

[Supplementary material]

Succeeding CORONA: declassified HEXAGON intelligence imagery for archaeological and historical research

Emily Hammer^{1,*}, Mackinley FitzPatrick² & Jason Ur²

¹ Department of Near Eastern Languages and Civilizations & Price Lab for the Digital Humanities, University of Pennsylvania, USA

² Anthropology Department, Harvard University, USA

* Author for correspondence ✉ ehammer@sas.upenn.edu

Table S1. Comparison of HEXAGON MCS and main cameras, GAMBIT and CORONA (sources: Dashora *et al.* 2007; www.usgs.gov).

| Program | Years active | Maximum ground resolution (m) | Nominal ground coverage (km) | Mission life (days) | Film size (inches) | No. of missions | No. of film recovery vehicles | Declassification year | Declassified archive (No. of scenes) | USGS Earth Explorer Collection |
|------------------|--------------|-------------------------------|------------------------------|---------------------|----------------------------------|-----------------------|-------------------------------|-----------------------|--------------------------------------|--------------------------------|
| CORONA KH-4A | 1963–1969 | 2.7–7.6 | 17 × 232 | 4–15 | 2.75 × 29.8 | 52 (94 recoveries) | 2 | 1995 | c. 700 000 combined | Declass1 |
| CORONA KH-4B | 1967–1972 | 1.8–7.6 | 14 × 188 | 19 | 2.75 × 29.8 | 17 (32 recoveries) | 2 | 1995 | | Declass1 |
| GAMBIT KH-7 | 1963–1967 | 0.61–0.91; 1.2 before 1966 | Variable | 1–8 | 9 × variable length (4 in–500ft) | 38 (30 w/usable film) | 2 | 2002 | c. 18 000 | Declass2 |
| HEXAGON KH-9 PCS | 1971–1984 | 0.61–1.2 | up to 24 × 685 | 45–220 | 6.5 × variable length | 20 (19 successful) | 4 | 2011 | c. 2 000 000 | Declass3 |

| | | | | | | | | | | |
|---------------------|---------------|---------|-----------|-----|--------|----|---|------|-----------|----------|
| HEXAGON KH-9 MCS | 1973– 1980 | 6.0–9.0 | 130 × 260 | 120 | 9 × 18 | 12 | 1 | 2002 | c. 29 000 | Declass2 |
|---------------------|---------------|---------|-----------|-----|--------|----|---|------|-----------|----------|

Table S2. Hexagon mission characteristics and statistics, with a focus on the returns of the main camera system. RV = Recovery capsules. B&W = Black and white (sources: National Reconnaissance Office 1978: 59 & 71; National Photographic Interpretation Center 1977; Chester 1985; Oder *et al.* 1992: 117–19).

| Block | Mission number | Orbital Parameters | Launch | Deorbit | RV-1 | RV-2 | RV-3 | RV-4 | RV-5 (MCS) | Active phase duration (days) | Film captured (linear feet) | PCS photographic coverage (million sq nautical miles) | PCS average ground resolution (ft) | PCS film types used | Notes |
|-------|----------------|---|---------|---------|-------------|-------------|-------------|-------------|------------|------------------------------|-----------------------------|---|------------------------------------|---------------------|---|
| | | Inclination (°) Perigee/Apogee (nautical miles) | | | | | | | | | | | | | |
| I | 1201 | 96.4 99.3/165.1 | 6/15/71 | 8/6/71 | 6/20 /71 | 6/26 /71 | 7/10 /71 | 7/16 /71 | – | 31 | 175601 | 15.9 | 3.5 | 1414 (B&W) | RV-3 lost |
| | 1202 | 97.0 86.1/188.7 | 1/20/72 | 2/28/72 | 1/26 /72 | 2/8/ 72 | 2/17 /72 | 2/28 /72 | – | 41 | 156192 | 21.1 | 2.8 | 1414 (B&W) | Forward camera failed 1202-2, monoscopic operation in 1202-3 and 1202-4 |
| | 1203 | 96.9 95.5/137.3 | 7/7/72 | 9/13/72 | 7/15 /72 | 7/29 /72 | 8/12 /72 | 9/12 /72 | – | 57 | 185325 | 26.4 | 3.1 | 1414 (B&W) | Film path disturbances 1203-3, |

| | | | | | | | | | | | | | | |
|------|--------------------|---------------|---------------|----------|---------|---------|---------|---------|-----|--------|------|-----|---|--|
| | | | | | | | | | | | | | | monoscopic operation in 1203-4 |
| 1204 | 96.5 85.3/156.6 | 10/10/73 2 | 1/8/73 | 10/21/72 | 11/5/72 | 11/2/72 | 12/1/72 | - | 69 | 218346 | 18.8 | 3.4 | 1414 (B&W) + 10 000ft of SO-255 (colour) | Degraded photography due to yaw error 1204-2 |
| 1205 | 95.7 85.3/158.5 | 3/9/73 | 5/18/73 | 3/21/73 | 4/5/73 | 4/19/73 | 5/11/73 | 4/21/73 | 64 | 218338 | 17.5 | 2.4 | 1414 (B&W) + 2000 ft of SO-255 (colour) | |
| 1206 | 96.2 87.7/154.4 | 7/13/73 | 10/12/73 3 | 8/1/73 | 8/14/72 | 9/8/73 | 9/25/73 | 9/24/73 | 74 | 212432 | 18.9 | 2.9 | 1414 (B&W) + 21 000ft of SO-255 (colour) + 500ft of SO-130 (infrared) | |
| 1207 | 96.9 88.7/154.4 | 11/10/73 3 | 3/13/74 | 11/24/73 | 12/1/73 | 1/13/74 | 2/20/74 | 1/8/74 | 103 | 213633 | 18 | 2.7 | 1414 (B&W) + 4984ft of SO-255 (colour) + 500ft of SO-130 (infrared) | |
| 1208 | 94.5 85.5/164.0 | 4/10/74 | 7/28/74 | 4/23/74 | 5/21/74 | 6/26/74 | 7/24/74 | 6/9/74 | 106 | 215693 | 16.6 | 2.5 | 1414 (B&W) + 2588ft of SO- | |

II

| | | | | | | | | | | | | | | |
|------|--------------------|--------------|---------|--------------|--------------|-------------|-------------|--------------|-----|--------|------|-----|--|--|
| | | | | | | | | | | | | | 255 (colour) + 500ft of SO-130 (infrared) | |
| 1209 | 96.7 85.3/155.7 | 10/29/7 4 | 3/18/75 | 11/1 7/74 | 12/2 3/74 | 1/21 /75 | 3/7/ 75 | 12/27/7 4 | 130 | 228619 | 18.6 | 2.1 | 1414 (B&W) + 8150ft of SO- 255 (colour) + 3400ft of SO-130 (infrared) | |
| 1210 | 96.4 88.8/157.0 | 6/8/75 | 10/5/75 | 6/24 /75 | 7/29 /75 | 9/4/ 75 | 10/6 /75 | 7/30/75 | 121 | 225691 | 17.4 | 2.3 | 1414 (B&W) + 3750ft of SO- 124 (higher resolution B&W) + 9150ft of SO- 255 (colour) + 3150ft of SO- 130 (infrared) | MCS power relay failure, limited performance |
| 1211 | 96.3 90.0/138.3 | 12/4/75 | 4/1/76 | 1/7/ 76 | 1/27 /76 | 2/21 /76 | 3/29 /76 | 2/2/76 | 117 | 167685 | 23.1 | 2.4 | 1414 (B&W) + 4500ft of SO- 208 (B&W) + 4500ft of SO-255 (colour) + 4500ft of SO- | Aft camera failure on day 20; resumed operation in 1211-4 |

| | | | | | | | | | | | | | | | |
|-----|------|--------------------|---------|----------|---------|---------|---------|---------|----------|-----|--------|--------------|----------------|---|--|
| | | | | | | | | | | | | | 130 (infrared) | | |
| | 1212 | 97.0 90.1/138.0 | 7/8/76 | 12/13/76 | 8/3/76 | 9/6/76 | 10/1/76 | 12/9/76 | 9/8/76 | 155 | 237425 | 17.9 | 2.3 | 1414 (B&W) + 4500ft of SO-255 (colour) + 4500ft of SO-130 (infrared) | Power problem 1212-1, limited terrain 1212-2 |
| III | 1213 | 97.0 90.5/138.1 | 6/27/77 | 12/23/77 | 8/2/77 | 9/5/77 | 11/4/77 | 12/1/77 | 10/17/77 | 176 | 239331 | Not reported | 2.6 | 1414 (B&W) + 20 000 ft of SO-208 (B&W) + 17 000ft of SO-460, 464, Aerial 15 (higher resolution B&W) + 3500ft of SO-255 (colour) + 5500ft of SO-130 (infrared) | B-side shutter problem 1213-1 |
| | 1214 | Not reported | 3/16/78 | 9/11/78 | 4/20/78 | 6/1/78 | 7/22/78 | 9/9/78 | 7/11/88 | 178 | 249630 | Not reported | 2.1 | SO-208 | |
| | 1215 | Not reported | 3/16/79 | 9/22/79 | 4/26/79 | 6/16/79 | 7/31/79 | 9/19/79 | 7/12/79 | 188 | 295750 | Not reported | Redacted | SO-315 | |

| | | | | | | | | | | | | | | |
|------------|--------------|---------|--------------|-------------|-------------|--------------|--------------|--------------|--|-----------------|--------------|---------------------------------------|--------|--|
| | | | | /79 | /79 | /79 | /79 | | | | | from Chester (1985) | | |
| 1216 | Not reported | 6/18/80 | 3/6/81 | 7/24 /80 | 9/7/ 80 | 10/2 4/80 | 3/5/ 81 | 10/14/8 0 | 261 | 295248 | Not reported | Redacted from Chester (1985) | SO-315 | |
| 1217 | Not reported | 5/11/82 | 12/5/82 | 6/15 /82 | 8/2/ 82 | 9/29 /82 | 11/3 0/82 | - | 204 | 303527 | Not reported | Redacted from Chester (1985) | SO-315 | Forward camera (A) failure on day 190; monoscopic coverage with B for remainder of mission |
| 1218 | Not reported | 6/20/83 | 3/21/84 | 8/24 /83 | 11/7 /83 | 1/9/ 84 | 3/16 /84 | - | 270 | 307733 | Not reported | 2 | SO-315 | |
| IV 1219 | Not reported | 6/25/84 | 10/11/8 4 | 8/5/ 84 | 9/24 /84 | 10/1 1/84 | not used | - | 115 mission; active days unknown | Not reported | Not reported | Not reported | | Serious failures in PPMU-A,B caused early mission termination |
| 1220 | - | 4/18/86 | - | - | - | - | - | - | 0 | 0 | 0 | Not reported | N/A | Entire |

