GEORGIA INSTITUTE OF TECHNOLOGY — OFFICE OF CONTRACT ADMINISTRATION

PROJECT ADMINISTRATION DATA SHEET

[x] ORIGINAL [ ] REVISION NO. _____

Project No. A-3423 GTRI/~~GIT~~ DATE 12/2/82

Project Director: Thomas B. Wells ~~School~~/Lab ECSL /EED

Sponsor: Harris Corporation, Government Electronics Systems Group, Melbourne Divisions

Type Agreement: Purchase Order No. 0217 2058718 dated 11/17/82

Award Period: From 11/19/82 To ~~1/10/83~~ 3/18/83 (Performance) 1/10/83 (Reports)

Sponsor Amount: Total Estimated: $ 5,000 Funded: $ 5,000

Cost Sharing Amount: $ _____ Cost Sharing No: _____

Title: Free Space Reflectance Measurements at Ku and Ka Band Frequencies

ADMINISTRATIVE DATA

OCA Contact Faith G. Costello

1) Sponsor Technical Contact:

R. C. Taylor or J. R. Eriksen
Harris Corp. GESD
Plant 16 - Palm Bay, FL 32905
ATTN: R. C. Taylor, Bldg. 15/605
PH: (305) 727-4155

2) Sponsor Admin/Contractual Matters:

Toni Flores 19/345
Harris Corp. GESD
P.O. Box 96000
Melbourne, FL 32901

Defense Priority Rating: N/A

Military Security Classification: N/A
(or) Company/Industrial Proprietary: _____

RESTRICTIONS

See Attached N/A Supplemental Information Sheet for Additional Requirements.

Travel: Foreign travel must have prior approval – Contact OCA in each case. Domestic travel requires sponsor approval where total will exceed greater of $500 or 125% of approved proposal budget category.

Equipment: Title vests with N/A

COMMENTS:

COPIES TO:

Research Administrative Network
Research Property Management
Accounting
Procurement/EES Supply Services
Research Security Services
Reports Coordinator (OCA)
GTRI
Library
Research Communications (2)
Project File
Other Project Director
Other _____

FORM OCA 4-781 (Rev 9/82)

GEORGIA INSTITUTE OF TECHNOLOGY — OFFICE OF CONTRACT ADMINISTRATION

SPONSORED PROJECT TERMINATION SHEET

Date May 18, 1983

Project Title: Free Space Reflectance Measurements at Ku and Ka Band Frequencies

Project No: A-3423

Project Director: Thomas B. Wells

Sponsor: Harris Corporation

Effective Termination Date: 3/18/83

Clearance of Accounting Charges: 3/18/83

Grant/Contract Closeout Actions Remaining:

- [x] Final Invoice ~~and Closing Documents~~
- [ ] Final Fiscal Report
- [ ] Final Report of Inventions
- [ ] Govt. Property Inventory & Related Certificate
- [ ] Classified Material Certificate
- [ ] Other _____

Assigned to: ECSL/EED (~~School~~/Laboratory)

COPIES TO:

Administrative Coordinator	Research Security Services	EES Public Relations (2)
Research Property Management	~~Reports Coordinator (OCA)~~	Computer Input
Accounting	Legal Services (OCA)	Project File
Procurement/EES Supply Services	Library	Other Wells

FORM OCA 10:781

A-3

ENGINEERING EXPERIMENT STATION
Georgia Institute of Technology
A Unit of the University System of Georgia
Atlanta, Georgia 30332

1 March 1983

Harris Corporation
Government Electronics Systems Group
Melbourne, Divisions
Melbourne, Florida 32901

Attention: Mr. Robert Taylor, 15/417

Reference: Purchase Order No. 0217-2058718
(Georgia Tech Ref. No. A-3423)

Title: "Free Space Reflectance Measurements at Ku and Ka Band Frequencies"

Subject: Initial Measurements

Gentlemen:

This report describes free space Ku- and Ka-band reflectance measurements of highly reflective meshes developed by the Harris Corporation and tabulates the results of measurements to date.

Harris Corporation provided eight numbered mesh samples mounted on fourteen inch square brass frames with a 12-inch by 12-inch opening. Orientations x and y are distinguished since the meshes are not symmetric with respect to 90° rotations. The measurements are to determine the specular reflection for an incidence angle 30° from the normal to the mesh sample. The geometrical configuration is an equilateral triangle with sides of approximately 20 inches and vertices centered on the transmitting horn, receiving horn, and the mesh sample.

In all respects, the measurement procedure is identical to that described in the Final Letter Report of Georgia Tech Project A-3349, Harris P.O. No. 0217-2045903. The measured reflectances are reported in the accompanying data sheets. All numbers are in dB.

Respectfully submitted,

Thomas B. Wells
Project Director

Approved:

Charles E. Ryan, Jr.
Chief,
EM Effectiveness Division

Mesh Reflectance Data (dB)

Band: Ku
Frequency: 15.121
Sample No.: G01
Date: 12/14/82

31/in.

Measurement	Maximum	Minimum	Corrected Mean
X(1)	+0.08	-.84	+.13
X(2)	+.02	-.92	+.06
X(3)	+.06	-.86	+.11
Y(1)	0.00	-.96	+.03
Y(2)	-.02	-.96	+.04
Y(3)	-.02	-.98	+.01
Short	0.01	-1.04	-.12
X(R)	-.08	-1.18	
Y(R)	-.14	-1.24	-.17

x Avg.	+.10
y Avg.	+.03
X(R)	-.12
Y(R)	-.17
Total Avg.	-.04

Mesh Reflectance Data (dB)

Band: Ku
Frequency: 15.121
Sample No.: G02
Date: 12/14/82

31/in.

Measurement	Maximum	Minimum	Corrected Mean
X(1)	0.00	-.94	+.06
X(2)	+0.2	-.92	+.08
X(3)	+0.3	-.92	+.08
Y(1)	-.06	-.99	.00
Y(2)	-.06	-.99	.00
Y(3)	-.06	-.99	.00
Short	0.00	-1.06	
X(R)	-.04	-1.12	-.05
Y(R)	-.06	-1.14	-.07

x Avg.	+.07
y Avg.	+0.0
X(R)	-.05
Y(R)	-.07
Total Avg.	-.01

Mesh Reflectance Data (dB)

Band: Ku
Frequency: 15.121
Sample No.: G03
Date: 12/15/82

31/in.

Measurement	Maximum	Minimum	Corrected Mean
X(1)	+.04	-.94	+.09
X(2)	+.05	-.92	+.10
X(3)	+.08	-.90	+.13
Y(1)	-.08	-.98	+.01
Y(2)	-.12	-1.01	+.02
Y(3)	-.12	-1.0	+.02
Short	-0.00	-1.08	
X(R)	+.02	-1.08	+.01
Y(R)	-.12	-1.26	-.15

x Avg.	+.11
y Avg.	+.02
X(R)	+.01
Y(R)	-.15
Total Avg.	0.00

Mesh Reflectance Data (dB)

Band: Ku
Frequency: 15.121
Sample No.: G04
Date: 12/15/82

31/in.

Measurement	Maximum	Minimum	Corrected Mean
X(1)	+.02	-.96	+.06
X(2)	+.02	-.92	+.08
X(3)	+.02	-.92	+.08
Y(1)	-.12	-1.08	-.07
Y(2)	-.14	-1.08	-.08
Y(3)	-.14	-1.1	-.09
Short	-0.00	-1.06	
X(R)	-.08	-1.18	-.10
Y(R)	-.12	-1.24	-.15

x Avg.	+.07
y Avg.	-.08
X(R)	-.10
Y(R)	-.15
Total Avg.	-.07

Mesh Reflectance Data (dB)

Band: Ku
Frequency: 15.121
Sample No.: G05

Date: 12/15/82

31/in.

Measurement	Maximum	Minimum	Corrected Mean
X(1)	+.14	-.88	+.16
X(2)	+.16	-.86	+.18
X(3)	+.18	-.82	+.21
Y(1)	-.14	-1.19	-.12
Y(2)	-.18	-1.16	-.13
Y(3)	-.18	-1.18	-.14
Short	-.01	-1.08	
X(reverse)	-.02	-1.12	-.03
Y(reverse)	-.24	-1.3	-.23

x Avg.	+.18
y Avg.	-.13
X(R)	-.03
Y(R)	-.23
Total Avg.	-.05

Mesh Reflectance Data (dB)

Band: Ku
Frequency: 15.121
Sample No.: G06
Date: 12/15/82

31/in.

Measurement	Maximum	Minimum	Corrected Mean
X(1)	+.1	-.92	+.12
X(2)	+.1	-.92	+.12
X(3)	+.08	-.92	+.11
Y(1)	-.04	-1.04	-.01
Y(2)	-.04	-1.04	-.01
Y(3)	-.04	-1.04	-.01
Short	0.00	-1.06	
X(rev.)	-.16	-1.16	-.13
Y(rev.)	-.19	-1.18	-.16

x Avg.	+.12
y Avg.	-.01
X(R)	-.13
Y(R)	-.16
Total Avg.	-.05

Mesh Reflectance Data (dB)

Band: Ku
Frequency: 15.121
Sample No.: G07
Date: 12/15/82

31/in.

Measurement	Maximum	Minimum	Corrected Mean
X(1)	+.24	-.74	+.28
X(2)	+.18	-.84	+.20
X(3)	+.19	-.8	+.23
Y(1)	-.06	-1.0	0.00
Y(2)	-.10	-1.04	-.04
Y(3)	-.10	-1.04	-.04
X(R)	0.00	-.99	+.04
Y(R)	-.20	-1.16	-.15
Short	+0.1	-1.08	

x Avg.	+.24
y Avg.	-.03
X(R)	+.04
Y(R)	-.15
Total Avg.	+.02

Mesh Reflectance Data (dB)

Band: Ku
Frequency: 15.121
Sample No.: G08
Date: 12/15/82

31/in.

Measurement	Maximum	Minimum	Corrected Mean
X(1)	+.21	-.66	+.36
X(2)	+.20	-.66	+.36
X(3)	+.20	-.66	+.36
Y(1)	+.10	-.70	+.36
Y(2)	+.08	-.70	+.27
Y(3)	+.09	-.70	+.26
X(R)	-.14	-1.20	+.26
Y(R)	-.12	-1.16	-.10
Short	-.02	-1.16	-.07

x Avg.	+.36
y Avg.	+.26
X(R)	-.10
Y(R)	-.07
Total Avg.	+.11

Mesh Reflectance Data (dB)

Band: Ku
Frequency: 18 GHz
Sample No.: Calibration

Date: 12/13/82

31/in.

Measurement	Maximum	Minimum	Corrected Mean
Short - 1	-.08	-.48	subject to re-test
Short - 4	0.00	-.44	since an alignment
Short - 3	-.04	-.44	problem was observed 12/14/82
Empty Frame	-.22		
Short Behind Frame	+.72	0.00	

x Avg.

y Avg.

Total Avg.

Orientation 4 will be used for reference checks.

Mesh Reflectance Data (dB)

Band: Ku
Frequency: 18
Sample No.: G01
Date: 12/14/82

31/in.

Measurement	Maximum	Minimum	Corrected Mean
X(1)	-.1	-.4	-.11
X(2)	-.14	-.46	-.16
X(3)	-.1	-.42	-.12
Y(1)	-.22	-.52	-.23
Y(2)	-.22	-.52	-.23
Y(3)	-.28	-.6	-.30
Short	0.00	-.29	

x Avg.	-.13
y Avg.	-.25
Total Avg.	-.19

Mesh Reflectance Data (dB)

Band: Ku
Frequency: 18
Sample No.: G02
Date: 12/14/82

31/in.

Measurement	Maximum	Minimum	Corrected Mean
X(1)	-.12	-.42	-.05
X(2)	-.18	-.44	-.09
X(3)	-.16	-.48	-.10
Y(1)	-.24	-.52	-.16
Y(2)	-.22	-.5	-.14
Y(3)	-.22	-.52	-.15
Short	-.04	-.4	

x Avg.	-.08
y Avg.	-.15
Total Avg.	-.12

Mesh Reflectance Data (dB)

Band: Ku
Frequency: 18
Sample No.: G03
Date: 12/14/82

31/in.

Measurement	Maximum	Minimum	Corrected Mean
X(1)	-.04	-.4	-.07
X(2)	-.04	-.4	-.07
X(3)	-.04	-.46	-.08
Y(1)	-.2	-.52	-.21
Y(2)	-.24	-.6	-.27
Y(3)	-.28	-.6	-.29
Short	-0.00	-.3	

x Avg.	-.07
y Avg.	-.26
Total Avg.	-.17

Mesh Reflectance Data (dB)

Band: Ku
Frequency: 18
Sample No.: G04

Date: 12/14/82

31/in.

Measurement	Maximum	Minimum	Corrected Mean
X(1)	-.02	-.38	-.04
X(2)	+0.00	-.36	-.02
X(3)	-.02	-.34	-.02
Y(1)	-.18	-.48	-.17
Y(2)	-.2	-.5	-.19
Y(3)	-.18	-.5	-.18
Short	0	-.32	

x Avg.	-.03
y Avg.	-.18
Total Avg.	-.22

Mesh Reflectance Data (dB)

Band: Ku
Frequency: 18
Sample No.: G05
Date: 12/14/82

Measurement	Maximum	Minimum	Corrected Mean
X(1)	-.02	-.42	-.08
X(2)	-.04	-.42	-.09
X(3)	-.04	-.42	-.09
Y(1)	-.24	-.58	-.27
Y(2)	-.2	-.52	-.22
Y(3)	-.24	-.56	-.26
Short	+.02	-.3	

x Avg.	-.09
y Avg.	-.25
Total Avg.	-.17

Mesh Reflectance Data (dB)

Band: Ku
Frequency: 18
Sample No.: G06

Date: 12/14/82

31/in.

Measurement	Maximum	Minimum	Corrected Mean
X(1)	0.00	-.32	-.01
X(2)	+.02	-.3	+.01
X(3)	+0.00	-.3	.00
Y(1)	-.2	-.48	-.19
Y(2)	-.2	-.5	-.2
Y(3)	-.2	-.49	-.2
Short	0.00	-.3	

x Avg.	0.0
y Avg.	-.2
Total Avg.	-.10

Mesh Reflectance Data (dB)

Band: Ku
Frequency: 18
Sample No.: G07
Date: 12/14/82

31/in.

Measurement	Maximum	Minimum	Corrected Mean
X(1)	-.04	-.38	-.06
X(2)	-.04	-.38	-.06
X(3)	-.06	-.4	-.08
Y(1)	-.28	-.52	-.25
Y(2)	-.28	-.56	-.27
Y(3)	-.28	-.52	-.25
Short	-.01	-.3	

x Avg.	-.07
y Avg.	-.26
Total Avg.	-.17

Mesh Reflectance Data (dB)

Band: Ku
Frequency: 18
Sample No.: G08

Date: 12/14/82

31/in.

Measurement	Maximum	Minimum	Corrected Mean
X(1)	0.00	-.32	+0.5
X(2)	0.00	-.32	+.05
X(3)	0.00	-.34	+.04
Y(1)	-.22	-.48	-.14
Y(2)	-.2	-.49	-.14
Y(3)	-.26	-.54	-.19
Short	-.06	-.36	

x Avg.	+.05
y Avg.	-.16
Total Avg.	-.06

Mesh Reflectance Data (dB)

Band: Ku **Date:** 11/22/82
Frequency: 26.5
Sample No.: Short, empty frame

	Measurement	Maximum	Minimum	Corrected Mean
	Short (1)	0.00	-.38	
	Short (2)	0.00	-.38	
	Short (3)	0.00	-.38	
11/23	Short (4)	0.00	-.42	
	Empty frame (1)	-24.6		
	Empty frame (2)	-25.8		
	Empty frame (3)	-25.9		
11/23	Plate behind frame	-.12	-.64	

x Avg.

y Avg.

Total Avg.

Mesh Reflectance Data (dB)

Band: Ka
Frequency: 26.5
Sample No.: G01

Date: 11/23/82

31/in.

Measurement	Maximum	Minimum	Corrected Mean
			0, -.40
X(1)	-.08	-.58	-.14
X(2)	-.2	-.64	-.22
X(3)	-.2	-.64	-.22
Y(1)	-.26	-.8	-.33
Y(2)	-.32	-.8	-.36
Y(3)	-.38	-.8	-.39

x Avg.	-.19
y Avg.	-.36
Total Avg.	-.28

Mesh Reflectance Data (dB)

Band: Ka
Frequency: 26.5
Sample No.: G03

Date: 11/23/82

31/in.

Measurement	Maximum	Minimum	Corrected Mean
		(Short	0, -.42)
X(1)	-.08	-.48	-.07
X(2)	-.01	-.4	0.00
X(3)	-.3	-.42	-.02
Y(1)	-.49	-.76	-.42
Y(2)	-.46	-.88	-.46
Y(3)	-.48	-.84	-.45

x Avg.	-.03
y Avg.	-.44
Total Avg.	-.24

Mesh Reflectance Data (dB)

Band: Ka
Frequency: 26.5
Sample No.: G02
Date: 11/22/82

31/in.

Measurement	Maximum	Minimum	Corrected Mean
			ref. 0, -.38
X(1)	-.04	-.3	+.02
X(2)	-.04	-.32	+.01
X(3)	-.1	-.4	-.06
Y(1)	-.32	-.64	-.29
Y(2)	-.31	-.59	-.26
Y(3)	-.32	-.61	-.28

x Avg.	-.01
y Avg.	-.28
Total Avg.	-.15

Mesh Reflectance Data (dB)

Band: Ka
Frequency: 26.5
Sample No.: G04
Date: 11/23/82

31/in.

	Measurement	Maximum	Minimum	Corrected Mean
	X(1)	-.2	-.68	-.23
11/24	X(2)	-.08	-.64	-.15
11/24	X(3)	-.04	-.6	-.11
	Y(1)	-.6	-1.0	-.59
11/24	Y(2)	-.44	-.94	-.48
11/24	Y(3)	-.56	-.99	-.57

x Avg.	-.16
y Avg.	-.55
Total Avg.	-.36

Mesh Reflectance Data (dB)

Band: Ka
Frequency: 26.5
Sample No.: G05
Date: 11/24/82

31/in.

Measurement	Maximum	Minimum	Corrected Mean
X(1)	+.02	-.56	-.08
X(2)	+.02	-.56	-.08
X(3)	+.04	-.54	-.08
Y(1)	-.44	-1.00	-.51
Y(2)	-.42	-.98	-.49
Y(3)	-.44	-.99	-.51

x Avg.	-.08
y Avg.	-.50
Total Avg.	-.29

Mesh Reflectance Data (dB)

Band: Ka
Frequency: 26.5
Sample No.: G06
31/in.

Date: 11/24/82

Measurement	Maximum	Minimum	Corrected Mean
X(1)	-.12	-.7	-.20
*X(2)	-.01	-.52	-.06
X(3)	-.01	-.52	-.06
Y(1)	-.6	-1.12	-.65
*Y(2)	-.5	-.98	-.53
Y(3)	-.5	-.99	-.54

x Avg.	-.11
y Avg.	-.57
Total Avg.	-.34

*Recalibrated short after X(1), Y(1)

Mesh Reflectance Data (dB)

Band: Ka
Frequency: 26.5
Sample No.: G07
Date: 11/24/82

31/in.

Measurement	Maximum	Minimum	Corrected Mean
X(1)	+.08	-.48	-.07
X(2)	+0.06	-.5	-.07
X(3)	+0.08	-.46	-.06
Y(1)	-.6	-1.0	-.59
Y(2)	-.58	-1.0	-.58
*Y(3)	-.49	-9.8	-.53

x Avg.	-.07
y Avg.	-.57
Total Avg.	-.32

There were 2 runs in the material.

*Y(3) was done on the peak and null closer to target. Using the next set, the figures for Y(2) were repeated.

Mesh Reflectance Data (dB)

Band: Ka
Frequency: 26.5
Sample No.: G08
Date: 11/24/82

31/in.

Measurement	Maximum	Minimum	Corrected Mean
X(1)	-.2	-.72	-.25
X(2)	-.18	-.72	-.24
X(3)	-.2	-.78	-.29
Y(1)	-.24	-.8	-.31
Y(2)	-.28	-.81	-.34
Y(3)	-.28	-.8	-.33

x Avg.	-.26
y Avg.	-.33
Total Avg.	-.29

Mesh Reflectance Data (dB)

Band: Ka
Frequency: 35
Sample No.: Short, empty frame

Date: 11/29/82

Measurement	Maximum	Minimum	Corrected Mean
Short (1)	-0.00	-.4	
Short (2)	-0.00	-.4	
Frame (1)	-27.4		
Plate behind frame (1)	*0.00	-.44	

x Avg.

y Avg.

Total Avg.

Mesh Reflectance Data (dB)

Band: Ka
Frequency: 35
Sample No.: G02

Date: 11/29/82

31/in.

Measurement	Maximum	Minimum	Corrected Mean
X(1)	-.2	-.64	-.22
X(2)	-.2	-.64	-.22
X(3)	-.2	-.64	-.22
Y(1)	-.48	-1.02	-.55
Y(2)	-.46	-1.0	-.53
Y(3)	-.48	-.96	-.52

x Avg.	-.22
y Avg.	-.53
Total Avg.	-.37

Mesh Reflectance Data (dB)

Band: Ka
Frequency: 35
Sample No.: G02
Date: 11/29/82

31/in.

Measurement	Maximum	Minimum	Corrected Mean
X(1)	-.2	-.68	-.24
X(2)	-.2	-.66	-.23
X(3)	-.2	-.64	-.22
Y(1)	-.48	-1.02	-.55
Y(2)	-.48	-1.02	-.55
Y(3)	-.48	-1.03	-.56

x Avg.	-.23
y Avg.	-.55
Total Avg.	-.39

Mesh Reflectance Data (dB)

Band: Ka
Frequency: 35
Sample No.: G03
Date: 11/29/82

31/in.

Measurement	Maximum	Minimum	Corrected Mean
X(1)	-.2	-.64	-.22
X(2)	-.2	-.64	-.22
X(3)	-.18	-.52	-.15
Y(1)	-.72	-1.16	-.74
Y(2)	-.70	-1.04	-.67
Y(3)	-.70	-1.08	-.69

x Avg.	-.20
y Avg.	-.70
Total Avg.	-.45

Mesh Reflectance Data (dB)

Band: Ka
Frequency: 35
Sample No.: G04
Date: 11/29/82

31/in.

Measurement	Maximum	Minimum	Corrected Mean
X(1)	-.24	-.6	-.22
X(2)	-.22	-.59	-.20
X(3)	-.2	-.6	-.20
Y(1)	-.72	-1.04	-.68
Y(2)	-.72	-1.06	-.69
Y(3)	-.70	-1.08	-.69

x Avg.	-.21
y Avg.	-.69
Total Avg.	-.45

Mesh Reflectance Data (dB)

Band: Ka
Frequency: 35
Sample No.: G05

Date: 11/29/82

31/in.

Measurement	Maximum	Minimum	Corrected Mean
X(1)	-.16	-.56	-.16
X(2)	-.16	-.58	-.17
X(3)	-.16	-.59	-.18
Y(1)	-.70	-1.08	-.69
Y(2)	-.70	-1.1	-.70
Y(3)	-.69	-1.12	-.70

x Avg.	-.17
y Avg.	-.70
Total Avg.	-.44

Mesh Reflectance Data (dB)

Band: Ka
Frequency: 35
Sample No.: G06

Date: 11/30/82

31/in.

Measurement	Maximum	Minimum	Corrected Mean
X(1)	-.28	-.52	-.20
X(2)	-.2	-.46	-.13
X(3)	-.19	-.46	-.13
Y(1)	-.56	-.84	-.50
Y(2)	-.72	-1.02	-.67
Y(3)	-.68	-.99	-.64
*X(4)	-.24	-.56	-.20
*Y(4)	-.74	-1.05	-.70

x Avg.	-.20*
y Avg.	-.70
Total Avg.	-.45

*Putting up short after 1, 2 & 3's were taken signal was .1 off so I recalibrated and took one more set.

Mesh Reflectance Data (dB)

Band: Ka
Frequency: 35
Sample No.: G07
Date: 11/30/82

31/in.

Measurement	Maximum	Minimum	Corrected Mean
X(1)	-.08	-.4	-.04
X(2)	-.06	-.42	-.04
X(3)	-.08	-.48	-.08
Y(1)	-.61	-.98	-.60
Y(2)	-.6	-.96	-.58
Y(3)	-.62	-.94	-.58

x Avg.	-.05
y Avg.	-.59
Total Avg.	-.32

Mesh Reflectance Data (dB)

Band: Ka
Frequency: 35
Sample No.: G08
Date: 11/30/82

31/in.

Measurement	Maximum	Minimum	Corrected Mean
X(1)	-.24	-.64	-.24
X(2)	-.22	-.64	-.23
X(3)	-.24	-.64	-.24
Y(1)	-.4	-.78	-.39
Y(2)	-.4	-.79	-.40
Y(3)	-.4	-.79	-.40

x Avg.	-.24
y Avg.	-.40
Total Avg.	-.32

Mesh Reflectance Data (dB)

Band: Ka
Frequency: 40
Sample No.: Short, frame

Date: 11/30/82

Measurement	Maximum	Minimum	Corrected Mean
Short	0.00	-.84	
Empty Frame	-32.4		
Short behind frame	-.02	-.84	

x Avg.

y Avg.

Total Avg.

Mesh Reflectance Data (dB)

Band: Ka
Frequency: 40
Sample No.: G01
31/in.

Date: 11/30/82

Measurement	Maximum	Minimum	Corrected Mean
X(1)	-.39	-1.1	-.33
X(2)	-.36	-1.2	-.36
X(3)	-.28	-1.02	-.22
Y(1)	-.68	-1.36	-.60
Y(2)	-.68	-1.36	-.60
Y(3)	-.63	-1.34	-.57

x Avg.	-.30
y Avg.	-.59
Total Avg.	-.45

Frame is too wide in x direction. Made repeatability hard.

Mesh Reflectance Data (dB)

Band: Ka
Frequency: 40
Sample No.: G02
Date: 11/30/82

31/in.

	Measurement	Maximum	Minimum		Corrected Mean	
	X(1)	-.24	-.98		-.19	
	X(2)	-.22	-.96		-.17	
	X(3)	-.2	-.96		-.16	
	Y(1)	-.64	-1.32		-.56	
	Y(2)	-.64	-1.32		-.56	
	Y(3)	-.62	-1.3		-.54	
12/1/82	X(1)	-.36	-.88	-.28		
	X(2)	-.26	-.86	-.22	-.24	
	X(3)	-.24	-.86	-.21		
	Y(1)	-.68	-1.22	-.61		-.43
	Y(2)	-.7	-1.24	-.63	-.62	
	Y(3)	-.68	-1.24	-.63		
	Short	0.00	-.69			

x Avg.	-.17
y Avg.	-.55
Total Avg.	-.36

Sample has some small holes (other than the 31/in.)

Mesh Reflectance Data (dB)

Band: Ka
Frequency: 40
Sample No.: G03
Date: 12/1/82

31/in.

Measurement	Maximum	Minimum	Corrected Mean
Short	0.00	-.72	
X(1)	-.44	-1.0	-.36
X(2)	-.44	-.98	-.35
X(3)	-.46	-.96	-.35
Y(1)	-1.2	-1.6	-1.04
Y(2)	-1.12	-1.54	-.98
Y(3)	-1.2	-1.58	-1.03

x Avg.	-.35
y Avg.	-1.02
Total Avg.	-.69

Sample too wide in Y direction

Mesh Reflectance Data (dB)

Band: Ka
Frequency: 40
Sample No.: G04
Date: 12/1/82

31/in.

Measurement	Maximum	Minimum	Corrected Mean
Short	0.00	-.72	
X(1)	-.12	-.88	-.14
X(2)	-.12	-.8	-.10
X(3)	-.12	-.8	-.10
Y(1)	-.8	-1.44	-.76
Y(2)	-.8	-1.4	-.74
Y(3)	-.8	-1.41	-.75

x Avg.	-.11
y Avg.	-.75
Total Avg.	-.43

Mesh Reflectance Data (dB)

Band: Ka
Frequency: 40
Sample No.: G05

Date: 12/1/82

31/in.

Measurement	Maximum	Minimum	Corrected Mean
Short	0.00	-.64	
X(1)	-.08	-.68	-.06
X(2)	-.04	-.72	-.06
X(3)	-.02	-.70	-.04
Y(1)	-.66	-1.26	-.64
Y(2)	-.66	-1.26	-.64
Y(3)	-.64	-1.28	-.64

x Avg.	-.05
y Avg.	-.64
Total Avg.	-.35

Mesh Reflectance Data (dB)

Band: Ka
Frequency: 40
Sample No.: G06
Date: 12/1/82

31/in.

Measurement	Maximum	Minimum	Corrected Mean
Short	0.00	-.68	
X(1)	-.04	-.72	-.04
X(2)	-.06	-.74	-.06
X(3)	-.04	-.76	-.06
Y(1)	-.78	-1.36	-.73
Y(2)	-.78	-1.38	-.74
Y(3)	-.78	-1.36	-.73

x Avg.	-.05
y Avg.	-.73
Total Avg.	-.39

Mesh Reflectance Data (dB)

Band: Ka
Frequency: 40
Sample No.: G07
Date: 12/1/82

31/in.

Measurement	Maximum	Minimum	Corrected Mean
Short	0.00	-.66	
X(1)	-.08	-.78	-.10
*X(2)	+0.	-.6	+.03*
X(3)	-.16	-0.8	-.15
Y(1)	-.66	-1.2	-.60
Y(2)	-.74	-1.32	-.70
Y(3)	-.76	-1.3	-.70
X(4)	-.08	-.82	-.12

To replace X(2)

x Avg.	-.12
y Avg.	-.67
Total Avg.	-.40

*Redid short here to see what happened

min.	max.
0	-.8

Mesh Reflectance Data (dB)

Band: Ka
Frequency: 40
Sample No.: G08

Date: 12/1/82

31/in.

Measurement	Maximum	Minimum	Corrected Mean
Short	0.00	-.7	
X(1)	-.24	-.92	-.23
X(2)	-.24	-.94	-.24
X(3)	-.24	-.92	-.23
Y(1)	-.62	-1.22	-.57
Y(2)	-.6	-1.22	-.56
Y(3)	-.62	-1.24	-.58
Short	0.00	-.72	

x Avg.	-.23
y Avg.	-.57
Total Avg.	-.40

ENGINEERING EXPERIMENT STATION
Georgia Institute of Technology
A Unit of the University System of Georgia
Atlanta, Georgia 30332

1 April 1983

Harris Corporation
Government Electronics Systems Group
Melbourne Divisions
Melbourne, Florida 32901

Attention: Robert Taylor, 15/417

Reference: Purchase Order No. 0217-2058718
(Georgia Tech Ref. No. A-3423)

Title: Free Space Reflectance Measurements at Ku- and Ka-band Frequencies

Subject: Final Letter Report

Gentlemen:

This report describes free space Ku- and Ka-band reflectance measurements of highly reflective meshes developed by the Harris Corporation and tabulates the results of measurements to date.

Harris Corporation provided eight numbered mesh samples mounted on fourteen inch square brass frames with a 12-inch by 12-inch opening. Orientations x and y are distinguished since the meshes are not symmetric with respect to 90° rotations. The measurements are to determine the specular reflection for an incidence angle 30° from the normal to the mesh sample. The geometrical configuration is an equilateral triangle with vertices centered on the transmitting horn antenna, receiving horn antenna, and the mesh sample. Alignment of the boresight directions of the transmitting and receiving horns is accomplished by aiming a laser through one of the horns, reflecting the laser beam by a mirror in the plane of the mesh sample, and verifying that the laser beam is centered in the other horn. To facilitate the fine angular adjustments necessary in aligning the system, the mesh sample and the receiving horn are mounted on tripods. This also allows the system to be well above the floor reducing ground reflections. The transmitting system is mounted on a stable platform that has a precision manual drive to accurately move the transmitting antenna toward or away from the sample and a 2-inch travel, 1 mil accuracy dial indicator to monitor the displacement.

In the course of the above referenced project, the Ku- and Ka-band reflectance of the above samples has been measured twice. The first series of measurements was performed in accordance with the procedure described in the Final Letter Report associated with P. O. No. 217-2045903 (Georgia Tech No. A-3349) and results have been previously transmitted. The second series of measurements was made after four of the mesh samples had been subjected to corrosion testing. The remaining four mesh samples served as a control. It is the second set of measurements, which incorporate measurement and processing of the amplitude and phase of the field, that is discussed below.

In both the Ku- and Ka-band measurements, the receiving system consists of a standard gain horn, an isolator and a diode detector. Signal detection is by a Scientific Atlanta 1780 digital receiver controlled by a Hewlett-Packard 9835 calculator. The mesh is held by a U-shaped mount attached to a tripod. The mount is designed to clamp the edge of the frame between the body of the mount and thin metal plates held on by set screws. The face of the mount is covered by a strip of Eccosorb LS 14 absorber to minimize reflections from the mount. The mesh sample is backed by a sheet of low density styrofoam when direct reflection measurements are made. The styrofoam eliminates motions of the mesh due to random small air currents passing through the mesh and the styrofoam backing has a negligible effect on the measured reflection. Transmission measurements were also made to support the reflection measurements and for these it was not appropriate to use a styrofoam backing sheet.

Error terms are minimized by working in the near-field of the transmitting and receiving horns at such a distance that the frame is not illuminated strongly. The specific separation of the horns from the mesh sample, nominally 20 inches for both Ku-band and Ka-band, was calculated so that the first null in the H-plane pattern of the standard gain horns should be on the frame at a mid-band frequency. The measured reflection from a bare frame was -46 dB below that of a flat plate at the lowest Ku-band frequency and -35 dB at the lowest Ka-band frequency. The measured reflection decreased within each band with increasing frequency (and hence increasing directivity).

The transmitting system consisted of a standard gain horn, a directional coupler and detector to provide a reference signal and a Weinschel sweep generator. The sweep generator is coupled to an E.I.P. locking counter controlled by the HP calculator to provide a precise, stable frequency, phase-locked signal. A Ka-band head with a waveguide output port is used with the Weinschel sweep generator.

The centers of the transmitting and receiving horns and of the mesh sample lie in the same horizontal plane. The transmitted (and received) polarization is vertical. For each sample at each frequency for both x and y orientation of the sample, the reflection measurements are made while incrementing the transmitter to sample separation by $\lambda/2$ steps. (The x or y orientation of the sample is specified by the side of the frame labeled x or y being parallel to the floor. The mesh is on the side of the frame away from the measurement apparatus.) Consistent with the 2-inch travel of the dial indicator, it is possible to make 6 measurements at each Ku-band frequency and 8 measurements at each Ka-band frequency. The k_o component of the Fourier Transform of this measurement record is compared to the k_o component of the return from the flat plate as obtained by the same type linear translation.

The transmission of the mesh samples is measured in an analogous fashion. For Ku-band, the mesh sample was inserted between the flat plate and the receiving horn with its normal at an angle of 30^o to the transmission path. For Ka-band, it was convenient (within geometrical constraints) to perform the more direct transmission measurement with the transmit and receive horns facing each other and the mesh in between them. The transmission measurements are not corrected for background.

The measurement results are tabulated at the end of this discussion in Tables I and II. These respectively list the Ku- and Ka-band results. The column labeled $|R|$ is obtained as described above by translating the transmitting horn in $\lambda/2$ steps with corrections for the background given by the return from the bare metal frame. The column labeled $|T|$ lists the comparison of the k_o components of the Fourier Transform for the $\lambda/2$ stepped measurements with and without the mesh sample in the transmission path. The remaining column, $|R_{Max}|$, is computed directly from the values of $|T|$. Specifically,

$$T = 20 \cdot \log |E_T| \tag{1}$$

$$|E_{Max}|^2 = 1 - |E_T|^2 \tag{2}$$

and

$$R_{Max} = 20 \log |E_{Max}| \ . \tag{3}$$

Equation (1) simply relates the transmitted field magnitude E_T and the transmission T in dB, for a unit incident field. The quantity E_{Max} defined by Equation (2) is from conservation of power, the power not transmitted. If all the power represented by $|E_{Max}|$ is reflected, none

absorbed or diffracted, then the reflection coefficient (consistent with observed transmission) is a maximum and is given in dB by Equation (3).

The transmission measurements are much less sensitive to alignment errors and give a more realistic and reproducible measure of the net reflection performance than the direct measurements of reflectance.

Respectfully submitted,

Thomas B. Wells
Project Director

Approved:

Charles E. Ryan, Jr.
Chief,
EM Effectiveness Division

TABLE I

Computed Results Corrected for Background in dB

	15.121			17.9		
	| R |	| T |	$\| R_{Max} \|$	| R |	| T |	$\| R_{Max} \|$
G01XKU	+.42	-18.85	-.06	+.09	-18.34	-.06
G01YKU	+.26	-13.49	-.20	-.28	-14.68	-.15
G02XKU	+.12	-17.04	-.09	-.16	-18.56	-.06
G02YKU	+.22	-13.55	-.20	-.23	-14.44	-.16
G03XKU	+.17	-19.87	-.04	+0.9	-21.30	-.03
G03YKU	-.09	-13.31	-.21	-.04	-11.34	-.33
G04XKU	+.21	-22.32	-.02	-.57	-19.44	-.05
G04YKU	+.21	-14.36	-.16	-.53	-11.58	-.31
G05XKU	+.38	-21.65	-.03	-.14	-18.88	-.06
G05YKU	+.09	-14.49	-.16	-.78	-11.68	-.30
G06XKU	+.43	-22.09	-.03	-.50	-19.17	-.05
G06YKU	+.18	-14.39	-.16	-.53	-11.61	-.31
G07XKU	+.16	-20.66	-.04	-.39	-17.82	-.07
G07YKU	+.16	-14.75	-.15	-.60	-12.09	-.28
G08XKU	+.25	-20.41	-.04	-.28	-17.77	-.07
G08YKU	+.28	-14.88	-.14	+0.4	-12.08	-.28

TABLE II

Computed Results Corrected for Background in dB

	26.51			35			40	
	|R|(dB)	|T|(dB)	$\|R_{Max}\|$	|R|	|T|	$\|R_{Max}\|$	|R|	|T|	$\|R_{Max}\|$
G01XKA	-.12	-12.32	-.26	-.46	-11.76	-.30	+.50	-11.80	-.30
G01YKA	-.12	-8.90	-.60	-.76	-8.36	-.68	-1.15	-8.33	-.69
G02XKA	-.17	-12.25	-.27	-.46	-11.66	-.31	-.13	-11.63	-.31
G02YKA	-1.97	-8.82	-.61	-.80	-8.29	-.70	-.53	-8.33	-.69
G03XKA	-.12	-14.79	-.15	-.76	-14.30	-.16	-.14	-14.39	-.16
G03YKA	-.38	-7.37	-.88	-.98	-6.87	-1.00	-.94	-6.86	-1.00
G04XKA	-.22	-15.39	-.13	-.60	-14.87	-.14	+.09	-14.98	-.14
G04YKA	-.46	-7.58	-.83	-1.22	-7.09	-.94	-.78	-7.12	-.93
G05XKA	-.13	-14.80	-.15	-.34	-14.22	-.17	+.08	-14.23	-.17
G05YKA	-.46	-7.74	-.80	-1.22	-7.20	-.92	-.66	-7.22	-.91
G06XKA	-.21	-17.23	-.08	-.58	-14.79	-.15	+.04	-14.23	-.14
G06YKA	-.47	-7.73	-.80	-1.10	-7.16	-.93	-.86	-7.23	-.91
G07XKA	-.10	-13.56	-.20	-.32	-12.88	-.23	+.27	-12.92	-.23
G07YKA	-.43	-8.16	-.72	-1.06	-7.57	-.84	-2.59	-7.67	-.81
G08XKA	-.26	-13.67	-.19	-.53	-12.99	-.22	+.14	-13.27	-.21
G08YKA	-.33	-8.59	-.65	-.81	-7.96	-.76	-.48	-8.17	-.72
TBLOCK		- 60.	-.000003		- 58.	-.000006		- 64	-.000001