Study of Geoplat Complementarity with NOAA GOES Instruments:

GEOPLATFORM INSTRUMENT STUDIES FINAL REPORT

Paul Menzel

15 July 1990

I. INTRODUCTION

This document is an attempt to summarize the potential overlap between the NOAA operational observation requirements and the Geoplatform observation capabilities anticipated in the late 1990s. Six tasks were identified at the outset; they are to (1) anticipate a realistic milestone schedule, (2) summarize the requirements, (3) estimate the GOES N instrument package, (4) define the expected data flow, (5) identify derived physical parameters that NOAA would be using, and (6) compare these with the plans for the Geoplatform.

To date the GOES N instrument package has not been defined. Phase A contract work is still proceeding; a final report is expected in October 1990. Therefore the estimates presented in this report are very preliminary. Much of what follows is the outgrowth of the following activities. (a) The document entitled "The Statement of Guidelines and Requirements: GOES N Phase-A Study" distributed by NOAA in May 1989 was reviewed. (b) Private sector input from ITT and SBRC was solicited regarding likely instrument capabilites in the mid 1990s. (c) Several discussions were held with the NOAA Office of Systems Development and the GOES N Phase A contractors.

This initial assessment of the potential complementarity of the proposed geoplatform instrument suite with the proposed NOAA GOES instruments proceeds by reporting on each of the six tasks. Section 2 indicates a likely schedule for GOES N, section 3 presents the requirements set forth by the NWS for GOES N, section 4 presents estimates of the likely instrument package (with size, power, weight, data rate numbers where possible), and section 5 briefly explores the issue of complementarity of NOAA GOES and Geoplat. An Appendix is attached indicating the anticipated GOES products.

2. SCHEDULE FOR GOES N

In the NOAA GOES N requirements document, it is indicated that the GOES N satellite should be ready to launch in the same time frame as GOES M, currently scheduled for 1997, in order to minimize the chance of an interruption to the two GOES service. The procurement of GOES N formally begins in 1991. The requirements, specified by the user community at the workshop of January 1989, are to be used as input for a Phase A feasibility study. The Phase A study will provide an initial review of technical feasibility and costs of achieving the specified user needs. The procurement specifications will be developed from the Phase A results and subsequent decisions. Table 1 presents the GOES N milestones.

Table 1. GOES N Milestones

Jan 1989	Meeting of GOES N Requirements Working Groups Imager (chaired by Zbar/McGinnis) Sounder (chaired by Petersen/Sparkman) DBS (chaired by Nestlebush) SAR (chaired by Bailey) Solar/Space Environment (chaired by Hildner/Mulligan) Spacecraft Systems (chaired by Shenk/Bisone)
May 1989	Draft of GOES N Requirements completed
Aug 1989 to	Phase A studies
Oct 1990	Phase A completed
Oct 1990 to Mar 1991	Modify Requirements based on Phase A Report
Mar 1991 to Sep 1991	Develop Phase B Request for Proposal
Sep 1991 to Sep 1992	Evaluate Phase B proposals and award contracts
Sep 1992 to Sep 1993	Complete Phase B
Sep 1993 to Jun 1994	Complete Phase C/D procurement activity and award contracts
Jun 1994 to Jun 2000	Design, build, and test spacecraft and payload
Jun 2000	Launch GOES N

3. REQUIREMENTS FOR GOES N

There are several instruments that are being considered for GOES N. They are an imager, a sounder, a solar and space environmental monitor, a search and rescue instrument, and a data collection and broadcast system. The requirements for these instruments have been specified with the recognition of the changing observational environment in the GOES N time frame, in which additional data from NEXRAD, wind profilers, and ASOS (Automated Surface Observation Systems) begin to make an impact on NWS operations and research studies.

The requirements for GOES N are specified by the National Weather Service. For imaging and sounding, they were reached by examining the NOAA meteorological current and evolving needs, by making judgments on the ability of the NWS to incorporate new capabilities, and by exploring the state of remote sensing technology. The requirements must be considered preliminary because some experience with the GOES I/M series performance is needed in order to fully evaluate enhancements which would be valuable to the NOAA.

As indicated in the NOAA requirements document, the GOES N satellite data are expected to have a greatly expanded operational use, both in quantitative and qualitative applications. One reason for this is the expected developments in data integration and display systems such as the Advanced Weather Interactive Processing System (AWIPS). Meteorologists will have easy and timely access to the satellite data from GOES N. The widespread distribution of the data may lead to local developments that cannot be anticipated at this time. The GOES data will be especially valuable with the increased emphasis on short-term forecasting over local areas. The expanded operational use of the data will increase the demand for operational reliability of the data and products, and also the demand for immediate data availability. These data will be especially important when used in combination with other data sets.

The use of geostationary satellite data by the time of GOES N will be affected by planned enhancements to other meteorological measurement systems. The implementation of a wind profiler network, NEXRAD doppler radar network, ASOS network, and increased meteorological measurements from commercial aircraft will provide additional information about the vertical structure of the atmosphere. These data will be used to support both numerical weather prediction and field forecast operations. Improvements to the GOES N sounding capabilities will be required in order for the satellite to add information to the expected data network in data rich regions. In the AWIPS, the satellite data will be combined with other data in common projections. The imagery and derived products must be of a quality and timeliness to complement existing data. The navigation accuracy will continue to be of particular importance when different types of data are combined.

It is also extremely important that GOES N support ongoing atmospheric research and development activities. This is particularly true because it is impossible to determine the precise needs and/or capabilities that will be present in the GOES N era.

In summary, the future use of geostationary satellite data by NOAA will be characterized by:

* expanded operational use;

* increased demand for improved reliability and immediate data availability;

* emphasis on short period forecasts and warnings over local areas;

* increased use of numerical data in more sophisticated models;

* increased use of animated imagery;

* flexibility for growth, development, and research;

* accompanying developments in dissemination, meteorological interpretation, and display systems;

* combination of satellite data with other data sets such as NEXRAD and wind profiler data.

The requirements for the GOES N instruments are presented separately in the following Tables. Each set of requirements is subdivided into three categories: (a) core-remedial are those requirements which are absolutely necessary to meet the original level of operations specified for GOES I/M; (b) options, enhancements, or clarification are requirements which can markedly enhance the capabilities of GOES I/M without substantial new development or expense; and (c) desirables are enhancements which will require new developments and/or are expected to be cost prohibitive.

Table 2. Imager Requirements

Core

1. navigation (3 sigma absolute of 4 km)
2. channel to channel registration (.5 km)
3. pixel to pixel registration (3 sigma 42 um)
4. image to image registration (1.5 km)
5. temporal resolution (30 min for full disk, 5 min for 3000x3000 km2, 2 min for 1000x1000 km2)
6. spatial resolution (1 km visible, 4 km IR)
7. NEDT (1.4 K at 4 um and .35 K at 12 um for 300 K target)
8. timeliness (distribution to user within observational repeat cycle)
9. simultaneity of multispectral data (8x8 km2 within 5 sec)
10. cloud smearing (within 2% after one IGFOV)

Options

1. navigation (3 sigma absolute of 2 km)
2. pixel to pixel (3 sigma 14 um)
3. image to image registration (.5 km)
4. recovery from eclipse or maneuver (one hour down to 5 min)
5. no data loss during eclipse
6. additional spectral channels (7.3, 13.3, 1.6, 0.86 um)
7. improved NEDT (.1 K for 300 K target for all wavelengths)
8. lessen effects of diffraction
9. improved spatial resolution (.5 km visible, 2 km 4 um)
10. lightning mapper

Desirables

1. increased dynamic range (IR windows out to 350 K)
2. additional imager (full scan and synoptic scan)
3. visible calibration (onboard)
4. low light capability (4 um)

Table 3. Sounder Requirements

Core

1. sounding accuracy (temperature 1000-700 mb +/-2.0 K
   700-300 mb 1.5 K
   300-100 mb 2.5 K
   humidity 1000-600 mb +/-20% RH
   600-200 mb 15% RH)
2. channel to channel registration (centroids within 2%, half power widths within 1%)
3. navigation (absolute within .5 FOV)
4. pixel to pixel (.1 FOV)
5. image to image (1 FOV)
6. temporal (synoptic observations every 40 min, sub synoptic every 10 min)
7. spatial (less than 8 km)
8. timeliness (non interference with imager)

Options

1. sounding accuracy (temperature 1 K, dewpoint 1.5-3.0 K at all levels)
2. vertical resolution (1-2 km below 300 mb
   2-3 km below 100 mb
   3-6 km above 100 mb)
3. contemporaneous visible imagery (improved cloud clearing with 1 km visible)
4. IFOV coregistration (within .5 km)
5. contiguous sounding product images on synoptic scale (within 1.5 K and 20% RH)

Desirables

1. higher horizontal resolution (4 km) but not at the expense of vertical resolution

Table 4. SEM, SAR, DCS/WEFAX Requirements

Solar and Space Environment Monitor (SEM)

Core
1. energetic particles (30 keV-700 MeV)
2. magnetic fields
3. full disk X-Ray sensor
4. solar X-ray imager

Options
1. low energy particles (10 eV-30 keV)
2. ionospheric radio beacon
3. solar EUV spectrometer
4. solar magnetograph
5. solar H-alpha imager

Search and Rescue (SAR)

Core
1. detection of emergency beacons

Options
1. earth location too

Data Collection System (DCS) / Weather Facsimile (WEFAX)

Core
1. 100 Baud transmission
2. 1 Wefax channel

Options
1. 300 and 1200 Baud
2. earth location of transmission
3. four Wefax channels

4. ESTIMATE OF THE GOES N INSTRUMENT PACKAGE

Efforts to estimate the instrument package are based largely on the GOES I/M package, GOES N interim phase A reports, and conversations with UW, ITT, and SBRC. Two options for an imager are presented; the first is the GOES I/M imager (Table 5a), while the second is the GOES I/M imager scaled up to increase spatial resolution, to shorten the full disk sampling interval, and to increase the number of spectral channels (Table 5b). Two options for the sounder are also presented; the first is the GOES I/M filter radiometer sounder (Table 6a), and the second is a high-resolution interferometer modification to the GOES I/M sounder (Table 6b). It is generally accepted that a filter radiometer cannot meet the sounding requirements of the NWS outlined in section 3; thus it is hoped that the latter option or something more ambitious will be developed. The SEM, SAR, and DCS/WEFAX are expected to increase 25% in size, weight, and power to accomodate some of the new observational requirements (see Table 7). These numbers are very preliminary and will be amended upon conclusion of the GOES N Phase A Report.

The launch vehicle will probably be an Atlas II, IIA, or IIAS indicating that the total weight that can be transfered to geostationary orbit ranges from 2680 to 3490 kg. The GOES N instrument package will fall in that weight range. The four attached figures indicate payload options and possible configurations. These figures are borrowed from the Third Quarterly Review of the GOES N Phase A Study.

Table 5a. Characteristics of the GOES I/M Imager

Measurement Objectives

Multispectral imaging of the full earth disk for mass and motion field determinations

Instrument Description

Filter Radiometer with five channels

- .55-.75 microns at 1km
- 3.8-4.0 microns at 4km
- 6.5-7.0 microns at 8km
- 10.2-11.2 microns at 4km
- 11.5-12.5 microns at 4km

Physical

Dimension: 1.15 x .80 x .75 meters
(envelope size of imager sensor components)

Mass: 118 kg
(Imager Sensor Module: 84.22 kg,
Imager Electronics: 28.17 kg,
Imager Power Supply: 5.56 kg)

Power: 130 W

Data/Communications

Data rate: 2.62 Mbps
(full disk every 25 min)

Point/Control

view: target earth plus periodic calibration looks at external blackbody (about every 10 min) and space (every 2 min)

scanning: yes

unobstructed view: full earth (+/- 10 degrees)

targets: full disk

knowledge: within 4km

ifov: 1km(vis),4km(IR),8km(H2O)

Table 5b. Characteristics of an Improved GOES N Imager

Measurement Objectives

Multispectral imaging of the full earth disk for mass and motion field determinations

Instrument Description

Filter Radiometer with seven channels

- .55-.75 microns at 1km
- 3.8-4.0 microns at 2km
- 6.5-7.0 microns at 4km
- 7.1-7.5 microns at 4km
- 10.5-11.2 microns at 4km
- 11.5-12.5 microns at 4km
- 13.1-13.6 microns at 4km

Physical

Dimension: .8 x .8 x 1.2 meters
(sensor assembly only .5 x .5 x 1.2 meters)
Mass: 125 kg
Power: 135 W

Data/Communications

Data rate: 6.8 Mbps
(full disk every 12.5 min)

Point/Control

view: target earth plus periodic calibration looks at external blackbody and space
scanning: yes
unobstructed view: full earth (+/- 10 degrees)
targets: full disk
knowledge: within 1km
ifov: 1km(vis),2km(near IR),4km(IR)

Table 6a. Characteristics of the GOES I/M Sounder

Measurement Objectives
  Temperature and moisture soundings;
  cloud and earth surface properties

Instrument Description
  Filter Radiometer with spectral coverage
  from .7 to 15 microns in 19 spectral bands

Physical
  Mass: 127.9 kg
  Dimension: 1.37 x .80 x .75 meters
    (envelope size of sounder sensor components)
  Power: 105 W

Data/Communications
  Data rate: 0.04 Mbps
  (Continental US every 35 minutes)

Point/Control
  view: target earth plus periodic calibration looks at
    external blackbody and space
  scanning: yes
  unobstructed view: full earth (+/- 10 degrees)
  targets: geographic regions
  ifov: 10 km
  knowledge: within half a field of view
  integration time: .1 sec, .2 sec, .4 sec

Table 6b. Characteristics of an Improved GOES N Sounder
(estimated from CIMSS Report of September 1988 entitled
"High Resolution Interferometer Modification of the
GOES L/M Sounder: Feasibility Study)

Measurement Objectives

Temperature and moisture soundings;
cloud and earth surface properties

Instrument Description

Michelson interferometer with spectral coverage
from 3.5 to 15 microns with a resolving power
between 1000 and 2000

Physical

Mass: 135 kg
Dimension: 1.4 x 0.8 x 0.8 meters
(sensor assembly only)
Power: 115 W

Data/Communications

Data rate: 1.0 Mbps
(Continental US every 60 minutes)

Point/Control

view: target earth plus periodic calibration looks at
external blackbody and space
scanning: yes
unobstructed view: full earth (+/- 10 degrees)
targets: geographic regions
ifov: 10 km
knowledge: within half a field of view
integration time: .1 sec, .2 sec, .4 sec,. 8 sec
stability: 1km/sec

Table 7a. Characteristics of the SEM

1. Energetic Particle Sensor (EPS) Package

Measurement Objectives

Monitor the directional energetic particle flux: 30 keV to greater than 700 MeV nucleon protons and alphas and less than 30 keV to 4 MeV electrons

Physical

EPS Telescope
- Power: 200 mW
- Mass: 0.59 kg
- Volume:
- Mounting Area: 57.4 cm2

EPS dome
- Power: 300 mW
- Mass: 1.86 kg
- Volume:
- Mounting Area: 78.7 cm2

High Energy Proton/Alpha Particle Detector (HEPAD)
- Power: 4 W
- Mass: 3.4 kg
- Volume:
- Mounting Area: 22.6 cm2

EPS/HEPAD Data Processor
- Power: 10.8 W
- Mass: 3.18 kg
- Volume:
- Mounting Area: 423.9 cm2

2. Three-axis Magnetometer

Measurement Objectives

Measure simultaneously each component of the ambient vector magnetic field to an accuracy of 1 nT

Physical

Magnetometer
- Power: 85 mW
- Mass: .34 kg
- Volume:
- Mounting Area: 107.7 cm2

Magnetometer Electronics
- Power: 78mA @ 43 VDC
- Mass: 2.59 kg
- Volume:
- Mounting Area: 331.6 cm2

3. Full-disk X-ray Sensor

Measurement Objectives

Measure the integrated brightness of the Sun in at least the 0.5 - and 1 - 8 A bands

Physical

Power: 2.5 W
Mass: 4.81 kg
Volume:
Mounting Area:

4. Solar X-ray Imager

Measurement Objectives

Image the Solar corona in several soft X-ray bands, simultaneously to greater than 1.5 solar radius

Physical

Power: 10 W
Mass: 12.6 kg
(sensor: 7.3 kg
electronics: 5.3 kg)
Volume: .26 x .26 x .79 meters
(electronics 5700 cc additional)

Data/Communications

Telemetry: 100 Kbps
(assumes MDL transmitter)

Point/Control

unobstructed view: 3 deg whole angle
pointing:
abs: 1 arcsec
rel: 2 arcsec/100 ms

5. Local Plasma (Low Energy Charged Particle)

Measurement Objective

Monitor the directional charged particle flux of 10 eV to 30 keV electrons and positive ions

Physical

Power: 3.5 W
(sensor: 2.1 W
DPU: 1.4 W)
Mass: 6.4 kg
(sensor: 4.3 kg
DPU: 2.1 kg)
Volume: .37 diam x .06 discus meters
(electronics .196 x .219 .076 meters additional)

Data/Communications

Telemetry: TBD

Point/Control

clear field of view: 45 deg x 360 deg annulus

Special

static magnetic and electric fields must be as low as possible at the sensor

6. Solar EUV Full-Disk Spectrometer

Measurement Objectives

Obtain calibrated (<5%) solar, extreme ultraviolet, time integrated flux in several spectral lines

Physical

TBD

7. Solar Magnetograph

Measurement Objectives

Measure solar photospheric vector magnetic field of each active region on the disk with sensivity of 2.5 mT in each component

Physical

Power: 50 W
Mass: 30 kg
(sensor: 20 kg
electronics: 10 kg)
Volume: .26 x .38 x 1.00 meters
(electronics 15000 cc additional)

Data/Communications

Telemetry: 150 kb/s

Point/Control

sun pointing: .5 arcsec per second

Special

bore site to XRI and XRS

8. Solar H-alpha Imager

Measurement Objectives

Obtain high quality H-alpha, on band and continuum images

Physical

TBD

9. Ionospheric Radio Beacon

Measurement Objectives

Measure total electron content along the ray path from any ground station to the platform as a function of time

Physical

TBD

Table 7b. Characteristics of the SAR

Objectives

Utilize low earth orbiting satellites to receive distress messages from aviators or mariners and provide alert and location (within 50 km) information

Description

receive 406 MHz uplink
relay 1544.5 MHz downlink

Physical

TBD (location interferometer will add 35 kg and 35 W)

Table 7c. Characteristics of the DCP/WEFAX

1. DCP

Objectives

Interrogate platforms and receive data from these and other appropriate non-interrogatable platforms

Description

226 channels at 300 baud with 1.5 KHz bandwidth
20 channels at 300 baud with 1.5 KHz bandwidth
20 channels at 1200 baud with 3.0 KHz bandwidth

Physical

- S-band receiver
  - Power: 6 W
  - Mass: 1.65 kg
  - Volume: 1469.9 cm3
  - Mounting area: 280.0 cm2
- DCP reply transponder
  - Power: 9.5 W
  - Mass: 3.31 kg
  - Volume 2825.1 cm3
  - Mounting area: 349.7 cm2
- DCP interrogation transmitter
  - Power: 16.6 W
  - Mass: 2.17 kg
  - Volume: 1961.5 cm3
  - Mounting area: 157.4 cm2

2. WEFAX

Objective

Transmit weather facsimile images

Description

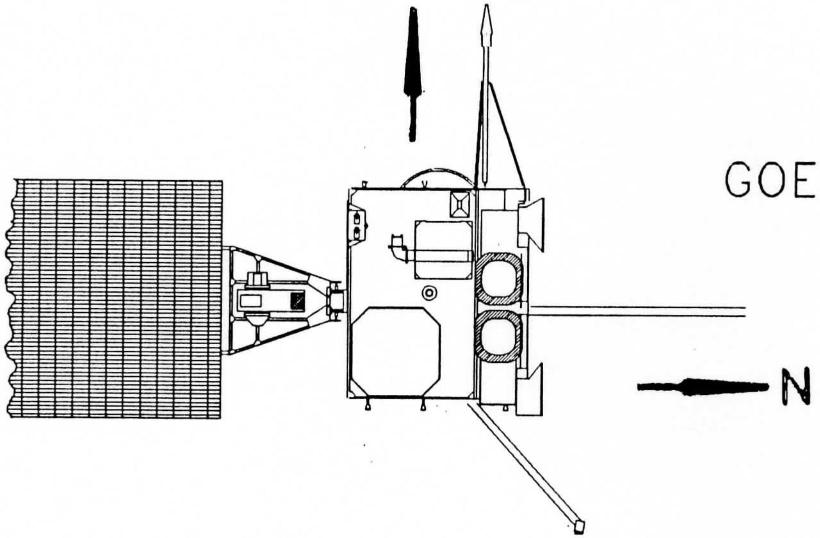
- Four channels
  - low resolution WEFAX A for expanded products
  - low resolution WEFAX B for expanded products
  - high resolution WEFAX for analog/digitial products
  - NOAA-Port products

Physical

TBD

GOES–N Orbit Configuration

Baseline

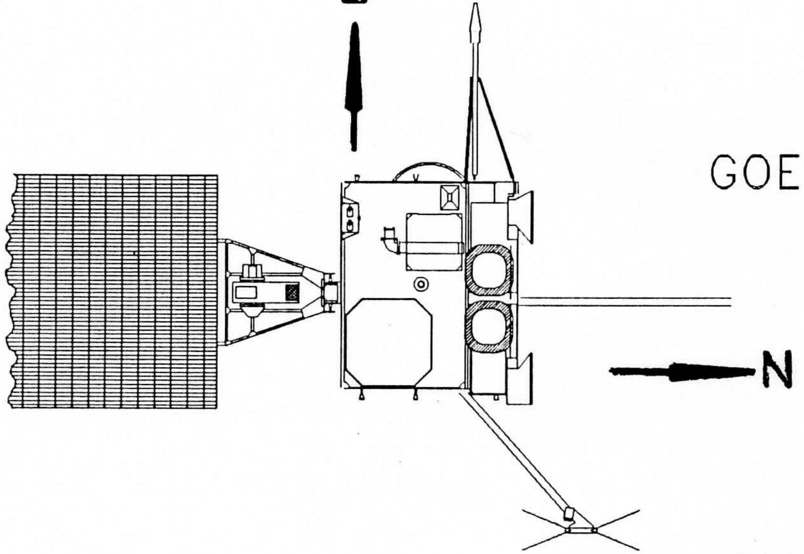


PAYLOAD/SPACECRAFT–OPTION MATRIX

	BASELINE	OPTION I	OPTION II	OPTION III
Spacecraft	I–M bus	I–M bus	Different	Different
Strawman Payload				
Imager (GOES I–M)	Y	--	--	--
Imager (improved)	--	Y	--	--
Imager (7 Spectral Band)	--	--	Y	--
Imager (new)	--	--	--	Y
Imager (additional)	--	--	--	Y
Lightning Mapper	--	--	Y	Y
Sounder (GOES I–M)	Y	--	--	--
Sounder (improved)	--	Y	--	--
Sounder (Hi Spectral Res.)	--	--	Y	Y
WEFAX	Y	Y	--	--
WEFAX (new)	--	--	Y	Y
DCS	Y	Y	--	--
DCS (new)	--	--	Y	Y
SAR	Y	Y	--	--
SAR (new)	--	--	Y	Y
SEM				
Energ. Part. Sens.(EPS)	Y	--	--	--
EPS (improved)	--	Y	Y	Y
Magnetometer	Y	Y	Y	Y
X–Ray Sens. (XRS)	Y	Y	Y	Y
Solar X–Ray Imager (new)	Y	Y	Y	Y
Low Energy Plasma Sen.(new)	--	Y	Y	Y
Solar Magnetograph/H–Alpha	--	--	--	Y
Total Electron Content Sen.	--	--	--	Y

goesn3\blo

full



GOES-N Orbit Configuration
Option I

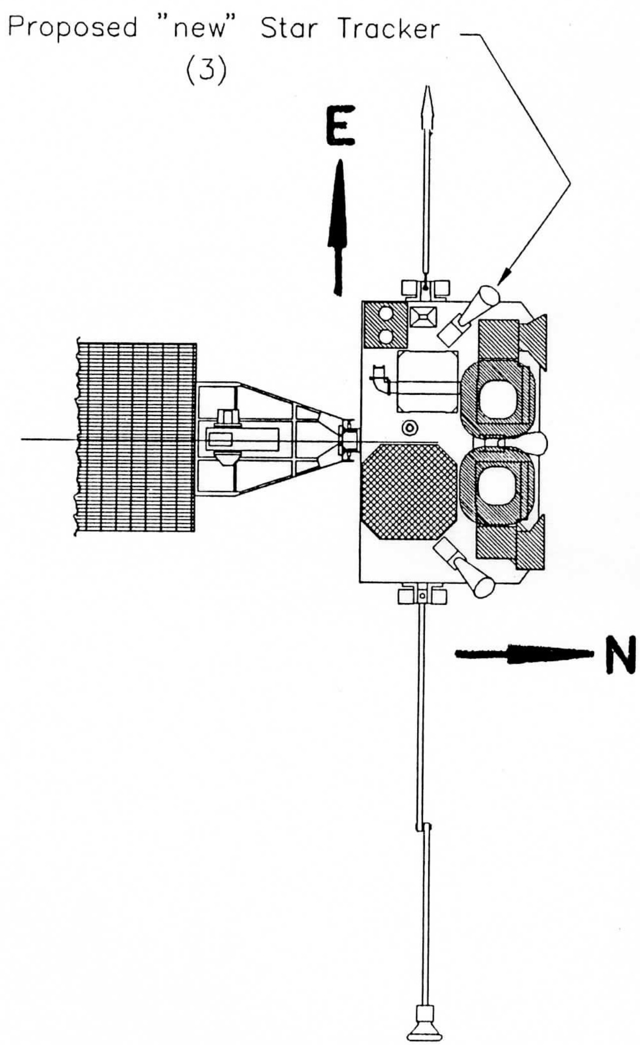
PAYLOAD/SPACECRAFT-OPTION MATRIX

	BASELINE	OPTION I	OPTION II	OPTION III
Spacecraft	I-M bus	I-M bus	Different	Different
Strawman Payload				
Imager (GOES I-M)	Y	--	--	--
Imager (improved)	--	Y	--	--
Imager (7 Spectral Band)	--	--	Y	--
Imager (new)	--	--	--	Y
Imager (additional)	--	--	--	Y
Lightning Mapper	--	--	Y	Y
Sounder (GOES I-M)	Y	--	--	--
Sounder (improved)	--	Y	--	--
Sounder (Hi Spectral Res.)	--	--	Y	Y
WEFAX	Y	Y	--	--
WEFAX (new)	--	--	Y	Y
DCS	Y	Y	--	--
DCS (new)	--	--	Y	Y
SAR	Y	Y	--	--
SAR (new)	--	--	Y	Y
SEM				
Energ. Part. Sens.(EPS)	Y	--	--	--
EPS (improved)	--	Y	Y	Y
Magnetometer	Y	Y	Y	Y
X-Ray Sens. (XRS)	Y	Y	Y	Y
Solar X-Ray Imager (new)	Y	Y	Y	Y
Low Energy Plasma Sen.(new)	--	Y	Y	Y
Solar Magnetograph/H-Alpha	--	--	--	Y
Total Electron Content Sen.	--	--	--	Y

goesn3\opt1o

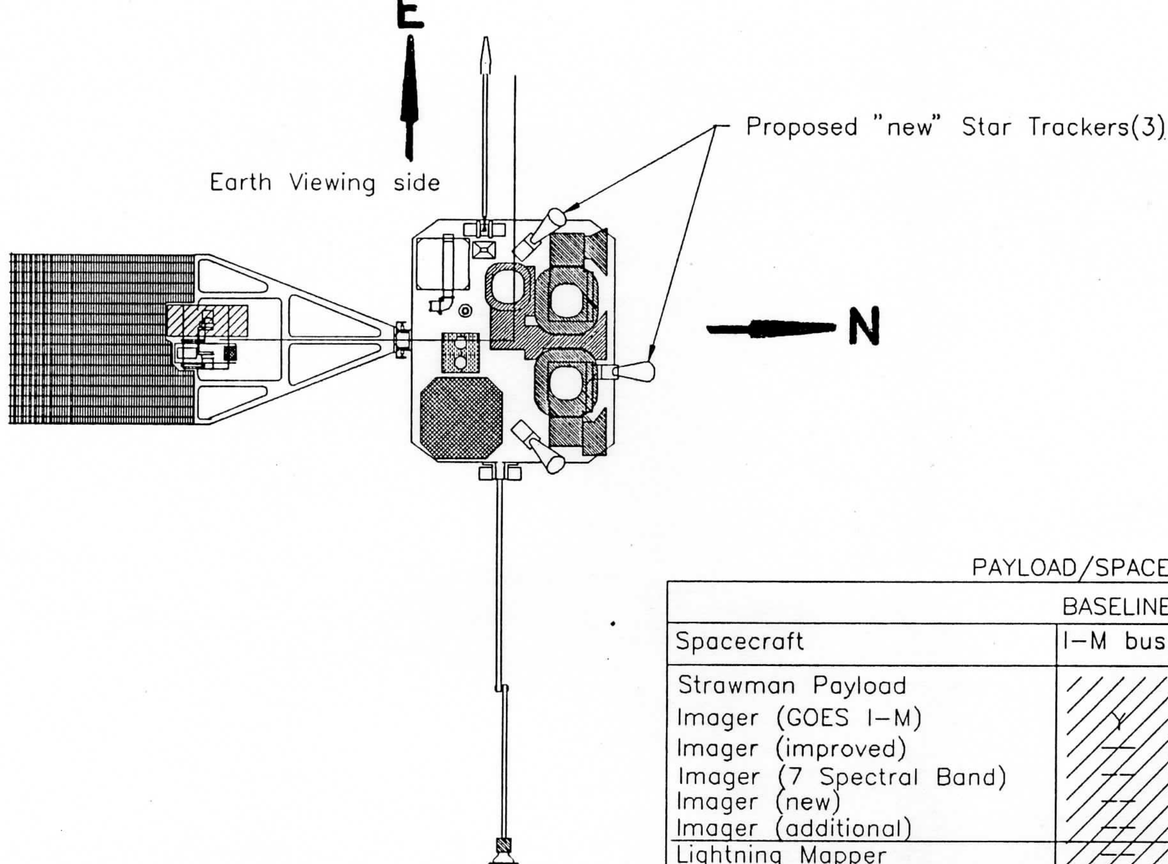
full

GOES–N Orbit Configuration
Option II



PAYLOAD/SPACECRAFT–OPTION MATRIX

	BASELINE	OPTION I	OPTION II	OPTION III
Spacecraft	I–M bus	I–M bus	Different	Different
Strawman Payload				
Imager (GOES I–M)	Y	––	––	––
Imager (improved)	––	Y	––	––
Imager (7 Spectral Band)	––	––	Y	––
Imager (new)	––	––	––	Y
Imager (additional)	––	––	––	Y
Lightning Mapper	––	––	Y	Y
Sounder (GOES I–M)	Y	––	––	––
Sounder (improved)	––	Y	––	––
Sounder (Hi Spectral Res.)	––	––	Y	Y
WEFAX	Y	Y	––	––
WEFAX (new)	––	––	Y	Y
DCS	Y	Y	––	––
DCS (new)	––	––	Y	Y
SAR	Y	Y	Y	––
SAR (new)	––	––	––	
SEM				
Energ. Part. Sens.(EPS)	Y	––	––	––
EPS (improved)	––	Y	Y	Y
Magnetometer	Y	Y	Y	Y
X–Ray Sens. (XRS)	Y	Y	Y	Y
Solar X–Ray Imager (new)	Y	Y	Y	Y
Low Energy Plasma Sen.(new)	––	Y	Y	Y
Solar Magnetograph/H–Alpha	––	––	––	Y
Total Electron Content Sen.	––	––	––	Y



GOES-N Orbit Configuration

Option III

PAYLOAD/SPACECRAFT-OPTION MATRIX

	BASELINE	OPTION I	OPTION II	OPTION III
Spacecraft	I-M bus	I-M bus	Different	Different
Strawman Payload				
Imager (GOES I-M)	Y	--	--	--
Imager (improved)	--	Y	--	--
Imager (7 Spectral Band)	--	--	Y	--
Imager (new)	--	--	--	Y
Imager (additional)	--	--	--	Y
Lightning Mapper	--	--	Y	Y
Sounder (GOES I-M)	Y	--	--	--
Sounder (improved)	--	Y	--	--
Sounder (Hi Spectral Res.)	--	--	Y	Y
WEFAX	Y	Y	--	--
WEFAX (new)	--	--	Y	Y
DCS	Y	Y	--	--
DCS (new)	--	--	Y	Y
SAR	Y	Y	--	Y
SAR (new)	--	--	[illegible]	--
SEM				
Energ. Part. Sens.(EPS)	Y	--	--	--
EPS (improved)	--	Y	Y	Y
Magnetometer	Y	Y	Y	Y
X-Ray Sens. (XRS)	Y	Y	Y	Y
Solar X-Ray Imager (new)	Y	Y	Y	Y
Low Energy Plasma Sen.(new)	--	Y	Y	Y
Solar Magnetograph/H-Alpha	--	--	--	Y
Total Electron Content Sen.	--	--	--	Y

goesn3\601plo

full

5. SUMMARY OF THE PRIMARY REQUIREMENTS FOR GEOPLATFORM COMPLEMENTARITY WITH NOAA GOES N

The major issues of complementarity are not instrument oriented, but rather are related to real time and continuous usage and control of data gathering and distribution.

It is relatively certain that Geoplatform will have a comparable or enhanced observing capability with respect to GOES N that features (a) improved reliability, (b) accurate navigation, (c) combination of satellite data with other observing systems such as NEXRAD and wind profilers, and (d) flexibility for growth, development, and research.

In terms of data distribution and dissemination, NOAA will be pursuing improved data dissemination with an emphasis on immediate data availability. There must be for real time continuous access to the data from the NOAA subset of the Geoplatform instruments. This is essential for NOAA to (a) expand operational use, (b) emphasize short period forecasts and local area warnings, (c) increase use of data in numerical models, and (d) increase use of animated imagery. NOAA will be maintaining two fixed geostationary observing positions at 75 W and 135 W, thus it is implicit that there must be two Geoplatforms at these locations.

These issues need to be resolved so that Geoplatform complementarity with NOAA GOES N can be ascertained. The promise is there; the reality must be arranged.

REFERENCES

GOES I/M Imager and Sounder System Level Critical Design Review: Ford Aerospace/ITT document, 12-13 July 1988

High Resolution Interferometer Modification of the GOES L/M Sounder: Feasibility Study: CIMSS report, September 1988

Statement of Guidelines and Requirements for the GOES N Phase A Study: NOAA/NESDIS 22 May 1989

The Observing System for the Weather Watch of the 1990's: Ford Aerospace/ITT document

GOES N,O,P Discussion at NASA-GSFC: ITT memorandum of 23 March 1989

GOES N Study Third Quarterly Review: Advanced Missions Analysis Office/GSFC, 2 May 1990

APPENDIX

GOES I-M Day 1 Product List
(February 3, 1989)

This is the working list of initial products for GOES I as of the date above. The list is organized into major product categories with a short description for each product. Each product will be made available after the launch of GOES I as soon as GOES I data and individual product production software have been checked out. The products listed here are currently awaiting approval by the NESDIS Satellite Products Review Board.

A. Cloud Parameters

Cloud Heights (11.2 um)

Cloud top brightness temperatures are determined from the radiance values observed in the infrared window of the GOES imager. These are compared to the atmospheric temperature profile fields available from NMC model output on the VDUC. The cloud top pressure for a given field of view (FOV) is the pressure at which the GOES infrared window brightness temperature matches the collocated NMC profile temperature. These heights are produced in concert with the cloud wind vector determinations and are thus available when winds are produced.

B. Enhanced Data Sets (Cloud Imagery)

GOES Projection

Imagery from the GOES I through M satellites will be produced in five spectral channels in the GOES projection. These five channels are described in the table below which includes information on wavelength, type of imagery and resolution at the satellite subpoint. Major improvements over the previous GOES imagery consists of the addition of 2 infrared channels (3.9μm and 12μm wavelengths) and better resolution for all infrared imagery (4 km versus 8 km).

Channel #	Wavelength(μm)	Type	Resolution (km)
1	.55-.75	VIS	1
2	3.9	IR	4
3	6.7	WV	8
4	10.7	IR	4
5	12.0	IR	4

GOES images will be produced in either full hemisphere (full disk), Northern Hemisphere (partial disk), or sectorized areas. The frequency of full earth disk images (including the entire Southern Hemisphere) will be every 30 minutes during Normal operations. During the Watch and Warning modes, full disk images will be available every 3 hours, with partial disk images (covering a small portion of the Southern Hemisphere) every 15 minutes.

GOES sectors will be produced every 30 minutes in Normal operations and every 15 minutes in the Watch mode. In the Warning mode, special 5 minute interval imagery will be available for selected areas of interest covering about 1000 km^2. The sectors will cover areas similar to those available in the GOES E-H era (A, B and C scales). Each sector will view an area 37% larger than that seen on the present GOES H facsimile sectors. This is necessary in order to maintain the same facsimile format.

Two types of composite images will be produced, resulting in visible/infrared and water vapor/infrared combinations. In producing composite images, the data in one channel is replaced by data from the second when certain threshold values (i.e., IR temperatures colder than -40°C) are exceeded. The resolution of composite images will be reduced to 8 km.

Although image data will be generated in all five channels, sectors transmitted on GOESFAX will be limited to three channels (for example, IR, VIS, and WV) plus one composite image. Full disk WEFAX images for three channels (IR, VIS, and WV) will be available every 3 hours. WEFAX images will be reduced to 8 km resolution.

<u>Full Earth Disk (5 channels)</u>
<u>Partial Disk (5 channels)</u>
  <u>Watch mode</u>
<u>Limited Disk (5 channels)</u>
  <u>Warning Mode</u>
<u>Composite imagery</u>
  <u>VIS/11.2 mu</u>
<u>WEFAX (3 channels)</u>
<u>GOES FAX (3 channels)</u>

<u>Mercator Projection*</u>

Sectors of the visible and infrared imagery covering the Contiguous United States (CONUS), Hawaii, and Puerto Rico are remapped to the mercator projection in real-time. The imagery are compressed to 8 bit pixel via a lookup table before remapping. Several derived products (not yet defined) are produced from the mercator mapped sectors.

AWIPS-90 requirements specify that forecast offices be able to display weather information on five scales. These include 1) the Northern Hemisphere, 2) a 6500 x 7500 km national scale (which

---

*Note. A Lambert conformal projection with one standard parallel will probably be used instead of the Mercator projection.

covers much of North America), 3) a 1500 x 1500 km regional scale centered on the Warning and Forecast Office (WFO), 4) a 750 x 750 km local scale, and 5) a 460 x 460 km WFO scale. GOES I-M imagery data are required to be remapped and displayed on all scales EXCEPT the hemispheric. The display capability will include imagery from all five available imagery channels. The image channels include: 1) the normal VIS data (0.55 - 0.75 μm), 2) a 3.9 μm channel, 3) mid-level water vapor (6.5 - 7.0 μm), 4) the normal IR data (10.2 -11.2 μm), and 5) the so-called "dirty window" channel (11.5 - 12.5 μm).

<u>Eastern CONUS Sector (5 ch.)</u>
<u>normal, watch and warning modes</u>
<u>Western CONUS Sector (5 ch.)</u>
<u>normal, watch and warning modes</u>
<u>Hawaii Sector (5 ch.)</u>
<u>normal, watch and warning modes</u>
<u>Puerto Rico Sector (5 ch.)</u>
<u>normal, watch and warning modes</u>

<u>Polar Stereographic Projection</u>

Sectors of the visible and infrared imagery covering the Northern Hemisphere and Alaska are remapped to the polar stereographic projection in real-time. Before remapping, the image data are compressed to 8 bit pixel resolution via a lookup table. Several products (undefined) are derived from the Alaska remapped sectors.

<u>Northern Hemisphere Sector (4 ch.)</u>
<u>normal and watch modes</u>

<u>Alaska Sector (5 ch.)</u>
<u>normal, watch and warning modes</u>

<u>Derived Product Imagery</u>

Derived product imagery will be produced from either the imager or the sounder. Data from the imager is limited to the longwave split window, the shortwave window, and the 6.7 micrometer water vapor channels. Initial GOES I/M derived product imagery, total precipitable water, and lifted index can be produced using only these channels with acceptable results.

Derived product imagery from the sounder is formed from pixel by pixel retrievals of atmospheric temperature and moisture profiles wherever the atmosphere is quasi clear. The derived product is scaled to the major part of the 6 bit quantization of the image area. The high order bits of the image are used to store "bright" 11 micron window values when cloud contamination is sensed. Thus the images appear as the derived product with the cloud cover superimposed.

Precipitable Water Imagery

The Day 1 product is total precipitable water in the atmosphere. This is a standard retrieval product adapted to the image format.

Stability Imagery

The initial stability product will be the lifted index described below under atmospheric parameters and adopted to the image format.

C. Atmospheric Parameters

Vertical Temp Profiles

Temperature profiles from sounder radiance measurements are produced at 40 pressure levels from 1000 to 0.1 mb using the simultaneous, physical algorithm which solves for surface skin temperature, atmospheric temperature, and atmospheric moisture. The profiles are archived at 20 levels, from 1000 to 10 mb. The retrieval begins with a first guess temperature profile which is obtained from a space/time interpolation of fields provided by the NWS forecast models. Hourly surface observations are also used to provide surface boundary information. Soundings are produced from a 6 x 6 array of IFOV whenever two or more FOV are determined to be either clear or "low cloud". The IFOV are "cloud filtered" to achieve a homogeneous set. The location (latitude and longitude) of the retrieval is assigned to the mean position of the filtered sample. A "type" indicator is included in the archive to indicate if the sounding represents "clear" or "low cloud" conditions. A quality indicator is included to indicate if the retrieval has failed any internal quality checks.

Vertical Moisture Profiles

Specific humidity, obtained in the simultaneous retrieval, is provided at the same levels as temperature up to 300 mb. Since the radiance measurements respond to the total integrated moisture above a particular pressure level, the specific humidity is a differentiated quantity rather than an absolute retrieval.

Layer Precipitable H_2O

Total Precipitable H_2O

Channel Brightness Temps

The filtered brightness temperatures for the available channels are archived with each retrieval. These values are filtered from the 6 x 6 arrays of IFOV used to produce a single retrieval. Only heterogeneous cloud contamination is removed. The values are not limb corrected, nor has solar contamination (if present) been removed. The brightness temperatures may represent either "clear" or low "uniform cloud" conditions.

Lifted Index

The lifted index is an estimate of atmospheric stability. It represents the buoyancy which an air parcel would experience if mechanically lifted to the 500 mb level. The lifted index expresses the difference in temperature between the ambient 500 mb temperature and the temperature of the lifted parcel. A negative value (warmer than the environment) suggests positive buoyancy (continued rising); whereas a positive value suggests stability (returning descent). The formulation used to derive LI is a statistical relationship requiring a mean pressure, temperature, and moisture for the boundary layer and the 500 mb temperature. These quantities are all available from the retrieved profile.

Thickness

The archive of each retrieval contains the geopotential height of the pressure level as derived from a 1000 mb height analysis (from the NMC forecast supplemented with hourly data), a topography obtained from a library (10 minute latitude/longitude resolution) and the retrieved temperature and moisture profile. Thickness can be calculated from this profile.

Thermal Wind Profiles (Gradient Winds)

Thermal winds are provided with each profile. These are derived from objective analyses of the geopotential profiles calculated with each retrieval. The objective analysis is a 3-dimensional, univariate recursive filter which uses as a background the same fields which provide the first guess to the temperature retrieval algorithm (NMC forecasts and surface analyses). The analyses are performed on a 1 degree latitude/longitude grid. Gradient winds are calculated using finite difference operators which involve surface-fitting over 5 x 5 gridpoints centered at the gridpoint closest to each retrieval. Wind estimates are provided from the surface to 100 mb.

Moisture Analysis (Interactive)

Meteorologists, after analyzing cloud patterns in GOES visible and infrared images, assign moisture profiles to specified data sparse oceanic areas. The moisture profiles consist of relative humidity values at six levels in the atmosphere (coded as set of 13 different humidity profiles). Profiles are assigned to a 2.5° latitude/longitude grid. The grid is located over the Pacific from 57.5 N to the equator and from 110 W to 180 W; over the Atlantic and Gulf the grid extends from 42.5 N to the equator and from 65 W to 110 W. The moisture profile grid is transmitted four times daily to NMC for use over the oceans.

Precipitation Estimates

The operational technique (Scofield-Oliver) for estimating convective rainfall from GOES data uses the Interactive Flash Flood Analyser (IFFA) to make computations. The technique uses half hourly enhanced IR imagery and visible imagery. It consists of two steps: (1) locating the active portion of the convective cloud system and (2) computing half-hourly rainfall estimates based on cloud-top temperature and cloud growth, divergence aloft, overshooting tops, mergers, saturated environment (stationary storms), and a moisture correction factor. A warm top modification is used for cloud tops warmer than -62°C. Techniques are also available for estimating precipitation from extratropical and tropical cyclones. When estimates are complete, a map graphic product is produced and sent to AFOS. The graphic product contains county level digital precipitation data. The worded AFOS product contains information about storm movement, rain rates, and reports rain totals at county resolution.

D. Ocean Surface Parameters

Great Lakes Ice Analysis

The Navy/NOAA Joint Ice Center (JIC) produces the Great Lakes Ice Analysis during the ice season from approximately December through April. The ice analysis is produced three times per week (Monday, Wednesday, and Friday) and depicts the ice cover, ice concentration, estimated ice thickness, and leads. Data sources include visible GOES and AVHRR imagery, Canadian ice reconnaissance, and ground station data. The final product is telecopied to NWSFO, Cleveland where it is used as guidance for the NWSFO to prepare their short range ice forecasts. The JIC analysis is also used by the Coast Guard, shipping industry, and research. The JIC also produces a Seasonal Ice Outlook and 30-day ice forecasts for the Great Lakes.

E. Data Bases

The data bases listed here are those currently planned for the NESDIS Data Processing Sub-System (DPSS). Other archive data bases are planned by the National Climatic Data Center (NCDC) but are not included here.

Imagery

There will be two imagery data bases. The first will contain hemispheric, 3 hourly 4 km VIS, 11.2um and 6.7um IR data; the second will contain 3 hourly, full resolution, unmapped VIS and 11.2mu IR for the CONUS sectors.

Sounder

The sounder data base will contain all the sounder data in a format similar to the 1B one used for polar satellites.

Calibration

A data base is planned for GOES I and beyond to serve as a source of data for offline vicarious calibration of the visible sensors. The data base will consist of hourly arrays of data from 50 targets for each GOES. The data will be collected daily. The targets will be 24 x 24 pixel arrays of visible data and 6 x 6 pixel arrays of IR data. Statistics and ancillary data will be collected for each target site. The data will be used to determine post-launch calibration and maintain sensor stability.

H. Winds

Cloud Drift (11 um)

Winds are derived from imagery data, from a sequence of 3 images over a one hour period. The winds are calculated by a three step objective procedure. The initial step selects targets, the second step assigns pressure altitude, and the third step derives motion. Altitude is assigned based on a temperature derived from the imagery brightness temperature data in the environment of the target. The exact method has not yet been defined. That temperature is "matched" to a pressure temperature profile obtained from NMC forecasts, time and space interpolated to the location of the target. An initial guess motion is used, based on NMC wind forecasts at the estimated cloud level. The cloud motion is estimated by a pattern recognition algorithm which locates a "target area" in one image within a "search area" in the second image. For each target, two winds are produced representing the motion from the first to the second and from the second to the third image. The first guess motion, the consistency of the two winds, the precision of the cloud height assignment, and the pattern recognition feedback are all used to assign a quality flag to the "vector" (which is actually two vectors). The horizontal density of the vectors is controlled by the target selector.

Moisture Drift (6.7 um, 7.2 um)

Winds from moisture imagery are derived by the same methods used with cloud drift imagery. However, the images are separated by a full rather than a half hour. An attempt is made to exclude cloud targets from the target data set. Tracer height assignment is currently an area of research. The CO2 slicing method will be used if 13.3 micron data is available from the sounder. Otherwise, a regression technique based on the 6.7 micrometer brightness temperature may be used. The 7.2 micrometer imagery will not be available from the GOES I/M imager, but it is anticipated that some tracers will be derived from the sounder data. For these a CO2 slicing height assignment is appropriate.

<u>Deep Layer Mean Wind</u>

The deep layer mean wind (DLM) field has been shown to best approximate the steering current of tropical cyclones. The DLM incorporates high density satellite information with conventional upper air data. Specifically, the satellite data includes cloud drift wind vectors (from both visible and IR images), water vapor motion vectors (from the 6.7um images), and derived gradient winds from the sounder temperature profiles. These data are stratified into 3 layers (100-350, 350-700, 700-950 mb) and combined with radiosonde winds. Each layer is then analyzed using a Barnes technique. A DLM analysis is then created from these three analyses using weighting coefficients determined statistically by the Hurricane Research Division of the NOAA Atlantic Oceanographic and Meteorological Laboratory.

PRI	ID	PRODUCTS	SENSOR SOURCE/ SYSTEM SOURCE	SYSTEM IMPLEMENTATION	SCIENCE DEVELOPMENT	ALGORITHM SPECIFICATION	SCIENCE IMPLEMENTATION	ASSESSMENT + VALIDATION	EVALUATION
	A TAGU01 TAGF01	Cloud Parameters o Cloud Heights (Cloud Top Temp)	Imager VDUC	Perkins/ Stewart	Menzel	Images/Clouds Panel	Menzel/ Stowe	Stewart ?	NMC
	B TBGF01	Enhanced Data Sets (Imagery) o GOES Projection (GOESFAX) (WEFAX)	Imager GSS DPSS	Staton	Ellrod Purdom	Images/Clouds Panel	Ellrod	Ellrod	NMC NWS Field
	TBGU01 TBGU01 TBGH01 TBGP01	o Lambert Conformal (AWIPS-90)	Imager CEMCSS	Shellman	PROFS	Images/Clouds Panel	Tarpley	Ellrod	NWS (MARD)
	TBGA01 TBGN01	o Polar Projection (AWIPS-90)	Imager CEMCSS	Shellman	PROFS	Images/Clouds Panel	Tarpley	Ellrod	NWS
	C TCGU01	Atmospheric Parameters o Vertical Temperature Profiles (°K)	Sounder VDUC	Perkins/ Holland	Hayden	Soundings Panel	Hayden/ McMillan	Hayden/ Gray	NMC
	TCGU02	o Layer Mean Virtual Temperatures (°K)	Sounder VDUC	Perkins/ Holland	Hayden	Soundings Panel	Hayden/ McMillan	Hayden/ Gray	NMC
	TCGU03 TCGF03	o Vertical Moisture Profiles (Specific Humidity)	Sounder VDUC	Perkins/ Holland	Hayden	Soundings Panel	Hayden/ McMillan	Hayden/ Gray	NMC
	TCGU04 TCGF04	o Layer Precipitable Water (mm)	Sounder VDUC	Perkins/ Holland	Hayden	Soundings Panel	Hayden/ McMillan	Hayden/ Gray	NMC
	TCGF05	o Total Precipitable Water (mm)	Sounder/Imager VDUC	Perkins/ Holland	Hayden	Soundings Panel	Hayden/McMillan Brown	Hayden/ Gray/Brown	NMC MKC
	TCGF06	o Channel Brightness Temps (°K)	Sounder VDUC	Perkins/ Holland	Hayden	Soundings Panel	Hayden/ McMillan	Gray	ORA

RKA:3/28/89

PRI	ID	PRODUCTS	SENSOR SOURCE/ SYSTEM SOURCE	SYSTEM IMPLEMENTATION	SCIENCE DEVELOPMENT	ALGORITHM SPECIFICATION	SCIENCE IMPLEMENTATION	ASSESSMENT + VALIDATION	EVALUATION
	TCGN07	o Lifted Index	Sounder/Imager VDUC	Perkins/ Holland	Hayden	Soundings Panel	Hayden/McMillan Brown	Hayden/ Gray	NMC MKC
	TCGF011	o Geopotential Heights (m)	Sounder VDUC	Perkins/ Holland	Hayden	Soundings Panel	Hayden/ McMillan	Hayden/ Gray	
	THGF09	o Thermal Wind Profiles (Gradient Winds)(m/s)	Sounder VDUC	Perkins/ Holland	Hayden	Soundings Panel	Hayden/ McMillan	Hayden/ Gray	
	TCGN10	o Moisture Analysis (Interactive)	Imager VDUC	Perkins/ Polanski	Brown	Soundings Panel	Brown	Brown	NMC
	TCGU01 TCGH01 TCGP01	o Precipitation Estimates (Scofield, Interactive)	Imager VDUC	Perkins/ Ambrose	Scofield	Precip Panel	Scofield	Scofield/ Ambrose	NWS NMC
	E	Data Bases							
	TEGF01	o Imager	DPSS	Hughes					
	TEGF02	o Sounder	?						
	TEGF03	o Calibration	?						
	H	Winds							
	THGF02	o Cloud Drift	VDUC	Perkins/ Stewart	Hayden	Winds Panel	Thomasell	Thomasell/ Stewart	NMC
		o Cloud Drift	NCCF	Hughes/ Shreitz	Thomasell	Winds Panel	Thomasell	Thomasell/ Stewart	NMC
	THGF04	o Moisture Drift	VDUC	Perkins/ Stewart	Hayden	Winds Panel	Thomasell	Thomasell/ Stewart	NMC
	THGF03	o Deep Layer Mean	VDUC	Perkins/ Stewart	Hayden	Winds Panel	Thomasell	Thomasell/ Stewart	NMC

RKA:3/28/89

E/RA21:RKA

GOES IM Proposed Day 2 Products
(December 20, 1988)

Items on this list are proposed products based on NWS and other requirements. These are Day Two Products (dates of implementation not yet defined).

Products

A. Cloud Parameters

Cloud Heights (6.7, 7.3mu)

Cloud Heights (CO_2)

Cloud Heights
Stereo (VIS/IR)

Cloud type and coverage
(ASOS PRODUCT)

Fog/Stratus Identification

Cirrus cloud heights (6.7/11.2um)

Cirrus/water vapor
differentiation

Convective cloud tracking

Cloud emissivity

Enhanced Data sets (Cloud Imagery)

GOES Projection

11.2/6.7 mu

C. Atmospheric Parameters

Precip Estimates
IFFA (Adler)
(Automated)

Lower troposphere moisture
(Split window, I or S)

Buoyancy parameter

Convective Cloud
Tops and intensity (Expansion; trop penetration)

D. Ocean Surface Parameters

SST thermal composite

E. Data Bases

F. Radiation Budget (Daily)

Solar Insolation

G. Radiation Budget (Monthly)

H. Winds

Cloud Drift Mesoscale
Land/Water (VIS, 11.2/3.8um)

I. Ozone

Total Ozone

J. Land Surface Parameters

Fires

Surface heating rate

Surface Temp

Soil Moisture

Skin Climatology
Two week

K. Aerosols

L. Storm Parameters

Dvorak Intensity

Hurricane Eye soundings