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Space Administration

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Reply to Attn of: Code 913

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To: Distribution

From: Michael D. King

Subject: Status of MODIS-N Airborne Simulator (MAS)

The intent of this memo is to provide you with an up to date status report on the development of the MODIS-N Airborne Simulator (MAS) and accompanying software for producing Level 1-B data products following an ER-2 flight campaign. I would appreciate any thoughts or concerns you have on these plans, so that we can best provide a state-of-the-art airborne radiometer for use by the general earth sciences research community.

A Wildfire Spectrometer was developed by Dædalus Enterprises under a Small Business Innovative Research (SBIR) contract and delivered to Ames Research Center in March 1991. The Ames principal investigator for Wildfire is Jim Brass. This instrument is a 50 channel spectrometer consisting of 4 spectrometer/detector subassemblies or ports with linear array detectors (InGaAs, InSb, InSb, and HgCdTe). The wavelength range of the Wildfire Spectrometer was 1.17-12.4 μm. This spectrometer is joined to a scanner subassembly that collects radiometric imaging data with the following characteristics:

1. Spatial resolution of 2.5 mrad, representing a ground resolution of 45 m from a nominal ER-2 altitude of 18 km,

2. Cross track scan of ±43°, equivalent to a swath width of 34 km with 716 pixels per scan,

3. Scan rate of 375 rpm (6.25 Hz).

The third and final element of this radiometer system is the data system which is currently restricted to recording 12 channels at 8 bit resolution (more on this later).

In August 1990 I approached Fred Osterwisch (engineering manager at Dædalus Enterprises, Ann Arbor) about the possibility of modifying the

Wildfire spectrometer to convert it into a MODIS-N Airborne Simulator (MAS). After considerable discussion with the MODIS, CERES and FIRE II Science Teams, NASA Headquarters, Ames Research Center, and JPL, there was general consensus to modify 2 of the 4 spectrometer ports of Wildfire (ports 1 and 4). In this manner the wavelength range of this new instrument (MAS) could be extended from 0.55-14.3 µm. This modification will be accomplished in part by replacing the detector array in the first shortwave infrared subassembly, thereby creating a new visible port with a silicon array, and by rotating the grating and replacing the detectors in the fourth (thermal) port in order to extend the wavelength range at both ends of the solar and infrared spectrum.

Table 1 summarizes the channel characteristics of the proposed MAS, together with the corresponding dynamic ranges and noise specifications for the 15 comparable bands of MODIS-N.

The most disappointing aspect of this instrument proposal is the fact that we are currently restricted to using one of the data systems available for this and other Dædalus radiometers at Ames. These data systems permit the recording of only 12 channels out of the available 50 channels, and of recording these channels at 8 bits, rather than 12 bits (as in MODIS-N). Jim Brass is currently looking into various options for upgrading the data system, but a new data system would not likely be available in time for the FIRE campaigns planned for November 1991 and June 1992. As an alternative, the current data system permits the use of one of the recording channels (8 bits) to record 2 bits each from 4 different spectral channels. In this way, after applying software to decode this "bit bucket," it is possible to record 7 spectral channels at 8 bits and 4 channels at 10 bits. This is the configuration planned for the upcoming research missions in 1991 and 1992. Table 1 contains a column indicating the bands and bit resolutions (8 or 10) currently being considered for the ASTEX experiment to be conducted over marine stratocumulus clouds near the Azores in June 1992.

I felt that there was sufficient interest and enthusiasm for this instrument modification to warrant pursuing this proposal, and have thus secured the necessary funds to award a contract to Dædalus to proceed as outlined above.

Prior to the award of this contract, a very informative and productive meeting was held at Dædalus Enterprises in Ann Arbor, MI on April 15, 1991. In addition to Dædalus engineers and managers (Osterwisch, Ory, Stanich), the meeting was attended by Jim Brass and Jeff Myers (Ames Research Center), Paul Menzel and Chris Moeller (University of Wisconsin), and Ken Brown, Peter Abel and me (Goddard Space Flight Center). At this meeting we learned that the Wildfire radiometer needs to fly with the new scanner at Ames (there are 2 scanners but only the new one has a hot blackbody required for calibrating hot, forest fire targets). We also discussed the need to modify the instrument in time for a November 1991 FIRE cirrus experiment, which left woefully little time in the schedule. We decided that only some of the instrument modifications that were planned for a full up MAS could possibly be accommodated in time for this experiment, so we discussed and later revised the wavelength specifications for a temporary instrument (see Table 2). The significant alterations required to meet the November flight schedule are changing the first port to 1 visible channel and lowering the wavelength range of the bands in the thermal port.

Dædalus Enterprises is now under contract to modify the Wildfire Spectrometer and deliver a MODIS-N Airborne Simulator (MAS) according to the specifications given in Tables 2 by November 1991 and Table 1 by April 1992.

Following the meeting in Ann Arbor and just prior to the award of the Goddard MAS Contract, Pat Grant (Ames Research Center) conducted some laboratory tests of the Wildfire Spectrometer delivered to Ames. In addition, this radiometer, which is somewhat larger than previous Dædalus scanners owned and operated by Ames, was integrated into the superpods and Q-bay of the ER-2 aircraft. Based on Grant's laboratory characterization experiments, Arvesen and Brass concurred that this radiometer was too noisy to justify an engineering flight of the ER-2 over normal terrestrial targets. As a consequence this spectrometer has not yet been flown. Instead, it has been returned to Dædalus where it currently resides for modification. Among the recommendations of Ames in their initial evaluation of this instrument were to:

1. Increase preamplifier gain in the majority of the MAS channels to permit normal terrestrial targets to be viewed, leaving low gain amplifiers for only a few channels to be used for hot fire targets,

2. Shield cabling to reduce radio frequency interference (RFI),

3. Reduce power supply induced noise.

Dædalus Enterprises now recognizes the incompatibility of the original system design with the acquisition of data over normal terrestrial targets. During negotiations with Goddard they have agreed to adjust the preamplifier gains and to make all repairs that are necessary to reduce the cable RFI noise and induced power supply noise. These actions are scheduled to be completed for the November flight campaign.

In support of data processing, the MODIS Science Data Support Team is currently developing a system that will ingest Level-1A data and aircraft navigation (INS) data provided by the High Altitude Research Branch at Ames, perform calibration and geolocation, and write the resulting Level-1B data to tape in a common format for viewing imagery. This will be adapted from existing software modules developed at the University of Wisconsin computer system (McIDAS) and will likely be performed on a Silicon Graphics (IRIS) Workstation. At Goddard Space Flight Center the processed Level-1B output data will contain calibrated MAS radiances for every pixel on every scanline and geolocation data for every tenth pixel on every scanline. These output data files will also contain all of the instrument data that were included in the Level-1A data set, as well as the ER-2 INS data for that flight. An archive of the MAS Level-1A and Level-1B data will be maintained at GSFC. Users will be able to order data from MAS flights on either magnetic tape, or by electronic transfer via Internet.

We envision that the shortwave calibration will be performed using the Ames 4 foot integrating sphere as well as the Goddard 6 foot integrating sphere. The first engineering flights of the partially modified MAS spectrometer will likely occur in late October or early November prior to the FIRE cirrus experiment which will be conducted by the ER-2 out of San Antonio, TX from November 13-December 7, 1991. I anticipate that Jim Spinhirne, Ken Brown, Jim Brass, Paul Menzel and I will be in the field for large if not all portions of this experiment. Furthermore, the ASTEX marine stratocumulus experiment is planned for the Azores in the mid-Atlantic from June 1-28, 1992. This experiment requires the fully modified MAS spectrometer. The intervening time (January-April) will be largely devoted to instrument modifications to be performed at Dædalus Enterprises, and thus the MAS spectrometer will not be available for other missions during this time period (e.g., Stormfest).

If you have any further comments or thoughts, especially with regard to which channels you would like to see recorded for either of the FIRE airborne field experiments (or later TOGA/COARE flights), you may contact Ken Brown (MAS Instrument Manager) at (301) 286-3296, or the undersigned at (301) 286-5909 [fax: (301) 286-4804].

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Enclosures

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Figure 1. MODIS-N Airborne Simulator (MAS) Spectral Characteristics.

Record band (bits)	*Band*	λ (µm)	Δλ (µm)	*Spectral range* (µm)	*Intensity* [W/(m^2-µm-sr)]		*SNR*	*Temperature* (K)		*NEDT* (K)
					Maximum	*Typical*		*Maximum*	*Typical*	
	1	0.550	0.040	0.535-0.575	518	21.0	130			
8	2	0.659	0.050	0.634-0.684	685	21.8	260			
	3	0.705	0.040	0.685-0.725						
	4	0.745	0.040	0.725-0.765						
	5	0.785	0.040	0.765-0.805						
	6	0.825	0.040	0.805-0.845						
?	7	0.865	0.040	0.845-0.895	285	24.7	270			
?	8	0.905	0.030	0.890-0.920	185	10.0	80			
	9	0.940	0.050	0.915-0.965	189	15.0	180			
8	10	1.630	0.050	1.605-1.655	70	7.3	200			
	11	1.680	0.050	1.655-1.705						
	12	1.730	0.050	1.705-1.755						
	13	1.780	0.050	1.755-1.805						
	14	1.830	0.050	1.805-1.855						
	15	1.880	0.050	1.855-1.905						
	16	1.930	0.050	1.905-1.955						
	17	1.980	0.050	1.955-2.005						
	18	2.030	0.050	2.005-2.055						
	19	2.080	0.050	2.055-2.105						
8	20	2.130	0.050	2.105-2.155	22	1.0	187			
	21	2.180	0.050	2.155-2.205						
	22	2.230	0.050	2.205-2.255						
	23	2.280	0.050	2.255-2.305						
	24	2.330	0.050	2.305-2.355						
	25	2.380	0.050	2.355-2.405						
	26	3.000	0.150	2.925-3.075						
	27	3.150	0.150	3.075-3.225						
	28	3.300	0.150	3.225-3.375						
	29	3.450	0.150	3.375-3.525						
	30	3.600	0.150	3.525-3.675						
8 or 10	31	3.750	0.150	3.675-3.825	1.71	0.45	115	335	300	1.30
	32	3.900	0.150	3.825-3.975						
	33	4.050	0.150	3.975-4.125						
	34	4.200	0.150	4.125-4.275						
	35	4.350	0.150	4.275-4.325						
?	36	4.500	0.150	4.325-4.575						
?	37	4.650	0.150	4.575-4.725						
	38	4.800	0.150	4.725-4.875						
	39	4.950	0.150	4.875-5.025						
	40	5.100	0.150	5.025-5.175						
	41	5.250	0.150	5.175-5.325						
10	42	8.550	0.500	8.30-8.80	9.59	2.35	71	300	240	0.49
	43	9.650	0.500	9.40-9.90	6.96	2.18	65	280	230	0.54
	44	10.300	0.500	10.15-10.55	13.23	3.06	73	320	240	0.56
10	45	11.030	0.500	10.78-11.28	12.59	3.20	95	320	240	0.46
10	46	12.020	0.500	11.77-12.27	11.54	2.62	79	320	230	0.56
	47	12.700	0.500	12.45-12.95	10.77	2.64	79	320	230	0.59
8	48	13.300	0.500	13.05-13.55	6.14	2.62	78	280	230	0.62
8	49	13.800	0.500	13.55-14.05	3.73	2.59	77	250	230	0.65
8	50	14.300	0.500	14.05-14.55	2.54	2.08	63	230	220	0.77

Figure 2. MODIS-N Airborne Simulator (MAS) Characteristics for FIRE.

Record band (bits)	*Band*	λ (µm)	Δλ (µm)	*Spectral range* (µm)	*Intensity* [W/(m^2-µm-sr)] *Maximum*	*Typical*	*SNR*	*Temperature* (K) *Maximum*	*Typical*	*NEDT* (K)
8	1	0.745	0.010	0.740-0.750	480	10.2	50			
8	2	1.630	0.050	1.605-1.655	70	7.3	200			
	3	1.680	0.050	1.655-1.705						
	4	1.730	0.050	1.705-1.755						
	5	1.780	0.050	1.755-1.805						
	6	1.830	0.050	1.805-1.855						
	7	1.880	0.050	1.855-1.905						
?	8	1.930	0.050	1.905-1.955						
	9	1.980	0.050	1.955-2.005						
	10	2.030	0.050	2.005-2.055						
?	11	2.080	0.050	2.055-2.105						
8	12	2.130	0.050	2.105-2.155	22	1.0	187			
	13	2.180	0.050	2.155-2.205						
	14	2.230	0.050	2.205-2.255						
	15	2.280	0.050	2.255-2.305						
	16	2.330	0.050	2.305-2.355						
	17	2.380	0.050	2.355-2.405						
	18	3.000	0.150	2.925-3.075						
	19	3.150	0.150	3.075-3.225						
	20	3.300	0.150	3.225-3.375						
	21	3.450	0.150	3.375-3.525						
	22	3.600	0.150	3.525-3.675						
8 or 10	23	3.750	0.150	3.675-3.825	1.71	0.45	115	335	300	1.30
	24	3.900	0.150	3.825-3.975						
	25	4.050	0.150	3.975-4.125						
	26	4.200	0.150	4.125-4.275						
	27	4.350	0.150	4.275-4.325						
?	28	4.500	0.150	4.325-4.575						
	29	4.650	0.150	4.575-4.725						
	30	4.800	0.150	4.725-4.875						
	31	4.950	0.150	4.875-5.025						
	32	5.100	0.150	5.025-5.175						
	33	5.250	0.150	5.175-5.325						
10	34	8.800	0.400	8.60-9.00	9.74	2.49	60	300	240	0.59
	35	9.200	0.400	9.00-9.40	9.89	2.68	65	300	240	0.57
	36	9.600	0.400	9.40-9.80	6.95	2.16	52	280	230	0.68
	37	10.000	0.400	9.80-10.20	9.92	2.97	71	300	240	0.56
	38	10.450	0.500	10.20-10.70	9.81	3.09	94	300	240	0.45
10	39	10.950	0.500	10.70-11.20	9.60	3.18	95	300	240	0.45
	40	11.450	0.500	11.20-11.70	9.32	2.58	77	300	230	0.54
10	41	11.950	0.500	11.70-12.20	9.00	2.62	78	300	230	0.56
	42	12.450	0.500	12.20-12.70	8.64	2.64	79	300	230	0.58
8	43	12.950	0.500	12.70-13.20	8.26	2.63	79	300	230	0.60