BELLCOMM, INC.
1100 Seventeenth Street, N.W. Washington, D.C. 20036

SUBJECT: AAP-1A - A Baseline Instrument Package for Earth Sensing-Case 630

DATE: July 15, 1968

FROM: W. W. Elam

ABSTRACT

The AAP-1A earth looking experiment complement provided strong support to earth resources and meteorology. It was not an optimum package from the point of view of user desires. Most of the more useful sensing concepts were included, but in some instances, the spatial resolution is inadequate or fewer spectral channels than desirable are used. No data on atmospheric density and winds for the advance of long range weather forecasting are obtained.

In view of the current interest in adding earth looking experiments to the AAP cluster, a detailed study was made of the support offered to earth resources and meteorology by a possible baseline, the AAP 1A experiment package. This work is summarized in a table. Most of the more useful sensing concepts are represented; in some instances, spatial resolution and spectral coverage are inadequate. One important earth resources sensing method, long wave infrared spectrometry, is inadequately supported by S049, a meteorology experiment.

(NASA-CR-73535) AAP-1A - A BASELINE INSTRUMENT PACKAGE FOR EARTH SENSING (Bellcomm, Inc.) 11 p

N79-72511

Unclas
00/19 11319

FF No. 602

CR-73535
(NASA CR OR TMX OR AD NUMBER)

(CODE)

(CATEGORY)

[redacted]

FEB 1969
RECEIVED
NASA STI FACILITY
INPUT BRANCH

BELLCOMM, INC.
1100 Seventeenth Street, N.W. Washington, D.C. 20036

SUBJECT: AAP-1A - A Baseline Instrument Package for Earth Sensing- Case 630

DATE: July 15, 1968

FROM: W. W. Elam

MEMORANDUM FOR FILE

INTRODUCTION

The Apollo Applications Mission 1-A which was cancelled had as its principal scientific payload 14 earth resources and meteorology experiments. This instrument group or parts of it is being used in a number of studies for future manned earth orbital missions. It is the purpose of this memorandum, considering the 1-A instruments as approximately state of the art, to compare the data provided by them to the data requirements of earth resources and meteorology.

Several good candidate experiments had to be excluded from the 1-A mission because of the short procurement time. For the same reason, some 1-A instruments are degraded from what could be considered state of the art. Nevertheless, considering the 1-A package as a baseline should be of assistance in planning for earth sensing on future manned space flights.

Although achieving earth resources and meteorology objectives by means of space experiments is strongly affected by orbital inclination and the time of year of the flight, these effects will not be discussed here. Long duration flights at high orbital inclination are asssumed.

EXPERIMENT/APPLICATION MATRIX

The experiment/application matrix (see Figure 1) is used as a means of showing which earth resources and meteorology sub-disciplines are served by each of the 1-A experiments. Each column corresponds to a single instrument; the spatial resolution, spatial coverage and spectral range of the instrument are given. For some instruments additional information is also given.

The rows correspond to applications. The earth resources applications are shown along the left edge and the meteorological applications are shown along the right edge. In that sense, the matrix is double.

The symbols in the matrix elements show on the left primary or secondary support for earth resources and the adequacy of the spatial resolution provided by the experiments. On the right, the symbols show primary or secondary support for meteorology and the relative importance of the sub-disciplines.

In a number of instances, the matrix shows that one experiment supports both meteorology and earth resources, often more than one sub-discipline.

EARTH RESOURCES APPLICATIONS

The earth resources applications shown on Figure 1 are in no sense exhaustive but are thought to be representative. The spectral coverage of interest and a range of desirable spatial resolution is shown for each application. A quantitative evaluation of the degradation of the usefulness of the data as the spatial resolution becomes greater than that shown here as desirable is beyond the scope of this memo. The desirable spatial resolutions stated do not reflect an "official" NASA or user agency position. They do reflect what has been stated by user agencies as being desirable. The rate of degradation of the usefulness of the data as the spatial resolution becomes coarser varies with different sub-disciplines. The emphasis on spatial resolution is stressed because of its dependence on altitude and because planned long duration missions must be flown at higher altitudes than 140 n.m. The instrument performance given in Figure 1 is based on the planned altitude of the 1A mission, 140 n.m.

Adequate spatial resolution is critical only to earth resources, not to meteorology. The degree of adequacy of spatial resolution provided by each instrument to each earth resources sub-discipline is shown where applicable by the amount of shading of the indicator rectangle as shown in Figure 1. The solid rectangles show good spatial resolution. The rectangles with dashed outlines indicate inadequate spatial resolution.

Figure 1 shows wide application for the cameras (S100, S101) and the infrared imager (S102). The radar imager (S106) the passive microwave imager (S075), and the two infrared spectrometers (S049, S103) have fewer but still a considerable number of applications.

Considering spatial resolution the cameras and the radar imager are, in general, adequate; the infrared imager less adequate; and the passive microwave imager and the infrared spectrometers marginal to inadequate.

A breakdown showing primary or secondary support to the sub-disciplines by experiment is presented in Table 1. The experiments are listed in the order of the number of sub-disciplines given primary support. Based on this criterion, the two camera experiments stand out as being most useful. The infrared imager (S102) and the long wave infrared spectrometer (S-049) rank next.

The infrared spectrometer (S049) although a primary instrument for 3 sub-disciplines and secondary for 9 others provides inadequate spatial resolution. S049 is an experiment designed primarily for meteorological purposes. It covers a broad spectral band, 5-22μ. The spectral region in the thermal infrared of most interest to earth resources is 8-14μ. An infrared spectrometer designed for maximum response in this spectral region is badly needed for earth resources.

METEOROLOGY APPLICATIONS

The meteorological applications shown in Figure 1 are strongly directed toward the objective of longer range weather prediction through numerical analysis of global weather data. The United Nations World Weather Watch (WWW) and its associated Global Atmospheric Research Programme (GARP) are international programs which pursue the above objective.

A characteristic of the data required for long range weather prediction is that it must be truly global in extent. An attractive feature of earth orbiting vehicle as a sensor platform is that it can provide the required global coverage.

A discussion of the data required to support the WWW and GARP, which are in large measure the meteorological applications shown on Figure 1, is found in References 1, 2, 3. By far the most important data are those listed under atmospheric structure and motion on Figure 1. Of these important atmospheric data, the 1-A instruments provide only temperature, humidity, and ozone measurements. There is no capability to measure the two most important--density and wind. A forthcoming companion memorandum will discuss in greater detail the data required for the WWW and GARP, the problems involved, and the methods for obtaining the data. There are four experiments which measure atmospheric temperature and three which measure water vapor. They are mutually supporting rather than needlessly redundant in that, in general, they sense different absorption bands or use different techniques. One reason for the multiple approach, which can be supported by a large spacecraft, is to determine which techniques or combination of techniques can best obtain this essential meteorological data.

A feature of great interest, shown on Figure 1, is the substantial amount of support given to meteorology by the earth resources experiments.

FURTHER OBSERVATIONS AND SUMMARY

The 1-A experiment complement includes most of the types of instruments needed to provide strong support to earth resources and meteorology. An important exception is the lack of methods to directly measure atmospheric density, and to measure wind. It should be noted, however, that as compared to the experiments considered in the APP"A" and APP"B" packages, that the 1-A instruments sense fewer channels of the electromagnetic spectrum, provide poorer spatial resolution, and omit some useful techniques.

As a specific comment, the longwave infrared spectrometer (S049) is a primary sensing method for three and secondary for nine earth resources sub-disciplines. It provides inadequate spatial resolution for earth resources. Earth resources need an infrared spectrometer designed for optimum performance in the 8-14μ spectral region rather than depending on S049, a meteorological instrument covering the 5-22μ spectral region.

The spatial resolution provided by the experiments for earth resources is less than desired for several techniques, even for a mission altitude as low as 140 n.m. For planned earth orbital missions at higher altitudes, it would be desirable to upgrade the performance of the instruments to meet the spatial resolution requirements.

W. W. Elam

1011-WWE-cas W. W. Elam

NUMBER OF EARTH RESOURCES SUB-DISCIPLINES GIVEN PRIMARY AND SECONDARY SUPPORT
(BY EXPERIMENT)

EXPERIMENT	TOTAL NUMBER SUPPORTED	PRIMARY SUPPORT		SECONDARY SUPPORT	
		NUMBER	SPATIAL RESOLUTION	NUMBER	SPATIAL RESOLUTION
S101	22	16	GOOD	9	FAIR TO GOOD
S100	23	16	GOOD TO FAIR	6	GOOD
S102	19	7	GOOD TO POOR	12	FAIR TO POOR
S049	12	3	INADEQUATE	9	INADEQUATE
S106	13	1	GOOD	12	GOOD TO FAIR
S075	10	1	POOR	9	POOR
S105	4	1	GOOD	3	FAIR TO POOR
S103	10	1	----	10	FAIR

TABLE 1

REFERENCES

1. The Global Atmospheric Research Programme (GARP), (Report of the Study Conference); ICSU/IUGG - Committee on Atmospheric Sciences, COSPAR, World Meteorological Organization, July 1967.

2. Research Aspects of the World Weather Watch; WWW Planning Report No. 5; W.M.O. 1966.

3. The Role of Meteorological Satellites in the World Weather Watch; WWW Planning Report No. 18; W.M.O. 1967.

FIGURE 1. SUMMARY OF APPLICATIONS MISSION 1A EXPERIMENTS SUPPORT TO EARTH RESOURCES AND METEOROLOGY

	EXPERIMENT		METRIC CAMERA (SPECIAL) (S 100)	MULTIBAND PHOTOGRAPHY (S 101)	DUAL—CHANNEL SCANNER—IMAGER (S 102)	SHORT WAVELENGTH SPECTROMETER (S 103)	RADAR IMAGER SYSTEM (S 106)	ALTIMETER/ SCATTEROMETER RADAR (S 105)	MICROWAVE TEMPERATURE SOUNDER (S 104)	ELECT SCAN MICRO-WAVE RADIOMETER (S 075)	IR TEMPERATURE PROFILE RADIOMETER (S 050)	IR INTERFEROMETER/ SPECTROMETER (S 049)	UHF SFERICS (S 048)	IR TEMPERATURE SOUNDER (S 043)	DIELECTRIC TAPE CAMERA (S 040)	DAY/NIGHT CAMERA (S 039)
	SPATIAL RESOLUTION SPECTRAL RANGE SPATIAL COVERAGF		40m .4-.7μ ~ 210 x 210 N.M.	50m .44-.92μ ~ 68 x 68 N.M.	300m .6-.7μ and 10-12.5μ SWATH 240 N.M. WIDE	.5 N.M. wide x .92 N.M. .4-2.5μ SWATH .5 N.M. WIDE	90m x 90m 10-15 GHz 12 N.M. WIDE SWATH 75-87 N.M.TO LEFT OF GROUND TRACK	ALT.-2.5m, SCATT.-14.4 x 16.6 km; 1.61 GHz SWATH 10 N.M. WIDE	50 N.M. 53.5 GHz, 55 GHz 50 N.M. SWATH	8.3 x 6.6 N.M. 19.35 GHz SWATH 335 N.M. WIDE	6.1 x 6.1 N.M. 11.0, 13.1, 13.3, 13.6, 18.7u SWATH 62 N.M. WIDE	5 N.M. 5-22μ 5 N.M. x 5 N.M. on 80 N.M. Centers	NA	30 x 60 N.M. (PROFILE) 6 x 16 N.M. (CLOUD COVER) 3.5-6.0μ 30 N.M. WIDE SWATH Will Detect Cirrus Clouds	91m .4-.8μ SWATH 133 N.M. WIDE	920 x 920 m .35-.80 μ 315 x 350 N.M.
EARTH RESOURCES APPLICATIONS	SPATIAL RESOLUTION AND SPECTRAL COVERAGE DESIRED FOR OPERATIONAL PURPOSES. SPATIAL SPECTRAL RESOLUTION COVERAGE (METERS)					AUGMENTS THE MULTI—CHANNEL RADIOMETRIC FEATURES OF S101 BY PROVIDING HIGH SPECTRIAL RESOLUTION DATA, AND ALSO EXTENDS THE SPECTRAL RANGE	DOES NOT COINCIDE WITH S 101 COVERAGE	ALTIMETER SUPPORTS METRIC CAMERA	2 Temperature segments centered at 4km, 10km.		2 Temperature segments in Troposphere 1 Water vapor segment in Troposphere	Multi-segment Temperature, water vapor and ozone.		6 Temperature segments center on 1, 4, 9, 22, 42, 48, km. 3 Water vapor segments in Troposphere Detects amount of clouds but does not produced image.		
GEOGRAPHY	TOPOGRAPHIC MAPPING	20-100 .4 - .9μ 5-10 GHz	P ○	S			S								◗	◗
GEOGRAPHY	LAND USE MAPPING	20-300 .4-.9μ .3-14μ 5-10 GHz	P ◗	P ◗	S ◗	S	S			S					◗	
GEOLOGY	GEOLOGICAL MAPPING (Major Features)	20-300 .3-1.0μ 8-15μ ~10 GHz	P ◗	S			S									
GEOLOGY	THERMAL ANOMALIES	20-300 .3-10μ 8-15μ	○	P ○	P ○					S				◠	◠	○
GEOLOGY	LITHOLOGY (Identification)	20-300 .4-.7μ 8-15μ ~10 GHz	S				S					P				
GEOLOGY	WATER BODY MAPPING	20-100 .5-.7μ 8-15μ ~10 GHz	P	P	S		S		●	S	●	S ●		●		
GEOLOGY	WATER POLLUTION AND WASTE EFFLUENT (Inland)	20-100 .3-1.0μ 8-15μ	S	P	S							S				
GEOLOGY	SNOW FIELD AND GLACIER INVENTORY	20-100 .5-.7μ 8-15μ 10 GHz	P	S	S		S			S	●	S ●		●		
GEOLOGY	RIVER BASIN GEOMORPHOLOGY	20-100 .2-1.0μ 8-15μ 10 GHz	P	P	S		S					S ◗				
GEOLOGY	SOIL MOISTURE MEASUREMENT	100-300 .3-1.0μ 8-15μ 10 GHz	P	P	P			○		S		S				
AGRICULTURE	AREA MEASUREMENT OF MAJOR CROPS	20-35 .4-.9μ 3-14μ .5-10 GHz	P	S	S	S	S			S						
AGRICULTURE	IDENTIFICATION OF MAJOR CROPS	20-35 .4-.9μ 3-14μ	S	P	S ◗	S					◗	P ◗		◗		
AGRICULTURE	SOIL CLASSIFICATION	30-200 .4-.9μ 3-14μ 3-35 GHz .3-.6 GHz	S	P	S	S		S ◗		S ◗		S				
AGRICULTURE	MEASUREMENTS OVER DISTRESSED AREAS	35(DISEASE) 300(MOISTURE) .4-.9μ 3-14μ	S ◗	P ◗	P ◗		S ◗			◗		S			◗	◗
FORESTRY	AREA MEASUREMENTS OF FORESTS	20-300 .4-.9μ 3-14μ 3-35 GHz	P	S	S	S	S			S						
FORESTRY	IDENTIFICATION OF FOREST TYPES	20-35 .4-14μ .5-10 GHz	S	P	S	S						S				
FORESTRY	MEASUREMENTS OVER DISTRESSED AREAS	30-300 .4-.9μ 3-14μ .3-.6 GHz 3-35 GHz	S	P	S	S		S				P				
FORESTRY	MEASUREMENTS OVER FIRES	30-100 .4-.9μ 3-14μ	S	S		S		S								
OCEANOGRAPHY	SEA STATE	1000 .4-3GHz	S				S	P		S ●						
OCEANOGRAPHY	CURRENTS AND SEA SURFACE TEMPERATURES	20-300 8-13μ 1-10 GHz	P ◠	P	P ◠								●		◠	◠
OCEANOGRAPHY	ESTUARY DISCHARGE AND SEDIMENT PATTERNS	20-100 .3-1.0μ 1-30 GHz	P	P	P	S ◗						S				
OCEANOGRAPHY	HYDROGRAPHIC MAPPING	20 .4-.9μ 1-30 GHz	P	P	S		S									
OCEANOGRAPHY	SEA FOOD/MARINE BIOTA	20-100 .3-1.0μ 8-13μ 1-10 GHz	P	P	P	S										
OCEANOGRAPHY	SEA/ICE INTERFACE	300 3-14μ 1-10 GHz	P	P	P		P			P						

METEOROLOGY APPLICATIONS

TOTAL COVERAGE (1-2 km, resolution; primarily automated spacecraft) HIGH RESOLUTION (Special phenomena; limited coverage) STEREOSCOPIC (3 dimensional data for research, special phenomena, limited coverage) SUPPORT FOR OTHER SENSORS (0.5-1.0 km resolution; day and night)	**IMAGERY** Detection and tracking of operationally important meteorological phenomena as evidence by cloud formations. For research to study these cloud formations in high resolution and three dimension. Automated systems give global coverage (2-3 km day; 11 km night). (ATS-3 images in color every 24 min. at 2-3 N.M. resolution an area of 40 x 10^6 NM^2. It is valuable data for temporal changes.
TEMPERATURE PRESSURE/DENSITY HUMIDITY OZONE WIND	**ATMOSPHERIC STRUCTURE AND MOTION** Global observations from surface to 30 km; horizontal spacing 500 km; time spacing 12 hours. Alternate methods are conventional radiosondes (25% area coverage and insitu sensors on long lifetime constant level balloons under development). THIS REQUIREMENT IS OF PRIMARY IMPORTANCE. A NUMBER OF METHODS SENSORS SHOULD BE EXERCISED AND COMPARED.
TEMPERATURE (or cloud top Temperatures) ROUGHNESS OTHER FEATURES (soil, ice, water, snow, vegatative burden, soil moisture, etc.)	**LOWER BOUNDARY CONDITIONS** At present this data is used in parameterized form. Further study is needed to determine the requirement for observed data. But if observed data were available it could be used in atmospheric circulation modeling studies. There are some operational uses.
	UPPER BOUNDARY CONDITIONS Net radiation flux at the top of the atmosphere. Data is provided by automated satellites.
PRECIPITATION MAPPING THUNDERSTORM DETECTION ATMOSPHERIC SCATTERING AND ABSORPTION	**MISCELLANEOUS PHENOMENA**

LEGEND — (EARTH RESOURCES)

1 **P** -Primary Support to Disciplinary Objective

2 **S** -Secondary or Augmenting Support to Disciplinary Objective

3 ▩ -Experiment Supports Disciplinary Objective with Adequate Spatial Resolution

4 ▨ -Experiment Supports Disciplinary Objective with Fair Spatial Resolution

5 □ -Experiment Supports Disciplinary Objectives with Poor Spatial Resolution

6 ⬚ -Experiment Supports Disciplinary Objectives with Sub-Marginal Spatial Resolution

LEGEND (METEOROLOGY)

● Application of Primary Importance with a Major Effort Needed

◗ Application of Secondary Importance, or of Primary Importance with a Lesser Effort Needed

○ Provides Support to Application of Primary Importance

◠ Provides Support to Application of Secondary Importance

BELLCOMM, INC.

Subject: AAP-1A - A Baseline Instrument Package for Earth Sensing

From: W. W. Elam

DISTRIBUTION LIST

Copy to
NASA Headquarters

Messrs. W. O. Armstrong - MTX
P. E. Culbertson - MLA
J. H. Disher - MLD
F. P. Dixon - MTY
E. W. Hall - MTG
L. Jaffe - SA
T. A. Keegan - MA-2
D. R. Lord - MTD
H. Luskin - ML
J. R. Porter - SAR
A. D. Schnyer - MTV
R. A. Summers - MTY
M. Tepper - SAD
M. G. Waugh - MTP
J. W. Wild - MTE

Manned Spacecraft Center

R. O. Piland - TA

Marshall Space Flight Center

R. G. Eudy - R-P2VE-XM
G. Hardy - I-S/AA

Bellcomm

Messrs. F. G. Allen
G. M. Anderson
A. P. Boysen, Jr.
D. A. Chisholm
C. L. Davis
J. P. Downs
D. R. Hagner
P. L. Havenstein
N. W. Hinners
B. T. Howard
D. B. James
J. Kranton
K. E. Martersteck
R. K. McFarland
J. Z. Menard
G. T. Orrok
T. L. Powers
I. M. Ross
F. N. Schmidt
J. W. Timko
J. M. Tschirgi
R. L. Wagner
J. E. Waldo
All Members Division 101
Central File
Department 1023
Library