actual physical location of lines, switching centers, etc. is not to be made public for fear of destructive acts. However, we did not need information to that level of detail at this point so we requested more general information. All four networks gave us route billing maps which show the direction of transmission, mode of transmission (AT&T, private net, broadcast intercept, etc.), and general routing. To obtain these maps we agreed not to republish them since the network officials consider them to be proprietary. (However, at the working level we found that all networks had copies of all other network's maps and used them to help each other out during equipment failures). The PBS map is shown in Figure 5-2 and a composite network map, altered to conceal any one network's pattern is shown in Figure 5-3.

Using the four network route billing maps and the locations of the WSFO's in the continental U.S., a pattern of up-stream station feeds was developed. WSFO's selected were to be collocated with stations from all three commercial nets. The attempt was made to keep the areas of each of the regions about

TYPICAL NETWORK DISTRIBUTION MAP

Figure 5-3



LOCATIONS OF WSFO'S FOR IVAM INTERFACE TO MEDIA
FIGURE 5-4

the same, but TV station coverage was also considered. For example, the region served from the Salt Lake City WSFO approximates the coverage of the Salt Lake City TV stations. We also required all networks to serve the same regions, which may not be necessary or desirable. Some regional boundaries fall along state boundaries but this was not an objective. A total of 24 regions emerged from the first attempt as shown in Figure 5-4. All distribution criteria were met except:

(1) Short transmission line links are required between three WSFO's (San Francisco, Topeka and Fort Worth) and the nearest network station. All other stations and WSFO's were collocated to the extent we were able to determine from the route billing maps.

(2) In the region in southern Illinois and Ohio and in the one containing most of Pennsylvania the network transmission paths differ so greatly that no one WSFO could serve all networks without rerouting. The WSFO's shown were the best compromise, but these areas require further study.

The capability of distributing IVAM presentations locally and nationally to network affiliated TV broadcast stations appears to exist and to be available. No additional costs are incurred by anyone except for the possibility of small additional personnel costs at the stations, and the cost of installing video lines between the 24 WSFO's and the local network stations. Neither of these appears to be a large cost, and both are compensated by the improved service and reduced weathercaster effort. In discussion with station managers the majority considered the cost to be acceptable and encouraged us to proceed with the program .

The methods for serving independent stations remain to be worked out. Nearly all independent stations are able to receive some network feeds.

Each has a different arrangement for obtaining outside programming and it is not possible to generalize with confidence. The two independent station managers we have approached were confident they could obtain the IVAM support they wanted from the networks. A much more careful and extensive survey is required to provide a plan for service to independent stations.

Cable TV

All cable TV stations have access to one or more networks. In some cases this access is via broadcast intercept; i.e., the cable station simply intercepts an out-of-town station and distributes it locally. Where the cable station has access to network feeds it is at least possible for the station to record and use the IVAM segments just as the broadcast stations do. However, this does not seem to be a valid basis for supporting cable TV outlets. The segments distributed by network feed will be intended to support up to five short (2.5 - 4.5 minute) presentations per day (0800, 1200, 1700, 1800, 2200) and perform some very short spot up-dates.

This much material, most of it probably received in short segments and requiring a weathercaster to present it, is of little value to the cable TV operator. He lacks the manpower to operate the recorders and to assemble the presentation and few if any cable TV stations employ weathercasters. The cable TV stations employ weathercasters. The cable TV station operators needs a service which will fill a complete channel for as many hours as the station operates - in return he will provide the channel.

It is reasonable to project a satisfactory cable station operation based on an endless loop tape recorder with five minute capacity operating continuously. Each 30 minutes, a five minute IVAM presentation is received and simultaneously cablecast and recorded. The recording is repeated each five minutes until the next presentation is received from IVAM. If the IVAM service were available, the cable stations would buy the loop recorder (estimated cost is $18,000) according to the cable operators we have interviewed.

The problem is to get the IVAM presentations to the cable TV stations. At this time we are not able to propose a detailed plan for distribution of IVAM presentations to cable TV stations. We have studied the cable TV industry sufficiently to know that it is too immature and chaotic to present a sufficiently unified and defined interface to treat on a system basis.

When considered on a local or regional basis each case must be treated individually. In the Fort Worth - Dallas area we have been assured that as soon as IVAM is ready at the Fort Worth WSFO the cable will be installed to feed the regional net already in existance. We believe that other major metropolitan areas, but not all of them, would also be prepared to provide the necessary cable to WSFO's in their vicinity. If we assume for the moment that the 24 WSFO's shown in Figure 5-4 are IVAM presentation generating points their 24 major areas will be well served. However, it seems clear that service to St. Louis, for example, will depend upon development of addition cable net facilities.

The inability to assure service to all cable TV outlets at this time should not retard development of IVAM however. Cable TV is in its infancy and is growing rapidly. The value of continuous, current, local weather service to the public is very great, and the value of the IVAM service to the cable TV stations is recognized by the cable industry representatives to be large. We are confident that as the cable TV industry grows it will incorporate the capability of distributing the IVAM presentations.

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6. PRESENTATION TEST & EVALUATION

The software development alternative which was chosen will produce the best final system, but it will also delay the date when enough of the software can run together to produce test presentations. However, the questions concerning presentation structure, aesthetics, timing, etc. require investigation early in the program to provide useful guidance to software and hardware design. The alternative was to simulate the IVAM system output using McIDAS and manually produced images to generate enough test presentations to support the required studies.

After examining the extent to which the simulated presentation would represent IVAM output, we decided that the simulations could provide a very useful service. Two presentations were carefully structured using segment definitions from the Content Studies. One presentation was designed to simulate IVAM output to the broadcast TV industry; the other was designed for cable TV. Two copies of video tapes of these presentations are being delivered to NOAA as part of this report.

As the presentations developed from segment specification, to storyboards, to senarios and finally to artwork, and motion pictures, the differences between the two presentations surprised even the creators. The same basic data set was used, October 30, 1974, and that day was picked because the weather was <u>not</u> spectacular. It was a "typical" Wisconsin fall day. (Haze, rain the night before, fog forecast for evening.) The differences between the presentations developed as the peculiarities of the broadcast and cable TV media were satisfied:

> The broadcast presentation is designed in easily separable segments, each carrying a complete message which could be assembled in several different logical orders. The cable presentation is

designed to be shown as a complete unit. We found that the broadcast segments had to have more informational redundancy than the cable segments.

The broadcast presentation was designed to serve as supporting visual aids to a weathercaster while the cable presentation could be shown with background music only. An audio commentary can be used with the cable presentation but no provision was made for a person to be on the screen. We found that with a weathercaster to guide the viewer, much more information could be placed in any particular image; however, without audio help the information density on the screen had to be reduced. Therefore, it takes longer to present the same amount of information on the screen (not considering additional information in the audio channel too) via cable TV.

We learned that the images for broadcast TV must be planned to provide room for the weathercasters image to be chromakeyed over the IVAM image without obscuring needed information. In some cases it will probably be necessary to designate certain segments as inappropriate for chromakey and only the weathercaster's voice will be added. The entire screen is available for the cable TV presentation.

The ratios of basic images to different images, and to final frame count were about the same for both presentations. That is, for a 5 minutes presentation 9000 frames are required of which about 450 are different in some respect, but which were derived by minor changes from 90 basic images. This implies that for the same amount of information fewer basic images were required for the broadcast presentation, and this proved to be true by about 10 per cent.

Analysis of the presentations is not completed, in fact, they have been shown to no one outside the IVAM program as this is written. Nevertheless, a great deal has been learned about the degree to which filmed presentations can simulate the IVAM product. For example:

All graphics for the films were produced by photographing opaque art work; therefore colors were limited to available colored papers and paints. When produced by IVAM the range of available colors, tints, and shades is unlimited, and more pleasing color relationships can be obtained. Color blends and transitions are not feasible by photographing opaque materials, while with IVAM color transitions (blending from one color to another in a smooth sequence) are easy.

Data overlays were laboriously registered and related by hand for the camera. With IVAM, image-to-image registry is inherent and error free.

With the camera technique it is not possible to overlay a transparent color on a colored background without completely losing the background color. IVAM can blend or retain colors with complete freedom when different domains are overlayed.

We have also relearned once again that great care must be exercised in selecting colors so that when the program is shown on black and white sets the information is not lost. We intend to incorporate the required grey scale-color rules in the IVAM logic to guarantee good black and white reception.

Mr. Terry Kelly, who served as our test presentation weathercaster is a highly skilled professional meteorologist with some experience before a TV camera. He enjoyed using the simulated IVAM product and found that it it was much easier than he had expected. Mr. Kelly viewed the IVAM segments twice, making timing notes the second time. From there he prepared cue cards and then ran the program. Neither Mr. Kelly nor the IVAM program people were satisfied with the results because it appeared flat and stilted. Mr. Kelly threw away the cue cards and ran the show again ad lib. The results are excellent. Based on this experience Mr. Kelly is convinced that he could review the IVAM segments once and then present the show with no worries about timing problems. It remains to be seen whether all weathercasters can perform at this level, but Terry Kelly is "sold" on IVAM.

In making the cable TV presentation we experimented with the alphanumerics to find out size and length limitations. There is a rule in the TV industry that more than 36 characters in a line is a mistake. We found that using 24 characters per line allowed easy viewing from a distance 14 times the screen width which is a reasonable standard. Also the larger letter size of 24 characters looked better, i.e. suffered less confusion, when placed over maps, etc.

We intend to use these two presentations to obtain feedback from viewers of different backgrounds so that we can evaluate the communications effectiveness of each segment. We plan to make comparative sets of some segments in which elements of interest are varied so that we can start to optimize image element concepts.

In January 1975, Mr. Haig delivered a paper on IVAM at the AWS Weathercasters Association Meeting in Denver, Colorado. He suggested to the weathercasters that they form a small group of volunteer members to serve as an advisory panel to the IVAM program. The suggestion was received warmly and several interested members of the association, as well as the current president, have volunteered to serve. We intend to convene this group semiannually and to request their assistance in criticizing our test presentations and development program.

In addition to the weathercaster's group we plan to involve as many citizen, industry, and farm groups as we can contact during the next few months. We will use simple, quick-to-answer questionnaires to obtain responses to a few key aspects of the presentations. Among those we will test are retention of specific weather facts, presentation acceptability relative to usual weathercast, value to viewer, length and timing, and specific sequence opinions.

While films and video tapes are limited in the fidelity of the simulation of IVAM, we believe we can achieve most of our test and evaluation goals during the next ten months by this means.

7.0 PROPOSED EFFORT FOR NEXT YEAR

The major effort for the next year will be on the software development. It is proposed to build up a set of development hardware on which the software efforts can proceed. Maximum use will be made of existing hardware at SSEC, namely McIDAS. The concept of using Parallel processors, as discussed in the report, will allow us to create an interface to McIDAS which will approximate the interface to AFOS in many ways. A minimum amount of hardware must be purchased as soon as possible to proceed with software development. Future development hardware procurements are postponed until needed. It should be emphasized that hardware purchased for development is chosen in such a way that it will not constrain the choice of hardware on which the eventual IVAM system will be implemented. The evaluation of hardware choices for future IVAM implementation is an ongoing effort, performed in parallel with the software development.

A second area of continued study is that of presentation contents and format. A basic list of presentation elements, called segments, has been identified. These segments are defined in terms of information content and time duration. The next year's effort will refine the information needs of the segments and carry them from a definition in terms of informational parameters to a "storyboard" format. The storyboard is the complete description of the scenario, image by image, defining color content, animation parameters, image content and layout, etc. The list of segment storyboards is the output specification for the software system.

Refinement of the segment contents will be done through a test and evaluation plan. The two major elements of the evaluation plan are:

1) Feedback from the AMS Weathercaster Advisory Group via semi-annual meeting of review and discussion.

2) Local test program to the public, using the UW closed channel campus TV system.

Methods of IVAM distribution for all three media, network, independent, and cable TV must be further defined. While feasibility has been shown, the methods described must be optimized. Network distribution plans must be further defined, working closely with NWS in designation of WSFO use in IVAM. Independent broadcast stations must be included in the distribution and cable TV networks related to the WSFO map. Considerable travel is anticipated to specify, in detail, how the IVAM NWS "terminal" will interface to the media.

Presentation Contents Studies - Test and Evaluation

The present list of about 400 segments is being refined, expected to be 80 to 100 different segments when complete. These segments must be defined and judged in terms of content, aesthetics, and timing. Judgement of the presentations will be done by two different groups, the AMS Weathercaster's Advisory Group, and a closed channel TV audience on the UW campus.

Organization of the AMS Weathercaster's Advisory Group on IVAM was suggested at the AMS Weathercaster's Conference in Denver this year and the idea was received with enthusiasm. We have received correspondence from individuals interested in being members. The committee, comprised of 5 or 6 members, will meet semi-annually at a geographically convenient location, to evaluate test programs produced by the IVAM team. Important elements to the weathercaster, timing, flexibility for chromakey, etc., will be evaluated and specific problems relating to distribution can be discussed as well. Travel costs of the group will be borne by the IVAM project, but they will receive no other fee.

As the software development progresses, the modular approach (discussed in the report) will allow some segments, depending on their content, to be available from the system during the first year. Likely choices are temperature information, presented in contour images. These can be used on the UW campus TV system with feedback questionnaires to evaluate their effectiveness in relating information and their aesthetic quality.

Certain complete presentations will be assembled for evaluation also, made by a combination of operating IVAM output and manual film animation techniques.

Hardware Concept Studies

Three different efforts are included in the hardware studies:

1) Development Hardware

2) Implementation Hardware

3) Distribution Specification

Development Hardware and AFOS Interface

The hardware needed for the development of the system is chosen by making maximum use of the already existing McIDAS system in-house. The McIDAS provides part of the data base, some CPU function, and to a good extent will be used in the same way the AFOS will related to the IVAM system. The AFOS/IVAM interface, both in the software and hardware sense, is obviously extremely important. The IVAM development hardware to McIDAS relationship will allow us to better define the AFOS/IVAM interface.

Choice of hardware for the development is based on the multi-processing concept explained in the report. Care has been taken to choose equipment which will maintain machine independence. Purchase of hardware is planned in a sequential fashion, minimizing cost necessary to support the software development during the first year. With the rapidly declining prices on many special purpose digital equipment, postponement of equipment is a further advantage.

A maximum use of McIDAS hardware, consistent with IVAM objectives for flexibility, allows the development to proceed on a minimal purchase of development hardware. McIDAS will provide in-process disc storage, input base, display, color added, and act as marter controller. The additional hardware components needed, besides McIDAS, are:

1 ea. Mini-computer (such as PDP-11/40)

3 ea. Micro-processors (such as PDP-LSI-11)

2 ea. Ann Arbor Terminals

1 ea. Disc Controller (local fabrication)

1 ea. McIDAS computer interface

1 ea. McIDAS Remote Terminal Interface

Parts, Cables, Misc.

Implementation Hardware

Study of Implementation hardware (equipment to be specified for field installation) is an ongoing effort. Key elements in its consideration are: a) rapidly falling costs for digital equipment, and b) output storage requirements. Purchase of processing equipment several years in the future as opposed to now appears to be an advantage. The drop of prices on small computer equipment is dynamic. Items once called "machines" are becoming "components", and inexpensive ones at that. Using micro processors allows one to take full advantage of the "component" approach.

Following on the heels of processor price drops, new memory technologies appear to be precipitating the start of a similar drop in memory cost. This study will continue in evaluating new products and their possible cost effective applications to IVAM.

Distribution Specification

The basic concepts of IVAM distribution have been developed for broadcast TV. Distribution for cable TV use has not been developed although the opportunity for it has been identified - cable networking.

A "first cut" distribution plan for serving broadcast TV has resulted in use of the 24 WSFO's identified in the report. Evaluation of how well that plan serves the networks and the independent stations will be performed. Part of that evaluation must include identifying how and where the cable stations, through their networks, will be served. While it is known that cable netting is rapidly growing, the IVAM team must identify specifically where the present and future cable nets will interface with NWS IVAM.

It is expected that the 24 WSFO plan will change somewhat. The final plan for distribution will be based on the combined requirements of the four established broadcast networks, independent broadcast station needs, cable network "headends", and work with the NWS on probable future use of certain WSFO's. Considerable travel effort is expected for this task.

Software Development

Efforts on the software task for the next year will be described in five tasks:

1. Define Net Structure in Detail
2. Define Module Interface
3. Code Modules
4. Install and Check-out Modules
5. Integrate and Operate System

The software net structure is the key element in making the software system efficient and flexible. Effort on the net structure will begin by organizing the structure relationship between the three levels of language; a) the IVAM descriptive language, b) the numerical language (FORTRAN) used for some operations, and c) the machine language of the hardware. This step is critical in making efficient use of the system. The machine dependence, which must be defined to some degree, is determined by how well this net structure is done. Carefully done, the machine dependence is minimized and precisely identified so that the software developed may be easily applied to a different machine.

Software modules will be defined, based on the requirements from the segment definition. Individual images are described by segment storyboards, so that modules may be independently considered.

The advantages of modular approach become apparent as the coding is commenced, for the modules may be independently developed. This is not only efficient use of programmer time, but allows some segments to be prepared for evaluation during the year. It further allows common needs for images to be identified and avoids solving the same problem twice for different segments. Coding of modules will proceed with effort concentrating on some modules already in use on McIDAS. Modules used on McIDAS are generally research oriented, so an importance of coding them for IVAM will be consideration for relevance and aesthetic value to the public.

As the development hardware is assembled and running, the modules can be "installed" and tested on the hardware system. The modules will be applied to the system and integrated into the net structure which controls the assembly of images (output of modules) into frames of video information.

By early summer 1976 the IVAM system will be operating, using coded, tested modules to assemble test segments. All modules will not be coded, but the basic operating system will be running for system tests.