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BONE DEMINERALIZATION DURING THE GEMINI IV, V, VII MISSIONS

Texas Woman's University

REPORT ON EXPERIMENT M-6

THE EFFECT OF SPACE FLIGHT

ON BONE DEMINERALIZATION

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Texas Woman's University

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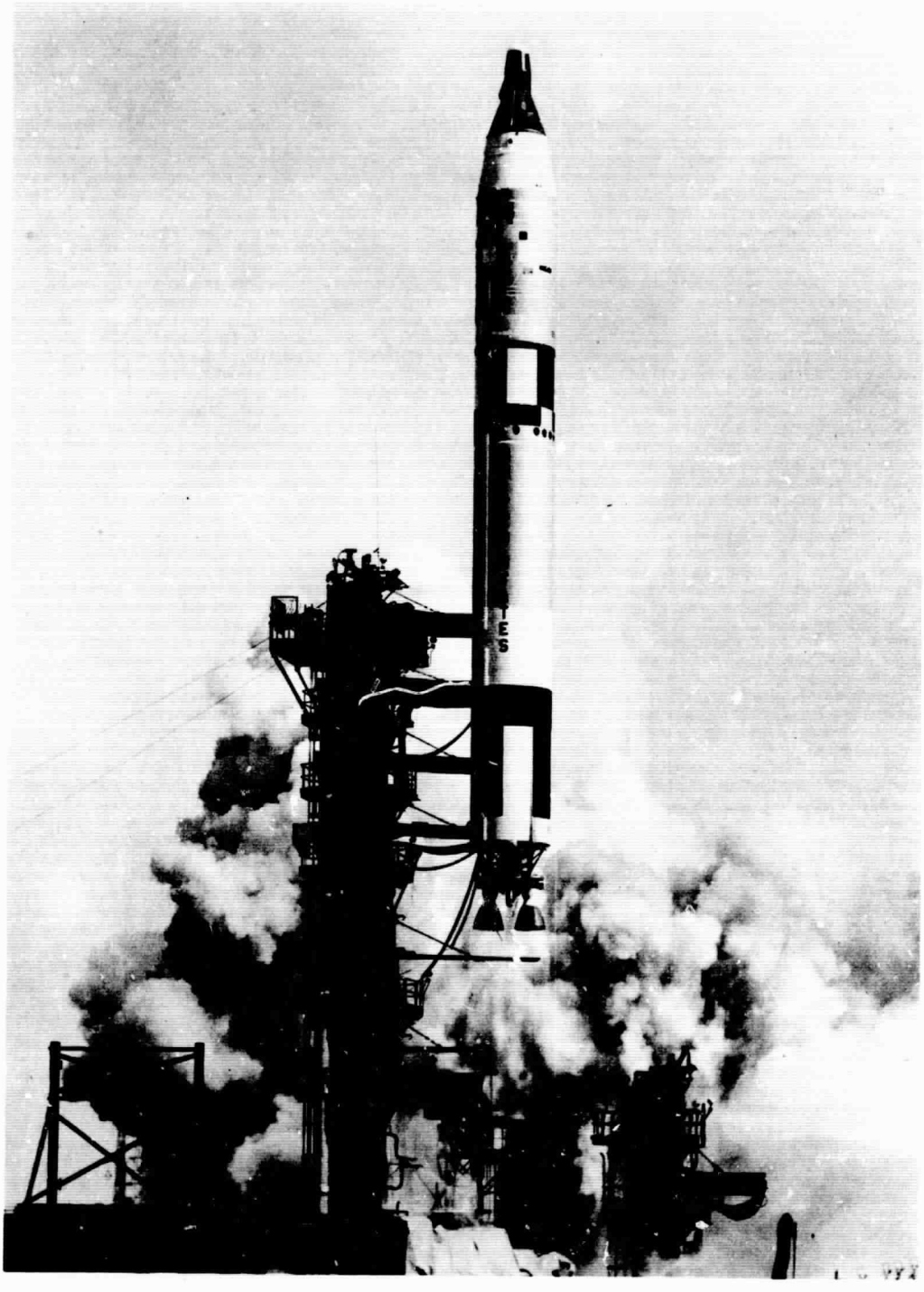
Frontispiece:

THE TITAN ROCKET WAS USED TO LAUNCH MANY OF THE GEMINI FLIGHTS. IN THIS ILLUSTRATION, THE NATIONAL AERONAUTICS AND SPACE ADMINISTRATION IS LAUNCHING THE GEMINI V SPACECRAFT FROM PAD 19 AT 9 A.M. (EST) AUGUST 21, 1965 ON A PLANNED EIGHT-DAY ORBITAL MISSION.

Photo, Courtesy National Aeronautics
and Space Administration



FOREWORD

This study is a part of a NASA investigation of the effect of space flight on bone demineralization. It was sponsored by NASA Manned Spacecraft Center under Contract NAS9-3687, with Dr. Paul A. LaChance of the Biomedical Specialties Branch of the Biomedical Research Office serving as the Manned Spacecraft Center Investigator.

This study was conducted in the Nelda Childers Stark Laboratory for Human Nutrition Research, a component part of the Texas Woman's University Research Institute. The following constituted the investigators:

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INTRODUCTION

It long has been known that immobilization or extended bed rest induces a general decrease in bone mass in the skeletal system. Does the prolonged weightlessness of space flight induce an even greater bone mass decrease? Experiment M-6 was designed to determine the extent of bone mass loss experienced during space flight and the rate of recovery of bone mass postflight. The method employed in these investigations consisted of radiographic bone densitometry, with the crew members of Gemini flights IV, V, and VII serving as subjects (1) (2) (3) (4). Calibrated and standardized radiographs were made at various times both preflight and postflight. By radiographing anatomical sites with a limited amount of soft tissue, the x-ray image of the bone was maximized. The radiographs were analyzed by a special analog computer to determine x-ray absorbency; and the data were reported in terms of changes in x-ray equivalent calibration wedge mass which could be converted to changes in calcium hydroxyapatite, the chief component of skeletal mineral. Decreases in x-ray absorbency indicated a decrease in bone mass; increases indicated bone mass recovery.

METHODS

EVALUATION OF BONE MASS CHANGES

The radiographic bone densitometric technique used in these studies was that developed by Mack and colleagues, reported first in

1938 and 1939 (5) (6). The instrumentation and basic methodology employed in measuring bone mass in this investigation have been described by Mack (7) (8), by Mack, Vose, and Nelson (9), and by Vogt, Mack, Beasley, Spencer, Cardus, and Valbonna (10).

Calibration of exposed films is effectuated by placing an aluminum alloy reference wedge on each film adjacent to the bone to be evaluated. The alloy in the wedge was selected because it exhibited an x-ray absorption coefficient similar to that of bone. The wedge serves as a means of correcting any bone scan which is traced, by first correcting the trace of the wedge for deviations resulting from slight differences in film characteristics or development techniques.

Bone mass is determined first as wedge mass equivalency. The wedge has been calibrated in terms of calcium hydroxyapatite $\left[3Ca_3(PO_4)_2 \cdot Ca(OH)_2\right]$ by x-raying the wedge on the same films with a series of quantities of the hydroxyapatite encased in thin walled leucite containers. In this way the values obtained from scanning certain sections of bone can be equated in terms of mass of calcium hydroxyapatite, the major mineral component of bone by means of a conversion factor.

The changes in bone mass given in this report do not denote changes in calcium alone, but of the chief mineral complex of bone, together with water-organic components of the bone itself as well as of

over- and under-lying soft tissue. In the major anatomical sites chosen for the x-ray measurements, soft tissue has only a slight effect upon the results because conditions of exposure are chosen so as to minimize the effect of organic materials and to maximize that of the mineral components.

Under the conditions of exposure used in this study, the mass absorption coefficients for calcium hydroxyapatite and soft tissue, respectively, have been measured as 0.70 and 0.17, with the soft tissue effect reduced further by the comparatively small amount present. In all evaluations made in this study the thickness of under- and over-lying soft tissue did not change, as shown by radiographs made at right angles to the films used for evaluations of density. Therefore, the changes reported are regarded as representing the bone sections scanned.

STANDARDIZATION OF X-RAY MACHINES

When more than one x-ray machine is used in taking serial radiographs that are to be used quantitatively for comparative purposes, the x-ray units and procedures must be standardized. This is the case with the astronauts who are filmed at Cape Kennedy three to four times over a 10-day period before their orbital flight, on the aircraft carrier immediately after recovery from a flight, usually a second time on the carrier, and later at the NASA Manned Spacecraft Center in Houston until they regain any lost skeletal mineral.

The methods used for the standardization of radiographs made on more than one x-ray unit are as follows: (a) a Victoreen roentgen meter is used immediately before making a radiograph to determine the calibrated kilovoltage which would produce identical x-ray beam qualities with all x-ray units used; and (b) at each testing period a phantom composed of a simulated os calcis made of calcium hydroxyapatite in an organic matrix is radiographed before and after each series of radiographs made at any one time. For the os calcis, for example, milliamperes, kilovolts, and time are set in such a way as to give an exposure level of 167 ± 2 milliroentgens for each radiograph which is made.

ANATOMIC SITES INVESTIGATED

The radiographs made on the astronauts have consisted of exposures of the hand in posterior-anterior aspect, and of the foot in lateral projection. For purposes of comparison of bone mass losses during orbital flight and during bed rest, the same anatomical sites were x-rayed in both series of tests, and scans were made by means of the densitometer assembly in the same location.

The anatomic sites at which bone sections were scanned included a single section of the central os calcis (Figure 1), multiple parallel scans covering approximately 60 per cent of the os calcis (Figure 2), a single section across the talus (Figure 1), parallel crosswise sections covering hand phalanges 4-2 and 5-2 (Figure 3), a section across the distal end

of the radius, and a single diagonal section across the capitate among the wrist carpals (Figure 3).

Figure 4 shows a cross-section of the os calcis at the position at which the "conventional" segment is scanned.

Cancellous or trabecular tissue is represented in a major area of the os calcis and in the central portion of hand phalanx 4-2 and phalanx 5-2. Cortical or compact tissue is present in the perimeter of all of the individual bones, and is found in generous amounts in the distal end of the os calcis.

Central Os Calcis Section. - The tracing path across the left os calcis ran diagonally between conspicuous posterior and anterior landmarks. By superimposing successive radiographs, this path was reproduced accurately in serial films of the same individual. This single path (1.3 millimeters in width) is known as the "conventional scan." It is a revealing site for measuring bone mass changes, as it is a highly trabecular area with a periphery of cortical bone (Figures 1 and 4).

Multiple Parallel Os Calcis Evaluations. - Approximately 60 per cent of the total os calcis mass was evaluated in the parallel path system, as noted. After the conventional scan was made, the parallel paths were scanned, 1.0 millimeter apart from center of scan to center of scan. These began 1 millimeter above the conventional path and continued to

the lowest portion of the bone. The total number of paths scanned was proportional to the size of the bone and therefore varied with the individual. Figure 3 illustrates the alignment of parallel paths through the os calcis.

Sections of Hand Phalanges 4-2 and 5-2. - The second phalanx of the fourth and the fifth finger of the left hand were scanned by parallel cross-sectional paths 1 millimeter from center of scan to center of scan. These paths were aligned tangentially with the longitudinal axis, covering the entire bone area (Figure 3).

Distal End of Radius. - A single scanning path was made through the diaphysis of the left radius parallel to the distal surface (Figure 3).

Section of Talus. - A single scanning path was made through the talus of the left foot originating at the inferior surface and projecting anteriorly to the conspicuous landmark shown in Figure 1.

Section of Capitate. - A section the width of the scanning beam was traced across the wrist carpal capitate. It followed a diagonal line from a point above the capitate-hamate joint on the left to a point at the lower right which avoided the scaphoid (Figure 3).

Figure 1. - Reproduction of positive of the lateral radiograph of the Gemini V command pilot indicating conventional scanning paths of os calcis and talus.

Figure 2. - This illustrates the alignment of parallel paths through the position of the os calcis examined for the pilot of Gemini V covering approximately 60 per cent of this bone.

Figure 3. - Positive of hand radiograph of the Command Pilot of Gemini VII in posterior-anterior projection, showing position of parallel traces on phalanges 5-2 and 4-2 and the scanning path on the capitate. The edges of the scans slightly overlap each other and cover the entire bone in each phalanx.

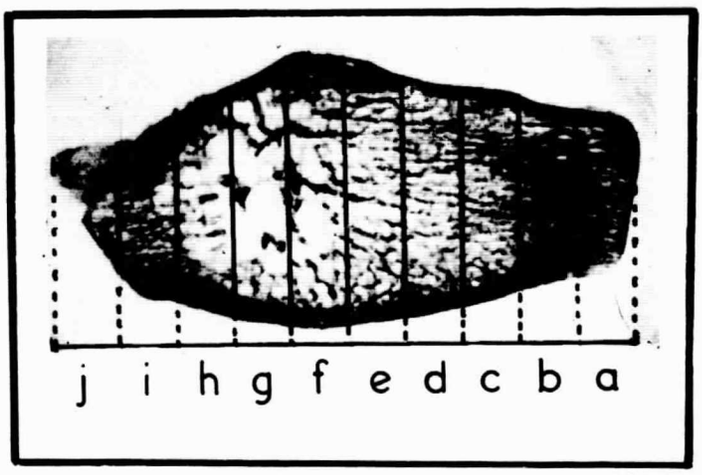


Figure 4. - Cross-section of os calcis at the position at which the "conventional" segment is scanned

SCHEDULE OF GEMINI RADIOGRAPHS

In the three units of the study completed to date, a series of roentgenograms was made of the left foot in lateral projection and of the left hand in posteroanterior projection of each astronaut preflight and postflight according to the following time schedule:

Gemini IV - preflight at 9 days and 3 days before lift off, respectively, at Cape Kennedy and on the morning of lift off also at the Cape; postflight immediately after recovery on the aircraft carrier U.S.S. Wasp and at Manned Spacecraft Center, Houston, 16 days and again 50 days following recovery. The length of this orbital flight was 4 days.

Gemini V - preflight at 10 days, 4 days, and 2 days before lift off, and on the morning of lift off at Cape Kennedy; postflight immediately after recovery and again 24 hours later on the aircraft carrier U.S.S. Lake Champlain, and at Manned Spacecraft Center, Houston, at 10 days and 66 days following termination of the flight. The length of this orbital flight was 8 days.

Gemini VII - preflight at 10 days and 3 days and on the day of launch at Cape Kennedy; postflight immediately after recovery and again 24 hours later on the aircraft carrier U.S.S.

Wasp, and at Manned Spacecraft Center, Houston, 11 days and 47 days following recovery. The length of this space flight was 14 days.

RESULTS

GENERAL COMPARATIVE FINDINGS

Representative data obtained from the three units of the investigation of bone demineralization during space flight are given in Summaries A, B, and C. Summary A gives the per cent change in the sections which were evaluated at the different anatomic sites for the crew members of the Gemini IV, Gemini V, and Gemini VII missions, respectively. Summary B shows the magnitude of the changes in the various multiple sections of the os calcis, with Summary C also giving the same findings for the parallel sections of hand phalanx 5-2 for the three groups of astronauts.

COMPARISON OF SKELETAL MASS LOSSES IN DIFFERENT ANATOMIC SITES

Summary A shows that two men on the same orbital flight exhibited individual differences in skeletal density changes, although certain trends are found between the flights themselves. The astronauts of the Gemini VII space flight experienced far lower over-all bone mass losses, for example, than did the men of the other two groups, although theirs was the longest orbital flight.

SUMMARY A

PER CENT CHANGE IN BONE MASS AT MAJOR ANATOMIC SITES OF ASTRONAUTS OF GEMINI IV, GEMINI V, AND GEMINI VII MISSIONS

Anatomic Position of Section Evaluated	Per Cent Change in Bone Mass (In terms of calibration wedge mass equivalency)					
	Gemini IV (from 6/3/65 to 6/7/65)		Gemini V (from 8/21/65 to 8/29/65)		Gemini VII (from 12/4/65 to 12/18/65)	
	Command Pilot	Pilot	Command Pilot	Pilot	Command Pilot	Pilot
Conventional Os Calcis Section	-7.80	-10.30	-15.10	-8.90	-2.91	-2.84
Multiple Os Calcis Sections	-6.82	-9.25	-10.27	-8.88	-2.46	-2.54
Range of Changes in Multiple Os Calcis Sections	From -1.50 to -9.73	From -2.08 to -13.42	From +3.55 to -29.52	From +0.55 to -13.76	From -0.49 to -5.17	From +1.39 to -7.66
Section of Talus	-10.69	-12.61	-13.24	-9.87	-7.06	-4.00
Multiple Sections of Hand Phalanx 5-2	-11.85	-6.24	-23.20	-16.98	-6.78	-7.83
Range of Changes in Hand Phalanx 5-2	From -4.4 to -12.2	From -0.5 to -14.3	From -19.6 to -26.1	From -0.4 to -22.1	From -1.84 to -12.07	From -2.19 to -14.86
Multiple Sections of Hand Phalanx 4-2	-4.19	-8.65	-9.86	-11.80	-6.55	-3.82
Range of Changes in Hand Phalanx 4-2	From -1.28 to -11.27	From +0.49 to -15.28	From -6.00 to -13.10	From 5.30 to -16.90	From -2.88 to -9.11	From -1.66 to 8.54
Section of Capitate	-4.48	-17.64	-17.10	-16.80	-4.31	-9.30

When the losses in all of the anatomic locations which were tested were pooled for each astronaut, those on the three missions ranked in this order:

Rank 1. Lowest negative bone mass changes, crew of Gemini VII (14 days).

Rank 2. Intermediate negative bone mass changes, crew of Gemini IV (4 days).

Rank 3. Highest negative bone mass changes, crew of Gemini V (8 days).

When the skeletal sites of the feet were evaluated, the rank order of per cent loss in bone mass was the same as that for all of the sites combined. The same rank was found for the bones of the hand.

Central Os Calcis Section. The scanning path across the left os calcis in lateral projection runs diagonally between conspicuous posterior and anterior landmarks which, by superimposing successive roentgenograms over the first film of a series can be reproduced accurately in serial films of the same individual. This single path (1.3 mm. in width), called the "conventional scan" sustained losses in bone mass (in terms of calibration wedge mass equivalency) in this section of 7.80 and 10.27 per cent for the command pilot and the pilot, respectively, for the astronauts of the Gemini IV mission; 15.10 and 8.78 for those of Gemini V; and 2.91 and 2.84 for those of Gemini VII. By setting the computer to scan the

sections in 10 subdivisions across the entire path of this section in each case, it was found that the losses were not uniform throughout the entire central os calcis section from the posterior to the anterior end. This is understandable when the illustration of the cross-section of this bone at the position of this scan is examined in Figure 4.

Multiple Parallel Os Calcis Sections. Approximately 60 per cent of the total os calcis mass is evaluated in the parallel path system, as noted. After making the "conventional" scan, a series of parallel paths 1.0 millimeter from center-to-center of the scans were traced, beginning one millimeter above the conventional path and continuing to the lowest portion of the bone. The total number of paths scanned depends upon the size of the bone which, of course, has individual variations. Summary B shows that the number of individual scans required to cover the desired space varied from 35 for the command pilot of Gemini V to 41 for the pilot of Gemini VII.

There was variance not only in the segments of the sections evaluated across the os calcis, but between the over-all changes in the different sections of the 60 per cent of the os calcis which was covered by the scans. Losses in these sections varied from one to another, which is understandable in view of the high proportion of trabecular tissue in this bone which is shown in roentgenographic studies to be highly dynamic. Summary B shows a wide range of changes between the multiple sections of the os calcis for each astronaut in this study.

SUMMARY B

COMPARISON OF PER CENT CHANGES IN THE MULTIPLE PARALLEL SECTIONS OF THE OS CALCIS OF THE ASTRONAUTS OF GEMINI IV, GEMINI V, AND GEMINI VII MISSIONS

Position of Tracing	Gemini IV Per Cent Change in 4 days		Gemini V Per Cent Change in 8 days		GeminiVII Per Cent Change in 14 days	
	Command Pilot	Pilot	Command Pilot	Pilot	Command Pilot	Pilot
1 mm. above Conventional	−7.09	−9.80	−14.10	−8.70	−3.99	−3.13
1 mm. below	−7.80	−10.27	−15.10	−8.78	−2.91	−2.84
2 mm. below	−7.26	−10.30	−11.04	−7.00	−3.00	−2.81
3 mm. below	−5.47	−9.04	−10.05	−7.97	−3.50	−2.08
4 mm. below	−6.91	−10.27	−11.10	−8.17	−3.09	−2.43
5 mm. below	−7.91	−10.95	−11.49	−8.66	−2.99	−3.88
6 mm. below	−6.42	−12.29	−13.81	−8.51	−2.87	−2.64
7 mm. below	−7.05	−10.98	−14.68	−7.90	−3.04	−1.13
8 mm. below	−8.14	−10.54	−13.94	−8.53	−3.85	−1.79
9 mm. below	−7.84	−10.43	−29.52	−10.48	−5.17	−2.01
10 mm. below	−7.72	−8.99	−17.45	−8.49	−3.82	−1.93
11 mm. below	−9.18	−13.12	−21.64	−9.69	−2.84	−3.34
12 mm. below	−7.09	−11.92	−20.84	−9.03	−3.97	−3.35
13 mm. below	−7.93	−9.36	−12.77	−8.62	−3.55	−2.33
14 mm. below	−8.35	−8.52	−12.26	−9.26	−3.10	−2.33
15 mm. below	−8.27	−10.29	−8.13	−9.21	−1.45	−2.73
16 mm. below	−3.04	−11.18	−4.83	−8.65	−2.06	−1.01
17 mm. below	−5.19	−11.82	−4.34	−9.99	−1.53	−2.10
18 mm. below	−6.69	−13.42	−7.94	−8.03	−2.78	−4.38
19 mm. below	−7.21	−11.65	−7.63	−9.96	−1.57	−7.66
20 mm. below	−6.48	−9.56	−9.86	−9.81	−1.90	−4.01
21 mm. below	−8.98	−9.65	−8.20	−13.76	−1.82	−0.27
22 mm. below	−7.67	−9.80	−8.42	−12.47	−1.18	−0.56
23 mm. below	−9.73	−8.45	−9.03	−13.27	−0.51	−1.01
24 mm. below	−6.78	−8.08	−9.21	−13.42	−0.49	+1.39
25 mm. below	−9.04	−10.33	−3.85	−12.36	−0.86	−0.68
26 mm. below	−6.74	−8.31	+2.16	−10.80	−0.96	−2.05
27 mm. below	−4.75	−7.16	+3.09	−10.03	−1.34	−4.77
28 mm. below	−4.34	−4.26	+3.55	−8.07	−1.10	−3.69
29 mm. below	−2.84	−6.16	+2.65	−8.98	−1.53	−3.23
30 mm. below	−3.06	−3.83	−1.05	+0.55	−1.72	−2.09
31 mm. below	−1.50	−2.08	−3.25	−6.44	−1.72	−1.45
32 mm. below	−3.87	−2.96	−5.43	−7.54	−0.95	−2.93
33 mm. below	−4.42	−3.41	−2.66	−10.15	−1.51	−4.72
34 mm. below	−5.15	−4.55	−12.56	−8.21	−0.54	−2.30
35 mm. below	−6.24	−2.63	−10.69	−6.21	−1.48	−3.81
36 mm. below	−8.81	−2.80	X	−12.69	−1.97	−2.44
37 mm. below	X	−7.57	X	X	−2.76	−5.63
38 mm. below	X	−10.82	X	X	X	−3.96
39 mm. below	X	−10.18	X	X	X	−2.51
40 mm. below	X	X	X	X	X	−2.06
Mean Change	−6.82	−9.25	−10.23	−9.10	−2.46	+8.22
						−2.54

Talus Section. A single scanning path was made through the talus of the left foot originating at the inferior surface and projecting anteriorly to the conspicuous landmark shown in Figure 1. The section of the talus that was evaluated, consisting of cancellous skeletal tissue chiefly, experienced losses in bone mass which generally were somewhat higher than was found in the central section of the os calcis.

Hand Phalanges 4-2 and 5-2. The second phalanx of the left hand in the fourth and fifth fingers was scanned by parallel cross-sectional paths 1.0 millimeter from center of scan to center of scan, aligned tangentially with the longitudinal axis and covering the entire bone area in each case. Both bones exhibited wide ranges of skeletal mass loss in the different sections.

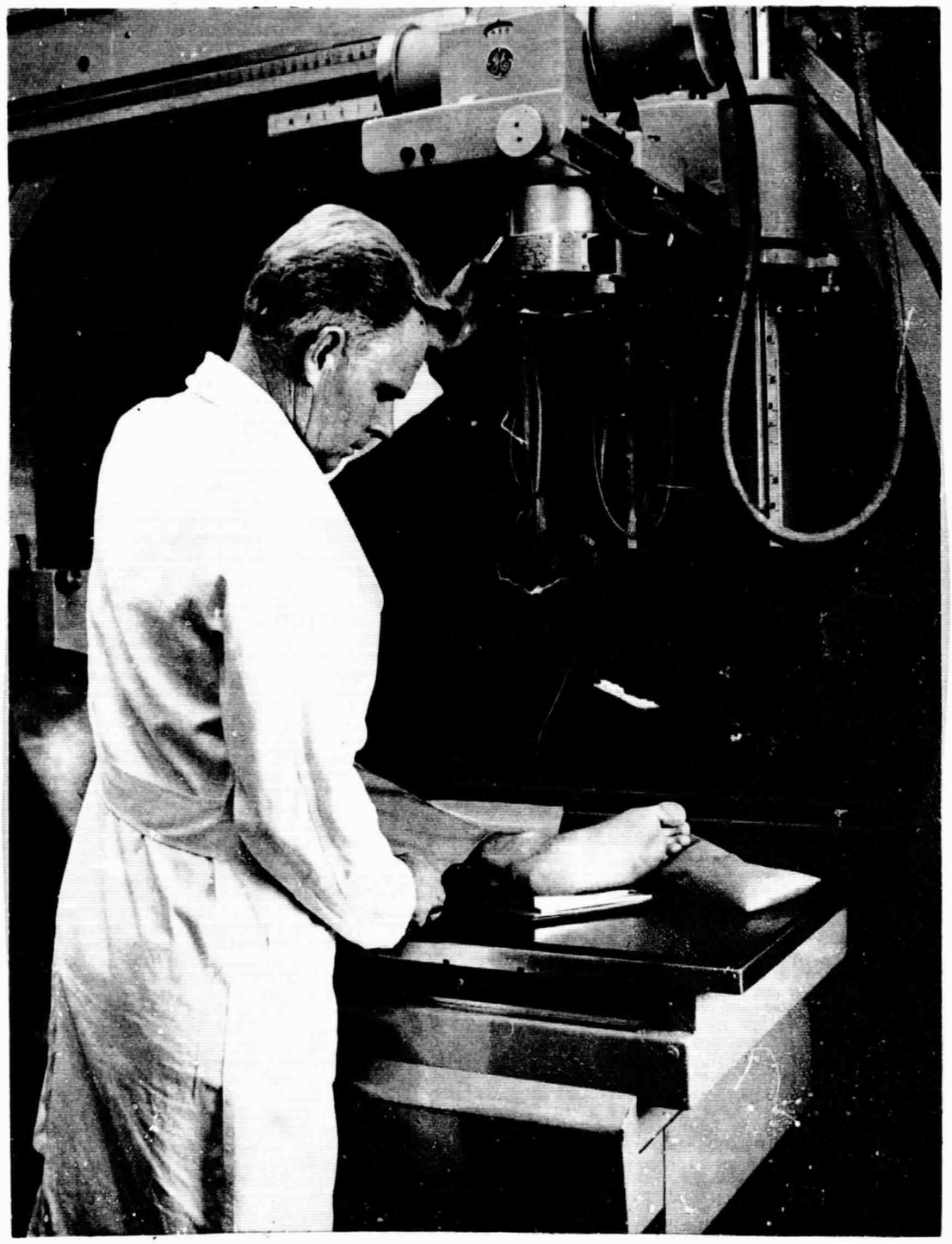
The losses in each of the parallel sections of hand phalanx 5-2 are shown in Summary C.

Capitate Section. In the diagonal section of the capitate which was evaluated in the site shown in Figure 3, losses were greatest in the astronauts of the Gemini V mission and least in those in Gemini VII.

SUMMARY C

COMPARISON OF PER CENT CHANGES IN THE MULTIPLE PARALLEL SECTIONS OF HAND PHALANX 5-2 OF THE COMMAND PILOT AND PILOT DURING GEMINI IV, GEMINI V, AND GEMINI VII MISSIONS

Anatomic Position of Section	Per Cent Change in Bone Mass (in Terms of Grams of Calibration Wedge Mass Equivalency)					
	Gemini IV (from 6/3/65 to 6/7/65)		Gemini V (from 8/21/65 to 8/29/65)		Gemini VII (from 12/4/65 to 12/18/65)	
	Command Pilot	Pilot	Command Pilot	Pilot	Command Pilot	Pilot
Distal End of Phalanx	-9.7	-4.9	-22.2	-18.3	-4.6	-10.9
1 mm. above	-9.6	-14.3	-22.3	-19.0	-9.3	-3.3
2 mm. above	-9.5	-8.3	-21.5	-17.7	-8.3	-10.5
3 mm. above	-10.3	-2.4	-22.9	-22.1	-10.4	-10.5
4 mm. above	-10.1	-0.5	-20.6	-20.2	-12.1	-12.2
5 mm. above	-10.2	-1.9	-19.6	-20.9	-6.8	-6.5
6 mm. above	-9.8	-3.8	-21.3	-18.3	-3.5	-14.9
7 mm. above	-6.2	-3.5	-21.9	-19.6	-1.8	-7.8
8 mm. above	-4.4	-3.4	-23.3	-17.9	-3.3	-6.3
9 mm. above	-3.5	-5.1	-23.1	-22.0	-4.7	-5.0
10 mm. above	-7.6	-3.3	-23.5	-17.3	-4.3	-4.2
11 mm. above	-7.8	-4.6	-23.5	-15.8	-3.8	-3.5
12 mm. above	-10.7	-7.1	-24.2	-14.2	-4.9	-2.2
13 mm. above	-12.2	-5.5	-26.1	-15.5	-6.2	-2.3
14 mm. above	-10.6	-5.4	-24.3	-0.4	-10.7	-4.2
15 mm. above	-11.7	-5.1	-24.3	-14.7	-8.9	-2.5
16 mm. above	X	-7.5	-23.8	-16.5	-8.4	-7.9
17 mm. above	X	-8.4	-25.9	X	-7.1	X
Mean Change	-9.0	-5.3	-23.0	-17.1	-6.6	-6.7



Positioning a subject for making a radiograph of the os calcis in lateral projection of the foot. The subject is protected by plastic vinyl coverings impregnated with a lead compound.

GEMINI IV DETAILED FINDINGS

Comparative results from the three orbital flights covered in this report (Gemini IV, V, and VII, missions) have been shown in Summaries A, B, and C in the Introduction. This and the two following sections give more details of the bone densitometric findings from the three missions.

Central Section of the Os Calcis, Gemini IV. The x-ray absorption values (in terms of calibration wedge mass equivalency) obtained from the central os calcis section (the "conventional" segment of this bone) throughout the Gemini IV study are shown in Table I, Parts A and B (Appendix) and in Figure 5. Table I (Appendix) includes the data as read from the computer in integrator counts, with the results converted to calibration wedge mass equivalency in grams in the last column of each part of the table.

Based on the immediate preflight and the immediate postflight radiographs, the command pilot showed a -7.80 per cent change in bone density. The corresponding value for the pilot was -10.27 per cent.

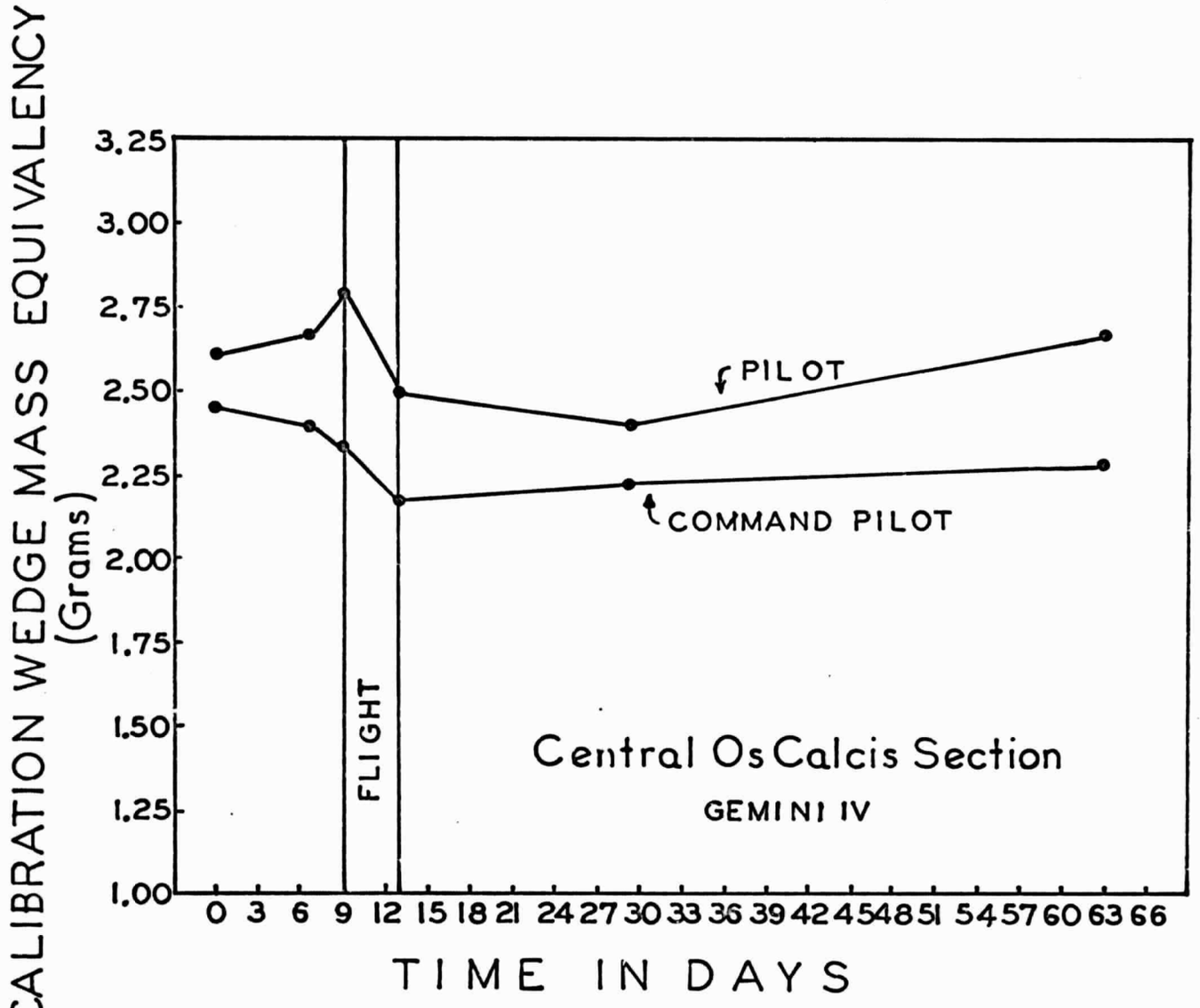


FIGURE 5. CHANGES IN THE CALIBRATION WEDGE MASS EQUIVALENCY OF THE CENTRAL OS CALCIS SECTION ("CONVENTIONAL" SECTION) OF EACH OF THE ASTRONAUTS THROUGHOUT THE GEMINI IV MISSION

Multiple Sections of the Os Calcis, Gemini IV. On each of the os calcis films of the command pilot, 37 parallel scans were made, and on the os calcis series of the pilot, 40 scans were made on each film, as noted. In the series of multiple os calcis scans of both astronauts, all values determined immediately postflight were lower than the preflight values.

In all 37 parallel os calcis segments of the command pilot series there was a decrease in calibration wedge mass equivalency when the first postflight film was compared to the last preflight film. These segments showed a range of change from -1.50 to -9.73 per cent. Of the 40 parallel scans of the os calcis radiograph of the pilot, the changes in calibration wedge mass equivalency ranged from -2.08 to -13.42 per cent. The bone mass values and the changes in values were not uniform because of the differences in the tissues which the segments penetrated. All positions of scans in the os calcis radiographs of each astronaut which demonstrated the greatest percentage change were found in cross-sectional areas of highly trabecular tissue.

Tables II and III, each with Parts A - E (Appendix) contain the full data on the multiple scans of the os calcis radiographs of both men, given in terms of integrator counts as read from the computer. Figure 6 shows the overall values for the multiple scans of both astronauts.

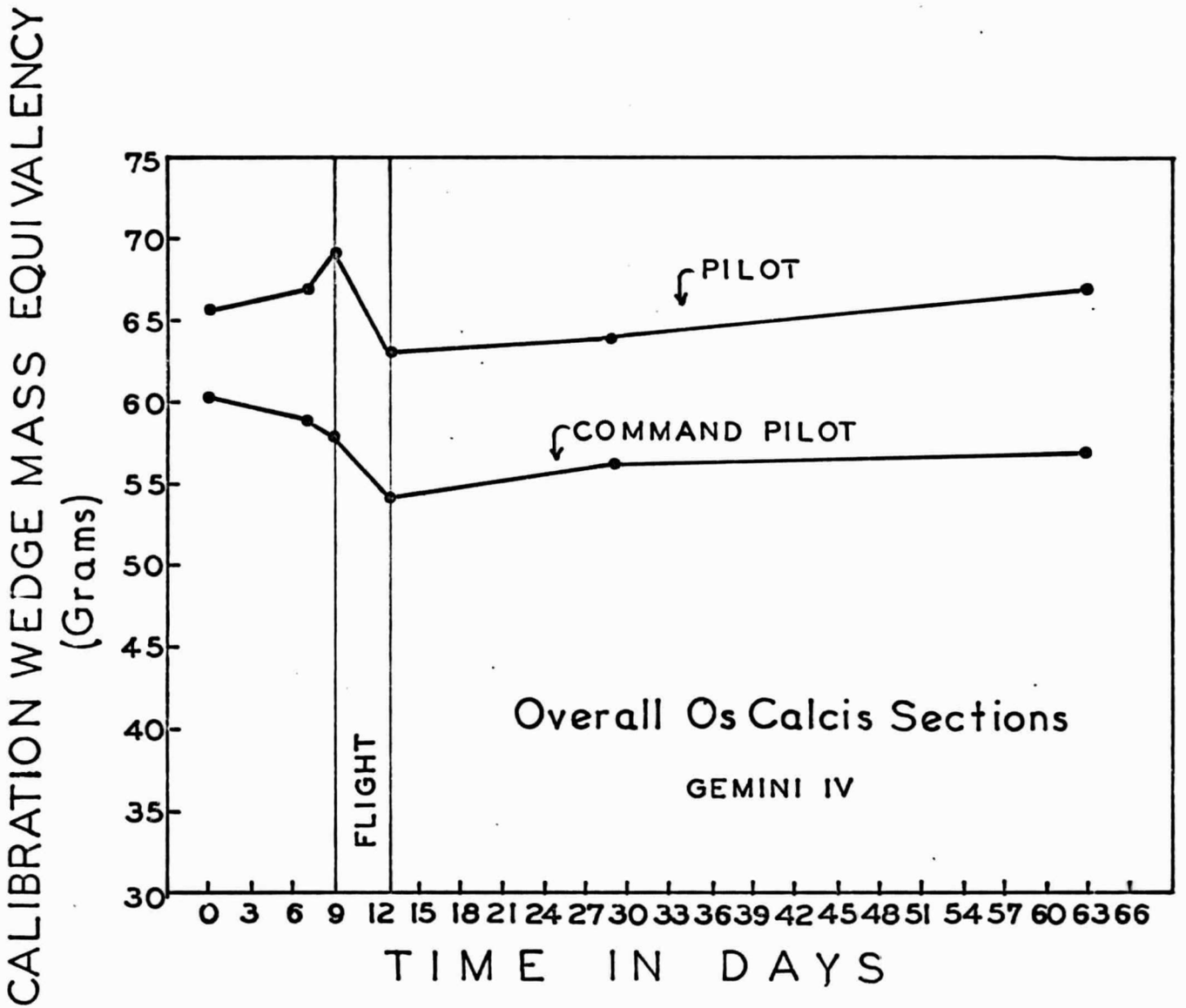


FIGURE 6. CHANGES IN THE CALIBRATION WEDGE MASS EQUIVALENCY OF THE OVERALL SERIES OF THE PARALLEL SECTIONS OF THE OS CALCIS OF EACH OF THE ASTRONAUTS OF THE GEMINI IV MISSION

Four Groups of Comparative Os Calcis Sections, Gemini IV. In order to compare different areas of the os calcis for changes in wedge mass equivalency during flight, the multiple scans were divided into four groups, with the sums of the values for each group compared before and after flight. See Figures 7 and 8 for the graphs of the highest and lowest quarterly bands of the multiple os calcis sections of the respective astronauts of this mission.

For the Command Pilot of the Gemini IV flight, the following percentage changes between the last radiograph before lift-off and the first film after recovery for the four groups of sections:

Proximal Section (Segments 1 millimeter above the conventional scan through Segment 7 below), per cent change in wedge equivalency of the group of bone sections ..... -7.15

Second Section (Segments 8 through 16 millimeters below conventional scan), per cent change in calibration wedge equivalency ..... -7.23

Third Section (Segments 17 through 25 millimeters below conventional scan), per cent change in wedge equivalency ..... -7.65

Distal Section (Segments 26 to bottom of bone), per cent change in wedge mass equivalency ..... -4.03

The changes in the four os calcis sections of the Pilot, measured from the radiograph taken immediately before in comparison with that which was taken immediately after the orbital flight, were the following:

Proximal Section (Segments 1 millimeter above the conventional scan through Segment 8 below), per cent change in wedge equivalency ..... -11.00

Second Section (Segments 9 through 18 below the conventional scan), per cent change in wedge equivalency ..... -10.99

Third Section (Segments 19 through 27 below conventional scan), per cent change in wedge equivalency ..... -8.53

Distal Section (Segments 28 to bottom of bone), per cent change in wedge equivalency ..... -3.87

It will be noted from the data given above that the per cent change in the group of the multiple sections at the distal end of the os calcis in the case of each astronaut is lower than that of any of the three higher quarter bands. It should be noted that these sections run across a cortical area near the bottom of this bone. The change in this cortical tissue, therefore, has been far less than that in the trabecular tissue higher up in the bone.

Figures 7 and 8 also show the differences in negative slope during flight of the tissue near the proximal part of the os calcis in comparison with that of the lowest quarter of the traces, which falls chiefly in cortical tissue.

Section of Talus, Gemini IV. Summary A shows that the section of the talus which was scanned experienced a loss of 10.69 per cent for the Command Pilot and 12.61 per cent for the Pilot. These losses can be attributed to the high proportion of trabecular and the low amount of cortical tissue in this bone.

Bones of the Hand, Gemini IV. It is remarkable that the phalanx of the fifth digit, which was evaluated for bone mass in cross-sectional segments, experienced losses in bone mass in only four days. The mean changes and the range of changes in hand phalanges 5-2 and 4-2 are shown in Summary A. The entire series of changes in bone mass in the crosswise sections covering 5-2 in the astronauts of this mission are given in Summary C.

The central wrist carpal, the capitate, lost 4.48 per cent in the Command Pilot and 17.64 per cent in the Pilot of Gemini IV. The individual differences in the two astronauts is difficult to explain, although the results indicate the need for further study of changes in bone mass of the hand during weightlessness is evident.

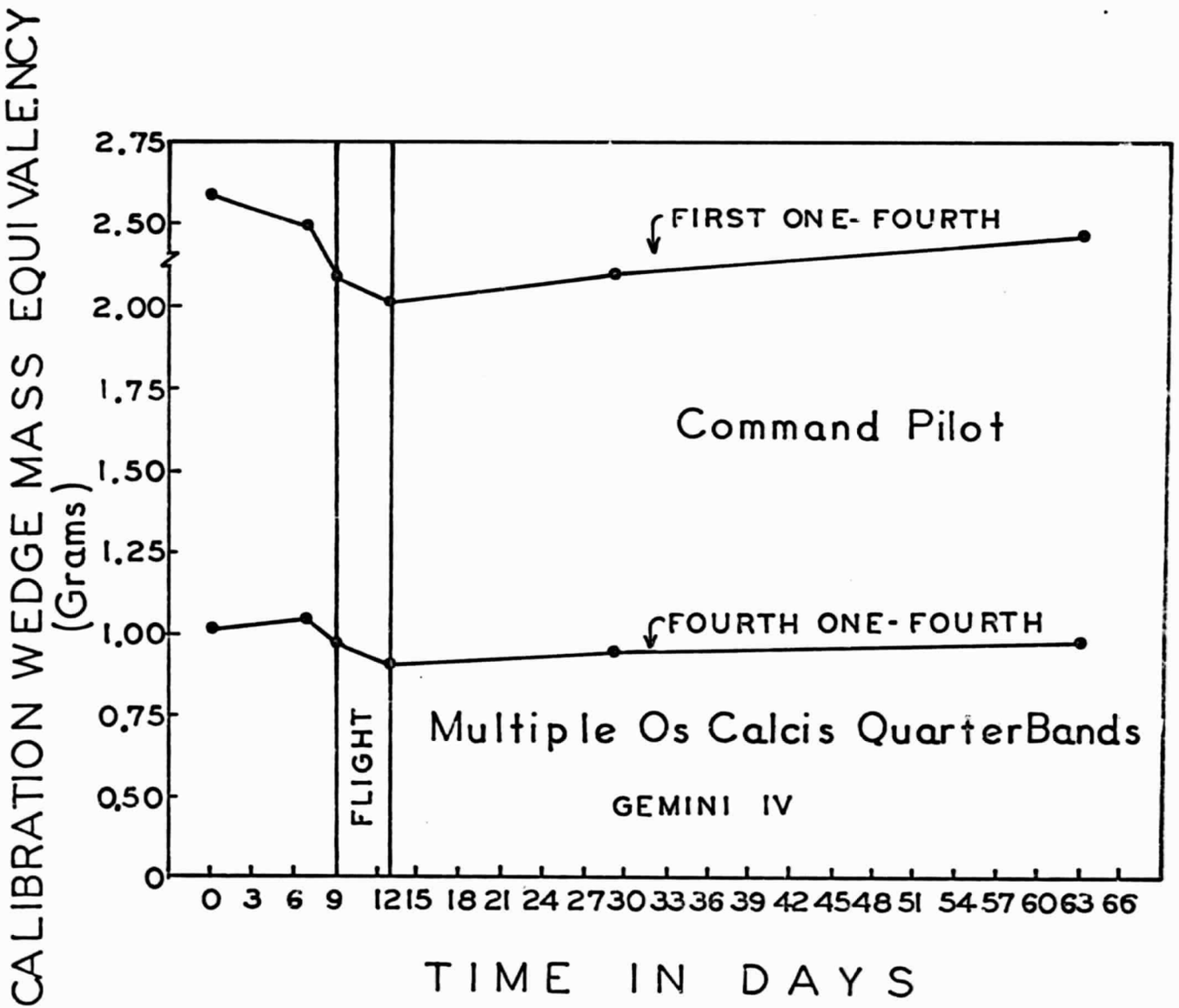


FIGURE 7. CHANGES IN THE CALIBRATION WEDGE MASS EQUIVALENCY VALUES OF THE HIGHEST AND LOWEST GROUPS OF PARALLEL SECTIONS OF THE OS CALCIS OF THE COMMAND PILOT OF THE GEMINI IV MISSION

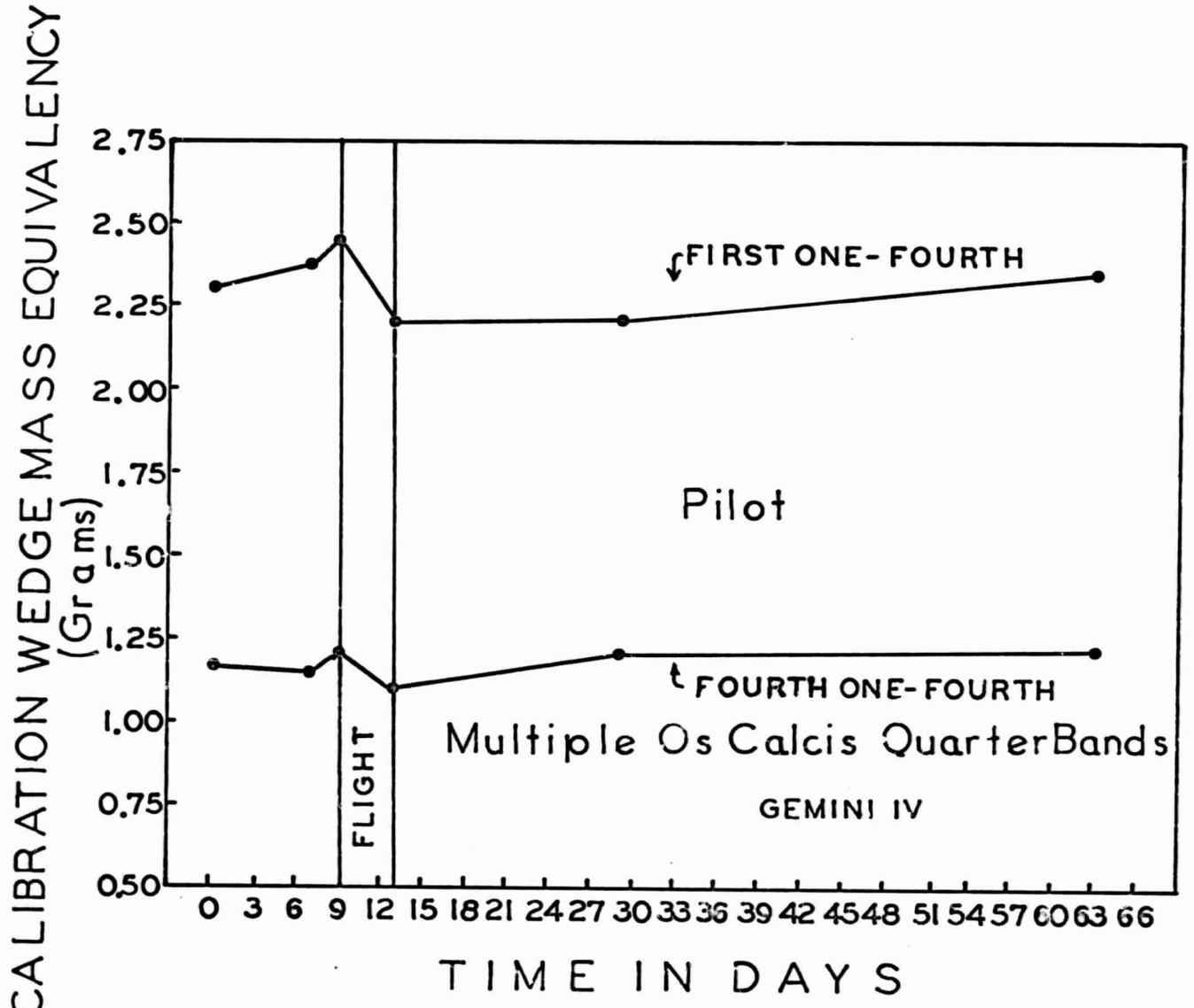


FIGURE 8. CHANGES IN THE CALIBRATION WEDGE MASS EQUIVALENCY VALUES OF THE HIGHEST AND LOWEST GROUPS OF PARALLEL SECTIONS OF THE OS CALCIS OF THE PILOT OF THE GEMINI IV MISSION

Astronauts Edward H. White, Jr., Pilot (left) and James A. McDivitt, Command Pilot (right) are shown entering the Gemini Simulator to prepare for their Gemini-Titan IV Four-Day Orbital Mission

GEMINI V DETAILED FINDINGS

Central Os Calcis Section, Gemini V. The bone mass values (in terms both of integrator counts and of calibration wedge mass equivalency in grams) obtained from the central os calcis section during the Gemini V study are shown in Table IV and in Figure 9. Based on the immediate postflight radiograph as compared with that made immediately preflight, the Command Pilot showed a -15.1 per cent change. The corresponding value for the pilot was -8.9 per cent. Recovery of the loss in this bone site approached completion in both astronauts on the twenty-eighth day of the experiment (10 days postflight). Full recovery had occurred by the fifty-eighth day postflight.

Table IV consists of two sections, both giving the data obtained by scanning the central section of the os calcis. Part A provides the data concerning this anatomical site for the Command Pilot and Part B for the Pilot of the Gemini V mission. The tables give the results both in terms of integrator counts and of calibration wedge mass equivalency in grams, as has been noted. The latter is a factor derived mathematically from the integrator counts obtained from the densitometer as explained in cited references (9)(10). Figure 9 is based on calibration wedge mass equivalency. Percentage change from one radiograph to another is the same regardless of which of these factors is used.

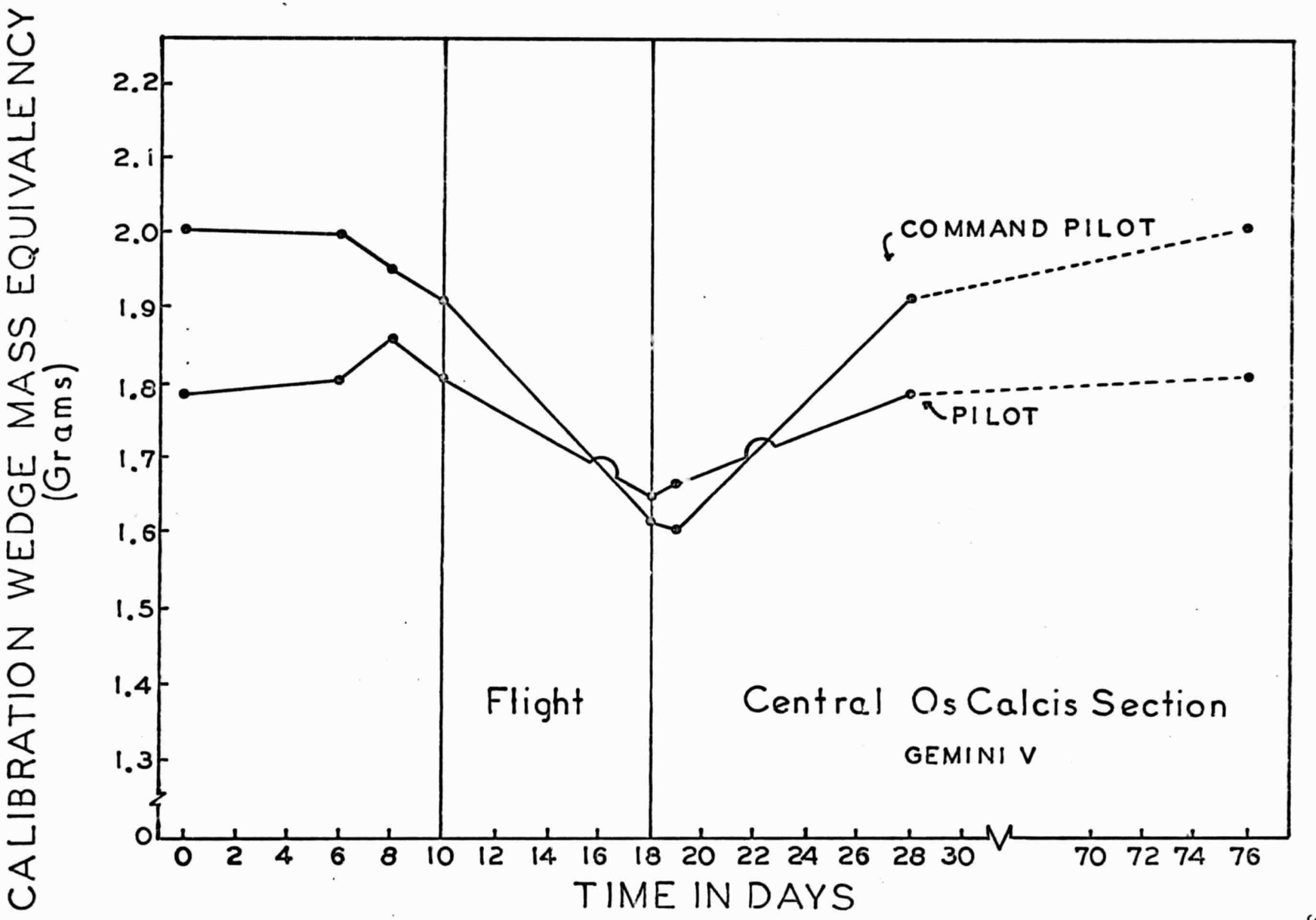


FIGURE 9. CHANGES IN THE CALIBRATION WEDGE MASS EQUIVALENCY OF THE CENTRAL OS CALCIS SECTION ("CONVENTIONAL SECTION") OF EACH OF THE ASTRONAUTS THROUGHOUT THE GEMINI V MISSION

Multiple Sections of the Os Calcis, Gemini V. On each os calcis radiograph of the command pilot of Gemini V, 37 scans parallel with the central os calcis section and including this section were needed to cover approximately 60 per cent of this bone. The same number also was needed for the pilot. Tables V and VI give the complete data for these sections in terms of integrator counts and of calibration wedge mass equivalency for the seven radiographs of both astronauts of the Gemini V mission.

Part C of these two tables includes the percentage changes in the os calcis central section bone density from the immediate preflight to the immediate postflight radiographs of these men. The total value for the command pilot was 10.3 per cent lower immediately after flight than immediately preflight, with 8.9 per cent the corresponding value for the pilot. The greatest loss in the entire series of sections across this bone was 29.52 per cent for the command pilot and 13.76 per cent for the pilot.

A graphic summarization of the overall findings from the multiple os calcis scans is presented in Figure 10. In this figure the total values for each of the os calcis radiographs for each astronaut are summarized.

The command pilot continued to lose some bone mass during the first 12 hours after flight, whereas the pilot began to regain lost bone mass during this period. By the time that the radiographs were made 10 days postflight, the command pilot had come back to his immediate

preflight overall os calcis bone density status, with some increase before this mission closed. The pilot had regained the level of the last preflight bone mass of the overall os calcis evaluations, with no further change.

Astronauts L. Gordon Cooper, Jr., Command Pilot (left), and Charles Conrad, Pilot (right), prime crew of the Gemini V Mission

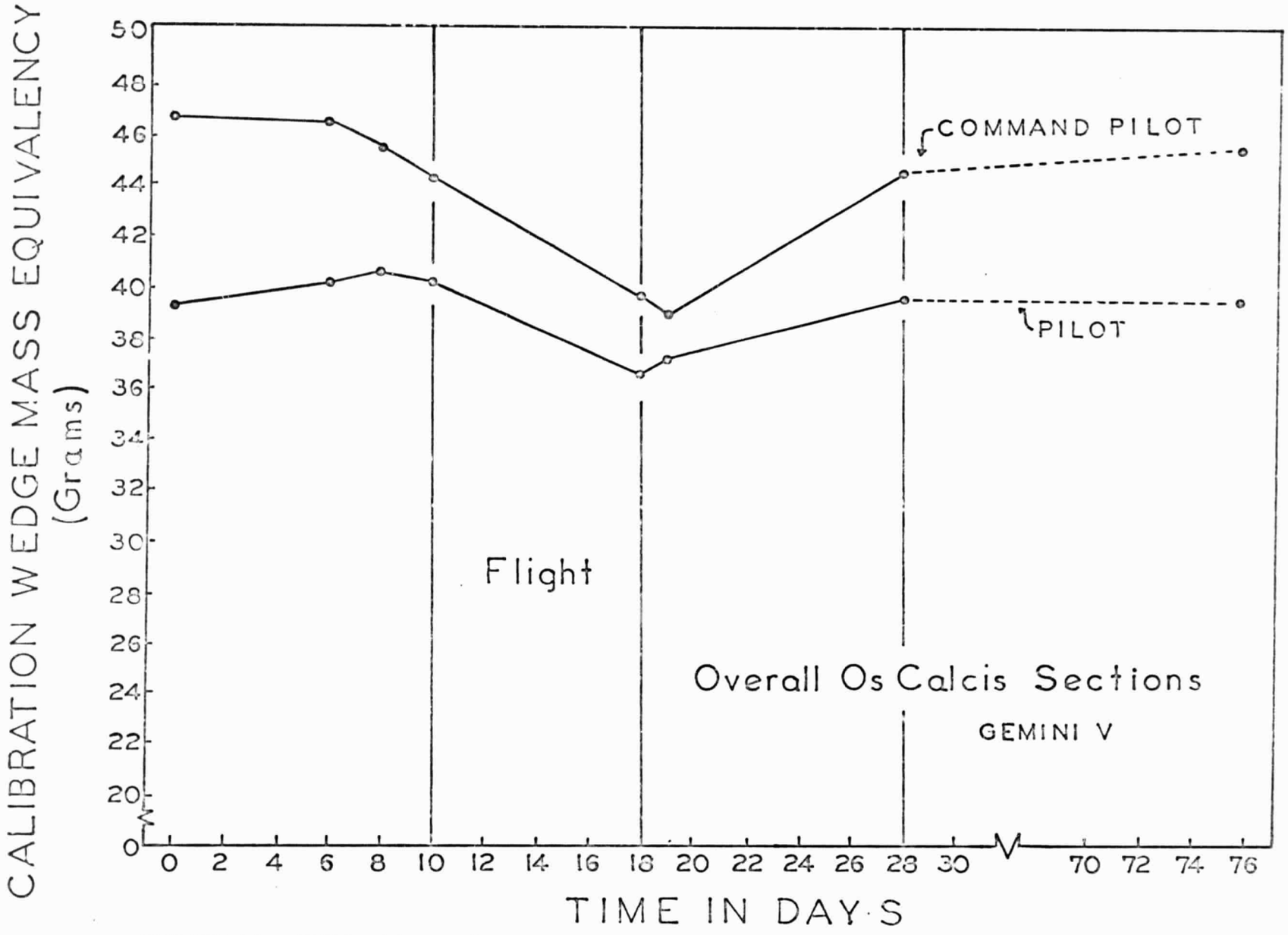


FIGURE 10. CHANGES IN CALIBRATION WEDGE MASS EQUIVALENCY OF THE OVERALL SERIES OF PARALLEL SCANS OF THE OS CALCIS OF EACH OF THE ASTRONAUTS OF THE GEMINI V MISSION

In an effort to determine which regions of the os calcis were the most sensitive reflectors of changes in bone mass, the multiple scans made on this bone were divided into four groups, as shown below, based on the data compiled from the immediate preflight and immediate postflight radiographs. In all four comparisons, the bone density values were lower immediately postflight than they had been immediately preflight.

Superior Section (1 mm. above conventional scan through Segment 7 below)

Astronaut	Per Cent Change
Command Pilot	-12.84 per cent
Pilot	- 8.25 per cent

Second Section (Segments 8 through 16 mm. below conventional scan)

Command Pilot	-13.44 per cent
Pilot	- 9.28 per cent

Third Section (Segments 17 through 25 mm. below conventional scan)

Command Pilot	- 7.13 per cent
Pilot	-11.46 per cent

Fourth Section (Inferior section, including segments 26 through 34 below conventional scan for the command pilot and segments 26 through 35 below conventional scan for the pilot)

Astronaut	Per Cent Change
Command Pilot	- 2.47 per cent
Pilot	- 7.64 per cent

It is apparent from these data that the bone mass decreased somewhat more in the superior sections than in the inferior sections in both astronauts. This effect may be attributed to the greater proportion of cancellous or trabecular tissue to cortical bone in the superior regions than in the inferior regions of the os calcis, explaining the fact that changes of greater magnitude often are seen in the conventional scanning path than in total multiple scans of the entire bone.

Section of Talus, Gemini V. The x-ray calibration wedge mass equivalencies at the talus scanning site made immediately postflight was 13.2 per cent lower than the final preflight value in the command pilot, and 9.8 per cent lower in the pilot. By the twenty-eighth day of the experiment, 10 days after the close of the orbital flight, both astronauts approached full recovery in this anatomical site, with full recovery to the preflight status accomplished by the close of the experiment, 58 days postflight.

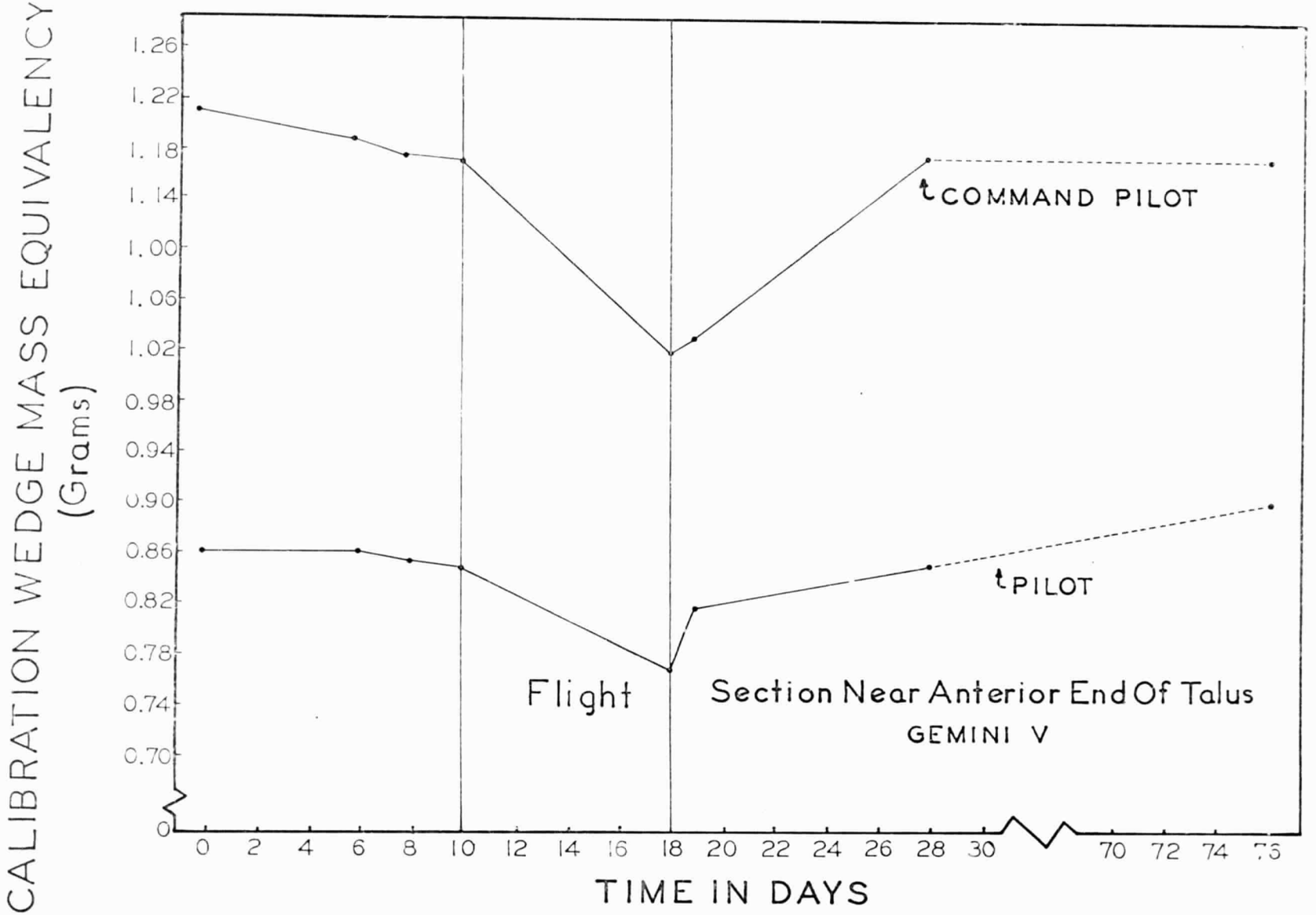


FIGURE 11. CHANGES IN THE CALIBRATION WEDGE MASS EQUIVALENCY OF THE TALUS SITE OF EACH OF THE ASTRONAUTS THROUGHOUT THE GEMINI V MISSION

Figure 11 consists of a graph of the data on the talus site as shown from measurements of the series of radiographs; and Table VII (Parts A and B) gives the full data derived from the measurements made in the talus site.

Hand Phalanges 5-2 and 4-2, Gemini V. The data for the values obtained from the series of radiographs made of hand phalanx 5-2 of the command pilot are given in Table VIII. The comparable data on the pilot are given in Table IX. In Tables X and XI, the basic data on phalanx 4-2 for the two astronauts are given. The data on the two hand phalanges of the command pilot are shown graphically in Figure 12. The companion graph for the pilot is found in Figure 13.

Decreases in wedge mass equivalency after the eight-day orbital flight occurred in hand phalanx 5-2 of both astronauts. The changes in the 18 parallel traces for phalanx 5-2 of the command pilot ranged from -19.6 to -26.1 per cent when the immediate postflight radiograph was compared with that made immediately before the flight. The overall mean change between the segments traced in the immediate preflight and postflight films of this astronaut was -23.0 per cent.

The changes in the parallel segments in phalanx 5-2 in the radiographs of the pilot made immediately postflight compared with the last preflight film ranged from -0.4 to -22.1 per cent, with an overall mean average of -17.0 per cent. See Part C of Tables X and XI.

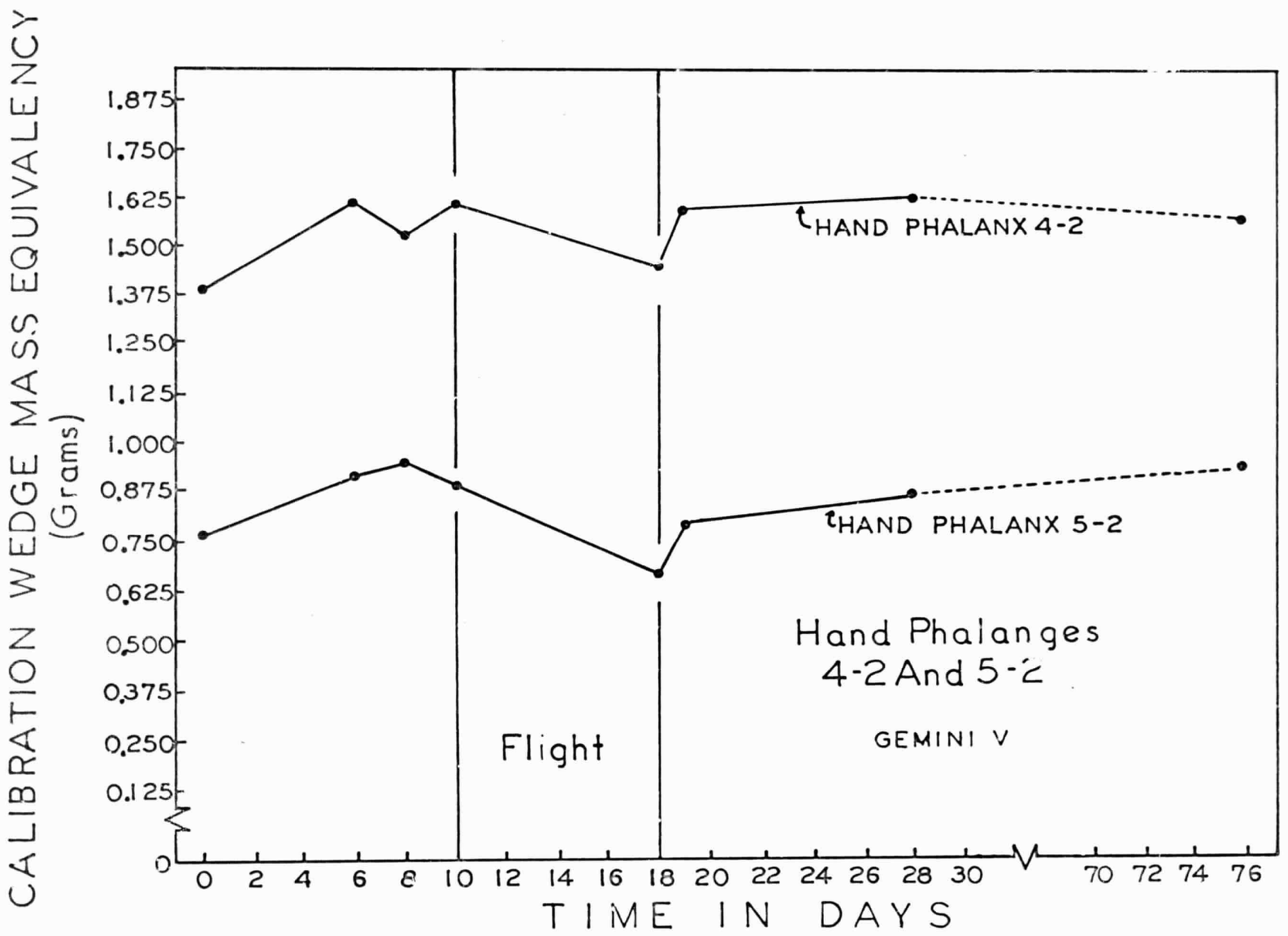


FIGURE 12. CHANGES IN THE CALIBRATION WEDGE MASS EQUIVALENCY OF HAND PHALANGES 4-2 AND 5-2 OF GEMINI V COMMAND PILOT

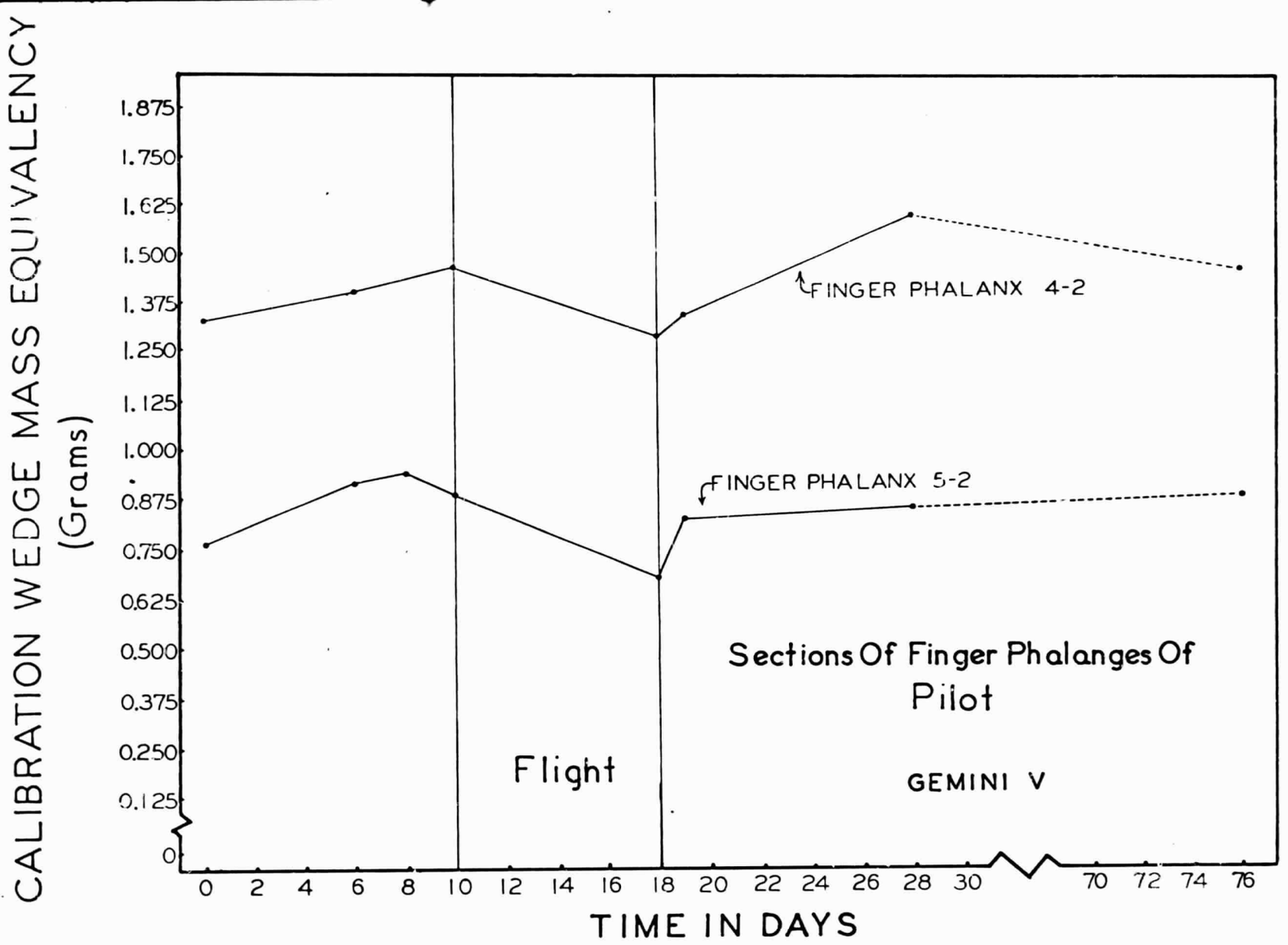


FIGURE 13. CHANGES IN THE CALIBRATION WEDGE MASS EQUIVALENCY OF HAND PHALANGES 4-2 AND 5-2 OF GEMINI V PILOT

Changes in hand phalanx 4-2 were smaller than those in phalanx 5-2 in both astronauts. The data on the changes in the 4-2 hand phalanx are summarized in Table XVI. The changes in the 22 parallel traces for phalanx 4-2 of the command pilot ranged from -6.0 to -13.1 per cent when the immediate preflight and immediate postflight values were compared. The overall mean change was -9.8 per cent.

The changes in the parallel segments in phalanx 4-2 of the pilot from film 4 to film 5 ranged from -5.3 to -16.9 per cent, with an overall mean average of -11.8 per cent.

Section near Distal End of Radius, Gemini V. The changes in bone mass in the distal end of the radius were evaluated only in the Gemini V study. During this eight-day flight, the calibration wedge mass equivalency of the distal end of the left radius decreased by -25.3 per cent in the command pilot and by -23.5 in the pilot, when the last radiograph before lift-off and the first preflight radiograph were compared. See Table XVII and Figure 14.

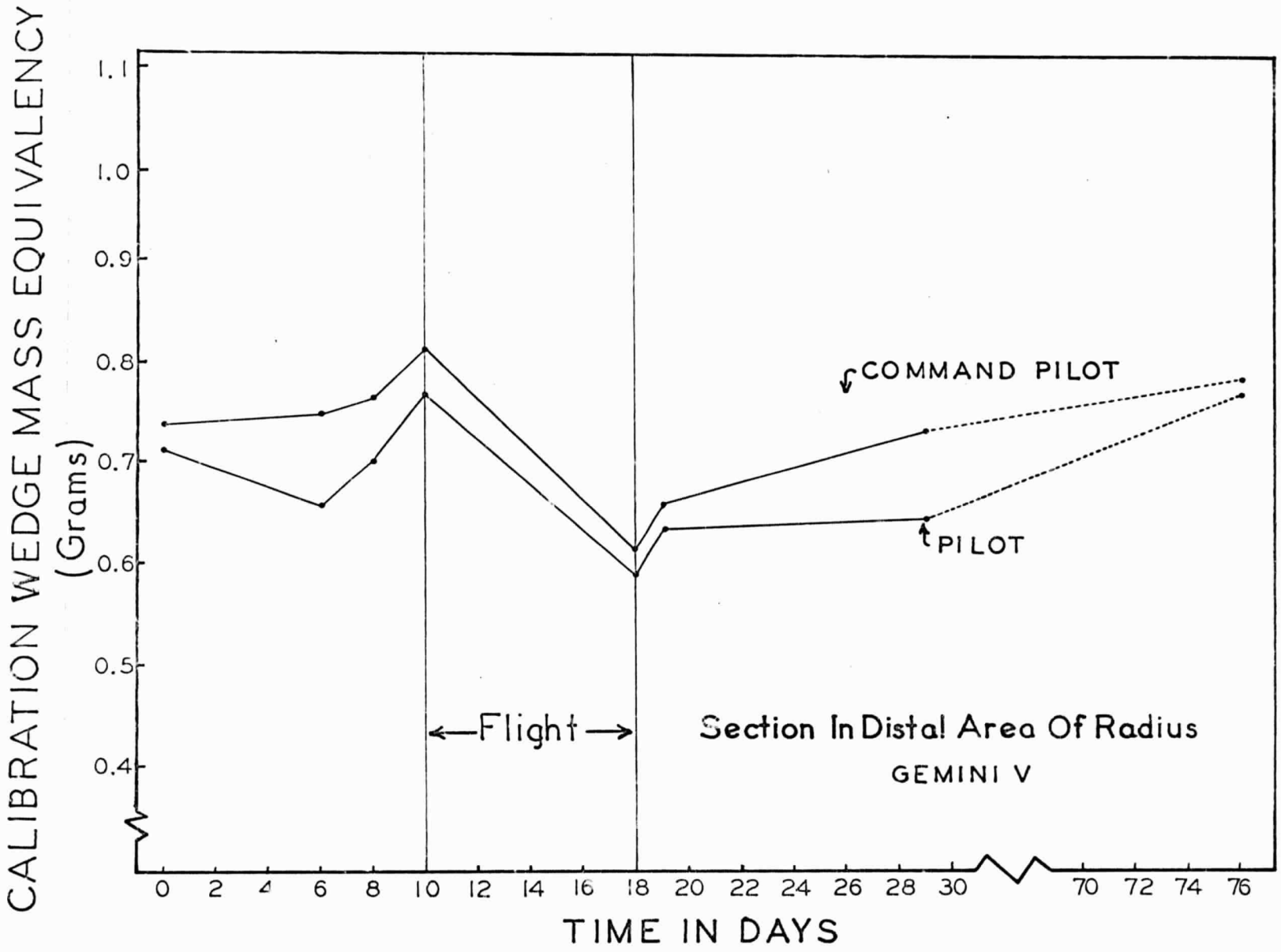


FIGURE 14. CHANGES IN THE CALIBRATION WEDGE MASS EQUIVALENCY OF THE DISTAL END OF THE RADIUS OF GEMINI V COMMAND PILOT AND PILOT

Astronauts James A. Lovell, Jr., Pilot (left) and Frank Borman, Command Pilot (right), prime crew of the Gemini-Titan VII Mission. These astronauts also constituted the back-up crew of the Gemini IV orbital flight.

GEMINI VII DETAILED FINDINGS

Central Os Calcis Section, Gemini VII. The bone mass values in terms of integrator counts and of calibration wedge mass equivalency which were obtained from the central os calcis section throughout the Gemini VII mission are given in Table XIII. Figure 15 shows the sequence of values graphically for this bone section. Based on a comparison of the calibration wedge mass equivalency of the immediate postflight radiograph with that made immediately before the launch, this central or "conventional" segment of the os calcis exhibited very minor changes during the orbital flight, both for the command pilot and pilot, with values of 2.91 and 2.84 per cent, respectively.

It should be noted that some increase in bone mass of this anatomical site took place during the first 24 hours following the orbital flight in both astronauts, with a marked increase in both men during the 11-day period after the flight, the latter more pronounced in the pilot. At the time of making the last radiograph of the series, 47 days postflight, the command pilot had levelled off in calibration wedge equivalency of this section of the os calcis at a value higher than any which was found in the preflight series. The pilot, on the other hand, had a value in the last central os calcis radiograph which was higher than that of any of his previous films except the next to the last measurement. It should be

noted that the flight ended on 18 December, 1965, and that the next 11 days thereafter included the Christmas holidays, a period during which both men stated that they had consumed considerable quantities of food, including milk.

Multiple Sections of the Os Calcis, Gemini VII. Table XIV gives the values for each of the 38 parallel scans needed to cover 60 per cent of the os calcis for each of the seven radiographs taken of the command pilot of Gemini VII throughout this mission. Table XV gives the comparable data for the 42 parallel scans made on the series of radiographs of the Gemini VII pilot. Part C of each of these tables shows the comparisons of the overall sections of the os calcis of each astronaut as determined from the radiographs made immediately preflight and those made immediately postflight.

These tables show that the changes in the overall sum of the sectional values obtained from the parallel scans made in the radiograph taken of the command pilot on the carrier immediately after his recovery was only -2.46 per cent different from that made immediately before launch. The comparable change in values for the pilot was -2.54 per cent. The tables show also that the greatest change during flight in bone mass in any of the multiple sections of the os calcis of the command pilot was -5.17 per cent, while that of the pilot was -7.66 per cent.

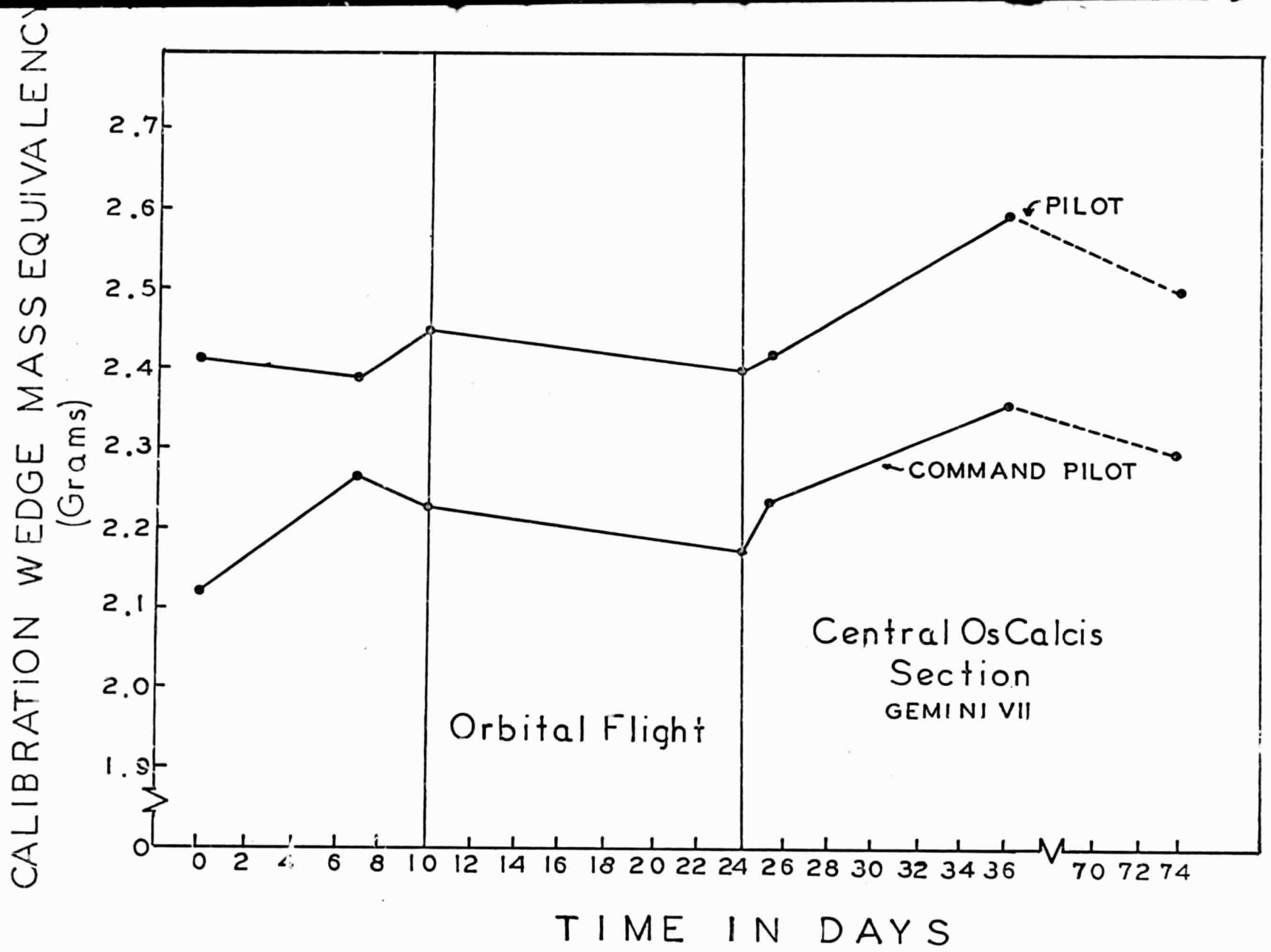


FIGURE 15. CHANGES IN THE CALIBRATION WEDGE MASS EQUIVALENCY OF THE CENTRAL OS CALCIS SECTION ("CONVENTIONAL" SECTION) WHICH WAS EVALUATED FOR EACH OF THE ASTRONAUTS THROUGHOUT THE GEMINI VII MISSION

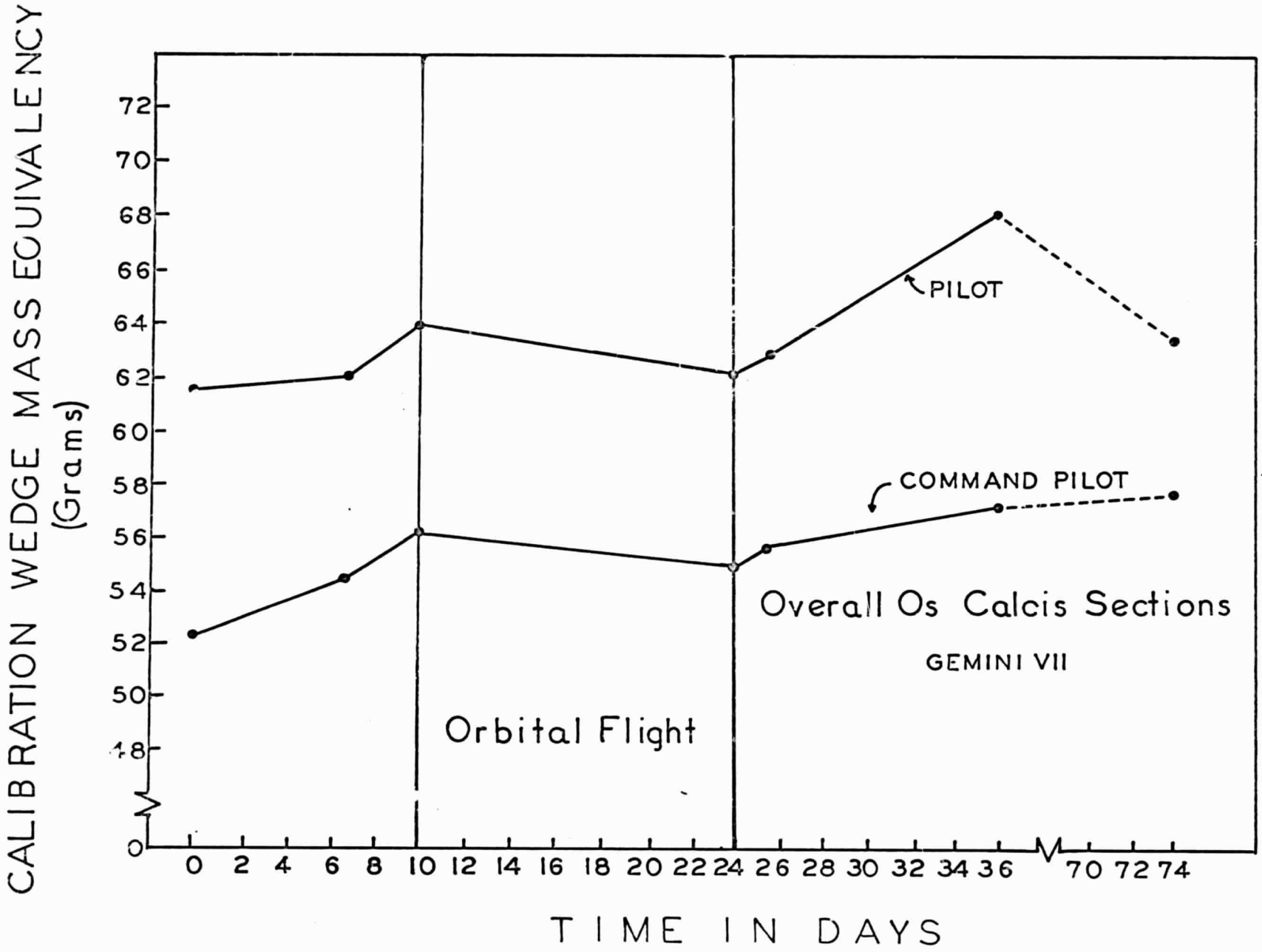


FIGURE 16. CHANGES IN THE CALIBRATION WEDGE MASS EQUIVALENCY OF THE OVERALL OS CALCIS MULTIPLE SECTIONS WHICH WERE EVALUATED FOR EACH OF THE ASTRONAUTS THROUGHOUT THE GEMINI VII MISSION

A graph of the sums of the calibration wedge equivalency values for the multiple os calcis sections for each of the preflight and postflight radiographs is shown for both astronauts in Figure 16. A general similarity between the graphs of the "conventional" section and that of the overall os calcis sections for these astronauts is seen by comparing Figures 15 and 16.

Table XIV shows that, of the 38 parallel scans required to cover 60 per cent of the os calcis of the command pilot, the bone mass changes during the 14-day orbital flight ranged from -5.17 to -0.49 per cent. The changes of the 42 scans in the parallel system of the os calcis of the pilot ranged from -7.66 to -0.27 per cent (Table XV). The irregularity in the trabulation of the os calcis is evident in Figure 14.

Section of Talus, Gemini VII. Table XVI and Figure 17 show that, during the preflight, the mass of the bone section evaluated in the talus first increased and then decreased for the command pilot. The pilot showed a slight decrease in this site preflight. Postflight, both astronauts exhibited a marked increase for 11 days, with final values not markedly different from the initial levels. In general this represents the same pattern of change as that shown by the os calcis. The calibration wedge mass equivalency at the talus scanning site obtained from the radiograph made immediately postflight was 7.06 per cent lower than the final preflight value for the command pilot and 4.00 per cent lower for the pilot.

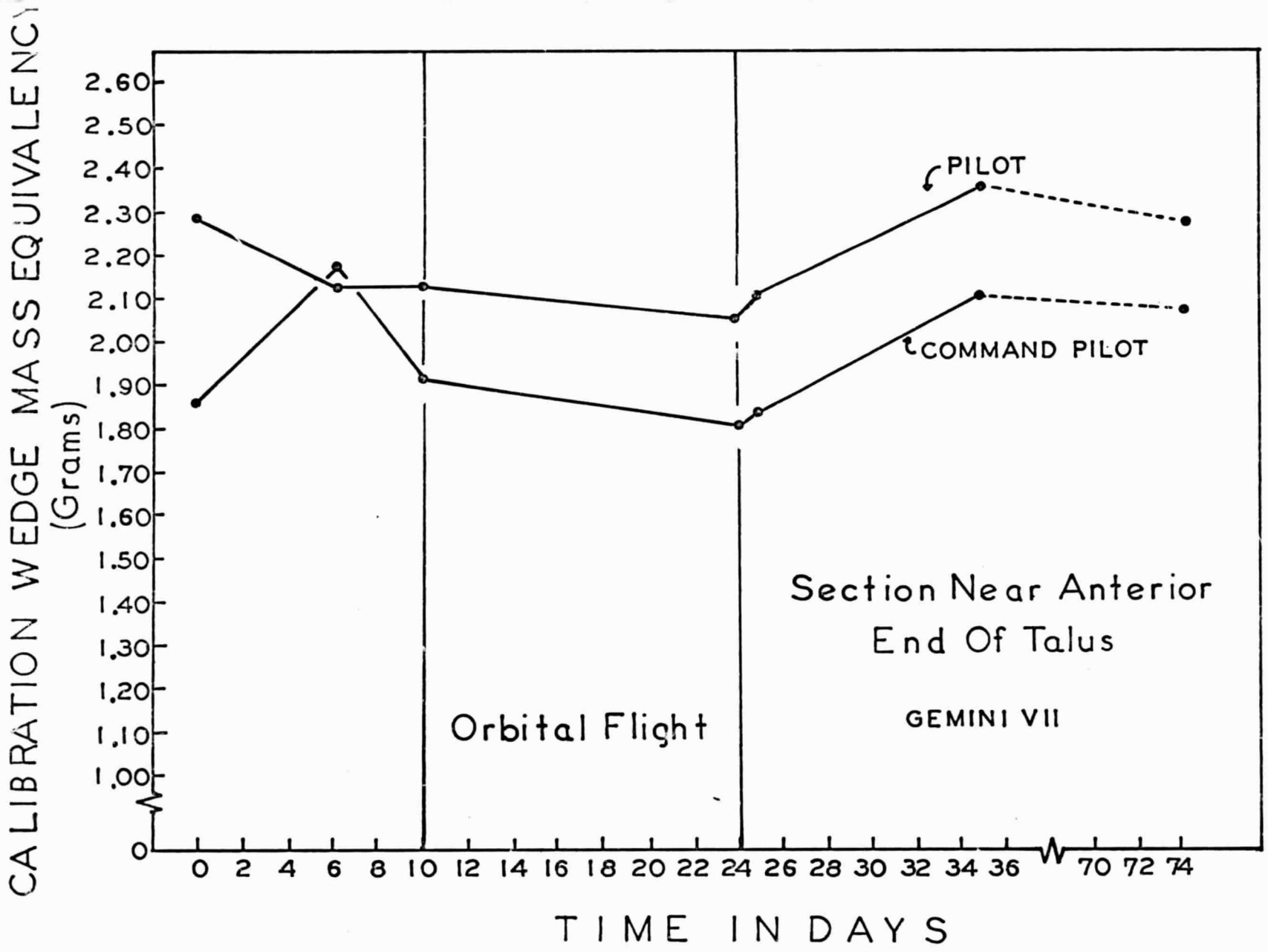


FIGURE 17. CHANGES IN THE CALIBRATION WEDGE MASS EQUIVALENCY OF THE TALUS SITE WHICH WAS EVALUATED FOR EACH OF THE ASTRONAUTS THROUGHOUT THE GEMINI VII MISSION

Hand Phalanges 5-2 and 4-2, Gemini VII. As in the case of the os calcis and of the hand phalanges sites scanned for the Gemini IV and Gemini V astronauts, multiple parallel scans were made across hand phalanges 5-2 and 4-2 of the Gemini VII radiographs, with distances of one mm. from the center of one scan to that of the next scan. In this manner, the entire area of each phalanx was evaluated in posterior-anterior projection.

Hand Phalanx 5-2, Gemini VII. Tables XVII and XVIII are given to show the data for the respective cross-sections of hand phalanx 5-2 for each of the two astronauts of Gemini VII. These tables show in Part C the comparison of the bone mass of the sections across hand phalanx 5-2 of each astronaut, evaluated in each case from the radiograph made immediately before the orbital flight as well as that made 14 days later, immediately after recovery of the astronauts on the carrier after the flight ended.

From the beginning to the close of the orbital flight, the command pilot sustained an overall change in the 18 parallel sections of phalanx 5-2 amounting to -6.78 per cent. In the 17 scans required to cover hand phalanx 5-2 of the pilot, an overall change in bone mass of -7.83 per cent was found. The greatest change in this bone for the command pilot in any of the cross-sectional segments was -12.07 per cent, and for the pilot, the corresponding change was -14.80 per cent.

Figure 18 includes a graph of the calibration wedge mass equivalency data of hand phalanx 5-2 for both Gemini VII astronauts.

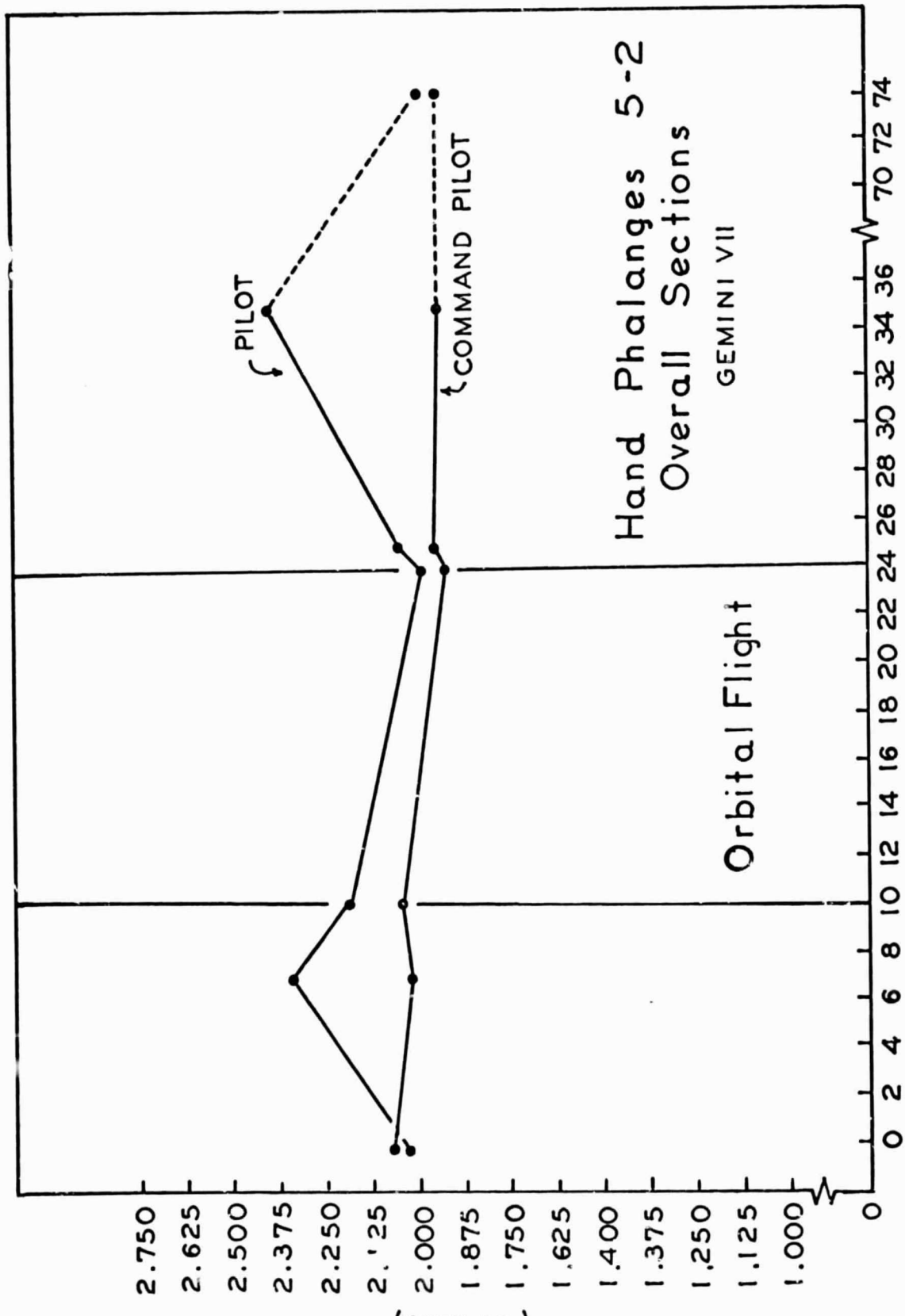


FIGURE 18. CHANGES IN THE CALIBRATION WEDGE MASS EQUIVALENCY OF THE SECTIONS OF HAND PHALANX 5-2 WHICH WERE EVALUATED FOR EACH OF THE ASTRONAUTS OF THE GEMINI VII MISSION

Hand Phalanx 4-2, Gemini VII. Figure 19 consists of graphs of the calibration wedge mass equivalency values for hand phalanges 4-2 for the serial radiographs of the two Gemini VII astronauts throughout their mission. The graph of the command pilot shows that the value for phalanx 4-2 was higher at the beginning of the orbital flight than the first preflight value, with a decline by the close of the flight. This was followed by a gradual increase after the flight. The graph for phalanx 4-2 for the pilot shows a marked increase in bone mass during the first seven days of preflight, followed by a decrease during the last four preflight days. Following the decrease during the flight, there was a continuous postflight increase.

Table XIX gives the bone mass changes found in each section of phalanx 4-2 of each astronaut, as derived from the evaluations made from the radiographs taken immediately before and immediately following the orbital flight of Gemini VII. From the time of taking the radiograph made immediately before launch until that which was made 14 days later, immediately after recovery on the carrier, the command pilot sustained an overall change in the 25 scans required to cover phalanx 4-2 of his hand of -6.53 per cent. The change in this anatomical site for the pilot during the same period was -3.82 per cent, with 25 scans required to cover this bone. The greatest change in any section of phalanx 4-2 was -9.11 per cent for the command pilot and -8.54 per cent for the pilot.

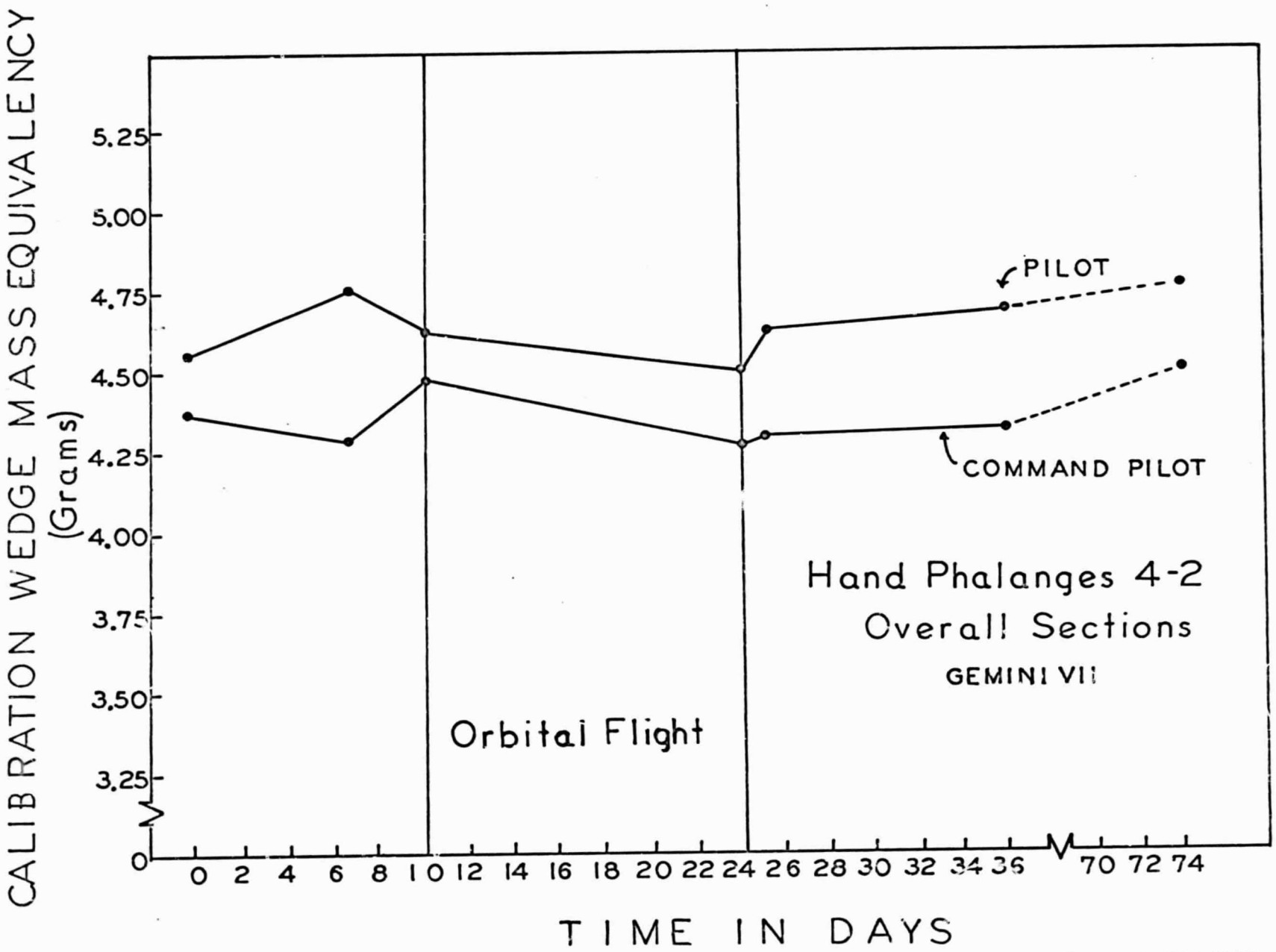


FIGURE 19. CHANGES IN THE CALIBRATION WEDGE MASS EQUIVALENCY OF THE SECTIONS OF HAND PHALANX 4-2 WHICH WERE EVALUATED FOR EACH OF THE ASTRONAUTS THROUGHOUT THE GEMINI VII MISSION

Section across the Capitate, Gemini VII. Table XX outlines the bone mass data for the seven radiographs which were made of the central wrist carpal of each of the Gemini VII astronauts, the capitate. As in the case of the x-rays made in some of the other anatomic sites, the astronauts both increased in bone mass slightly between the first two films of the series, and then decreased in calibration wedge mass equivalency between the second and final preflight radiographs. Between the x-ray made immediately before the orbital flight and that made immediately after recovery on the carrier, the change in mass of the section of the capitate which was evaluated was -4.31 per cent for the command pilot and -9.30 per cent for the pilot.

As in the case of most of the x-rays made of other anatomical locations, the capitate made a marked recovery in bone mass (in terms of calibration wedge mass equivalency) during the first 24 hours following the mission in both astronauts. Then there was a marked increase in mass of this bone during the next 10 days, reaching the highest level at this time, with this period as noted coming within the Christmas holidays. Then the bone mass decreased somewhat until the last radiograph was taken after the orbital flight was over. The final level of mass in this bone for both men, however, was higher in the last radiograph than in the x-ray immediately before the flight. Figure 20 shows the capitate data graphically.

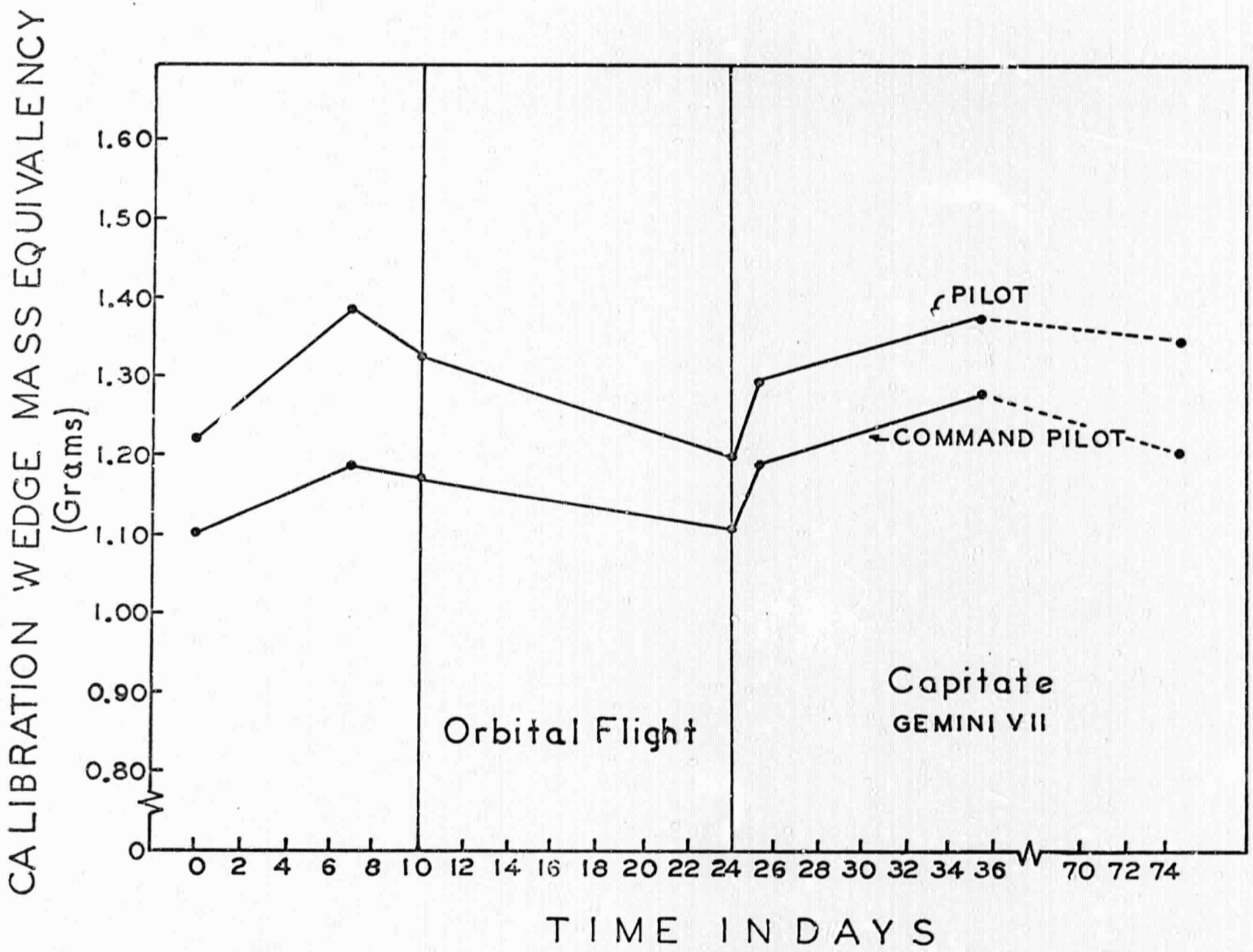


FIGURE 20. CHANGES IN THE CALIBRATION WEDGE MASS EQUIVALENCY OF THE CAPITATE WHICH WAS EVALUATED FOR EACH OF THE ASTRONAUTS THROUGHOUT THE GEMINI VII MISSION

CALCIUM CONSUMPTION BY THE ASTRONAUTS DURING ORBITAL FLIGHT

Use has been made of the background information secured from the bed rest studies concerning bone densitometry results for comparison with the findings from the astronauts consuming similar levels of calcium during space flight for an equal period of time. It should be noted that the astronauts of Gemini IV consumed only a daily mean of 679 and 739 milligrams of calcium for the command pilot and the pilot, respectively, during their 4-day mission, which represents a moderate level of calcium. The corresponding mean levels of daily calcium consumption by the command pilot and the pilot of the Gemini V mission were 373 and 313 milligrams per day. This represented between one-third and one-fourth of the calcium provided for them for their eight-day flight. In addition, they also were consuming about the same proportionately low levels of energy and of other major nutrients by eating only a moderate proportion of their total food.

The command pilot and the pilot of Gemini VII, on the other hand, consumed means of 945 and 921 milligrams daily of the approximately 1,200 milligrams per day available of the calcium in the calcium fortified diet provided for their 14-day mission. The three groups of astronauts, therefore, showed the following rank order as to their levels of calcium consumption:

Rank 1. Gemini VII, command pilot 945 and pilot 921 milligrams of calcium daily;

Rank 2. Gemini IV, command pilot 679 and pilot 739 milligrams of calcium daily;

Rank 3. Gemini V, command pilot 373 and pilot 313 milligrams of calcium daily.

Comparison of Bone Density Losses in Bed Rest Subjects during Recumbency and in Astronauts during Space Flight

Bone mass losses for men at horizontal bed rest may be computed for any number of bed rest days, since radiographs of the hand and foot are made daily during the bed rest period. Hence comparisons may be made between bone mass losses in bed rest subjects and in astronauts who have consumed similar amounts of calcium for the same period of time. Losses of bone mass may be reported either in terms of calcium hydroxyapatite mass equivalency or of calibration wedge mass equivalency, since the former has been derived from the latter by multiplying by a constant factor.

Figures 21 and 22 show graphically the bone mass changes in the central os calcis and in hand phalanx 5-2 during the orbital flights of the command pilot and the pilot of Gemini missions IV, V, and VII, together

with the mean of the bone density changes in the bed rest subjects who consumed comparable levels of calcium daily for the same periods of time. Summaries D, E, and F cover the same information as the two tables, with additional data on the calcium intake and the per cent change in bone mass of the two atomic sites under consideration for individual bed rest subjects.

Figure 21 and the three summaries listed above show that the astronauts of the Gemini-Titan VII mission experienced generally lower losses in bone density of the central section of the os calcis than were found in the Gemini IV crew and particularly in the crew of Gemini V during flight. The losses in this section for the Gemini VII astronauts were even lower than were the losses found in the subjects who had been at horizontal bed rest on a similar level of dietary calcium for the same period of time.

Figure 22 and the three summaries under consideration show that, in the hand phalanx 5-2 notably greater decreases in bone mass during flight were shown for all astronauts than for the TWU bed rest subjects who consumed equivalent quantities of calcium for a time period equal to the time of the respective flights. This would indicate to the authors the need for further study of the reasons for the differences found in these two skeletal sites.

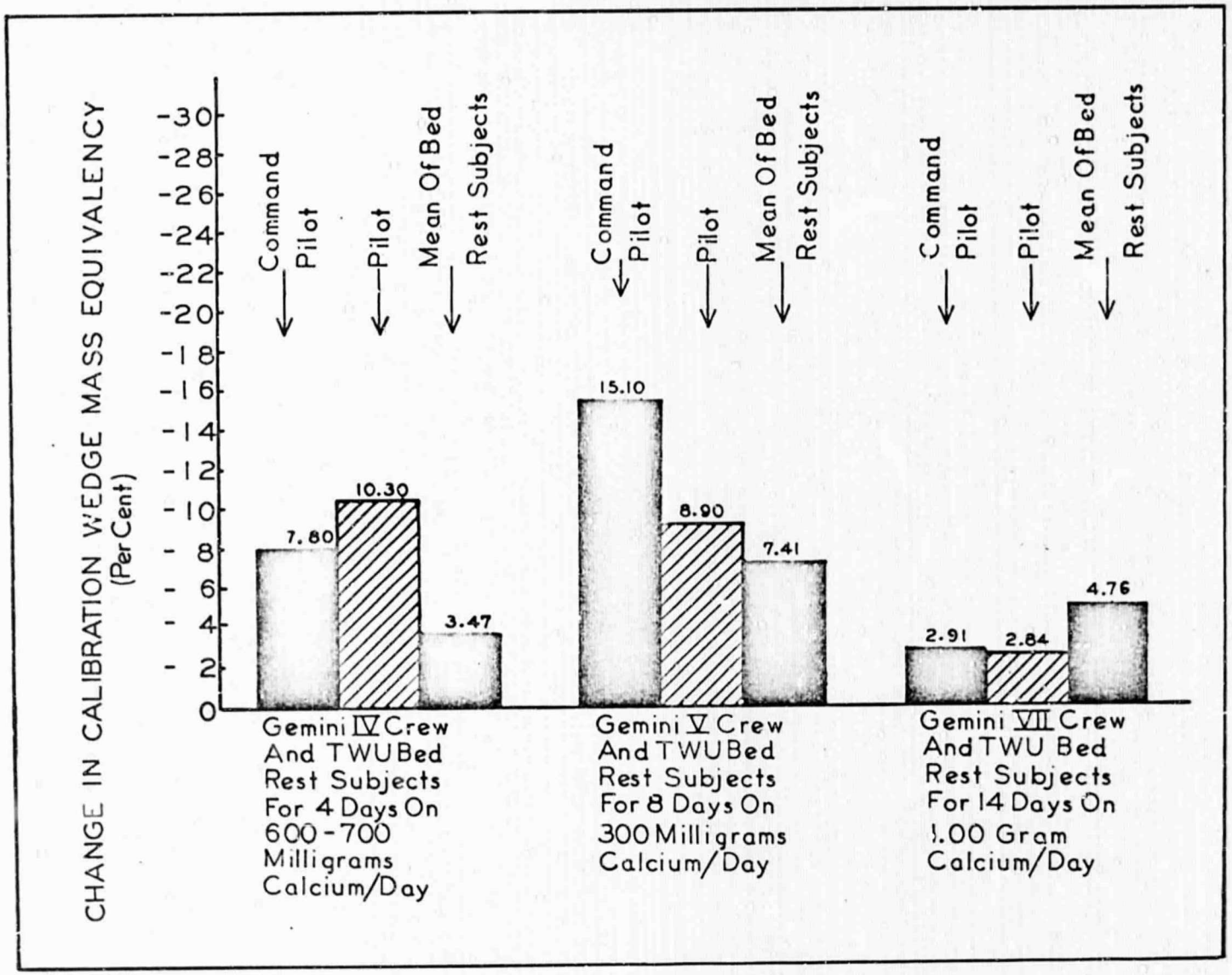


Figure 21. Comparison of the per cent change in bone mass (in terms of calibration wedge mass equivalency) in the central section of the os calcis of the command pilot and pilot of the Gemini IV, V, and VII missions together with the mean of TWU bed rest subjects for the same anatomic site who consumed a comparable daily level of calcium for the same period of time.

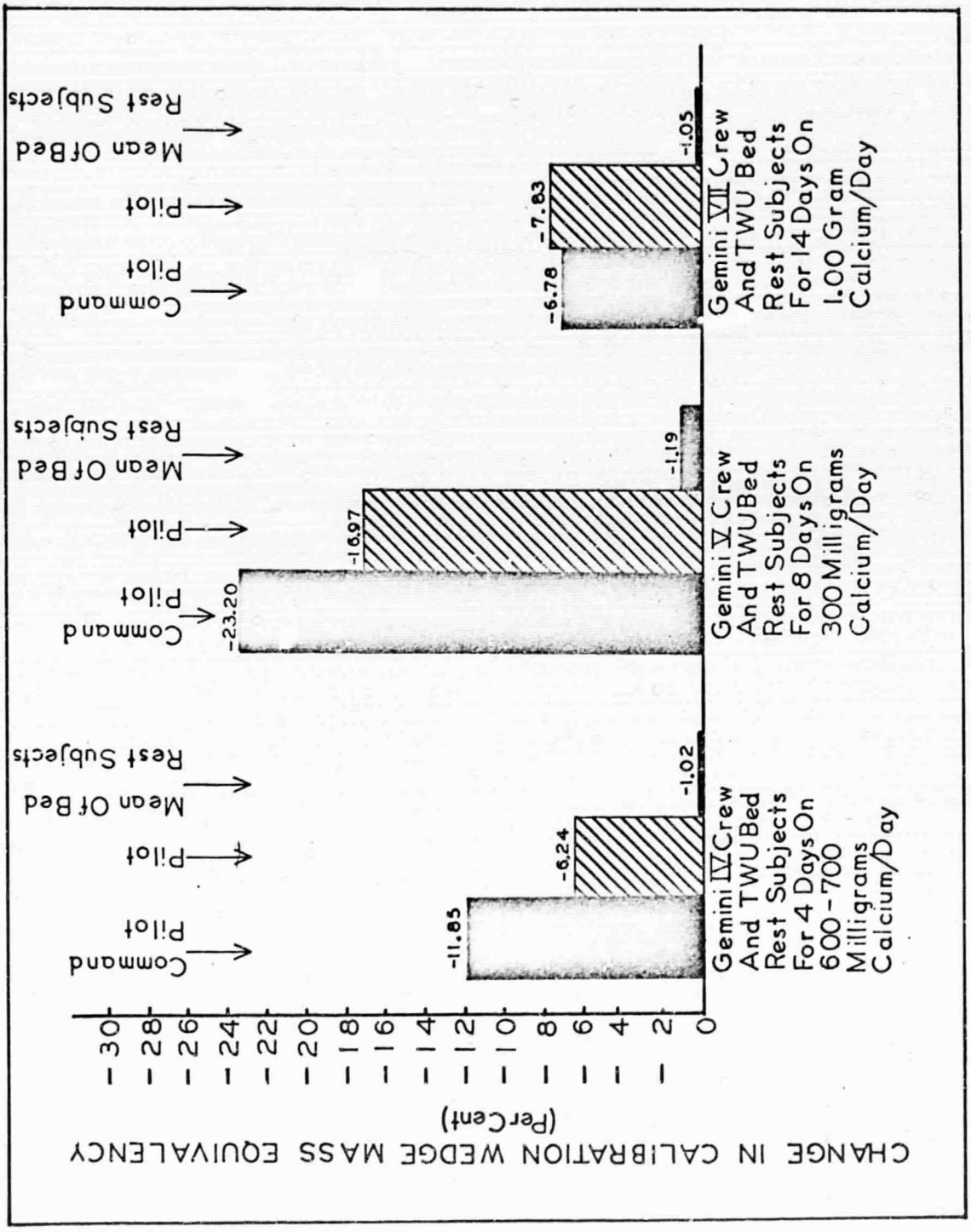


Figure 22. Comparison of the per cent change in bone mass (in terms of calibration wedge mass equivalency) in hand phalanx 5-2 of the command pilot and the pilot of the Gemini IV, V, and VII missions together with the mean of the TWU bed rest subjects for the same anatomic site who consumed a comparable level of calcium for the same period of time.

SUMMARY D

CHANGE IN BONE MASS* IN THE CENTRAL OS CALCIS AND IN THE HAND PHALANX 5-2 OF ASTRONAUTS OF GEMINI IV, AND IN BED REST SUBJECTS ON SIMILAR DIETARY CALCIUM LEVELS FOR THE SAME PERIOD OF TIME (FOUR DAYS)

Subjects	Level of Daily Calcium Intake (milligrams)	Change in Central Os Calcis Bone Mass* (per cent)
GEMINI IV		
Command Pilot	679	-7.80
Pilot	739	-10.30
TWU BED REST SUBJECTS		
Subject 1	675	-2.67
Subject 2	659	-4.25
Subject 3	636	-3.39
Subject 4	636	-3.59
Mean	651	-3.47

Subjects	Level of Daily Calcium Intake	Change in Hand Phalanx 5-2 Bone Mass (per cent)
GEMINI IV		
Command Pilot	679	-11.85
Pilot	739	-6.24
TWU BED REST SUBJECTS		
Subject 1	675	-1.61
Subject 2	659	-1.80
Subject 3	636	-2.28
Subject 4	636	+1.61
Mean	651	-1.02

*In terms of calibration wedge mass equivalency (grams)

SUMMARY E

CHANGE IN BONE MASS* IN THE CENTRAL OS CALCIS AND IN THE HAND PHALANX 5-2 OF ASTRONAUTS OF GEMINI V, AND IN BED REST SUBJECTS ON SIMILAR DIETARY CALCIUM LEVELS FOR THE SAME PERIOD OF TIME (EIGHT DAYS)

Subjects	Level of Daily Calcium Intake (milligrams)	Change in Central Os Calcis Bone Mass* (per cent)
GEMINI V		
Command Pilot	373	-15.10
Pilot	333	-8.90
TWU BED REST SUBJECTS		
Subject 1	307	-8.65
Subject 2	292	-5.06
Subject 3	303	-7.89
Subject 4	308	-8.06
Mean	303	-7.41

Subjects	Level of Daily Calcium Intake	Change in Hand Phalanx 5-2 Bone Mass (per cent)
GEMINI V		
Command Pilot	373	-23.20
Pilot	333	-16.97
TWU BED REST SUBJECTS		
Subject 1	307	-1.52
Subject 2	292	+0.06
Subject 3	303	-1.65
Subject 4	308	-1.67
Mean	303	-1.19

*In terms of calibration wedge mass equivalency (grams)

SUMMARY F

CHANGE IN BONE MASS* IN THE CENTRAL OS CALCIS AND IN THE HAND PHALANX 5-2 OF ASTRONAUTS OF GEMINI VII, AND IN BED REST SUBJECTS ON SIMILAR DIETARY CALCIUM LEVELS FOR THE SAME PERIOD OF TIME (14 DAYS)

Subjects	Level of Daily Calcium Intake (milligrams)	Change in Central Os Calcis Bone Mass* (per cent)
GEMINI VII		
Command Pilot	945	-2.91
Pilot	921	-2.84
TWU BED REST SUBJECTS		
Subject 1	931	-3.46
Subject 2	1,021	-3.56
Subject 3	1,034	-5.79
Subject 4	1,020	-5.11
Subject 5	930	-5.86
Mean	987	-4.76

Subjects	Level of Daily Calcium Intake (milligrams)	Change in Hand Phalanx 5-2 Bone Mass (per cent)
GEMINI VII		
Command Pilot	945	-6.78
Pilot	921	-7.83
TWU BED REST SUBJECTS		
Subject 1	931	-1.47
Subject 2	1,021	-1.25
Subject 3	1,034	-0.44
Subject 4	1,020	-0.96
Subject 5	930	-1.24
Mean	987	-1.05

*In terms of calibration wedge mass equivalency (grams)

Dietary Components Other than Calcium Consumed by Astronauts

In making comparisons of bone density between the astronauts and the Texas Woman's University bed rest subjects, it should be noted that calcium was the major dietary variable in the TWU studies conducted to date, with an effort made to keep energy and other nutrients optimum, and as nearly constant as possible. Bed rest studies of 14 days duration have been conducted at TWU with daily levels of calcium ranging from 300 to 2,000 milligrams. During the ambulatory equilibration, the bed rest, and the reconditioning periods the remainder of the diet has been held at the following levels: 2,600 calories (adjusted to fit the subjects' needs with carbohydrate foods), 90 - 100 grams of protein, 280 grams of carbohydrate, 120 grams of fat, 18 - 20 milligrams of iron, 10,000 International Units of vitamin A equivalency, 400 International Units of vitamin D, 100 - 150 milligrams of ascorbic acid, and minima of 1.6 milligrams of thiamine, 1.8 milligrams of riboflavin, and 21 milligrams of niacin per day. A minimum of 250 milligrams of magnesium has been supplied daily.

The diets were designed with respect to the types of foods selected and their preparation so as to fall within the low residue category. For each calcium level, three or four master menus were prepared which were rotated.

The astronauts, on the other hand, had been provided a diet which was regarded as adequate in energy and in all major nutrients if all of the food provided had been consumed. Therefore, a reduction in calcium intake by the astronauts was accompanied by comparable reductions in energy and in all other nutrients. This is illustrated in Summaries G, H, and I. The summaries include the food provided for the command pilot and the pilot for each of the missions, and the quantities of certain of the major nutrients consumed by the two respective astronauts in each case. The summaries include comparisons of the levels of the following provided and consumed: energy, protein, fat, carbohydrate, calcium, phosphorus, iron, magnesium, sodium, potassium, and chloride (as NaCl). The diets were computerized in the Statistical Laboratories at the Texas Woman's University, with calcium and phosphorus in specimens identical with items placed in the space crafts analyzed chemically in the TWU Bionutrition Laboratories.

The Summaries confirm the statement that a reduction in calcium intake by the astronauts was accompanied by comparable reduction in energy and various nutrients in diets which were planned to have overall adequacy.

SUMMARY G

COMPARISON OF ENERGY AND NUTRIENTS PROVIDED FOR EACH ASTRONAUT IN THE SPACECRAFT OF GEMINI IV IN COMPARISON WITH THAT CONSUMED BY THE COMMAND PILOT AND THE PILOT DURING THEIR ORBITAL FLIGHT

ITEMS	Food Provided for Flight for Daily Consumption		Food Consumed During Flight by:	
	Command Pilot	Pilot	Command Pilot	Pilot
Energy (calories)	2,654.0	2,635.0	2,066.0	2,230.0
Protein (grams)	110.8	111.4	79.8	89.2
Fat (grams)	113.0	111.2	88.8	94.8
Carbohydrate (grams)	283.4	300.6	238.8	257.2
Calcium (milligrams)	903.0	867.0	679.0	739.0
Phosphorus (milligrams)	1,522.0	1,550.0	1,167.0	1,308.0
Iron (milligrams)	9.4	10.4	7.0	8.6
Magnesium (milligrams)	180.5	187.3	157.7	164.4
Sodium (milligrams)	4,356.0	4,048.0	3,146.0	3,117.0
Potassium (milligrams)	2,042.0	2,757.0	2,098.0	2,248.0
Chloride as NaCl (grams)	10.98	10.23	8.17	7.96

SUMMARY H

COMPARISON OF ENERGY AND NUTRIENTS PROVIDED FOR EACH ASTRONAUT IN THE SPACECRAFT OF GEMINI V IN COMPARISON WITH THAT CONSUMED BY THE COMMAND PILOT AND THE PILOT DURING THEIR ORBITAL FLIGHT

ITEMS	Food Provided for Daily Consumption during Flight	Food Consumed During Flight by:	
		Command Pilot	Pilot
Energy (calories)	2,755	1,075	915
Protein (grams)	96.4	41.9	35.8
Fat (grams)	116.6	38.3	30.6
Carbohydrate (grams)	330.3	140.9	124.2
Calcium (milligrams)	849	373	333
Phosphorus (milligrams)	1,555	723	556
Iron (milligrams)	9.5	3.8	3.4
Magnesium (milligrams)	210.9	82.7	73.4
Sodium (milligrams)	4,949.0	2,197.0	1,845.0
Potassium (milligrams)	2,127.0	1,007.0	914.0
Chloride as NaCl (grams)	10.29	4.70	4.06

SUMMARY I

COMPARISON OF ENERGY AND NUTRIENTS PROVIDED FOR EACH ASTRONAUT IN THE SPACECRAFT OF GEMINI VII IN COMPARISON WITH THAT CONSUMED BY THE COMMAND PILOT AND THE PILOT DURING THEIR ORBITAL FLIGHT

ITEMS	Food Provided for Daily Consumption during Flight	Food Consumed during Flight by:	
		Command Pilot	Pilot
Energy (calories)	2,337.0	1,817.0	1,848.0
Protein (grams)	91.1	69.2	70.0
Fat (grams)	98.3	71.3	73.6
Carbohydrate (grams)	272.3	224.7	226.6
Calcium (milligrams)	Command Pilot 1,083.0 Pilot 1,096.0	945.0	921.0
Phosphorus (milligrams)	1,617.0	1,230.0	1,216.0
Iron (milligrams)	9.5	7.3	7.5
Magnesium (milligrams)	188.7	142.9	141.4
Sodium (milligrams)	4,190.0	3,318.0	3,398.0
Potassium (milligrams)	2,307.0	1,808.0	1,735.0
Chloride as NaCl (grams)	8.84	6.82	7.04

BONE DENSITY VALUES OF THE BACK-UP CREWS OF THE GEMINI IV, V, AND VII MISSIONS

For each of the three Gemini prime crews who have been discussed in this report, there was a back-up crew consisting of two men for each mission. Each member of the back-up crews was radiographed four times, with the conventional os calcis trace evaluated for changes in comparison with those of the command pilots and pilots who made the orbital flights. The men of the back-up crews could not be regarded strictly as controls for the astronauts assigned to the respective missions because they were not kept on an assigned diet, with limited dietary records kept preflight and none kept postflight. Nevertheless, it was considered to be of interest to find the range of change in bone density which occurred for colleagues engaged in ground-based activities similar to those in which the flight astronauts took part before their orbital flights. The radiographs made of the back-up crews extended from the preflight to the postflight periods of the prime astronauts.

The prime crew members of the Gemini IV mission were Astronaut James A. McDivitt and Astronaut Edward H. White II. The back-up crew for this mission included Astronaut Frank Borman and Astronaut James Lovell.

The members of the Gemini V mission who took part in the orbital flight were Astronaut L. Gordon Cooper, Jr. and Astronaut Charles

Conrad, Jr. The back-up crew for this mission consisted of Astronaut Neil A. Armstrong and Astronaut Elliott See.

The prime crew members of the Gemini VII mission were Frank Borman and James Lovell. The back-up crew was composed of Astronaut Edward H. White II and Astronaut Mike Collins.

The summary which follows gives the overall span of bone mass values (in terms of per cent difference in calibration wedge mass equivalency) from the lowest to the highest value, and the greatest percentage span between any two successive radiographs of the members of the respective back-up crews.

From this summary it is shown that the overall change from the lowest to the highest value in four radiographs, covering approximately three months in each case was less than the negative change in the bone mass of the same anatomic site during orbital flight of the prime crew members of the respective missions.

Mission	Astronaut	Overall Per Cent Span	Greatest Span between Two Successive Radiographs (per cent)
Gemini IV	Borman	1.63	1.44
	Lovell	1.24	0.50
Gemini V	Armstrong	8.70	7.09
	See	8.95	4.99
Gemini VII	White	2.50	1.53
	Collins	3.00	0.75

New Variable in Gemini VII Orbital Flight

A new variable was inserted into the Gemini VII space flight which was believed to have had an effect on the bone densitometric changes in the central section of the os calcis. This consisted of a planned exercise program used throughout this orbital flight for the first time. Dietlein and Rapp (11) of the NASA Manned Spacecraft Center developed an inflight exerciser and planned a program of isotonic and isometric exercise which was followed routinely by the astronauts of this mission. The purpose of these investigators was to evaluate day-by-day the physical condition of the flight crew with increasing time under space flight conditions. The basis of the evaluations was the response of the cardiovascular system to a calibrated work load.

The exercise device which was used for isotonic exercise in the flight consisted of a pair of bungee cords attached to a nylon plastic handle at one end and to a nylon foot strap at the other. A stainless-steel stop cable limited the stretch of the bungee cords and fixed the isotonic work load of each pull. The device was used to exercise the lower extremities by pushing the foot against the foot strap and lifting the leg in a rigid position. Stress in other parts of the body, including the back, was effectuated by other phases of the isotonic exercise.

A series of isometric exercises also was used in the program which were planned in advance to include stretching of certain muscles without changing position of any part of the body.

It is believed by the authors that the isotonic exercise involving pressure on the ball of the foot was a factor in the lowering of the loss of skeletal mass of the os calcis in the Gemini VII astronauts. No aspect of the exercise program, on the other hand, involved pressure on hand phalanx 5-2, which could account for the fact that bone density was not increased in this skeletal site.

In order to find whether or not the introduction of the exercise variable may have had an effect upon the better retention of bone mass in the central os calcis of the Gemini VII crew during space flight, two 14-day bed rest periods were conducted at the Texas Woman's University, with the same two subjects in both, and with the dietary provision and all other aspects of the units the same, except for the fact that the exercise program was carried out only during the second bed rest trial. The same subjects were used in the two bed rest periods, because, after an extended period of equilibration following the first bed rest, these men were brought to a bone density level both in the os calcis and in hand phalanx 5-2 which matched their status at the beginning of the first bed rest period far more closely than would have been possible had other subjects been used as controls. The exercise program was carried out during the second bed rest four times daily as was done by the Gemini VII astronauts, with the same routine followed and the same exercisers used.

The bone mass values in the central os calcis section during the second bed rest period with exercise surpassed those during the first bed rest without exercise, with the data pooled for both subjects, by a difference which was highly significant ($P < 0.01$). The bone density results with the os calcis were supported by the finding that the amount of calcium excreted during the bed rest period with no exercise exceeded that during the bed rest period with exercise by a significant difference ($P < 0.05$) (12).

The os calcis changes and the changes in calcium excretion with the same subjects during bed rest with and without exercise has a counterpart in an investigation carried on jointly by the Texas Institute of Rehabilitation and Research at the Texas Medical Center, Houston, Texas, and the Texas Woman's University (10).

During the two experimental bed rest trials with and without exercise, hand phalanx 5-2 lost very little bone mass (based on the sum of all of the cross-sectional scans in each case), whether exercise was followed or not, with no statistically significant differences in this respect between the two bed rest results. The considerable difference in the bone mass losses in the small finger during bed rest and during orbital flight requires further study.

STUDIES ON CHANGES IN BONE MASS DURING RECUMBENCY

The first recumbency studies in which Texas Woman's University personnel participated were conducted at the Texas Institute for Rehabilitation and Research at Houston, Texas (10). This study included seven healthy adult males, ages 21 to 34 years of age. After the beginning of the bed rest period, all subjects showed a marked and progressive decrease in bone mass, a type of response which had been observed in a three-day bed rest study done previously at TIRR, in which the TWU personnel also had taken part (13).

In independent 14-day Bed Rest studies conducted at the Texas Woman's University, bone mass has been lowered and calcium excretion has been increased on levels of calcium intake during the Bed Rest period ranging from 300 to 2,000 milligrams per day.

Summary J gives the mean losses in bone mass in the central os calcis section of 14-day bed rest subjects consuming the designated daily mean amounts of dietary calcium. The table also shows the mean daily urinary and fecal output of calcium, reported first in terms of milligrams, and then as per cent of calcium intake.

Figures 21, 22, and 23 together with related data have been included in a report read at a meeting at Manned Spacecraft Center, and later published (14).

SUMMARY J

PER CENT CHANGE IN BONE MASS OF THE CENTRAL OS CALCIS SECTION DURING THE SERIES OF 14-DAY BED REST PERIODS IN COMPARISON WITH THE LOSS OF CALCIUM IN THE EXCRETA

Level of Dietary Calcium Provided (milligrams)	Mean Daily Calcium Intake	Mean Per Cent Change in Bone Mass* in 14 Days of Bed Rest ± Standard Deviation	Mean Daily Calcium Output	
			Urine and Feces (milligrams)	Calcium Output as Per Cent of Intake
300 (4 subjects)	302	-2.35 ± 0.25	724	239.7
500 (5 subjects)	452	-11.65 ± 1.29	1,029	227.6
700 (4 subjects)	664	-7.67 ± 1.72	977	147.1
800 (4 subjects)	841	-8.07 ± 1.37	998	118.7
1,000 (5 subjects)	987	-4.76 ± 1.33	1,061	107.5
1,500 (4 subjects)	1,446	-5.96 ± 0.87	1,620	112.0
2,000 (4 subjects)	2,012	-4.96 ± 0.92	2,281	113.4

*In terms of change in calibration wedge mass equivalency

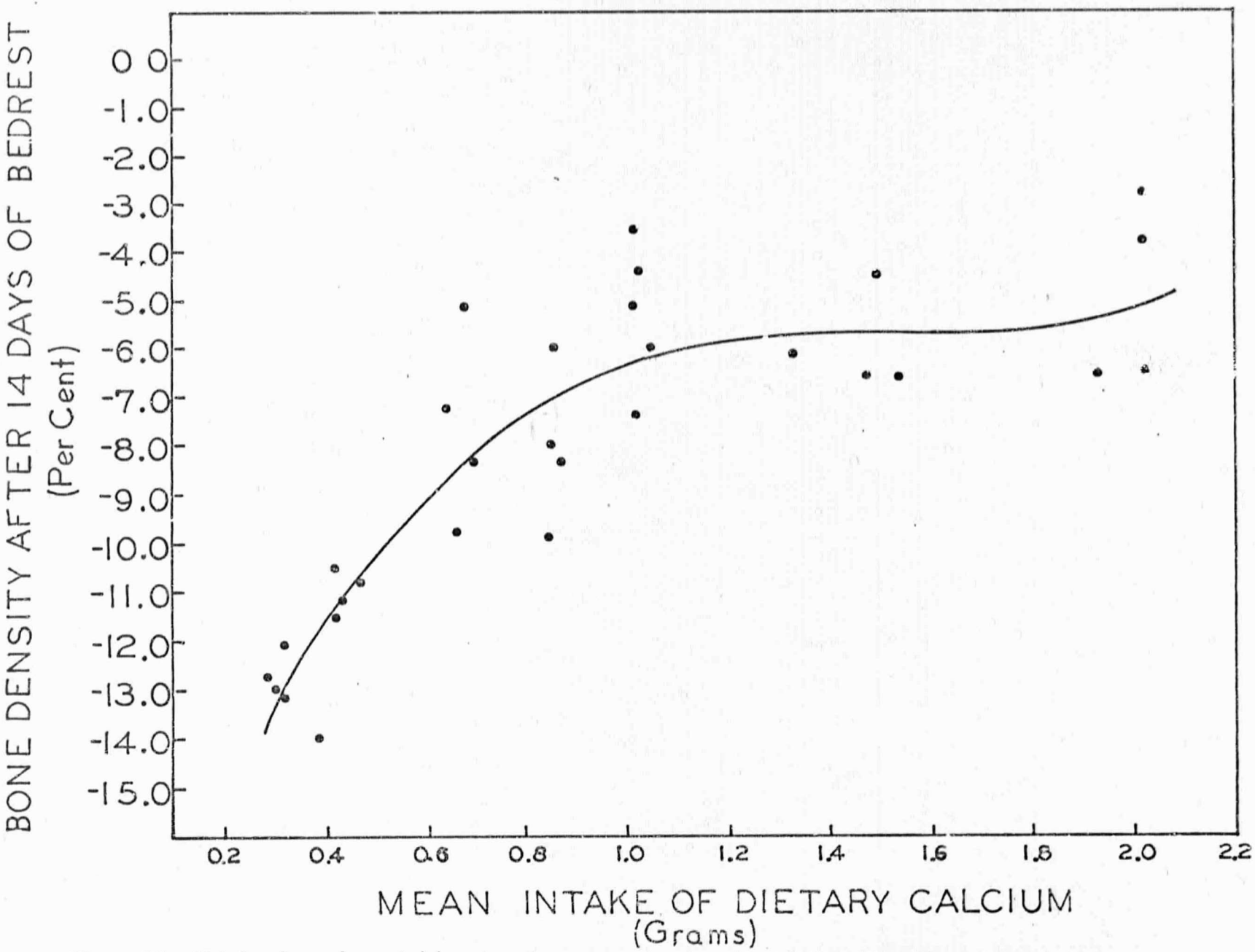


Figure 23. Third order polynomial least square curve showing the relationship of bone mass loss in the central os calcis section to the mean daily intake of calcium by 30 adult male subjects participating in a series of 14-day bed rest trials on different levels of dietary calcium.

Figure 23 consists of a graph in which the bone mass loss of the central os calcis section of each of the 30 men in the studies after 14 days of bed rest, calculated in per cent, is plotted against their mean daily calcium intake for the 14 days. In preparing this graph, a third order polynomial least square method was employed, in which the calcium intake was taken as the independent variable and the following function was generated:

$$\text{Per cent bone mass change} = f(\text{calcium intake})$$

After computing a set of coefficients, these values served to obtain the best fit curve for the data. A negative correlation coefficient of 0.728 was found in the comparison of bone mass loss and mean calcium intake during 14 days.

The output of urinary and fecal calcium tended to be higher with the higher levels of calcium intake. A statistical comparison of daily calcium consumption and daily urinary and fecal excretion from the dat pooled for each of the 30 subjects in these bed rest studies yielded a positive correlation coefficient of 0.934. On the other hand the mean calcium excretion levels (urinary and fecal), calculated as per cent of the calcium intake for each of the subjects was higher for the lower amounts of daily calcium consumption, and lower as the intake increased.

In the Bed Rest units outlined in Summary J, higher levels of dietary calcium were provided during the Pre-Bed Rest ambulatory equilibration periods than during the Bed Rest periods during the first three units, when 300, 500, and 700 milligrams, respectively, were provided daily. This was done for the purpose of bringing the bone mass and the calcium balance status to an equilibrium before the Bed Rest period began in each case.

The other four Bed Rest units were designed in each case so that the same daily level of calcium was provided as during the subsequent bed rest. These levels were 800, 1,000, 1,500 and 2,000 milligrams per day, respectively. In these cases, bone mass remained virtually the same during the last five days of Pre-Bed Rest, with the subjects in calcium balance.

For these four Bed Rest units the calcium excretion levels of urine alone and of urine and feces combined were compared by means of the "t" test for the Pre-Bed Rest ambulatory and the Bed Rest periods, with the results given in Summary K.

Summary K shows that the excretion of calcium during bed rest was higher than that during the ambulatory period on the same calcium dietary level, both for urinary calcium alone and for the calcium of urine and feces.

SUMMARY K

COMPARISON OF CALCIUM EXCRETED IN THE URINE AND IN THE URINE AND FECES COMBINED DURING THE PRE-BED REST AMBULATORY AND THE BED REST PERIODS WHEN THE SAME LEVELS OF DIETARY CALCIUM WERE PROVIDED

Level of Calcium Provided in the Diet	Mean Urinary Calcium Excreted	"t" value	Probability
800 mg.	Pre-bed rest .. 241 Bed rest 310	3.5819	$P < 0.001$
1,000 mg.	Pre-bed rest .. 239 Bed rest 278	2.5549	$P < 0.02$
1,500 mg.	Pre-bed rest .. 282 Bed rest 344	2.4804	$P < 0.02$
2,000 mg.	Pre-bed rest .. 328 Bed rest 393	3.1464	$P < 0.01$
Level of Calcium Provided in the Diet	**Mean Calcium Excreted (urinary and fecal)**	**"t" value**	**Probability**
800 mg.	Pre-bed rest .. 825 Bed rest 999	18.4068	$P < 0.001$
1,000 mg.	Pre-bed rest .. 942 Bed rest ... 1,061	6.867	$P < 0.001$
1,500 mg.	Pre-bed rest 1,387 Bed rest ... 1,619	6.861	$P < 0.001$
2,000 mg.	Pre-bed rest 1,787 Bed rest ... 2,281	15.982	$P < 0.001$

STUDIES ON CHANGES IN BONE MASS DURING ORBITAL FLIGHT

The data accumulated on bone mass during orbital flight is limited in comparison with that obtained from the horizontal bed rest TWU recumbency studies. Even with the relatively small amount of data which has been obtained from six astronauts during orbital flight, however, preliminary comparisons of bone loss with dietary intake is possible.

From Summaries G, H, and I of this report, the quantities of energy and of certain major nutrients consumed daily by the astronauts of Gemini-Titan IV, V, and VII during flight are given. In Summary A, the per cent changes in bone mass in six anatomic sites during orbital flight have been shown. Correlation coefficients were determined for bone mass changes between each of the skeletal sites paired with energy and with each of seven major nutrients. The nutrients featuring in the correlation coefficients were the following: protein, fat, carbohydrate, calcium, phosphorus, magnesium and iron.

Significant correlations were found between the following pairs of dietary components and bone density changes.

All Skeletal Sites Evaluated. Pooled data for all skeletal sections which were considered were found to be significantly related to the levels of intake of energy, carbohydrate, calcium, phosphorus, iron, and

magnesium. Each of the skeletal sites investigated was found to have a significant correlation coefficient when paired with calcium.

Hand Phalanges 4-2 and 5-2. The only other skeletal sections found to be significantly correlated with the dietary factors investigated were hand phalanx 4-2 and hand phalanx 5-2. Both of these phalanges had a statistically significant correlation with energy, protein, fat, carbohydrate, calcium, phosphorus, iron, and magnesium.

The calculation of a simple coefficient of correlation between a bone site and a dietary factor may give a statistically significant finding because of a relationship between two or more dietary factors. In the case of calcium, however, the relationship of this mineral component of bone is understandably related significantly to each skeletal section investigated. The correlation coefficients and the probabilities of significance of the comparisons between the losses in bone mass of the various bone sites and the levels of calcium intake by the astronauts during orbital flight are given in Summary L.

A linear regression line showing the first order relationships between dietary calcium intake and the data for all skeletal sections pooled is shown in Figure 24. Figures 25, 26, and 27 consist of linear regression lines for calcium intake and bone density changes in the central os calcis, in the summation of the multiple sections of the os calcis, and in hand phalanx 5-2, respectively.

SUMMARY L

CORRELATION COEFFICIENTS AND LEVELS OF SIGNIFICANCE FOUND BY COMPARISON OF DIETARY CALCIUM MEAN DAILY INTAKE AND LOSSES IN BONE MASS IN DESIGNATED SKELETAL SITES BY ASTRONAUTS OF GEMINI-TITAN IV, V, AND VII MISSIONS DURING ORBITAL FLIGHT

Pairs of Variables Compared	Correlation Coefficient	Probability of Significance
Calcium Intake All anatomic sites pooled	0.9078	$P < 0.01$
Calcium Intake Central os calcis	0.8069	$P < 0.02$
Calcium Intake Multiple os calcis sections	0.8462	$P < 0.01$
Calcium Intake Talus	0.7085	$P < 0.05$
Calcium Intake Hand phalanx 5-2	0.8886	$P < 0.01$
Calcium Intake Hand phalanx 4-2	0.7850	$P < 0.05$
Calcium Intake Capitate	0.7563	$P < 0.05$

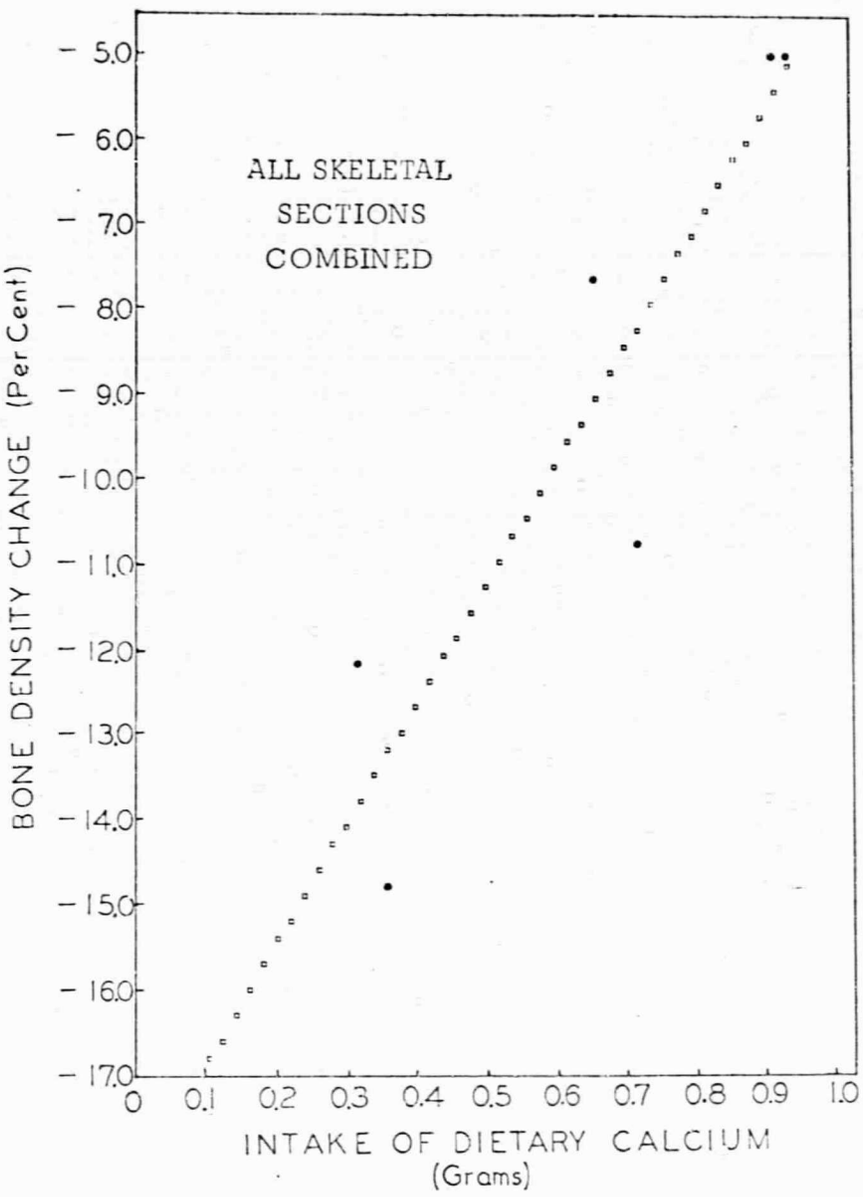


FIGURE 24. LINEAR REGRESSION LINE SHOWING THE RELATIONSHIP BETWEEN THE MEAN DAILY CALCIUM INTAKE AND THE MEAN VALUES FOR CHANGES IN DENSITY VALUES OF ALL SKELETAL SITES COMBINED FROM THE RADIOGRAPHS OF ASTRONAUTS OF THE GEMINI IV, V, AND VII MISSIONS

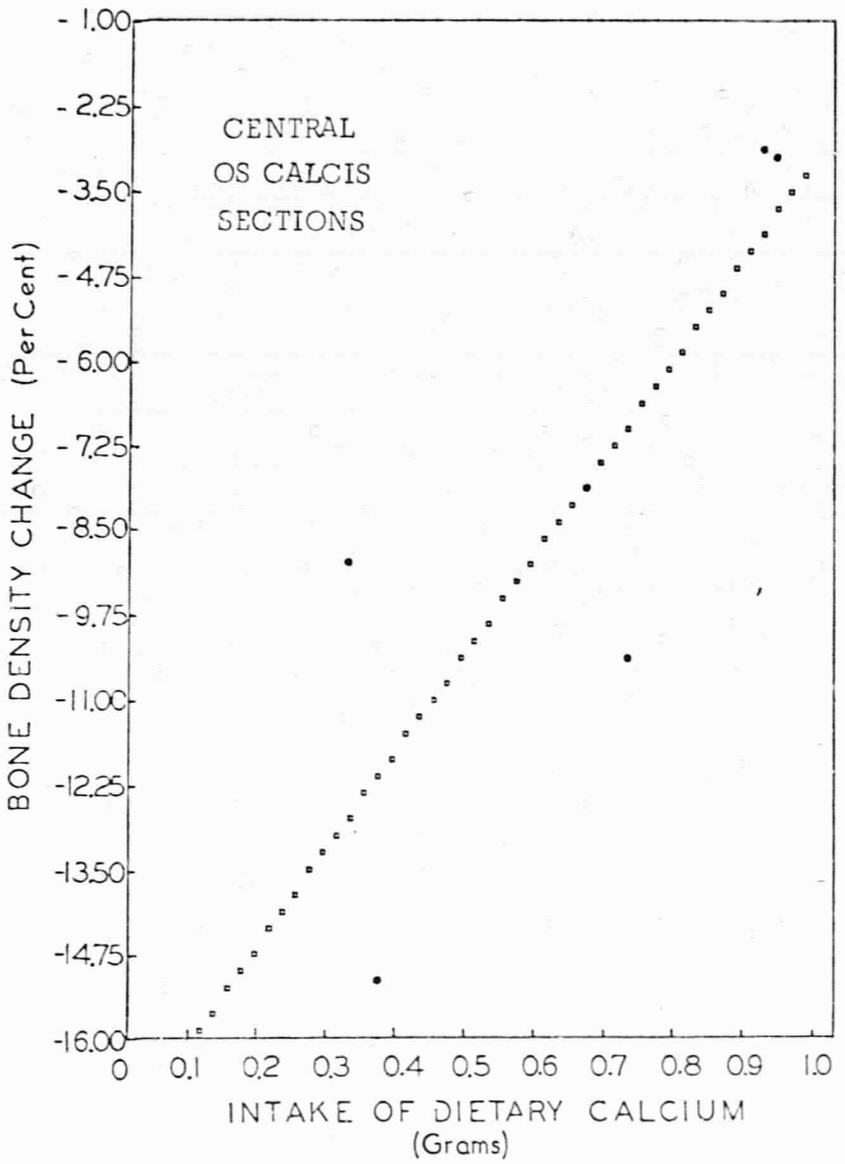


FIGURE 25. LINEAR REGRESSION LINE SHOWING THE RELATIONSHIP BETWEEN MEAN DAILY DIETARY CALCIUM INTAKE AND MEAN VALUES FOR CHANGES IN THE DENSITY VALUES OF THE CENTRAL OS CALCIS SECTIONS FROM THE RADIOGRAPHS OF ASTRONAUTS OF THE GEMINI IV, V, AND VII MISSIONS

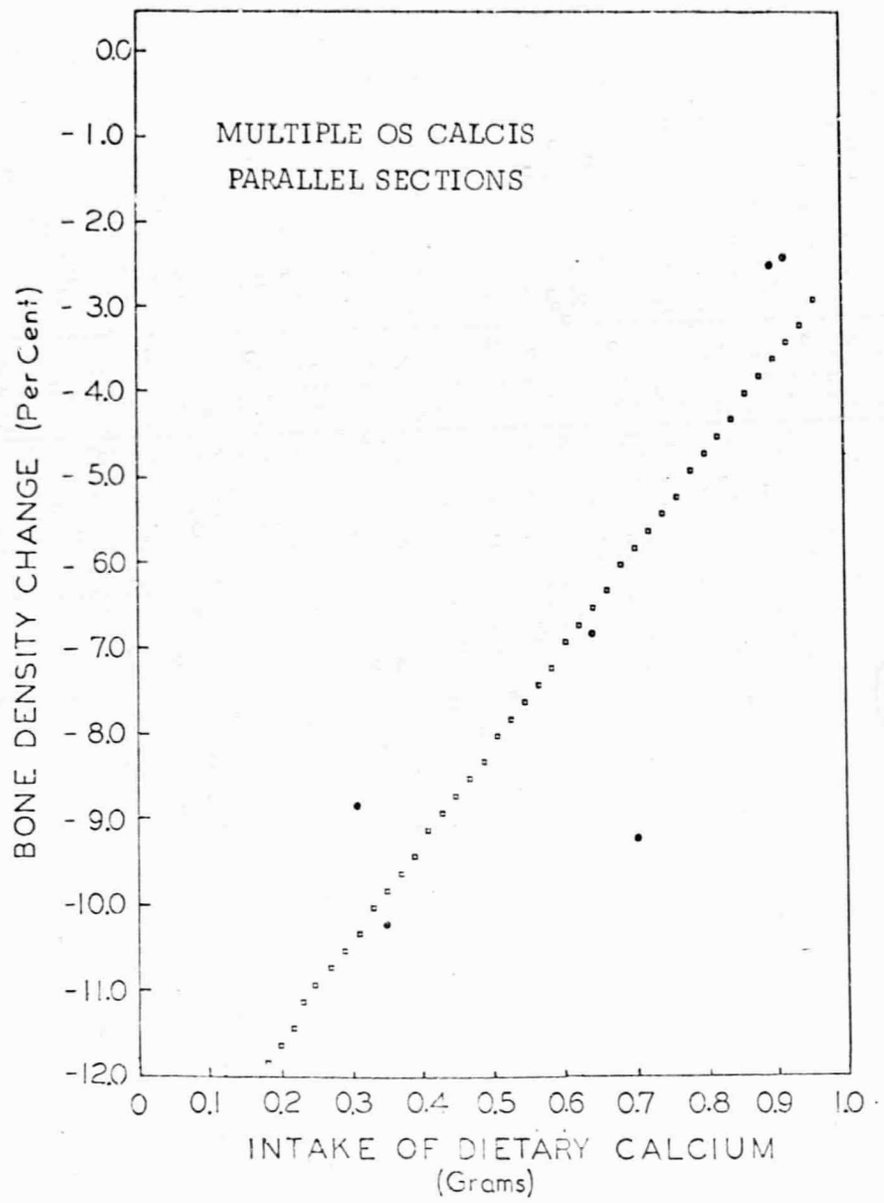


FIGURE 26. LINEAR REGRESSION LINE SHOWING THE RELATIONSHIP BETWEEN MEAN DAILY DIETARY CALCIUM INTAKE AND MEAN VALUES FOR CHANGES IN THE OVERALL DENSITY OF 60 PER CENT OF THE OS CALCIS DERIVED FROM SCANNING MULTIPLE PARALLEL SECTIONS FROM THE OS CALCIS RADIOGRAPHS OF ASTRONAUTS OF THE GEMINI IV, V, AND VII MISSIONS

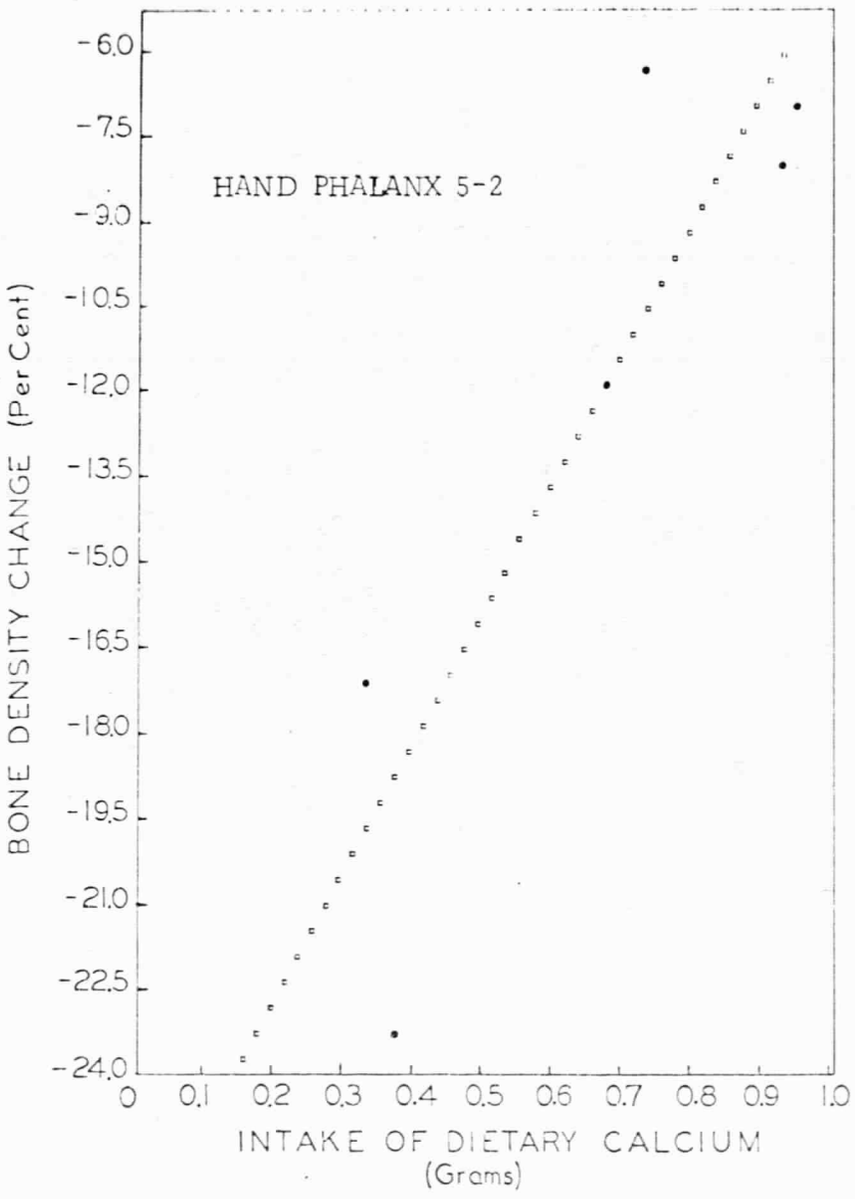


FIGURE 27. LINEAR REGRESSION LINE SHOWING THE RELATIONSHIP BETWEEN MEAN DAILY DIETARY CALCIUM INTAKE AND MEAN VALUES FOR CHANGES IN THE OVERALL DENSITY VALUES DERIVED FROM SCANNING PARALLEL SECTIONS OF HAND PHALANX 5-2 RADIOGRAPHS OF ASTRONAUTS OF THE GEMINI IV, V, AND VII MISSIONS

DYNAMICS OF BONE DENSITY CHANGE

Reproducibility of Bone Densitometer Tracing Technique

The data presented in this report show that rapid changes in bone density measurements may appear both in bed rest studies and during changes in environment of the astronauts. Before discussing the basis for confidence in such changes as have been shown by means of the radiographic bone density technique used in the studies covered in this report, the reproducibility of the bone densitometer tracing technique should be considered. In a Chapter by Mack (8) from the Report on Progress in Development of Methods in Bone Densitometry published by the National Aeronautics and Space Administration (NASA SP-64), the following is quoted:

"As a test of the reproducibility of the bone densitometer tracing technique which has been discussed in this report, eight films of Dr. Fred B. Vogt's heel bone were taken within a period of one-half hour. Dr. Vogt monitored the tracing of the films and the analysis of the data which are presented in Summary M.

"The author positioned the subject and supervised the taking of the x-rays, as is done for all x-rays taken in this laboratory. The subject was required to get on and off the x-ray table and be repositioned for each film taken. After being located on the table, a positive of an

os calcis film was placed under his foot over the x-ray film, which was encased in a cardboard holder. The purpose of the x-ray positive was to position the foot identically for each film and to insure that the location of the wedge with reference to the os calcis remained the same each time an exposure was made. The positive was removed before the film was taken. This procedure is followed in all longitudinal studies, with a subject's positive made from the first radiograph taken in a series.

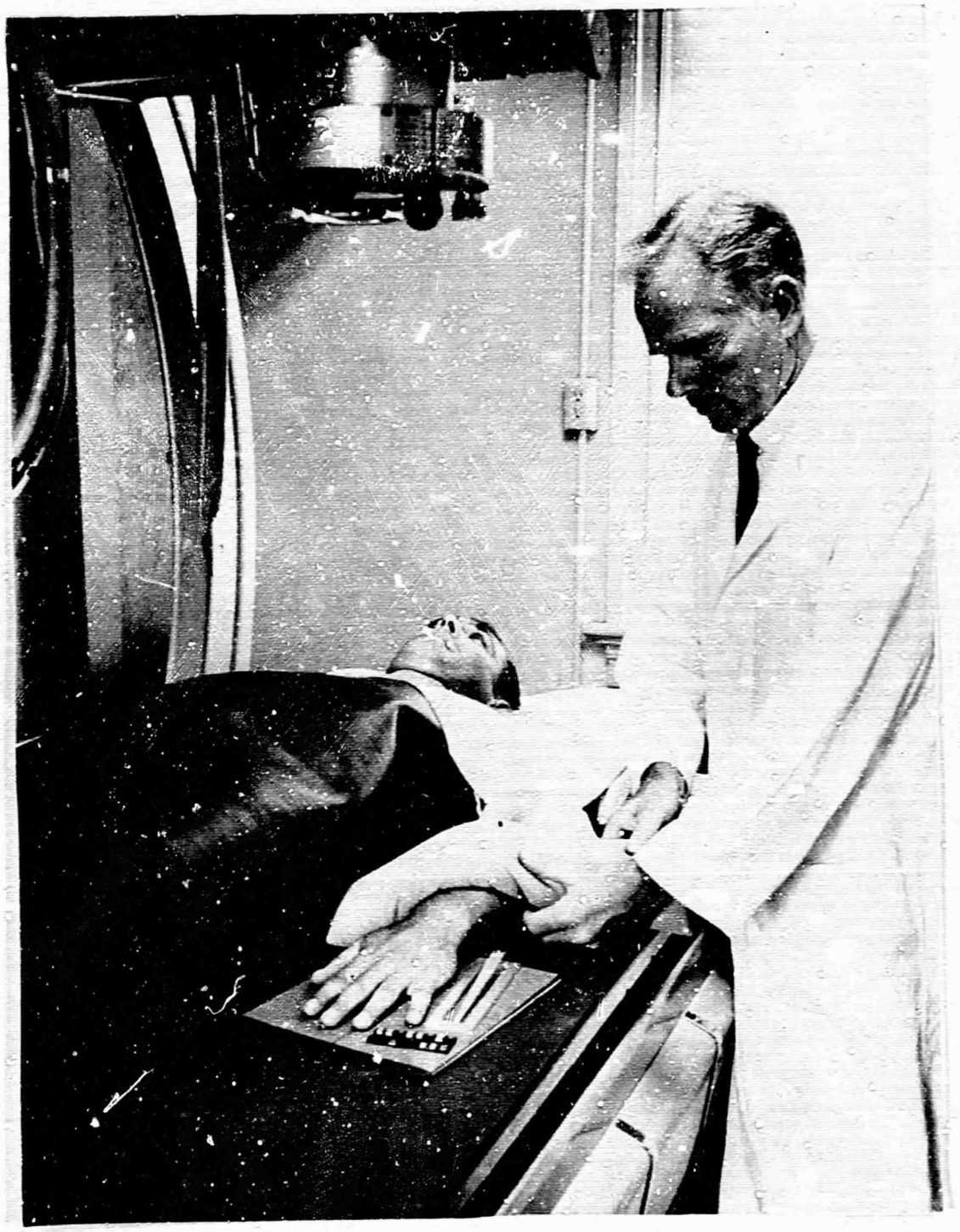
"The position of the x-ray tube and of the illuminated center spot which coincides with the center of the x-ray beam was adjusted for each film, with the center light spot made to coincide with the same place on the side of the foot with each repeated position.

"The same exposure conditions were used for each film— namely, 60 kV, 100 mA, and 0.6 second. All films were processed in the developer at the same time. The subject was protected during all exposures by lead shielding placed over his body, covering all areas except the foot, with the shielding replaced for each new positioning.

"The results in the summary represent the analysis of the central section of the os calcis (See Figure 1). The section was segmented as it was traced by interrupting the scan and taking an integrator count for 10 separate segments in each bone scan, as shown in the cross-sectional view through which this scan is traced (See Figure 4).

"On each film the os calcis was analyzed three separate times, with the film completely repositioned in the densitometer before each analysis, and with the wedge scanned, the uncorrected wedge trace corrected, and the proper section of the bone scanned independently for each trial. The positions of the scan on os calcis and on the wedge were located on each film by needle pricks at the posterior-anterior extremities of the bone scan position, but outside of the bone. Exact locations of the landmarks for the scans were found for the various films by superimposing the films one at a time on top of the initial film and locating the positions of the needle pricks from this first film. To give some evaluation of the range of error that can be expected for the total process of taking the film, developing the film, and analyzing the film on the densitometer, an analysis of variance was performed on the sums of the counts for the segments for each of the three analyses made on the eight films. The data are presented in integrator counts. The 99% confidence interval is expressed in mean densitometer counts of 11,160, with a range of counts above and below this mean approximating 0.75% of the total counts. Thus it could be said that the "error" which is found between the films as analyzed is represented at the 99% confidence interval by a span or range of 0.75% above and below the mean for a total range of 1.5%."

Summary M gives the data used in this test.



Positioning the subject for making a radiograph of the hand in posterior-anterior projection. The subject is protected by a plastic vinyl covering impregnated with a lead compound.

SUMMARY M

INTEGRATOR COUNTS MADE OF EIGHT OS CALCIS FILMS PROCESSED AND ANALYZED THREE TIMES FOR EACH FILM, WITH THE EIGHT FILMS TAKEN OF THE SAME SUBJECT WITHIN ONE-HALF HOUR, WITH THE SUBJECT REPOSITIONED BETWEEN FILM EXPOSURES

	Film 1			Film 5			
Segment 1	496	498	506	Segment 1	500	501	502
Segment 2	791	796	782	Segment 2	804	799	800
Segment 3	1037	1041	1041	Segment 3	1053	1058	1054
Segment 4	1240	1237	1253	Segment 4	1264	1269	1239
Segment 5	1287	1281	1302	Segment 5	1311	1314	1310
Segment 6	1279	1275	1294	Segment 6	1306	1304	1306
Segment 7	1232	1239	1240	Segment 7	1241	1245	1240
Segment 8	1230	1226	1229	Segment 8	1232	1238	1243
Segment 9	1265	1264	1254	Segment 9	1265	1278	1269
Segment 10	1223	1231	1225	Segment 10	1229	1236	1249
Total	11080	11088	11126	Total	11205	11242	11212
	Film 2			Film 6			
Segment 1	506	502	497	Segment 1	504	503	505
Segment 2	787	784	787	Segment 2	796	799	798
Segment 3	1034	1039	1033	Segment 3	1048	1051	1051
Segment 4	1241	1236	1234	Segment 4	1259	1253	1268
Segment 5	1250	1294	1274	Segment 5	1301	1290	1310
Segment 6	1286	1301	1281	Segment 6	1300	1286	1297
Segment 7	1222	1229	1227	Segment 7	1247	1245	1245
Segment 8	1234	1239	1235	Segment 8	1243	1240	1243
Segment 9	1271	1269	1251	Segment 9	1270	1266	1278
Segment 10	1239	1240	1255	Segment 10	1243	1241	1247
Total	11100	11133	11074	Total	11211	11174	11242
	Film 3			Film 7			
Segment 1	501	498	497	Segment 1	503	503	502
Segment 2	783	781	800	Segment 2	803	810	806
Segment 3	1046	1053	1041	Segment 3	1041	1046	1044
Segment 4	1254	1247	1237	Segment 4	1241	1244	1243
Segment 5	1299	1283	1291	Segment 5	1294	1310	1302
Segment 6	1286	1277	1290	Segment 6	1291	1300	1297
Segment 7	1240	1242	1231	Segment 7	1231	1236	1239
Segment 8	1237	1234	1236	Segment 8	1229	1233	1231
Segment 9	1275	1265	1258	Segment 9	1274	1265	1268
Segment 10	1228	1236	1234	Segment 10	1244	1241	1234
Total	11149	11116	11115	Total	11151	11188	11166
	Film 4			Film 8			
Segment 1	507	502	502	Segment 1	496	503	507
Segment 2	800	801	804	Segment 2	797	807	791
Segment 3	1041	1041	1039	Segment 3	1038	1029	1058
Segment 4	1260	1262	1237	Segment 4	1236	1240	1265
Segment 5	1304	1291	1296	Segment 5	1300	1304	1314
Segment 6	1295	1287	1301	Segment 6	1294	1311	1302
Segment 7	1240	1243	1230	Segment 7	1230	1232	1239
Segment 8	1249	1240	1236	Segment 8	1240	1238	1243
Segment 9	1263	1260	1278	Segment 9	1267	1275	1275
Segment 10	1237	1228	1250	Segment 10	1228	1239	1252
Total	11195	11155	11173	Total	11126	11178	11246

DISCUSSION

Biological Changes in Bone Density Values. Changes in bone density as measured by the technique developed by staff members of the Texas Woman's University Research Institute which come within the range of 0.75 per cent above and below the mean, with a total span not to exceed 1.5 per cent, as discussed above, are regarded by those associated with this radiographic method as the result of factors related to differences in exposure techniques, to minor film differences, and to possible differences in positioning a subject or exposure differences. Differences which exceed the above spans have been demonstrated in these laboratories as resulting from biological factors, such as changes in dietary intake, physical activity, or illness. Certain other factors, such as stress, undoubtedly also are operative.

Marked Reduction of Calcium during Recumbency and Weightlessness. Marked changes in calcium intake levels have been shown in the TWU bed rest series to result in relatively rapid changes in bone mass. The changes are more rapid, the wider the change in calcium intake. As an example, a subject who has been at bed rest for three days, who has had a mean daily calcium provision of 2,000 milligrams during his pre-bed rest ambulatory equilibration period and who averaged 395 milligrams during his bed rest period of 14 days duration, followed a more rigorous reduction in bone density change than a

subject who was maintained on a diet which provided 2,000 milligrams of calcium daily throughout his equilibration and his bed rest periods, all other dietary provisions being the same for both subjects throughout. The same has been shown in orbital flight during the Gemini missions as shown, for example, in the astronauts of Gemini V and Gemini VII.

Stability of Bone Mass during Ambulation. Many persons have the misconception that, when a subject is ambulatory, the bone density of the various skeletal sites is stable. Nothing could be more erroneous. Bone density undergoes changes with relative rapidity, whether in recumbency or ambulation depending upon various factors, including dietary changes and changes in physical activity, as noted.

Cantarow and Schepartz (15) state that, in common with other tissues, bone experiences continual metabolic turnover, its various components undergoing degradation, mobilization, and replacement. These authors state further that interchange of ions between the bone and the extracellular fluid occurs more rapidly in newly formed trabecular bone than in older compact bone.

Analysis of Changes in Bone Density by Microdensitometry

The cooperation of Data Corporation in Dayton, Ohio, was sought in order to find whether or not their scientists, who had devoted themselves chiefly to the interpretation of optical and photographic imagery, could apply some of their techniques to radiographic films. It was their belief that this could be done and this report includes the first phase of what will be a continuing program of cooperation based on the x-rays of astronauts and of bed rest subjects made in the TWU program for which verification of extremely rapid changes seem desirable.

In this first report, Data Corporation brought to bear a series of techniques which are used primarily by themselves in the analysis and reconstruction of photographic images as obtained in reconnaissance missions. Because of the marked changes found in bone mass of 74 cross-sections scanned in the possible anatomic sites of the command pilot of the Gemini-Titan V orbital flight, it seemed desirable to begin this analytical evaluation with certain of this astronaut's films. To accomplish the analysis, three os calcis x-rays were used: (a) the one taken just before launch; (b) the one taken on the carrier immediately after recovery; and (c) the one taken on the carrier 24 hours after recovery.

Microdensitometry. The first step in the process of analysis consisted of image scanning, digitizing, and recording, using a Micro-Analyzer built by Data Corporation for the purpose. This instrument is a scanning microdensitometer built by the Corporation for its own work.

The scanning aperture projected into the image plane was a circular spot 100 microns in diameter. Both the reference calibration wedge and the subject image area on the radiograph were scanned with identical sample format and instrument settings.

A single scan was taken down the center line of the calibration wedge. Density measurements were made every 75 microns along the scan, providing 25 per cent longitudinal overlap between successive sample points. Two thousand data points were taken over the entire wedge length.

The image subjects came from radiographs of the os calcis, for which a scan line of 60 mm. was selected. As in the scanning of the wedge, density samples were measured at 75 micron intervals along each scan line, giving a total of 800 data points per line. At the end of each line, the specimen table was moved 75 microns in the direction orthogonal to the scan line, producing an overlapping raster pattern of density measurements. In the 375 scan lines, there was a total of

300,000 data points for each image studied. All data recording was performed on magnetic tape in digital form.

Digital Data Reduction. The data analysis and computation consisted of three parts: (a) recovery of calibration control from the recording of the wedge; (b) the arrangement and storage of data points in their proper positions within the image array; and (c) the adjustment of density measurements to the mass equivalence base provided by the wedge. An IBM 360/40 was used for computing and reconstructing the image, and the internal storage of the digital array was handled by magnetic disk files.

The wedge information was recovered from the continuous line scan by reference to an edge at one end of the physical wedge. This provided a steep gradient in the density samples, and allowed recovery of a reference origin within an accuracy of a few microns. Each set of wedge measurements was related to the same origin, providing an identity equation for the correlation of equivalent wedge mass with image density for each exposure.

Successive scans on the Micro-Analyzer were made in opposite directions. Therefore, the primary task in reconstructing the array of image points was the inversion of scan coordinates for every other line. A two dimensional array was established on the disk files of the computer, with each density data point occupying a unique storage

location corresponding to its measured image position. The array size corresponded to the density scanning program, having 800 by 375 elements respectively in the X and Y directions.

After the density values were stored in their proper locations in the array, the wedge calibration corrections corresponding to that image were applied. No interpolations or truncations were performed, since the wedge values and the recorded density values were maintained at their full precision of 0.001 density units.

A specialized printer is attached to the Data Corporation computer, having variable sized half-tone dots on the printing hammers in place of conventional alphabetic and numeric characters. This printer permits the selection of any of 24 shades of gray by digital control, and any shade may be exactly recaptured from one printing operation to the next.

A display table was constructed mathematically to control the printer with the control of printing dot size related to ranges of mass equivalence. Since the original radiograph was a negative, the display was also printed as a negative. Therefore, the lightest shades of gray correspond to points of least exposure and darkest shades to greatest exposure. Since exposure of the radiograph varies in an inverse

manner with the mass of the material interposed in the beam, the lightest shades of the display correspond to the more massive materials.

Because the eye can respond to only a limited number of shades of gray, an additional form of display was devised. This has the characteristic of plotting contours of equal mass equivalence with a small number of contrasting shades, then repeating the cycle as many times as is required to cover the total range of information. The shades used for this purpose were White, Light Gray, Dark Gray, and Black and then the shades were repeated in the same order through a total of five cycles. See Figures 17, 18, and 19 for the contour displays of the Launch, Recovery, and Post-Recovery film analyses, respectively.

Comparison of Data from the Microanalyzer with the TWU Bone Densitometer Report. In the report to the National Aeronautics and Space Administration, Manned Spacecraft Center, on Experiment M-6, Bone Demineralization on Gemini V issued on January 15, 1966 by the Nelda Childers Stark Laboratory of the Texas Woman's University Research Institute, the graph shown in Figure 20 on changes in the calibration wedge mass equivalency of the central os calcis section for the Command Pilot of this mission was included. Also the following data were given for this graph (Summary N).

SUMMARY N

CALIBRATION WEDGE MASS EQUIVALENCY FOR THE CENTRAL OS CALCIS SECTION OF THE COMMAND PILOT OF THE GEMINI V MISSION TAKEN FOR EIGHT FOOT X-RAYS OF THIS SERIES

Radiograph	Date	Calibration Wedge Mass Equivalency
1	8/11/65	2.10
2	8/17/65	2.08
3	8/19/65	1.97
4	8/21/65 (launch)	1.92
5	8/29/65 (Recovery)	1.63
6	8/30/65 (24 hours after recovery)	1.61
7	9/8/65	1.92
8	11/3/65	2.01

In addition, values and graphs for each date were given for 36 other sections of the os calcis, for the central section of the talus, for 18 cross-sections of hand phalanx 5-2, for 22 cross-sections of hand phalanx 4-2, and for the distal end of the radius.

To return to the central section of the os calcis, the change from launch to recovery eight days later was reported by us as -15.1 per cent, while an additional small loss was shown during the 24 hours subsequent to recovery.

The Data Corporation found similar values for the changes in the central section of the os calcis during flight and a further minor loss during the 24-hour post-recovery period, indicating that he had not yet begun to rebuild his lost skeletal mineral. With structural details of the entire os calcis region analyzed, other extremely valuable data were obtained. The greatest changes occurred in the most highly trabecular area, with the least negative changes located toward the base of the bone in largely cortical tissue.

Our two laboratories look upon this cooperation as a means of giving detail which will elaborate our findings in special cases, not as a substitute for our technique.

The x-ray films used in these studies are standardized by the National Bureau of Standards, with funds supplied by the Texas Woman's University.

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APPENDIX

TABLE I

EVALUATION OF THE CENTRAL OS CALCIS POSTERIOR-ANTERIOR SECTION ("CONVENTIONAL" SCAN) FOR GEMINI IV ASTRONAUTS THROUGHOUT THEIR MISSION

PART A. COMMAND PILOT

Film Numbers and Dates	Evaluations in Terms of Integrator Counts			Evaluations in Terms of Calibration Wedge Mass Equivalency (grams)
	Evaluation Number 1	Evaluation Number 2	Average of Both Evaluations	
Film 1 (5/25/65)	13,569	13,479	13,493	2.429
Film 2 (6/1/65)	13,323	13,401	13,362	2.405
Film 3 (6/3/65) (Launch)	13,195	12,946	13,070	2.353
Film 4 (6/7/65) (Recovery)	11,956	12,144	12,050	2.169
Film 5 (6/23/65)	12,349	12,272	12,310	2.216
Film 6 (7/27/65)	12,611	12,661	12,636	2.274

TABLE I, CONTINUED

EVALUATION OF THE CENTRAL OS CALCIS POSTERIOR-ANTERIOR SECTION ("CONVENTIONAL" SCAN) FOR GEMINI IV ASTRONAUTS THROUGHOUT THEIR MISSION

PART B. PILOT

Film Numbers and Dates	Evaluations in Terms of Integrator Counts			Evaluations in Terms of Calibration Wedge Mass Equivalency (grams)
	Evaluation Number 1	Evaluation Number 2	Average of Both Evaluations	
Film 1 (5/25/65)	14,041	14,213	14,127	2.543
Film 2 (6/1/65)	14,503	14,639	14,571	2.623
Film 3 (6/3/65) (Launch)	15,403	15,289	15,346	2.762
Film 4 (6/7/65) (Recovery)	13,724	13,816	13,770	2.479
Film 5 (6/23/65)	13,364	13,519	13,441	2.419
Film 6 (7/27/65)	14,417	14,394	14,406	2.593

TABLE II

VALUES OF THE COMPLETE SERIES OF RADIOGRAPHS OF THE MULTI
FOR THE COMMAND PILOT OF THE GEMINI IV M

PART A. MULTIPLE SECTIONS IN TERMS OF INTEGRATOR COUNTS

Position of Tracing	Preflight Radiographs			Mean of Preflight Radiographs Mean of Films 1, 2, and 3	Post
	Film 1 (5/25/65)	Film 2 (6/1/65)	Film 3 (6/3/65)		Film 4 (6/7/65)
1 m.m. above	13,533	13,379	13,013	13,308	12,090
Conventional Trace	13,524	13,362	13,070	13,318	12,050
1 m.m. below	13,299	13,411	12,934	13,215	11,995
2 m.m. below	12,894	12,691	12,366	12,650	11,690
3 m.m. below	12,518	12,335	12,008	12,287	11,178
4 m.m. below	12,337	12,105	11,899	12,114	10,958
5 m.m. below	12,266	11,988	11,740	11,998	10,986
6 m.m. below	12,200	11,832	11,798	11,943	10,966
7 m.m. below	12,025	11,492	11,661	11,726	10,712
8 m.m. below	11,762	11,198	11,596	11,519	10,687
9 m.m. below	11,464	10,874	11,276	11,205	10,406
10 m.m. below	11,132	10,624	11,198	10,985	10,170
11 m.m. below	10,920	10,281	10,772	10,658	10,008
12 m.m. below	10,654	10,434	10,566	10,551	9,728
13 m.m. below	10,397	10,070	10,391	10,286	9,523
14 m.m. below	10,203	9,845	10,260	10,102	9,412
15 m.m. below	9,843	9,508	9,618	9,656	9,326
16 m.m. below	9,617	9,267	9,041	9,308	8,572
17 m.m. below	8,996	8,836	8,696	8,842	8,114
18 m.m. below	8,497	8,188	8,346	8,344	7,744
19 m.m. below	7,982	7,851	8,024	7,952	7,504
20 m.m. below	7,663	7,028	7,702	7,464	7,010
21 m.m. below	7,442	7,024	7,312	7,259	6,751
22 m.m. below	7,012	6,901	7,020	6,978	6,337
23 m.m. below	6,862	6,739	6,638	6,746	6,188
24 m.m. below	6,818	6,310	6,582	6,570	5,987
25 m.m. below	6,430	6,694	6,380	6,501	5,950
26 m.m. below	6,403	6,540	6,142	6,362	5,850
27 m.m. below	6,253	6,526	5,973	6,251	5,714
28 m.m. below	6,044	6,373	5,852	6,090	5,686
29 m.m. below	5,979	6,334	5,692	6,002	5,518
30 m.m. below	5,824	5,746	5,478	5,683	5,396
31 m.m. below	5,594	5,794	5,347	5,578	5,140
32 m.m. below	5,318	5,576	5,227	5,374	4,996
33 m.m. below	5,045	5,366	5,034	5,148	4,775
34 m.m. below	4,920	5,142	4,888	4,983	4,583
35 m.m. below	4,646	4,588	4,709	4,648	4,294
TOTAL	334,316	328,252	326,249	329,605	303,994

ABLE II

OGRAPHS OF THE MULTIPLE OS CALCIS SECTIONS
OT OF THE GEMINI IV MISSION

R COUNTS

Mean of Preflight Radiographs Mean of Films 1, 2, and 3	Postflight Radiographs			Mean of Postflight Radiographs Mean of Films 4, 5, and 6
	Film 4 (6/7/65)	Film 5 (6/23/65)	Film 6 (7/27/65)	
13,308	12,090	12,353	12,770	12,404
13,318	12,050	12,310	12,636	12,332
13,215	11,995	12,321	12,581	12,299
12,650	11,690	12,033	12,104	11,942
12,287	11,178	11,474	11,696	11,449
12,114	10,958	11,314	11,624	11,299
11,998	10,986	11,208	11,702	11,299
11,943	10,966	11,191	11,565	11,241
11,726	10,712	11,106	11,434	11,084
11,519	10,687	11,058	11,202	10,982
11,205	10,406	10,979	10,835	10,740
10,985	10,170	10,686	10,564	10,473
10,658	10,008	10,378	10,300	10,229
10,551	9,728	10,156	10,128	10,004
10,286	9,523	9,886	9,870	9,760
10,102	9,412	9,671	9,454	9,512
9,656	9,326	9,462	9,206	9,331
9,308	8,572	9,107	8,780	8,820
8,842	8,114	8,746	8,292	8,384
8,344	7,744	8,292	7,972	8,003
7,952	7,504	7,754	7,325	7,528
7,464	7,010	7,349	7,086	7,148
7,259	6,751	7,073	6,841	6,888
6,978	6,337	6,778	6,579	6,565
6,746	6,188	6,528	6,448	6,388
6,570	5,987	6,380	6,243	6,203
6,501	5,950	6,132	6,039	6,040
6,362	5,850	5,868	5,962	5,893
6,251	5,714	5,666	5,812	5,731
6,090	5,686	5,664	5,639	5,663
6,002	5,518	5,552	5,608	5,559
5,683	5,396	5,328	5,390	5,371
5,578	5,140	5,245	5,242	5,209
5,374	4,996	5,092	5,068	5,052
5,148	4,775	4,946	4,965	4,895
4,983	4,583	4,753	4,724	4,687
4,648	4,294	4,645	4,589	4,509
329,605	303,994	314,484	314,275	310,916

TABLE II, CONTINUE

VALUES OF THE COMPLETE SERIES OF RADIOGRAPHS OF T

FOR THE COMMAND PILOT OF THE GE

PART B. MULTIPLE SECTIONS IN TERMS OF CALIBRATION WEDGE MASS

Position of Tracing	Preflight Radiographs			Mean of Preflight Radiographs Mean of Films 1, 2, and 3
	Film 1 (5/25/65)	Film 2 (6/1/65)	Film 3 (6/3/65)	
1 m.m. above	2.4359	2.4082	2.3423	2.3954
Conventional Trace	2.4343	2.4052	2.3526	2.3973
1 m.m. below	2.3938	2.4140	2.3281	2.3786
2 m.m. below	2.3209	2.2844	2.2259	2.2770
3 m.m. below	2.2532	2.2203	2.1614	2.2116
4 m.m. below	2.2207	2.1789	2.1418	2.1804
5 m.m. below	2.2079	2.1578	2.1132	2.1596
6 m.m. below	2.1960	2.1298	2.1236	2.1498
7 m.m. below	2.1645	2.0686	2.0990	2.1107
8 m.m. below	2.1172	2.0156	2.0873	2.0733
9 m.m. below	2.0635	1.9573	2.0297	2.0168
10 m.m. below	2.0038	1.9123	2.0156	1.9772
11 m.m. below	1.9656	1.8506	1.9390	1.9184
12 m.m. below	1.9177	1.8781	1.9019	1.8992
13 m.m. below	1.8715	1.8126	1.8704	1.8515
14 m.m. below	1.8365	1.7721	1.8468	1.8184
15 m.m. below	1.7717	1.7114	1.7312	1.7381
16 m.m. below	1.7311	1.6681	1.6274	1.6755
17 m.m. below	1.6193	1.5905	1.5653	1.5917
18 m.m. below	1.5295	1.4738	1.5023	1.5019
19 m.m. below	1.4368	1.4132	1.4443	1.4314
20 m.m. below	1.3793	1.2650	1.3864	1.3436
21 m.m. below	1.3396	1.2643	1.3162	1.3067
22 m.m. below	1.2622	1.2422	1.2636	1.2560
23 m.m. below	1.2352	1.2130	1.1948	1.2143
24 m.m. below	1.2272	1.1358	1.1848	1.1326
25 m.m. below	1.1574	1.2049	1.1484	1.1702
26 m.m. below	1.1525	1.1772	1.1056	1.1451
27 m.m. below	1.1255	1.1747	1.0751	1.1251
28 m.m. below	1.0879	1.1471	1.0534	1.0861
29 m.m. below	1.0762	1.1401	1.0246	1.0803
30 m.m. below	1.0483	1.0343	0.9860	1.0228
31 m.m. below	1.0069	1.0429	0.9625	1.0041
32 m.m. below	0.9572	1.0037	0.9409	0.9672
33 m.m. below	0.9081	0.9659	0.9061	0.9267
34 m.m. below	0.8856	0.9256	0.8798	0.8970
35 m.m. below	0.8363	0.8258	0.8476	0.8366
TOTAL	60.1768	59.0853	58.7249	59.3284

CONTINUED

RAPHS OF THE MULTIPLE OS CALCIS SECTIONS
OF THE GEMINI IV MISSION

WEDGE MASS EQUIVALENCY (GRAMS)

Mean of Preflight Radiographs Mean of Films 1, 2, and 3	Postflight Radiographs			Mean of Postflight Radiographs Mean of Films 4, 5, and 6
	Film 4 (6/7/65)	Film 5 (6/23/65)	Film 6 (7/27/65)	
2.3954	2.1762	2.2235	2.2986	2.2327
2.3973	2.1690	2.2158	2.2745	2.2197
2.3786	2.1591	2.2178	2.2646	2.2138
2.2770	2.1012	2.1659	2.1787	2.1496
2.2116	2.0120	2.0653	2.1053	2.0608
2.1804	1.9724	2.0365	2.0923	2.0337
2.1596	1.9775	2.0174	2.1064	2.0337
2.1498	1.9739	2.0144	2.0817	2.0233
2.1107	1.9282	1.9991	2.0581	1.9951
2.0733	1.9237	1.9904	2.0164	1.9768
2.0168	1.8731	1.9762	1.9503	1.9332
1.9772	1.8306	1.9235	1.9015	1.8852
1.9184	1.8014	1.8680	1.8540	1.8411
1.8992	1.7510	1.8281	1.8230	1.8007
1.8515	1.7141	1.7795	1.7766	1.7567
1.8184	1.6942	1.7408	1.7017	1.7122
1.7381	1.6787	1.7032	1.6571	1.6796
1.6755	1.5430	1.6393	1.5804	1.5876
1.5917	1.4605	1.5743	1.4926	1.5091
1.5019	1.3939	1.4926	1.4350	1.4405
1.4314	1.3507	1.3957	1.3185	1.3550
1.3436	1.2618	1.3228	1.2755	1.2867
1.3067	1.2152	1.2731	1.2314	1.2399
1.2560	1.1407	1.2200	1.1842	1.1816
1.2143	1.1138	1.1750	1.1506	1.1498
1.1826	1.0777	1.1484	1.1237	1.1166
1.1702	1.0710	1.1038	1.0870	1.0873
1.1451	1.0530	1.0562	1.0732	1.0608
1.1251	1.0285	1.0199	1.0462	1.0315
1.0861	1.0235	1.0195	1.0151	1.0193
1.0803	0.9932	0.9994	1.0094	1.0007
1.0228	0.9713	0.9590	0.9702	0.9668
1.0041	0.9252	0.9441	0.9436	0.9376
0.9672	0.8993	0.9166	0.9122	0.9094
0.9267	0.8595	0.8903	0.8937	0.8812
0.8970	0.8249	0.8555	0.8503	0.8436
0.8366	0.7729	0.8361	0.8260	0.8117
59.3284	54.7189	56.6070	56.5595	55.9646

TABLE II, CONTINUED

VALUES OF THE COMPLETE SERIES OF RADIOGRAPHS OF THE MULTIPLE OS CALCIS SECTIONS FOR THE COMMAND PILOT OF THE GEMINI IV MISSION

PART C. PER CENT CHANGE BETWEEN THE IMMEDIATE PREFLIGHT AND IMMEDIATE POSTFLIGHT RADIOGRAPHS

Position of Tracing	Integrator Counts		Per Cent Change
	Film 3 (Launch)	Film 4 (Recovery)	
1 m.m. above Conventional Trace	13,013	12,090	-7.09
1 m.m. below	13,070	12,050	-7.80
2 m.m. below	12,934	11,995	-7.26
3 m.m. below	12,366	11,690	-5.47
4 m.m. below	12,008	11,178	-6.91
5 m.m. below	11,899	10,958	-7.91
6 m.m. below	11,740	10,986	-6.42
7 m.m. below	11,798	10,956	-7.05
8 m.m. below	11,661	10,712	-8.14
9 m.m. below	11,596	10,687	-7.84
10 m.m. below	11,276	10,406	-7.72
11 m.m. below	11,198	10,170	-9.18
12 m.m. below	10,772	10,008	-7.09
13 m.m. below	10,566	9,728	-7.93
14 m.m. below	10,391	9,523	-8.35
15 m.m. below	10,260	9,412	-8.27
16 m.m. below	9,618	9,326	-3.04
17 m.m. below	9,041	8,572	-5.19
18 m.m. below	8,696	8,114	-6.69
19 m.m. below	8,346	7,744	-7.21
20 m.m. below	8,024	7,504	-6.48
21 m.m. below	7,702	7,010	-8.98
22 m.m. below	7,312	6,751	-7.67
23 m.m. below	7,020	6,337	-9.73
24 m.m. below	6,638	6,188	-6.78
25 m.m. below	6,582	5,987	-9.04
26 m.m. below	6,380	5,950	-6.74
27 m.m. below	6,142	5,850	-4.75
28 m.m. below	5,973	5,714	-4.34
29 m.m. below	5,852	5,686	-2.84
30 m.m. below	5,692	5,518	-3.06
31 m.m. below	5,478	5,396	-1.50
32 m.m. below	5,347	5,140	-3.87
33 m.m. below	5,227	4,996	-4.42
34 m.m. below	5,034	4,775	-5.15
35 m.m. below	4,888	4,583	-6.24
TOTAL	4,709	4,294	-8.81
	326,249	303,994	-6.82

TABLE III

VALUES OF THE COMPLETE SERIES OF RADIOGRAPHS OF THE MULTIPL
OF THE GEMINI IV MISSION

PART A. MULTIPLE SECTIONS IN TERMS OF INTEGRATOR COUNTS

Position of Tracing	Preflight Radiographs			Mean of Preflight Radiographs Mean of Films 1, 2, and 3	F (6/
	Film 1 (5/25/65)	Film 2 (6/1/65)	Film 3 (6/3/65)		
1 m.m. above	14,143	14,518	15,162	14,607	13
Conventional Trace	14,127	14,571	15,346	14,681	13
1 m.m. below	13,300	13,972	14,404	13,892	12
2 m.m. below	12,898	13,136	13,752	13,262	12
3 m.m. below	12,506	12,998	13,286	12,930	11
4 m.m. below	12,228	12,888	13,198	12,771	11
5 m.m. below	12,258	12,606	13,139	12,668	11
6 m.m. below	12,233	12,541	12,984	12,586	11
7 m.m. below	12,168	12,472	12,889	12,510	11
8 m.m. below	12,032	12,423	12,692	12,382	11
9 m.m. below	11,194	12,051	12,542	11,929	11
10 m.m. below	11,421	11,761	12,104	11,762	10
11 m.m. below	10,909	11,339	11,673	11,307	10
12 m.m. below	10,326	10,734	11,136	10,732	10
13 m.m. below	10,018	10,388	10,791	10,399	9
14 m.m. below	9,764	10,064	10,407	10,078	9
15 m.m. below	9,598	9,762	10,266	9,875	9
16 m.m. below	9,352	9,490	9,961	9,601	8
17 m.m. below	9,079	9,291	9,734	9,368	8
18 m.m. below	8,964	9,220	9,562	9,249	8
19 m.m. below	8,660	8,616	9,032	8,769	8
20 m.m. below	8,304	8,446	8,684	8,478	7
21 m.m. below	8,217	8,266	8,358	8,280	7
22 m.m. below	7,898	7,987	8,168	8,018	7
23 m.m. below	7,804	7,832	7,997	7,878	7
24 m.m. below	7,592	7,661	7,784	7,679	6
25 m.m. below	7,402	7,491	7,594	7,496	6
26 m.m. below	7,308	7,271	7,336	7,305	6
27 m.m. below	7,037	7,052	7,138	7,076	6
28 m.m. below	6,761	6,884	7,046	6,897	6
29 m.m. below	6,732	6,780	6,801	6,771	6
30 m.m. below	6,512	6,501	6,667	6,560	6
31 m.m. below	6,426	6,375	6,583	6,461	6
32 m.m. below	6,416	6,261	6,508	6,395	6
33 m.m. below	6,344	6,222	6,422	6,329	6
34 m.m. below	6,246	6,116	6,271	6,211	6
35 m.m. below	6,043	5,906	6,136	6,028	5
36 m.m. below	5,712	5,700	5,783	5,732	5
37 m.m. below	5,234	5,371	5,517	5,374	4
38 m.m. below	4,984	4,872	4,923	4,926	4
TOTAL	366,151	373,835	385,774	375,252	350

TABLE III

OGRAPHS OF THE MULTIPLE OS CALCIS SECTIONS FOR THE PILOT
THE GEMINI IV MISSION

EGRATOR COUNTS

s	Mean of Preflight Radiographs Mean of Films 1, 2, and 3	Postflight Radiographs			Mean of Postflight Radiographs Mean of Films 4, 5, and 6
Film 3 6/3/65)		Film 4 (6/7/65)	Film 5 (6/23/65)	Film 6 (7/27/65)	
5,162	14,607	13,675	13,348	14,329	13,784
5,346	14,681	13,770	13,441	14,406	13,872
4,404	13,892	12,920	12,908	13,351	13,060
3,752	13,262	12,508	12,342	13,048	12,632
3,286	12,930	11,921	12,052	12,513	12,162
3,198	12,771	11,753	11,926	12,288	11,989
3,139	12,668	11,524	11,772	12,260	11,852
2,984	12,586	11,558	11,738	12,257	11,851
2,889	12,510	11,530	11,756	12,156	11,814
2,692	12,382	11,368	11,478	11,966	11,604
2,542	11,929	11,414	11,208	11,672	11,431
2,104	11,762	10,516	10,906	11,199	10,873
1,673	11,307	10,282	10,461	10,935	10,559
1,136	10,732	10,094	10,153	10,454	10,233
0,791	10,399	9,871	9,795	10,179	9,948
0,407	10,078	9,336	9,499	9,760	9,531
0,266	9,875	9,118	9,274	9,578	9,323
9,961	9,601	8,784	9,108	9,602	9,164
9,734	9,368	8,428	8,640	9,365	8,811
9,562	9,249	8,448	8,471	9,038	8,652
9,032	8,769	8,168	8,230	9,151	8,516
8,684	8,478	7,846	8,040	8,768	8,218
8,358	8,280	7,539	7,864	8,644	8,015
8,158	8,018	7,478	7,746	8,253	7,825
7,997	7,878	7,351	7,698	7,832	7,627
7,784	7,679	6,980	7,564	7,822	7,455
7,594	7,496	6,963	7,477	7,798	7,412
7,336	7,305	6,811	7,335	7,497	7,214
7,138	7,076	6,834	7,106	7,302	7,080
7,046	6,897	6,612	6,972	7,073	6,885
6,801	6,771	6,595	6,808	7,048	6,817
6,667	6,560	6,528	6,778	6,778	6,694
6,583	6,461	6,388	6,596	6,602	6,529
6,508	6,395	6,286	6,504	6,508	6,433
6,422	6,329	6,130	6,489	6,348	6,322
6,271	6,211	6,106	6,409	6,228	6,248
6,136	6,028	5,964	6,117	6,062	6,048
5,783	5,732	5,345	5,658	5,778	5,594
5,517	5,374	4,920	5,221	5,208	5,116
4,923	4,926	4,422	4,773	4,736	4,644
5,774	375,252	350,084	357,661	371,793	359,807

TABLE III, A

VALUES OF THE COMPLETE SERIES OF RADIOGRAPHS OF

OF THE GEMINI

PART B. MULTIPLE SECTIONS IN TERMS OF CALIBRATION WE

Position of Marking	Preflight Radiographs			M Pr Rad M Fil
	Film 1 (5/25/65)	Film 2 (5/1/65)	Film 3 (6/3/65)	
1 m.m. above	2.5457	2.6132	2.7292	2
Conventional Trace	2.5429	2.6228	2.7623	2
1 m.m. below	2.3940	2.5150	2.5927	2
2 m.m. below	2.3216	2.3645	2.4754	2
3 m.m. below	2.2511	2.3396	2.3915	2
4 m.m. below	2.2010	2.3198	2.3756	2
5 m.m. below	2.2064	2.2691	2.3650	2
6 m.m. below	2.2019	2.2574	2.3371	2
7 m.m. below	2.1902	2.2450	2.3200	2
8 m.m. below	2.1658	2.2361	2.2846	2
9 m.m. below	2.0149	2.1692	2.2576	2
10 m.m. below	2.0558	2.1170	2.1737	2
11 m.m. below	1.9636	2.0410	2.1011	2
12 m.m. below	1.8587	1.9321	2.0045	1
13 m.m. below	1.8032	1.8698	1.9424	1
14 m.m. below	1.7575	1.8115	1.8733	1
15 m.m. below	1.7276	1.7572	1.8479	1
16 m.m. below	1.6834	1.7082	1.7930	1
17 m.m. below	1.6342	1.6724	1.7521	1
18 m.m. below	1.6135	1.6596	1.7212	1
19 m.m. below	1.5588	1.5509	1.6258	1
20 m.m. below	1.4947	1.5203	1.5631	1
21 m.m. below	1.4791	1.4879	1.5044	1
22 m.m. below	1.4216	1.4377	1.4702	1
23 m.m. below	1.4047	1.4098	1.4395	1
24 m.m. below	1.3666	1.3790	1.4011	1
25 m.m. below	1.3324	1.3484	1.3669	1
26 m.m. below	1.3154	1.3088	1.3205	1
27 m.m. below	1.2667	1.2694	1.2848	1
28 m.m. below	1.2170	1.2391	1.2683	1
29 m.m. below	1.2118	1.2204	1.2242	1
30 m.m. below	1.1722	1.1702	1.2001	1
31 m.m. below	1.1567	1.1475	1.1849	1
32 m.m. below	1.1549	1.1270	1.1714	1
33 m.m. below	1.1419	1.1200	1.1560	1
34 m.m. below	1.1243	1.1009	1.1288	1
35 m.m. below	1.0877	1.0631	1.1015	1
36 m.m. below	1.0282	1.0260	1.0409	1
37 m.m. below	0.9421	0.9668	0.9931	0
38 m.m. below	0.8921	0.8770	0.8861	0
TOTAL	65.9069	67.2997	69.4398	6

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L, CONTINUED

OF THE MUSCULOS CALCIS SECTIONS FOR THE PILOT

MINI IV MISSION

N WEDGE MASS EQUIVALENCY (GRAMS)

Mean of Preflight Radiographs Mean of Films 1, 2, and 3	Postflight Radiographs			Mean of Postflight Radiographs Mean of Films 4, 5, and 6
	Film 4 (6/7/65)	Film 5 (6/23/65)	Film 6 (7/27/65)	
2.6293	2.4615	2.4026	2.5792	2.4811
2.6426	2.4786	2.4194	2.5931	2.4970
2.5005	2.3256	2.3234	2.4032	2.3507
2.3871	2.3514	2.2216	2.3486	2.2738
2.3274	2.1458	2.1694	2.2523	2.1891
2.2988	2.1155	2.1467	2.2118	2.1580
2.2601	2.0743	2.1190	2.2068	2.1333
2.2654	2.0804	2.1128	2.2063	2.1331
2.2517	2.0754	2.1161	2.1881	2.1265
2.2288	2.0462	2.0660	2.1539	2.0887
2.1472	2.0545	2.0174	2.1010	2.0576
2.1171	1.8929	1.9631	2.0158	1.9572
2.0352	1.8508	1.8830	1.9683	1.9007
1.9317	1.8169	1.8275	1.8817	1.8420
1.8718	1.7768	1.7631	1.8322	1.7907
1.8141	1.6805	1.7098	1.7568	1.7157
1.7775	1.6412	1.6693	1.7240	1.6781
1.7282	1.5811	1.6394	1.7284	1.6496
1.6862	1.5170	1.5552	1.6859	1.5860
1.6648	1.5206	1.5248	1.6268	1.5574
1.5785	1.4702	1.4614	1.5472	1.5329
1.5260	1.4123	1.4472	1.5782	1.4792
1.4905	1.3570	1.4155	1.5559	1.4428
1.4432	1.3460	1.3943	1.4855	1.4086
1.4180	1.3232	1.3856	1.4098	1.3729
1.3822	1.2564	1.3615	1.4080	1.3420
1.3492	1.2533	1.3459	1.4036	1.3343
1.3149	1.2260	1.3203	1.3495	1.2986
1.2736	1.2301	1.2791	1.3144	1.2745
1.2415	1.1902	1.2550	1.2731	1.2394
1.2188	1.1871	1.2254	1.2686	1.2270
1.1808	1.1750	1.2200	1.2200	1.2050
1.1630	1.1498	1.1373	1.1884	1.1752
1.1511	1.1315	1.1707	1.1714	1.1579
1.1393	1.1034	1.1680	1.1426	1.1380
1.1180	1.0991	1.1536	1.1210	1.1246
1.03	1.0735	1.1011	1.0912	1.0886
1.03[illegible]	0.9821	1.0184	1.0400	1.0068
0.9673	0.8856	0.9398	0.9374	0.9209
0.8867	0.7960	0.8591	0.8525	0.8359
67.5449	63.0148	64.3488	66.9225	64.7714

TABLE III, CONTINUED

VALUES OF THE COMPLETE SERIES OF RADIOGRAPHS OF THE MULTIPLE OS CALCIS SECTIONS FOR THE PILOT OF THE GEMINI IV MISSION

PART C. PER CENT CHANGE BETWEEN THE IMMEDIATE PREFLIGHT AND IMMEDIATE POSTFLIGHT RADIOGRAPHS

Position of Tracing	Integrator Counts		Per Cent Change
	Film 3 (Launch)	Film 4 (Recovery)	
1 m.m. above	15,162	13,675	-9.80
Conventional Trace	15,346	13,770	-10.27
1 m.m. below	14,404	12,920	-10.30
2 m.m. below	13,752	12,508	-9.04
3 m.m. below	13,286	11,921	-10.27
4 m.m. below	13,198	11,753	-10.95
5 m.m. below	13,139	11,524	-12.29
6 m.m. below	12,984	11,558	-10.98
7 m.m. below	12,889	11,530	-10.54
8 m.m. below	12,692	11,368	-10.43
9 m.m. below	12,542	11,414	-8.99
10 m.m. below	12,104	10,516	-13.12
11 m.m. below	11,673	10,282	-11.92
12 m.m. below	11,136	10,094	-9.36
13 m.m. below	10,791	9,871	-8.52
14 m.m. below	10,407	9,336	-10.29
15 m.m. below	10,266	9,118	-11.18
16 m.m. below	9,961	8,784	-11.82
17 m.m. below	9,734	8,428	-13.42
18 m.m. below	9,562	8,448	-11.65
19 m.m. below	9,032	8,168	-9.56
20 m.m. below	8,684	7,846	-9.65
21 m.m. below	8,358	7,539	-9.30
22 m.m. below	8,168	7,478	-8.45
23 m.m. below	7,997	7,351	-8.08
24 m.m. below	7,784	6,980	-10.33
25 m.m. below	7,594	6,963	-8.31
26 m.m. below	7,336	6,811	-7.16
27 m.m. below	7,138	6,834	-4.26
28 m.m. below	7,046	6,612	-6.16
29 m.m. below	6,801	6,595	-3.03
30 m.m. below	6,667	6,528	-2.08
31 m.m. below	6,583	6,388	-2.96
32 m.m. below	6,508	6,286	-3.41
33 m.m. below	6,422	6,130	-4.55
34 m.m. below	6,271	6,106	-2.63
35 m.m. below	6,136	5,964	-2.80
36 m.m. below	5,783	5,345	-7.57
37 m.m. below	5,517	4,920	-10.82
38 m.m. below	4,923	4,422	-10.18
TOTAL	385,774	350,084	-9.25

TABLE IV

EVALUATION OF THE CENTRAL OS CALCIS POSTERIOR-ANTERIOR SECTION ("CONVENTIONAL" SCAN) FOR GEMINI V ASTRONAUTS THROUGHOUT THEIR MISSION

PART A. COMMAND PILOT

Film Numbers and Dates	Evaluations in Terms of Integrator Counts			Evaluations in Terms of Calibration Wedge Mass Equivalency (grams)
	Evaluation Number 1	Evaluation Number 2	Average of Both Evaluations	
Film 1 (8/11/65)	11,739	11,654	11,696	2.1053
Film 2 (8/17/65)	11,545	11,627	11,586	2.0855
Film 3 (8/19/65)	10,902	11,008	10,955	1.9719
Film 4 (8/21/65) (Launch)	10,696	10,628	10,663	1.9193
Film 5 (8/29/65) (Recovery)	9,093	9,014	9,053	1.6295
Film 6 (8/30/65)	8,939	8,964	8,952	1.6114
Film 7 (9/8/65)	10,682	10,667	10,675	1.9215
Film 8 (11/4/65)	11,161	11,173	11,167	2.0101

TABLE IV, CONTINUED

EVALUATION OF THE CENTRAL OS CALCIS POSTERIOR-ANTERIOR SECTION ("CONVENTIONAL" SCAN) FOR GEMINI V ASTRONAUTS THROUGHOUT THEIR MISSION

PART B. PILOT

Film Numbers and Dates	Evaluations in Terms of Integrator Counts			Evaluations in Terms of Calibration Wedge Mass Equivalency (grams)
	Evaluation Number 1	Evaluation Number 2	Average of Both Evaluations	
Film 1 (8/11/65)	9,995	9,899	9,947	1.7905
Film 2 (8/17/65	10,075	10,034	10,055	1.8099
Film 3 (8/19/65)	10,350	10,408	10,379	1.8682
Film 4 (8/21/65) (Launch)	10,116	10,072	10,094	1.8169
Film 5 (8/29/65) (Recovery)	9,220	9,176	9,198	1.6556
Film 6 (8/30/65)	9,310	9,268	9,289	1.6720
Film 7 (9/8/65)	9,945	10,014	9,979	1.7962
Film 8 (11/3/65)	10,096	10,082	10,089	1.8160

TABLE V

VALUES OF THE COMPLETE SERIES OF RADIOGRAPHS OF THE

COMMAND PILOT OF THE GEM

PART A. MULTIPLE SECTIONS IN TERMS OF INTEGRATOR COUNTS

Position of Tracing	Pre-Flight Radiographs				Mean of Pre-Flight Radiograph
	Film 1 (8/11/65)	Film 2 (8/17/65)	Film 3 (8/19/65)	Film 4 (8/21/65)	Mean of Films 1, 2, 3, 4
1 m.m. above Conventional Trace	11,490	11,439	11,020	10,428	11,107
	11,696	11,586	10,955	10,663	11,225
1 m.m. below	10,960	11,048	10,270	10,072	10,588
2 m.m. below	10,141	10,162	9,667	9,336	9,868
3 m.m. below	10,034	10,067	9,626	9,283	9,765
4 m.m. below	9,954	9,967	9,580	9,243	9,685
5 m.m. below	9,854	9,894	9,414	9,198	9,590
6 m.m. below	9,785	9,763	9,423	9,161	9,532
7 m.m. below	9,710	9,686	9,396	8,991	9,446
8 m.m. below	9,571	9,521	9,304	8,939	9,334
9 m.m. below	9,415	9,395	9,125	8,894	9,210
10 m.m. below	9,317	9,309	8,868	8,854	9,087
11 m.m. below	8,914	8,861	8,531	8,609	8,729
12 m.m. below	7,967	7,907	7,958	7,723	7,889
13 m.m. below	7,836	7,585	7,505	7,604	7,631
14 m.m. below	7,526	7,311	7,354	7,216	7,352
15 m.m. below	7,281	7,128	7,100	6,939	7,112
16 m.m. below	6,946	6,863	6,922	6,629	6,865
17 m.m. below	6,816	6,732	6,683	6,540	6,693
18 m.m. below	6,532	6,498	6,451	6,314	6,449
19 m.m. below	6,298	6,217	6,154	6,016	6,171
20 m.m. below	6,003	6,032	6,030	5,632	5,924
21 m.m. below	5,834	5,814	5,728	5,501	5,719
22 m.m. below	5,651	5,619	5,601	5,406	5,569
23 m.m. below	5,401	5,381	5,319	5,318	5,354
24 m.m. below	5,213	5,202	5,198	4,990	5,151
25 m.m. below	4,992	5,046	5,016	4,636	4,922
26 m.m. below	4,836	4,843	4,911	4,528	4,760
27 m.m. below	4,710	4,702	4,652	4,418	4,622
28 m.m. below	4,688	4,626	4,609	4,375	4,574
29 m.m. below	4,599	4,623	4,530	4,388	4,535
30 m.m. below	4,526	4,592	4,456	4,374	4,487
31 m.m. below	4,374	4,328	4,314	4,255	4,318
32 m.m. below	4,190	4,167	4,036	3,941	4,084
33 m.m. below	4,109	4,010	4,028	3,756	3,976
34 m.m. below	3,258	3,178	3,213	3,069	3,179
35 m.m. below	X	X	X	X	X
Total	260,438	259,180	253,180	245,380	254,522

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OF THE MULTIPLE OS CALCIS SECTIONS FOR THE

E GEMINI V MISSION

Mean of re-Flight diographs	Post-Flight Radiographs				Mean of Post-Flight Radiographs
Mean of Films 1, , 3, 4	Film 5 (8/29/65)	Film 6 (8/30/65)	Film 7 (9/8/65)	Film 8 (11/4/65)	Mean of Films 5, 6, 7, 8
1,107	9,001	8,895	10,662	11,086	9,911
1,225	9,053	8,952	10,575	11,167	9,962
0,588	8,960	8,437	10,104	10,393	9,473
9,868	8,398	8,041	9,460	9,809	8,927
9,765	8,253	7,981	9,399	9,726	8,840
9,685	8,181	7,961	9,312	9,501	8,739
9,590	7,928	7,880	9,288	9,488	8,645
9,532	7,816	7,801	9,193	9,397	8,552
9,446	7,738	7,742	8,977	9,209	8,416
9,334	7,724	7,812	8,971	9,147	8,363
9,210	7,342	7,353	8,823	8,996	8,128
9,087	6,938	7,041	8,762	8,986	7,932
8,729	6,815	6,896	8,226	8,532	7,617
7,889	6,737	6,798	7,794	8,006	7,334
7,631	6,672	6,601	7,661	7,818	7,188
7,352	6,529	6,525	7,386	7,632	7,023
7,112	6,618	6,478	6,956	7,284	6,819
6,865	6,341	5,924	6,615	6,858	6,434
6,693	6,021	5,878	6,516	6,741	6,289
6,449	5,832	5,734	6,298	6,532	6,099
6,171	5,423	5,368	6,017	6,250	5,764
5,924	5,170	5,031	5,714	5,960	5,469
5,719	5,038	4,972	5,534	5,746	5,322
5,569	4,918	4,807	5,400	5,588	5,178
5,354	4,828	4,752	5,378	5,484	5,110
5,151	4,798	4,699	5,091	5,282	4,967
4,922	4,736	4,631	4,618	4,748	4,683
4,780	4,638	4,561	4,538	4,678	4,611
4,622	4,575	4,490	4,469	4,538	4,518
4,574	4,491	4,447	4,414	4,528	4,470
4,535	4,342	4,264	4,382	4,436	4,356
4,487	4,232	4,092	4,378	4,410	4,278
4,318	4,024	3,974	4,297	4,385	4,170
4,084	3,836	3,801	3,999	4,038	3,933
3,976	3,284	3,213	3,731	3,829	3,514
3,179	2,741	2,664	3,082	3,114	2,885
X	X	X	X	X	X
4,522	220,101	216,296	245,981	253,313	233,923

TABLE V, C

VALUES OF THE COMPLETE SERIES OF RADIOGRAPHS

COMMAND PILOT OF THE

PART B. MULTIPLE SECTIONS IN TERMS OF CALIBRATION WEDGE MA

Position of Tracing	Pre-Flight Radiographs				Me Pre Radi
	Film 1 (8/11/65)	Film 2 (8/17/65)	Film 3 (8/19/65)	Film 4 (8/21/65)	Me Fi 2,
1 m.m. above	2.0682	2.0590	1.9836	1.8860	1
Conventional Trace	2.1053	2.0855	1.9719	1.9193	2
1 m.m. below	1.9728	1.9886	1.8466	1.8130	1
2 m.m. below	1.8254	1.8292	1.7598	1.6805	1
3 m.m. below	1.8061	1.8121	1.7417	1.6709	1
4 m.m. below	1.7917	1.7901	1.7280	1.6637	1
5 m.m. below	1.7737	1.7809	1.6945	1.6556	1
6 m.m. below	1.7613	1.7573	1.6958	1.6490	1
7 m.m. below	1.7478	1.7435	1.6913	1.6184	1
8 m.m. below	1.7230	1.7138	1.6747	1.6090	1
9 m.m. below	1.6965	1.6911	1.6427	1.6009	1
10 m.m. below	1.6771	1.6756	1.5962	1.5937	1
11 m.m. below	1.6045	1.5950	1.5356	1.5496	1
12 m.m. below	1.4341	1.4233	1.4324	1.3901	1
13 m.m. below	1.4094	1.3653	1.3509	1.3687	1
14 m.m. below	1.3547	1.3160	1.3237	1.2989	1
15 m.m. below	1.3106	1.2830	1.2760	1.2490	1
16 m.m. below	1.2503	1.2533	1.2460	1.1932	1
17 m.m. below	1.2269	1.2118	1.2079	1.1772	1
18 m.m. below	1.1758	1.1696	1.1612	1.1365	1
19 m.m. below	1.1336	1.1191	1.1077	1.0828	1
20 m.m. below	1.0805	1.0858	1.0854	1.0138	1
21 m.m. below	1.0501	1.0465	1.0310	0.9902	1
22 m.m. below	1.0172	1.0114	1.0082	0.9731	1
23 m.m. below	0.9722	0.9686	0.9572	0.9572	0
24 m.m. below	0.9383	0.9364	0.9356	0.8982	0
25 m.m. below	0.8986	0.9083	0.9029	0.8345	0
26 m.m. below	0.8705	0.8717	0.8840	0.8150	0
27 m.m. below	0.8489	0.8464	0.8374	0.7932	0
28 m.m. below	0.8438	0.8327	0.8296	0.7875	0
29 m.m. below	0.8278	0.8321	0.8154	0.7898	0
30 m.m. below	0.8147	0.8266	0.8021	0.7873	0
31 m.m. below	0.7873	0.7790	0.7765	0.7659	0
32 m.m. below	0.7542	0.7561	0.7265	0.7094	0
33 m.m. below	0.7396	0.7218	0.7250	0.6761	0
34 m.m. below	0.5864	0.5720	0.5783	0.5524	0
35 m.m. below	X	X	X	X	
Total	46.8788	46.6524	45.5724	44.1530	45

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THE MULTIPLE OS CALCIS SECTIONS FOR THE

EMINI V MISSION

EQUIVALENCY (GRAMS)

of light raphs of s 1, 4	Post-Flight Radiographs				Mean of Post-Flight Radiographs
	Film 5 (8/29/65)	Film 6 (8/30/65)	Film 7 (9/8/65)	Film 8 (11/4/65)	Mean of Films 5, 6, 7, 8
992	1.6202	1.6011	1.9192	1.9955	1.7840
205	1.6295	1.6114	1.9215	2.0101	1.7931
057	1.6128	1.5187	1.8187	1.8707	1.7052
762	1.5116	1.4474	1.7028	1.7656	1.6068
577	1.4855	1.4366	1.6918	1.7507	1.5911
434	1.4726	1.4330	1.6762	1.7102	1.5730
262	1.4270	1.4184	1.6720	1.7068	1.5560
158	1.4069	1.4042	1.6547	1.6915	1.5393
002	1.3928	1.3936	1.6159	1.6576	1.5150
801	1.3903	1.3702	1.6148	1.6465	1.5054
578	1.3216	1.3255	1.5981	1.6187	1.4635
356	1.2488	1.2674	1.5772	1.6175	1.4277
712	1.2267	1.2413	1.4807	1.5358	1.3711
200	1.2127	1.2236	1.4029	1.4411	1.3201
736	1.2010	1.1882	1.3790	1.4072	1.2938
233	1.1932	1.1745	1.3151	1.3738	1.2641
801	1.1912	1.1660	1.2521	1.3003	1.2274
357	1.1414	1.0663	1.1907	1.2344	1.1582
047	1.0838	1.0580	1.1729	1.2134	1.1320
608	1.0498	1.0321	1.1336	1.1758	1.0978
108	0.9761	0.9662	1.0831	1.1250	1.0376
0664	0.9306	0.9056	1.0285	1.0728	0.9844
0294	0.9068	0.8950	0.9961	1.0343	0.9580
0025	0.8852	0.8653	0.9730	1.0058	0.9321
9638	0.8690	0.8554	0.9680	0.9871	0.9199
9271	0.8636	0.8458	0.9164	0.9508	0.8941
8861	0.8525	0.8336	0.8312	0.8546	0.8430
8603	0.8402	0.8210	0.8168	0.8420	0.8300
8320	0.8235	0.8082	0.8044	0.8168	0.8132
8234	0.8084	0.8005	0.7945	0.8150	0.8046
8163	0.7816	0.7675	0.7838	0.7985	0.7841
8077	0.7618	0.7366	0.7884	0.7938	0.7700
7772	0.7243	0.7153	0.7735	0.7893	0.7506
7350	0.6905	0.6842	0.7198	0.7376	0.7080
7156	0.5911	0.5783	0.6716	0.6892	0.6325
5723	0.4934	0.4795	0.5440	0.5605	0.5193
X	X	X	X	X	X
8142	39.6182	38.9333	44.2765	45.5963	42.1061

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TABLE V, CONTINUED

VALUES OF THE COMPLETE SERIES OF RADIOGRAPHS OF THE MULTIPLE OS CALCIS SECTIONS FOR THE COMMAND PILOT OF THE GEMINI V MISSION

PART C. PER CENT CHANGE BETWEEN THE IMMEDIATE PREFLIGHT AND IMMEDIATE POSTFLIGHT RADIOGRAPHS

Position of Tracing	Integrator Counts		Per Cent Change
	Film 1 (Launch)	Film 5 (Recovery)	
1 m.m. above	10,478	9,001	-14.10
Conventional Trace	10,663	9,053	-15.10
1 m.m. below	10,072	8,960	-11.03
2 m.m. below	9,336	8,398	-10.05
3 m.m. below	9,283	8,253	-11.10
4 m.m. below	9,243	8,181	-11.49
5 m.m. below	9,198	7,928	-13.81
6 m.m. below	9,161	7,816	-14.68
7 m.m. below	8,991	7,738	-13.94
8 m.m. below	10,939	7,724	-29.52
9 m.m. below	8,894	7,342	-17.45
10 m.m. below	8,854	6,938	-21.64
11 m.m. below	8,609	6,815	-20.84
12 m.m. below	7,723	6,737	-12.77
13 m.m. below	7,604	6,672	-12.26
14 m.m. below	7,216	6,629	-8.13
15 m.m. below	6,939	6,618	-4.63
16 m.m. below	6,629	6,341	-4.34
17 m.m. below	6,540	6,021	-7.94
18 m.m. below	6,314	5,832	-7.63
19 m.m. below	6,016	5,423	-9.86
20 m.m. below	5,632	5,170	-8.20
21 m.m. below	5,501	5,038	-8.42
22 m.m. below	5,406	4,918	-9.03
23 m.m. below	5,318	4,828	-9.21
24 m.m. below	4,990	4,798	-3.85
25 m.m. below	4,636	4,736	+2.16
26 m.m. below	4,528	4,668	+3.09
27 m.m. below	4,418	4,575	+3.55
28 m.m. below	4,375	4,491	+2.65
29 m.m. below	4,388	1,342	-1.05
30 m.m. below	4,374	4,232	-3.25
31 m.m. below	4,255	4,024	-5.43
32 m.m. below	3,941	3,836	-2.66
33 m.m. below	3,756	3,284	-12.56
34 m.m. below	3,069	2,741	-10.69
35 m.m. below	X	X	X
TOTAL	245,289	220,101	

TABLE VI

VALUES OF THE COMPLETE SERIES OF RADIOGRAPHS OF THE MU

OF THE GEMINI V MISSI

PART A. MULTIPLE SECTIONS IN TERMS OF INTEGRATOR COUNTS

Position of Tracing	Pre-Flight Radiographs				Mean of Pre-Flight Radiograph
	Film 1 (8/11/65)	Film 2 (8/17/65)	Film 3 (8/19/65)	Film 4 (8/21/65)	Mean of Films 1, 2, 3, 4
1 m.m. above	9,978	10,019	10,273	10,083	10,088
Conventional Trace	9,947	10,055	10,379	10,094	10,118
1 m.m. below	9,474	9,557	9,712	9,372	9,529
2 m.m. below	8,974	9,032	9,144	9,060	9,052
3 m.m. below	8,766	8,828	8,959	8,853	8,852
4 m.m. below	8,522	8,704	8,712	8,662	8,650
5 m.m. below	8,494	8,652	8,705	8,602	8,613
6 m.m. below	8,352	8,374	8,488	8,406	8,405
7 m.m. below	8,139	8,196	8,350	8,198	8,221
8 m.m. below	7,848	7,936	8,106	7,933	7,956
9 m.m. below	7,456	7,512	7,634	7,534	7,534
10 m.m. below	7,090	7,226	7,388	7,276	7,245
11 m.m. below	6,905	6,946	7,042	7,012	6,976
12 m.m. below	6,804	6,818	6,938	6,888	6,862
13 m.m. below	6,502	6,564	6,825	6,607	6,625
14 m.m. below	6,332	6,403	6,548	6,468	6,438
15 m.m. below	6,128	6,218	6,387	6,196	6,232
16 m.m. below	5,901	5,986	6,100	5,955	5,986
17 m.m. below	5,659	5,750	5,919	5,652	5,745
18 m.m. below	5,482	5,522	5,616	5,600	5,555
19 m.m. below	5,225	5,337	5,488	5,310	5,340
20 m.m. below	4,986	5,174	5,242	5,144	5,136
21 m.m. below	4,918	4,994	5,102	5,019	5,008
22 m.m. below	4,864	4,924	4,988	4,928	4,926
23 m.m. below	4,740	4,818	4,903	4,874	4,834
24 m.m. below	4,646	4,641	4,717	4,692	4,674
25 m.m. below	4,422	4,424	4,494	4,502	4,461
26 m.m. below	4,292	4,268	4,386	4,379	4,331
27 m.m. below	4,164	4,192	4,296	4,299	4,238
28 m.m. below	3,798	3,845	3,905	3,965	3,878
29 m.m. below	3,705	3,700	3,824	3,475	3,676
30 m.m. below	3,474	3,543	3,631	3,446	3,523
31 m.m. below	3,331	3,354	3,416	3,315	3,354
32 m.m. below	3,272	3,282	3,341	3,272	3,292
33 m.m. below	3,006	3,091	3,168	3,009	3,069
34 m.m. below	2,602	2,688	2,787	2,674	2,688
35 m.m. below	1,742	1,816	1,759	1,820	1,784
Total	219,940	222,389	226,672	222,574	222,894

TABLE VI

PHS OF THE MULTIPLE OS CAUGHS SECTIONS FOR THE PILOT

GEMINI V MISSION

OUNTS

	Mean of Pre-Flight Radiographs	Post-Flight Radiographs				Mean of Post-Flight Radiographs
m 4 /65)	Mean of Films 1, 2, 3, 4	Film 5 (8/29/65)	Film 6 (8/30/65)	Film 7 (9/8/65)	Film 8 (11/3/65)	Mean of Films 5, 6, 7, 8
83	10,088	9,206	9,262	9,990	10,016	9,618
94	10,113	9,203	9,289	9,979	10,089	9,641
72	9,529	8,716	8,731	9,548	9,504	9,125
60	9,052	8,338	8,326	9,106	9,018	8,697
53	8,852	8,130	8,020	8,642	8,807	8,400
62	8,650	7,912	7,850	8,548	8,500	8,217
02	8,613	7,870	7,712	8,511	8,508	8,150
05	8,405	7,742	7,673	8,407	8,361	8,046
98	8,221	7,499	7,477	8,132	8,138	7,811
33	7,956	7,102	7,153	7,924	7,878	7,514
34	7,534	6,894	6,842	7,478	7,445	7,165
76	7,245	6,571	6,766	7,166	7,136	6,910
12	6,976	6,379	6,497	6,981	6,918	6,694
88	6,862	6,294	6,342	6,868	6,770	6,568
07	6,625	5,995	6,313	6,504	6,477	6,322
68	6,438	5,872	6,139	6,412	6,340	6,191
96	6,232	5,660	6,028	6,122	6,150	5,990
55	5,986	5,360	5,674	5,982	5,894	5,727
52	5,745	5,198	5,454	5,694	5,621	5,492
00	5,555	5,042	5,232	5,558	5,501	5,333
10	5,340	4,789	5,100	5,222	5,288	5,100
44	5,136	4,436	4,644	5,008	5,036	4,781
19	5,008	4,393	4,594	4,918	4,930	4,709
28	4,926	4,274	4,492	4,914	4,868	4,637
74	4,834	4,220	4,364	4,822	4,772	4,544
92	4,674	4,112	4,203	4,647	4,622	4,396
02	4,461	4,016	4,026	4,392	4,411	4,211
79	4,331	3,940	3,909	4,335	4,294	4,120
99	4,238	3,952	3,832	4,231	4,242	4,064
55	3,878	3,609	3,577	3,924	3,863	3,743
75	3,676	3,494	3,463	3,730	3,722	3,602
46	3,523	3,224	3,280	3,462	3,489	3,364
15	3,354	3,065	3,202	3,298	3,370	3,234
72	3,292	2,940	3,145	3,217	3,310	3,153
09	3,069	2,762	3,010	3,008	3,068	2,962
74	2,688	2,508	2,509	2,602	2,638	2,579
20	1,784	1,589	1,606	1,738	1,806	1,683
74	222,894	202,311	205,736	221,014	220,920	212,495

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TABLE VI.

VALUES OF THE COMPLETE SERIES OF RADIOGRAPHS O

OF THE GEMI

PART B. MULTIPLE SECTIONS IN TERMS OF CALIBRATION WEDGE N

Position of Tracing	Pre-Flight Radiographs				R
	Film 1 (8/11/65)	Film 2 (8/17/65)	Film 3 (8/19/65)	Film 4 (8/21/65)	
1 m.m. above	1.7960	1.8034	1.8493	1.8149	
Conventional Trace	1.7905	1.8099	1.8682	1.8169	
1 m.m. below	1.7053	1.7203	1.7514	1.6870	
2 m.m. below	1.6153	1.6258	1.6460	1.6308	
3 m.m. below	1.5779	1.5890	1.6126	1.5935	
4 m.m. below	1.5340	1.5667	1.5682	1.5592	
5 m.m. below	1.5289	1.5574	1.5669	1.5484	
6 m.m. below	1.5034	1.5073	1.5278	1.5131	
7 m.m. below	1.4650	1.4753	1.5030	1.4756	
8 m.m. below	1.4126	1.4285	1.4591	1.4279	
9 m.m. below	1.3421	1.3582	1.3741	1.3561	
10 m.m. below	1.2762	1.3007	1.3298	1.3097	
11 m.m. below	1.2429	1.2503	1.2676	1.2622	
12 m.m. below	1.2247	1.2272	1.2488	1.2398	
13 m.m. below	1.1704	1.1815	1.2285	1.1893	
14 m.m. below	1.1398	1.1525	1.1786	1.1642	
15 m.m. below	1.1030	1.1192	1.1497	1.1153	
16 m.m. below	1.0622	1.0775	1.0980	1.0719	
17 m.m. below	1.0186	1.0350	1.0654	1.0174	
18 m.m. below	0.9868	0.9940	1.0108	1.0080	
19 m.m. below	0.9405	0.9607	0.9878	0.9558	
20 m.m. below	0.8975	0.9313	0.9436	0.9259	
21 m.m. below	0.8852	0.8989	0.9184	0.9034	
22 m.m. below	0.8755	0.8863	0.8978	0.8870	
23 m.m. below	0.8532	0.8672	0.8325	0.8773	
24 m.m. below	0.8363	0.8354	0.8491	0.8446	
25 m.m. below	0.7960	0.7963	0.8089	0.8104	
26 m.m. below	0.7726	0.7682	0.7895	0.7882	
27 m.m. below	0.7495	0.7546	0.7733	0.7738	
28 m.m. below	0.6836	0.6921	0.7029	0.7137	
29 m.m. below	0.6669	0.6660	0.6883	0.6255	
30 m.m. below	0.6253	0.6377	0.6536	0.6203	
31 m.m. below	0.5996	0.6037	0.6149	0.5967	
32 m.m. below	0.5890	0.5908	0.6014	0.5890	
33 m.m. below	0.5411	0.5564	0.5702	0.5416	
34 m.m. below	0.4684	0.4838	0.5017	0.4813	
35 m.m. below	0.3135	0.3269	0.3166	0.3276	
Total	39.5892	40.0300	40.8010	40.0633	4

I, CONTINUED

IS OF THE MULTIPLE OS CALCIS SECTIONS FOR THE PILOT

EMINI V MISSION

GE MASS EQUIVALENCY (GRAMS)

	Mean of Pre-Flight Radiographs	Post-Flight Radiographs				Mean of Post-Flight Radiographs
5)	Mean of Films 1, 2, 3, 4	Film 5 (8/29/65)	Film 6 (8/30/65)	Film 7 (9/8/65)	Film 8 (11/3/65)	Mean of Films 5, 6, 7, 8
	1.8158	1.6571	1.6672	1.7982	1.8029	1.7313
	1.8214	1.6574	1.6720	1.7762	1.8160	1.7304
	1.7160	1.5689	1.5716	1.7185	1.7107	1.6424
	1.6295	1.5008	1.4987	1.6391	1.6232	1.5654
	1.5932	1.4634	1.4436	1.5556	1.5853	1.5120
	1.5570	1.4242	1.4130	1.5386	1.5408	1.4791
	1.5504	1.4166	1.3882	1.5320	1.5314	1.4670
	1.5129	1.3936	1.3811	1.5133	1.5050	1.4482
	1.4797	1.3498	1.3459	1.4638	1.4648	1.4061
	1.4320	1.2784	1.2875	1.4263	1.4180	1.3525
	1.3561	1.2409	1.2316	1.3460	1.3401	1.2896
	1.3041	1.1828	1.2179	1.2893	1.2845	1.2438
	1.2557	1.1482	1.1695	1.2566	1.2452	1.2049
	1.2351	1.1329	1.1416	1.2362	1.2186	1.1823
	1.1924	1.0791	1.1363	1.1707	1.1659	1.1380
	1.1580	1.0570	1.1050	1.1542	1.1412	1.1143
	1.1218	1.0188	1.0850	1.1020	1.1070	1.0782
	1.0774	0.9648	1.0213	1.0763	1.0609	1.0309
	1.0341	0.9355	0.9817	1.0249	1.0118	0.9885
	0.9999	0.9076	0.9418	1.0004	0.9902	0.9600
	0.9612	0.8620	0.9180	0.9400	0.9518	0.9179
	0.9246	0.7985	0.8359	0.9014	0.9065	0.8606
	0.9015	0.7907	0.8269	0.8852	0.8874	0.8475
	0.8866	0.7693	0.8086	0.8845	0.8762	0.8346
	0.8700	0.7596	0.7855	0.8680	0.8590	0.8180
	0.8413	0.7402	0.7565	0.8365	0.8320	0.7913
	0.8029	0.7229	0.7247	0.7905	0.7940	0.7580
	0.7796	0.7092	0.7036	0.7803	0.7729	0.7415
	0.7628	0.7114	0.6898	0.7716	0.7636	0.7316
	0.6981	0.6496	0.6439	0.7013	0.6953	0.6738
	0.6617	0.6289	0.6233	0.671	0.6700	0.6484
	0.6342	0.5803	0.5904	0.623	0.6280	0.6055
	0.6037	0.5517	0.5764	0.5936	0.6066	0.5821
	0.5925	0.5292	0.5661	0.5791	0.5958	0.5675
	0.5523	0.4972	0.5418	0.5414	0.5522	0.5331
	0.4838	0.4514	0.4516	0.4684	0.4856	0.4642
	0.3212	0.2860	0.2891	0.3118	0.3251	0.3030
	40.1209	36.4160	37.0325	39.7825	39.7656	38.2491

TABLE VI, CONTINUED

VALUES OF THE COMPLETE SERIES OF RADIOGRAPHS OF THE MULTIPLE OS CALCIS SECTIONS FOR THE PILOT OF THE GEMINI V MISSION

PART C. PER CENT CHANGE BETWEEN THE IMMEDIATE PREFLIGHT AND IMMEDIATE POSTFLIGHT RADIOGRAPHS

Position of Tracing	Integrator Counts		Per Cent Change
	Film 4 (Launch)	Film 5 (Recovery)	
1 m.m. above	10,083	9,206	-8.70
Conventional Trace	10,094	9,208	-8.78
1 m.m. below	9,372	8,716	-7.00
2 m.m. below	9,060	8,338	-7.97
3 m.m. below	8,853	8,130	-8.17
4 m.m. below	8,662	7,912	-8.66
5 m.m. below	8,602	7,870	-8.51
6 m.m. below	8,406	7,742	-7.90
7 m.m. below	8,198	7,499	-8.53
8 m.m. below	7,933	7,102	-10.48
9 m.m. below	7,534	6,894	-8.49
10 m.m. below	7,279	6,571	-9.69
11 m.m. below	7,012	6,379	-9.03
12 m.m. below	6,888	6,294	-8.62
13 m.m. below	6,607	5,995	-9.26
14 m.m. below	6,468	5,872	-9.21
15 m.m. below	6,196	5,660	-8.65
16 m.m. below	5,955	5,360	-9.99
17 m.m. below	5,652	5,198	-8.03
18 m.m. below	5,600	5,042	-9.96
19 m.m. below	5,310	4,789	-9.81
20 m.m. below	5,144	4,436	-13.76
21 m.m. below	5,019	4,393	-12.47
22 m.m. below	4,928	4,274	-13.27
23 m.m. below	4,874	4,220	-13.42
24 m.m. below	4,692	4,112	-12.36
25 m.m. below	4,502	4,016	-10.80
26 m.m. below	4,379	3,940	-10.03
27 m.m. below	4,299	3,952	-8.07
28 m.m. below	3,965	3,609	-8.98
29 m.m. below	3,475	3,494	+0.55
30 m.m. below	3,446	3,224	-6.44
31 m.m. below	3,315	3,065	-7.54
32 m.m. below	3,272	2,940	-10.15
33 m.m. below	3,009	2,762	-8.21
34 m.m. below	2,674	2,508	-6.21
35 m.m. below	1,820	1,589	-12.69
TOTAL	222,574	202,589	

TABLE VII

EVALUATION OF A SECTION ACROSS THE TALUS FOR GEMINI V ASTRONAUTS THROUGHOUT THEIR MISSION

PART A. COMMAND PILOT

Film Numbers and Dates	Evaluations in Terms of Integrator Counts			Evaluations in Terms of Calibration Wedge Mass Equivalency (grams)
	Evaluation Number 1	Evaluation Number 2	Average of Both Evaluations	
Film 1 (8/11/65)	6,720	6,742	6,731	1.2116
Film 2 (8/17/65)	6,644	6,660	6,652	1.1974
Film 3 (8/19/65)	6,537	6,551	6,544	1.1779
Film 4 (8/21/65) (Launch)	6,522	6,532	6,527	1.1749
Film 5 (8/29/65) (Recovery)	5,656	5,670	5,663	1.0193
Film 6 (8/30/65)	5,715	5,703	5,709	1.0276
Film 7 (9/8/65)	6,470	6,464	6,467	1.1641
Film 8 (11/3/65)	6,472	6,456	6,464	1.1635

TABLE VII, CONTINUED

EVALUATION OF A SECTION ACROSS THE TALUS FOR GEMINI V ASTRONAUTS THROUGHOUT THEIR MISSION

PART B. PILOT

Film Numbers and Dates	Evaluations in Terms of Integrator Counts			Evaluations in Terms of Calibration Wedge Mass Equivalency (grams)
	Evaluation Number 1	Evaluation Number 2	Average of Both Evaluations	
Film 1 (8/11/65)	4,844	4,858	4,851	0.8732
Film 2 (8/17/65)	4,782	4,774	4,778	0.8600
Film 3 (8/19/65)	4,756	4,740	4,748	0.8546
Film 4 (8/21/65) (Launch)	4,703	4,713	4,708	0.8474
Film 5 (8/29/65) (Recovery)	4,247	4,245	4,246	0.7643
Film 6 (8/30/65)	4,550	4,540	4,545	0.8181
Film 7 (9/8/65)	4,693	4,711	4,702	0.8464
Film 8 (11/3/65)	4,864	4,870	4,867	0.8761

TABLE VIII

VALUES OF THE COMPLETE SERIES OF THE RADIOGRAPHS OF MULTIPLE SECTIONS OF HAND PHALANX 5-2 OF THE COMMAND PILOT OF THE GEMINI V MISSION

PART A. MULTIPLE SECTIONS IN TERMS OF INTEGRATOR COUNTS

Position of Tracing	Film 1 (8/11/65)	Film 2 (8/17/65)	Film 3 (8/19/65)	Film 4 (8/21/65)	Film 5 (8/29/65)	Film 6 (8/30/65)	Film 7 (9/8/65)	Film 8 (11/4/65)
Proximal End of Phalanx	414	479	480	475	352	450	445	445
1 m.m. below	328	386	389	382	291	354	353	357
2 m.m. below	271	320	332	305	231	299	296	306
3 m.m. below	226	282	294	263	199	240	247	252
4 m.m. below	204	250	245	238	176	220	236	238
5 m.m. below	199	242	244	231	175	218	234	231
6 m.m. below	217	252	260	243	186	230	231	244
7 m.m. below	227	275	269	259	198	243	238	252
8 m.m. below	236	285	271	268	206	250	254	270
9 m.m. below	237	286	278	271	208	252	258	269
10 m.m. below	223	276	268	256	200	247	246	260
11 m.m. below	218	259	263	249	196	232	241	254
12 m.m. below	208	236	255	229	184	227	231	252
13 m.m. below	208	237	255	228	181	218	231	244
14 m.m. below	204	237	253	231	178	214	221	231
15 m.m. below	208	246	257	233	183	213	224	224
16 m.m. below	229	268	265	260	202	231	242	243
17 m.m. below	233	273	292	266	207	237	258	264
TOTAL	4290	5089	5170	4887	3753	4575	4686	4836

TABLE VIII, CONTINUED

VALUES OF THE COMPLETE SERIES OF THE RADIOGRAPHS OF MULTIPLE SECTIONS OF HAND PHALANX 5-2 OF THE COMMAND PILOT OF THE GEMINI V MISSION

PART B. MULTIPLE SECTIONS IN TERMS OF CALIBRATION WEDGE MASS EQUIVALENCY (GRAMS)

Position of Tracing	Film 1 (8/11/65)	Film 2 (8/17/65)	Film 3 (8/19/65)	Film 4 (8/21/65)	Film 5 (8/29/65)	Film 6 (8/30/65)	Film 7 (9/8/65)	Film 8 (11/4/65)
Proximal End of Phalanx	0.037	0.043	0.043	0.043	0.032	0.040	0.040	0.040
1 m.m. below	0.030	0.035	0.035	0.034	0.026	0.032	0.032	0.032
2 m.m. below	0.024	0.029	0.030	0.027	0.021	0.027	0.027	0.028
3 m.m. below	0.020	0.025	0.026	0.024	0.018	0.022	0.022	0.023
4 m.m. below	0.018	0.023	0.022	0.021	0.016	0.020	0.021	0.021
5 m.m. below	0.018	0.022	0.022	0.021	0.016	0.020	0.021	0.021
6 m.m. below	0.020	0.023	0.023	0.022	0.017	0.021	0.021	0.022
7 m.m. below	0.020	0.025	0.024	0.023	0.018	0.022	0.021	0.023
8 m.m. below	0.021	0.026	0.024	0.024	0.019	0.022	0.023	0.024
9 m.m. below	0.021	0.026	0.025	0.024	0.019	0.023	0.023	0.024
10 m.m. below	0.020	0.025	0.024	0.023	0.018	0.022	0.022	0.023
11 m.m. below	0.020	0.023	0.024	0.022	0.018	0.021	0.022	0.023
12 m.m. below	0.019	0.021	0.023	0.021	0.017	0.020	0.021	0.023
13 m.m. below	0.019	0.021	0.023	0.021	0.016	0.020	0.021	0.022
14 m.m. below	0.018	0.021	0.023	0.021	0.016	0.019	0.020	0.021
15 m.m. below	0.019	0.022	0.023	0.021	0.016	0.019	0.020	0.020
16 m.m. below	0.021	0.024	0.024	0.023	0.018	0.021	0.022	0.022
17 m.m. below	0.021	0.025	0.026	0.024	0.019	0.021	0.023	0.024
TOTAL	0.386	0.459	0.464	0.439	0.340	0.412	0.422	0.436

TABLE VIII, CONTINUED

VALUES OF THE COMPLETE SERIES OF THE RADIOGRAPHS OF MULTIPLE SECTIONS OF HAND PHALANX 5-2 OF THE COMMAND PILOT OF THE GEMINI V MISSION

PART C. PER CENT CHANGE BETWEEN THE IMMEDIATE PREFLIGHT AND THE IMMEDIATE POSTFLIGHT RADIOGRAPHS

Position of Tracing	Integrator Counts		Per Cent Change
	Film 4 (Launch)	Film 5 (Recovery)	
Proximal End of Phalanx	475	352	-25.9
1 m.m. below	382	291	-23.8
2 m.m. below	305	231	-24.3
3 m.m. below	263	199	-24.3
4 m.m. below	238	176	-26.1
5 m.m. below	231	175	-24.2
6 m.m. below	243	186	-23.5
7 m.m. below	259	198	-23.5
8 m.m. below	268	206	-23.1
9 m.m. below	271	208	-23.3
10 m.m. below	256	200	-21.9
11 m.m. below	249	196	-21.3
12 m.m. below	229	184	-19.6
13 m.m. below	228	181	-20.6
14 m.m. below	231	178	-22.9
15 m.m. below	233	183	-21.5
16 m.m. below	260	202	-22.3
17 m.m. below	266	207	-22.2
TOTAL	4887	3753	-23.0

TABLE IX

VALUES OF THE COMPLETE SERIES OF THE RADIOGRAPHS OF MULTIPLE SECTIONS OF HAND PHALANX 5-2 OF THE PILOT OF THE GEMINI V MISSION

PART A. MULTIPLE SECTIONS IN TERMS OF INTEGRATOR COUNTS

Position of Tracing	Film 1 (8/11/65)	Film 2 (8/17/65)	Film 3 (8/19/65)	Film 4 (8/21/65)	Film 5 (8/29/65)	Film 6 (8/30/65)	Film 7 (9/8/65)	Film 8 (11/4/65)
Proximal End of Phalanx	396	450	445	455	380	448	450	443
1 m.m. below	320	381	371	373	318	378	376	379
2 m.m. below	273	328	321	268	267	326	321	322
3 m.m. below	256	296	302	296	250	295	311	293
4 m.m. below	244	279	293	282	242	277	291	278
5 m.m. below	231	270	276	265	223	267	282	272
6 m.m. below	225	259	258	260	215	257	250	264
7 m.m. below	216	251	345	255	199	249	247	262
8 m.m. below	231	267	271	263	216	266	255	274
9 m.m. below	235	274	269	266	214	268	249	276
10 m.m. below	224	228	262	262	214	227	244	274
11 m.m. below	218	248	256	258	204	246	234	255
12 m.m. below	211	244	242	243	194	242	231	251
13 m.m. below	222	249	249	258	201	247	254	252
14 m.m. below	243	279	280	282	232	278	280	274
15 m.m. below	256	294	278	300	243	290	292	290
16 m.m. below	224	266	250	262	214	264	267	257
TOTAL	4225	4863	4968	4848	4026	4825	4834	4916

TABLE IX, CONTINUED

VALUES OF THE COMPLETE SERIES OF THE RADIOGRAPHS OF MULTIPLE SECTIONS OF HAND PHALANX 5-2 OF THE PILOT OF THE GEMINI V MISSION

PART B. MULTIPLE SECTIONS IN TERMS OF CALIBRATION WEDGE MASS EQUIVALENCY (GRAMS)

Position of Tracing	Film 1 (8/11/65)	Film 2 (8/17/65)	Film 3 (8/19/65)	Film 4 (8/21/65)	Film 5 (8/29/65)	Film 6 (8/30/65)	Film 7 (9/8/65)	Film 8 (11/4/65)
Proximal End of Phalanx	0.036	0.041	0.040	0.041	0.034	0.040	0.041	0.040
1 m.m. below	0.029	0.034	0.033	0.034	0.029	0.034	0.034	0.034
2 m.m. below	0.024	0.030	0.029	0.024	0.024	0.029	0.029	0.029
3 m.m. below	0.023	0.027	0.027	0.027	0.022	0.026	0.028	0.026
4 m.m. below	0.022	0.025	0.026	0.025	0.022	0.025	0.026	0.025
5 m.m. below	0.021	0.024	0.025	0.024	0.020	0.024	0.025	0.024
6 m.m. below	0.020	0.023	0.023	0.023	0.019	0.023	0.022	0.024
7 m.m. below	0.019	0.022	0.031	0.023	0.018	0.022	0.022	0.024
8 m.m. below	0.021	0.024	0.024	0.024	0.019	0.024	0.023	0.025
9 m.m. below	0.021	0.025	0.024	0.024	0.019	0.024	0.022	0.025
10 m.m. below	0.020	0.021	0.024	0.024	0.019	0.020	0.022	0.025
11 m.m. below	0.020	0.022	0.023	0.023	0.018	0.022	0.021	0.023
12 m.m. below	0.019	0.022	0.022	0.022	0.017	0.022	0.021	0.022
13 m.m. below	0.020	0.022	0.022	0.023	0.018	0.022	0.023	0.023
14 m.m. below	0.022	0.025	0.025	0.025	0.021	0.025	0.025	0.025
15 m.m. below	0.023	0.026	0.025	0.027	0.022	0.026	0.026	0.026
16 m.m. below	0.020	0.024	0.022	0.024	0.019	0.024	0.024	0.023
TOTAL	0.380	0.437	0.445	0.437	0.360	0.432	0.434	0.443

TABLE IX, CONTINUED

VALUES OF THE COMPLETE SERIES OF THE RADIOGRAPHS OF MULTIPLE SECTIONS OF HAND PHALANX 5-2 OF THE PILOT OF THE GEMINI V MISSION

PART C. PER CENT CHANGE BETWEEN THE IMMEDIATE PREFLIGHT AND THE IMMEDIATE POSTFLIGHT RADIOGRAPHS

Position of Tracing	Integrator Counts		Per Cent Change
	Film 4 (Launch)	Film 5 (Recovery)	
Proximal End of Phalanx	455	380	-16.5
1 m.m. below	373	318	-14.7
2 m.m. below	268	267	- 0.4
3 m.m. below	296	250	-15.5
4 m.m. below	282	242	-14.2
5 m.m. below	265	223	-15.8
6 m.m. below	260	215	-17.3
7 m.m. below	255	199	-22.0
8 m.m. below	263	216	-17.9
9 m.m. below	266	214	-19.6
10 m.m. below	262	214	-18.3
11 m.m. below	258	204	-20.9
12 m.m. below	243	194	-20.2
13 m.m. below	258	201	-22.1
14 m.m. below	282	232	-17.7
15 m.m. below	300	243	-19.0
16 m.m. below	262	214	-18.3
TOTAL	4848	4026	-17.0

TABLE X

VALUES OF THE COMPLETE SERIES OF RADIOGRAPHS OF THE MULTIPLE SECTIONS OF HAND PHALANX 4-2 OF THE COMMAND PILOT OF THE GEMINI V MISSION

PART A. MULTIPLE SECTIONS IN TERMS OF INTEGRATOR COUNTS

Position of Tracing	Film 1 (8/11/65)	Film 2 (8/17/65)	Film 3 (8/19/65)	Film 4 (8/21/65)	Film 5 (8/29/65)	Film 6 (8/30/65)	Film 7 (9/8/65)	Film 8 (11/4/65)
Proximal End of Phalanx	564	654	638	647	562	641	650	626
1 m.m. below	450	558	532	539	484	512	541	524
2 m.m. below	425	481	470	478	437	471	487	464
3 m.m. below	387	453	429	439	394	441	446	431
4 m.m. below	368	439	417	422	380	422	427	412
5 m.m. below	341	409	391	399	347	402	399	392
6 m.m. below	318	383	354	370	331	371	377	368
7 m.m. below	334	394	381	386	343	383	390	389
8 m.m. below	344	402	388	399	348	392	403	400
9 m.m. below	357	405	406	416	368	410	413	410
10 m.m. below	354	392	384	402	354	388	406	398
11 m.m. below	343	399	371	383	340	375	387	386
12 m.m. below	347	403	373	394	346	383	400	398
13 m.m. below	332	386	365	370	335	363	367	372
14 m.m. below	329	369	354	364	334	354	369	372
15 m.m. below	322	370	355	362	340	354	372	365
16 m.m. below	320	364	348	355	331	344	369	363
17 m.m. below	318	360	343	355	331	340	369	356
18 m.m. below	316	350	338	349	328	346	364	358
19 m.m. below	327	364	352	364	332	362	376	366
20 m.m. below	328	350	345	356	329	351	370	358
21 m.m. below	302	335	322	338	306	338	346	337
TOTAL	7826	9020	8656	8887	8000	8743	9028	8845

TABLE X, CONTINUED

VALUES OF THE COMPLETE SERIES OF RADIOGRAPHS OF THE MULTIPLE SECTIONS OF HAND PHALANX 4-2 OF THE COMMAND PILOT OF THE GEMINI V MISSION

PART B. MULTIPLE SECTIONS IN TERMS OF CALIBRATION WEDGE MASS EQUIVALENCY (GRAMS)

Position of Tracing	Film 1 (8/11/65)	Film 2 (8/17/65)	Film 3 (8/19/65)	Film 4 (8/21/65)	Film 5 (8/29/65)	Film 6 (8/30/65)	Film 7 (9/8/65)	Film 8 (11/4/65)
Proximal End of Phalanx	0.051	0.059	0.057	0.058	0.051	0.058	0.058	0.056
1 m.m. below	0.041	0.050	0.048	0.049	0.044	0.046	0.049	0.047
2 m.m. below	0.038	0.043	0.042	0.043	0.039	0.042	0.044	0.042
3 m.m. below	0.035	0.041	0.039	0.040	0.035	0.040	0.040	0.039
4 m.m. below	0.033	0.040	0.038	0.038	0.034	0.038	0.038	0.037
5 m.m. below	0.031	0.037	0.035	0.036	0.031	0.036	0.036	0.035
6 m.m. below	0.029	0.034	0.032	0.033	0.030	0.033	0.034	0.033
7 m.m. below	0.030	0.035	0.034	0.035	0.031	0.034	0.035	0.035
8 m.m. below	0.031	0.036	0.035	0.036	0.031	0.035	0.036	0.036
9 m.m. below	0.032	0.036	0.037	0.037	0.033	0.037	0.037	0.037
10 m.m. below	0.032	0.035	0.035	0.036	0.032	0.035	0.037	0.036
11 m.m. below	0.031	0.036	0.033	0.034	0.031	0.034	0.035	0.035
12 m.m. below	0.031	0.036	0.034	0.035	0.031	0.034	0.036	0.036
13 m.m. below	0.030	0.035	0.033	0.033	0.030	0.033	0.033	0.033
14 m.m. below	0.030	0.033	0.032	0.033	0.030	0.032	0.033	0.033
15 m.m. below	0.029	0.033	0.032	0.033	0.031	0.032	0.033	0.033
16 m.m. below	0.029	0.033	0.031	0.032	0.030	0.031	0.033	0.033
17 m.m. below	0.029	0.032	0.031	0.032	0.030	0.031	0.033	0.032
18 m.m. below	0.028	0.032	0.030	0.031	0.030	0.031	0.033	0.032
19 m.m. below	0.029	0.033	0.032	0.033	0.030	0.033	0.034	0.033
20 m.m. below	0.030	0.032	0.031	0.032	0.030	0.032	0.033	0.032
21 m.m. below	0.027	0.030	0.029	0.030	0.028	0.030	0.031	0.030
TOTAL	0.706	0.811	0.779	0.799	0.722	0.787	0.811	0.795

TABLE X, CONTINUED

VALUES OF THE COMPLETE SERIES OF RADIOGRAPHS OF THE MULTIPLE SECTIONS OF HAND PHALANX 4-2 OF THE COMMAND PILOT OF THE GEMINI V MISSION

PART C. PER CENT CHANGE BETWEEN THE IMMEDIATE PREFLIGHT AND THE IMMEDIATE POSTFLIGHT RADIOGRAPHS

Position of Tracing	Integrator Counts		Per Cent Change
	Film 4 (Launch)	Film 5 (Recovery)	
Proximal End of Phalanx	647	562	-13.1
1 m.m. below	539	484	-10.2
2 m.m. below	478	437	- 8.6
3 m.m. below	439	394	-10.3
4 m.m. below	422	380	- 9.9
5 m.m. below	399	347	-13.0
6 m.m. below	370	331	-10.5
7 m.m. below	386	343	-11.1
8 m.m. below	399	348	-12.8
9 m.m. below	416	368	-11.5
10 m.m. below	402	354	-11.9
11 m.m. below	383	340	-11.2
12 m.m. below	394	346	-12.2
13 m.m. below	370	335	- 9.5
14 m.m. below	364	334	- 8.2
15 m.m. below	362	340	- 6.1
16 m.m. below	355	331	- 6.8
17 m.m. below	355	331	- 6.8
18 m.m. below	349	328	- 6.0
19 m.m. below	364	332	- 9.6
20 m.m. below	356	329	- 7.6
21 m.m. below	338	306	- 9.5
TOTAL	8887	8000	- 9.8

TABLE XI

VALUES OF THE COMPLETE SERIES OF RADIOGRAPHS OF THE MULTIPLE SECTIONS OF HAND PHALANX 4-2 OF THE PILOT OF THE GEMINI V MISSION

PART A. MULTIPLE SECTIONS IN TERMS OF INTEGRATOR COUNTS

Position of Tracing	Film 1 (8/11/65)	Film 2 (8/17/65)	Film 3 (8/19/65)	Film 4 (8/21/65)	Film 5 (8/29/65)	Film 6 (8/30/65)	Film 7 (9/8/65)	Film 8 (11/4/65)
Proximal End of Phalanx	504	513	532	548	519	547	602	548
1 m.m. below	367	405	420	425	388	401	453	439
2 m.m. below	360	380	396	413	360	382	439	403
3 m.m. below	336	354	376	389	353	356	425	388
4 m.m. below	345	350	370	380	346	349	418	379
5 m.m. below	358	362	369	382	344	347	413	380
6 m.m. below	339	358	360	377	338	344	409	372
7 m.m. below	344	350	356	375	334	340	406	368
8 m.m. below	351	360	356	376	336	343	417	374
9 m.m. below	335	361	351	377	338	348	419	377
10 m.m. below	347	357	344	374	332	340	416	368
11 m.m. below	328	348	328	369	327	331	403	355
12 m.m. below	330	350	332	365	325	327	391	353
13 m.m. below	313	331	327	350	317	322	381	339
14 m.m. below	301	316	315	337	296	310	368	326
15 m.m. below	305	322	309	325	288	297	358	316
16 m.m. below	287	316	313	335	280	288	349	322
17 m.m. below	292	310	315	320	269	271	343	319
18 m.m. below	275	293	299	314	261	268	335	313
19 m.m. below	280	307	301	311	259	261	339	310
20 m.m. below	278	296	306	326	277	277	346	314
21 m.m. below	294	322	314	338	287	294	373	330
TOTAL	7269	7661	7689	8106	7174	7343	8803	7993

TABLE XI, CONTINUED

VALUES OF THE COMPLETE SERIES OF RADIOGRAPHS OF THE MULTIPLE SECTIONS OF HAND PHALANX 4-2 OF THE PILOT OF THE GEMINI V MISSION

PART B. MULTIPLE SECTIONS IN TERMS OF CALIBRATION WEDGE MASS EQUIVALENCY (GRAMS)

Position of Tracing	Film 1 (8/11/65)	Film 2 (8/17/65)	Film 3 (8/19/65)	Film 4 (8/21/65)	Film 5 (8/29/65)	Film 6 (8/30/65)	Film 7 (9/8/65)	Film 8 (11/4/65)
Proximal End of Phalanx	0.045	0.046	0.048	0.049	0.047	0.049	0.054	0.049
1 m.m. below	0.033	0.036	0.038	0.038	0.035	0.036	0.041	0.040
2 m.m. below	0.032	0.034	0.036	0.037	0.032	0.034	0.040	0.036
3 m.m. below	0.030	0.032	0.034	0.035	0.032	0.032	0.038	0.035
4 m.m. below	0.031	0.032	0.033	0.034	0.031	0.031	0.038	0.034
5 m.m. below	0.032	0.033	0.033	0.034	0.031	0.031	0.037	0.034
6 m.m. below	0.031	0.032	0.032	0.034	0.030	0.031	0.037	0.033
7 m.m. below	0.031	0.032	0.032	0.034	0.030	0.031	0.037	0.033
8 m.m. below	0.032	0.032	0.032	0.034	0.030	0.031	0.038	0.034
9 m.m. below	0.030	0.032	0.032	0.034	0.030	0.031	0.038	0.034
10 m.m. below	0.031	0.032	0.031	0.034	0.030	0.031	0.037	0.033
11 m.m. below	0.030	0.031	0.030	0.033	0.029	0.030	0.036	0.032
12 m.m. below	0.030	0.032	0.030	0.033	0.029	0.029	0.035	0.032
13 m.m. below	0.028	0.030	0.029	0.032	0.029	0.029	0.034	0.031
14 m.m. below	0.027	0.028	0.028	0.030	0.027	0.028	0.033	0.029
15 m.m. below	0.027	0.029	0.028	0.029	0.026	0.027	0.032	0.028
16 m.m. below	0.026	0.028	0.028	0.030	0.025	0.026	0.031	0.029
17 m.m. below	0.026	0.028	0.028	0.029	0.024	0.024	0.031	0.029
18 m.m. below	0.025	0.026	0.027	0.028	0.023	0.024	0.030	0.028
19 m.m. below	0.025	0.028	0.027	0.028	0.023	0.023	0.031	0.028
20 m.m. below	0.025	0.027	0.028	0.029	0.025	0.025	0.031	0.028
21 m.m. below	0.026	0.029	0.028	0.030	0.026	0.026	0.034	0.030
TOTAL	0.653	0.689	0.692	0.728	0.644	0.659	0.793	0.719

TABLE XI, CONTINUED

VALUES OF THE COMPLETE SERIES OF RADIOGRAPHS OF THE MULTIPLE SECTIONS OF HAND PHALANX 4-2 OF THE PILOT OF THE GEMINI V MISSION

PART C. PER CENT CHANGE BETWEEN THE IMMEDIATE PREFLIGHT AND THE IMMEDIATE POSTFLIGHT RADIOGRAPHS

Position of Tracing	Integrator Counts		Per Cent Change
	Film 4 (Launch)	Film 5 (Recovery)	
Proximal End of Phalanx	548	519	- 5.3
1 m.m. below	425	388	- 8.7
2 m.m. below	413	360	-12.8
3 m.m. below	389	353	- 9.3
4 m.m. below	380	346	- 8.9
5 m.m. below	382	344	- 9.9
6 m.m. below	377	338	-10.3
7 m.m. below	375	334	-10.9
8 m.m. below	376	336	-10.6
9 m.m. below	377	338	-10.3
10 m.m. below	374	332	-11.2
11 m.m. below	369	327	-11.4
12 m.m. below	365	325	-11.0
13 m.m. below	350	317	- 9.4
14 m.m. below	337	296	-12.2
15 m.m. below	325	288	-11.4
16 m.m. below	335	280	-16.4
17 m.m. below	320	269	-15.9
18 m.m. below	314	261	-16.9
19 m.m. below	311	259	-16.7
20 m.m. below	326	277	-15.0
21 m.m. below	338	287	-15.1
TOTAL	8106	7174	-11.8

TABLE XII

EVALUATION OF A SECTION ACROSS THE DISTAL END OF THE RADIUS FOR GEMINI V ASTRONAUTS THROUGHOUT THEIR MISSION

PART A. COMMAND PILOT

Film Numbers and Dates	Evaluations in Terms of Integrator Counts			Evaluations in Terms of Calibration Wedge Mass Equivalency (grams)
	Evaluation Number 1	Evaluation Number 2	Average of Both Evaluations	
Film 1 (8/11/65)	4,088	4,096	4,092	0.7365
Film 2 (8/17/65)	4,171	4,156	4,163	0.7493
Film 3 (8/19/65)	4,225	4,237	4,231	0.7616
Film 4 (8/21/65) (Launch)	4,523	4,511	4,517	0.8131
Film 5 (8/29/65) (Recovery)	3,393	3,353	3,373	0.6071
Film 6 (8/30/65)	3,688	3,700	3,694	0.6649
Film 7 (9/8/65)	4,027	4,037	4,032	0.7258
Film 8 (11/3/65)	4,281	4,295	4,289	0.7720

TABLE XII, CONTINUED

EVALUATION OF A SECTION ACROSS THE DISTAL END OF THE RADIUS FOR GEMINI V ASTRONAUTS THROUGHOUT THEIR MISSION

PART B. PILOT

Film Numbers and Dates	Evaluations in Terms of Integrator Counts			Evaluations in Terms of Calibration Wedge Mass Equivalency (grams)
	Evaluation Number 1	Evaluation Number 2	Average of Both Evaluations	
Film 1 (8/11/65)	3,992	4,010	4,001	0.7202
Film 2 (8/17/65)	3,652	3,659	3,656	0.6580
Film 3 (8/19/65)	3,908	3,896	3,902	0.7023
Film 4 (8/21/65) (Launch)	4,273	4,284	4,281	0.7706
Film 5 (8/29/65) (Recovery)	3,264	3,286	3,275	0.5895
Film 6 (8/30/65)	3,498	3,512	3,505	0.6309
Film 7 (9/8/65)	3,552	3,560	3,556	0.6401
Film 8 (11/3/65)	4,246	4,230	4,238	0.7628

TABLE XIII

EVALUATION OF THE CENTRAL OS CALCIS POSTERIOR-ANTERIOR SECTION ("CONVENTIONAL" SCAN) FOR GEMINI VII ASTRONAUTS THROUGHOUT THEIR MISSION

PART A. COMMAND PILOT

Film Numbers and Dates	Evaluations in Terms of Integrator Counts			Evaluations in Terms of Calibration Wedge Mass Equivalency (grams)
	Evaluation Number 1	Evaluation Number 2	Average of Both Evaluations	
Film 1 (11/24/65)	12,012	11,933	11,973	2.1551
Film 2 (12/1/65)	12,625	12,567	12,596	2.2673
Film 3 (12/4/65) (Launch)	12,407	12,411	12,409	2.2336
Film 4 (12/18/65) (Recovery)	11,994	12,103	12,049	2.1689
Film 5 (12/19/65)	12,314	12,465	12,390	2.2302
Film 6 (12/29/65)	12,985	13,155	13,070	2.3526
Film 7 (2/3/66)	12,901	12,745	12,823	2.3081

TABLE XIII, CONTINUED

EVALUATION OF THE CENTRAL OS CALCIS POSTERIOR-ANTERIOR SECTION ("CONVENTIONAL" SCAN) FOR GEMINI VII ASTRONAUTS THROUGHOUT THEIR MISSION

PART B. PILOT

Film Numbers and Dates	Evaluations in Terms of Integrator Counts			Evaluations in Terms of Calibration Wedge Mass Equivalency (grams)
	Evaluation Number 1	Evaluation Number 2	Average of Both Evaluations	
Film 1 (11/24/65)	13,438	13,296	13,367	2.4061
Film 2 (12/1/65)	13,253	13,243	13,248	2.3846
Film 3 (12/4/65) (Launch)	13,724	13,713	13,718.5	2.4693
Film 4 (12/18/65) (Recovery)	13,306	13,351	13,328.5	2.3991
Film 5 (12/19/65)	13,523	13,305	13,414	2.4145
Film 6 (12/29/65)	14,750	14,614	14,682	2.6428
Film 7 (2/3/66)	14,001	13,968	13,984	2.5171

TABLE XLI

VALUES OF THE COMPLETE SERIES OF RADIOGRAPHS

FOR THE COMMAND PILOT OF THE

PART A. MULTIPLE SECTIONS IN TERMS OF INTEGRATOR COUNTS

Position of Tracing	Preflight Radiographs			Mean of Preflight Radiographs
	Film 1 (11/24/65)	Film 2 (12/1/65)	Film 3 (12/4/65)	Mean of Films 1, 2, and 3
1 m.m. above	11,643	12,321	12,136	12,033
Conventional Trace	11,973	12,596	12,409	12,326
1 m.m. below	11,024	11,733	11,468	11,408
2 m.m. below	10,571	11,418	11,229	11,072
3 m.m. below	10,375	11,259	10,988	10,874
4 m.m. below	10,321	11,275	10,956	10,851
5 m.m. below	10,185	10,993	10,726	10,635
6 m.m. below	9,956	10,902	10,460	10,439
7 m.m. below	9,678	10,723	10,332	10,244
8 m.m. below	9,667	10,550	10,238	10,152
9 m.m. below	9,348	10,359	9,978	9,894
10 m.m. below	9,051	9,982	9,690	9,574
11 m.m. below	8,979	9,827	9,630	9,478
12 m.m. below	8,611	9,471	9,294	9,125
13 m.m. below	8,428	9,184	8,968	8,860
14 m.m. below	8,340	8,942	8,694	8,659
15 m.m. below	8,201	8,713	8,557	8,490
16 m.m. below	7,804	8,437	8,090	8,110
17 m.m. below	7,324	7,881	7,795	7,667
18 m.m. below	7,148	7,702	7,570	7,473
19 m.m. below	6,991	7,533	7,470	7,331
20 m.m. below	6,912	7,350	7,403	7,222
21 m.m. below	6,828	7,192	7,295	7,105
22 m.m. below	6,731	6,940	7,221	6,964
23 m.m. below	6,590	6,673	7,176	6,813
24 m.m. below	6,485	6,511	7,192	6,729
25 m.m. below	6,371	6,306	7,172	6,616
26 m.m. below	6,130	6,038	7,097	6,422
27 m.m. below	5,952	5,906	6,914	6,257
28 m.m. below	5,897	5,830	6,845	6,191
29 m.m. below	5,880	5,446	6,801	6,042
30 m.m. below	5,641	5,214	6,319	5,725
31 m.m. below	5,399	4,873	6,022	5,431
32 m.m. below	5,082	4,532	5,694	5,103
33 m.m. below	4,710	4,136	4,989	4,608
34 m.m. below	4,076	3,623	4,448	4,049
35 m.m. below	3,463	3,234	3,750	3,482
36 m.m. below	2,656	2,462	2,896	2,671
TOTAL	290,421	304,056	311,912	302,125

XLV

PHS OF THE MULTIPLE OS CALCS SECTIONS

THE GEMINI VII MISSION

f t phs f 2,	Postflight Radiographs				Mean of Postflight Radiographs Mean of Films 4, 5, 6, and 7
	Film 4 (12/18/65)	Film 5 (12/19/65)	Film 6 (12/29/65)	Film 7 (2/3/66)	
	11,652	12,172	12,753	12,609	12,296
	12,049	12,390	13,070	12,823	12,583
	11,124	11,521	12,047	11,895	11,647
	10,836	11,330	11,672	11,449	11,322
	10,648	11,097	11,491	11,251	11,122
	10,628	11,026	11,365	11,279	11,074
	10,418	10,983	11,244	11,185	10,957
	10,142	10,798	11,030	11,024	10,748
	9,934	10,622	10,879	10,853	10,572
	9,709	10,489	10,829	10,630	10,414
	9,597	10,246	10,706	10,498	10,262
	9,415	10,083	10,375	10,146	10,005
	9,248	9,856	10,054	10,013	9,793
	8,964	9,512	9,649	9,787	9,478
	8,690	9,318	9,382	9,516	9,226
	8,568	8,979	9,126	9,181	8,963
	8,381	8,634	8,833	8,954	8,700
	7,966	8,320	8,503	8,419	8,302
	7,578	7,883	7,907	8,036	7,851
	7,451	7,641	7,718	7,778	7,647
	7,328	7,507	7,536	7,654	7,506
	7,268	7,357	7,411	7,492	7,382
	7,209	7,184	7,283	7,251	7,232
	7,184	6,946	7,111	7,057	7,074
	7,141	6,752	6,913	6,843	6,912
	7,130	6,511	6,785	6,708	6,783
	7,103	6,324	6,518	6,695	6,660
	7,002	6,146	6,273	6,327	6,437
	6,838	6,029	6,086	6,088	6,260
	6,740	5,911	5,898	5,929	6,119
	6,684	5,624	5,689	5,901	5,974
	6,210	5,255	5,447	5,532	5,611
	5,965	5,111	5,236	5,381	5,423
	5,608	4,796	4,790	4,980	5,043
	4,962	4,320	4,412	4,610	4,576
	4,382	4,214	3,906	3,977	4,120
	3,676	3,610	3,411	3,498	3,549
	2,816	2,638	2,645	2,667	2,691
	304,244	305,135	311,983	311,916	308,314

TABLE XIV, CON

VALUES OF THE COMPLETE SERIES OF RADIOGRAPHS

FOR THE COMMAND PILOT OF THE

PART B. MULTIPLE SECTIONS IN TERMS OF CALIBRATION WEDGE MASS

Position of Tracing	Preflight Radiographs			Mean of Preflight Radiographs Mean of Films 1, 2, and 3
	Film 1 (11/24/65)	Film 2 (12/1/65)	Film 3 (12/4/65)	
1 m.m. above	2.0957	2.2178	2.1845	2.1660
Conventional Trace	2.1551	2.2673	2.2336	2.2186
1 m.m. below	1.9843	2.1119	2.0642	2.0534
2 m.m. below	1.9028	2.0552	2.0212	1.9930
3 m.m. below	1.8675	2.0266	1.9778	1.9573
4 m.m. below	1.8578	2.0295	1.9721	1.9531
5 m.m. below	1.8333	1.9787	1.9307	1.9142
6 m.m. below	1.7921	1.9624	1.8828	1.8791
7 m.m. below	1.7420	1.9301	1.8598	1.8439
8 m.m. below	1.7401	1.8990	1.8428	1.8273
9 m.m. below	1.6826	1.8646	1.7961	1.7811
10 m.m. below	1.6292	1.7968	1.7442	1.7234
11 m.m. below	1.6162	1.7689	1.7334	1.7061
12 m.m. below	1.5500	1.7048	1.6729	1.6426
13 m.m. below	1.5170	1.6531	1.6142	1.5948
14 m.m. below	1.5012	1.6096	1.5649	1.5586
15 m.m. below	1.4762	1.5682	1.5403	1.5282
16 m.m. below	1.4047	1.5187	1.4562	1.4598
17 m.m. below	1.3183	1.4186	1.4031	1.3800
18 m.m. below	1.2866	1.3864	1.3626	1.3452
19 m.m. below	1.2584	1.3559	1.3446	1.3196
20 m.m. below	1.2442	1.3230	1.3325	1.2999
21 m.m. below	1.2290	1.2946	1.3131	1.2789
22 m.m. below	1.2116	1.2492	1.2998	1.2535
23 m.m. below	1.1862	1.2011	1.2917	1.2263
24 m.m. below	1.1673	1.1720	1.2946	1.2113
25 m.m. below	1.1468	1.1351	1.2910	1.1910
26 m.m. below	1.1034	1.0868	1.2775	1.1559
27 m.m. below	1.0714	1.0631	1.2445	1.1263
28 m.m. below	1.0615	1.0494	1.2321	1.1143
29 m.m. below	1.0584	0.9803	1.2242	1.0876
30 m.m. below	1.0154	0.9385	1.1374	1.0304
31 m.m. below	0.9718	0.8771	1.0840	0.9776
32 m.m. below	0.9148	0.8158	1.0249	0.9185
33 m.m. below	0.8478	0.7427	0.8980	0.8295
34 m.m. below	0.7337	0.6521	0.8006	0.7288
35 m.m. below	0.6233	0.5821	0.6750	0.6268
36 m.m. below	0.4781	0.4432	0.5213	0.4809
TOTAL	52.2758	54.7302	56.1442	54.3828

ONTINUED

IS OF THE MULTIPLE OS CALCIS SECTIONS

HE GEMINI VII MISSION

SS EQUIVALENCY (GRAMS)

ns	Postflight Radiographs				Mean of Postflight Radiographs Mean of Films 4, 5, 6, and 7
	Film 4 (12/18/65)	Film 5 (12/19/65)	Film 6 (12/29/65)	Film 7 (2/3/66)	
	2.0974	2.1910	2.2955	2.2696	2.2134
	2.1688	2.2300	2.3526	2.3081	2.2649
	2.0023	2.0738	2.1685	2.1411	2.0964
	1.9505	2.0394	2.1010	2.0608	2.0379
	1.9166	1.9975	2.0684	2.0252	2.0019
	1.9130	1.9847	2.0457	2.0302	1.9934
	1.8752	1.9769	2.0239	2.0133	1.9723
	1.8256	1.9436	1.9854	1.9843	1.9347
	1.7881	1.9120	1.9582	1.9535	1.9029
	1.7476	1.8880	1.9492	1.9134	1.8745
	1.7275	1.8443	1.9271	1.8896	1.8471
	1.6947	1.8149	1.8675	1.8263	1.8008
	1.6646	1.7741	1.8097	1.8023	1.7627
	1.6135	1.7122	1.7368	1.7617	1.7060
	1.5642	1.6772	1.6888	1.7129	1.6608
	1.5422	1.6162	1.6427	1.6526	1.6134
	1.5086	1.5541	1.5899	1.6117	1.5661
	1.4339	1.4976	1.5305	1.5154	1.4943
	1.3640	1.4189	1.4233	1.4465	1.4132
	1.3412	1.3754	1.3892	1.4000	1.3764
	1.3190	1.3513	1.3565	1.3777	1.3511
	1.3082	1.3243	1.3340	1.3486	1.3288
	1.2976	1.2931	1.3109	1.3052	1.3017
	1.2931	1.2503	1.2800	1.2703	1.2734
	1.2854	1.2154	1.2443	1.2317	1.2442
	1.2834	1.1720	1.2213	1.2074	1.2210
	1.2785	1.1383	1.1732	1.2051	1.1988
	1.2604	1.1063	1.1291	1.1389	1.1587
	1.2308	1.0852	1.0955	1.0958	1.1268
	1.2132	1.0640	1.0616	1.0672	1.1015
	1.2031	1.0123	1.0240	1.0622	1.0754
	1.1178	0.9459	0.9805	0.9958	1.0100
	1.0737	0.9200	0.9425	0.9686	0.9762
	1.0094	0.8633	0.8622	0.8964	0.9078
	0.8932	0.7776	0.7942	0.8298	0.8237
	0.7888	0.7585	0.7031	0.7159	0.7416
	0.6617	0.6498	0.6140	0.6296	0.6388
	0.5069	0.4748	0.4761	0.4801	0.4845
	54.7637	54.9242	56.1569	56.1448	55.4971

TABLE XIV, CONTINUED

VALUES OF THE COMPLETE SERIES OF RADIOGRAPHS OF THE MULTIPLE OS CALCIS SECTIONS FOR THE COMMAND PILOT OF THE GEMINI VII MISSION

PART C. PER CENT CHANGE BETWEEN THE IMMEDIATE PREFLIGHT AND IMMEDIATE POSTFLIGHT RADIOGRAPHS

Position of Tracing	Integrator Counts		Per Cent Change
	Film 4 (Launch)	Film 5 (Recovery)	
1 m.m. above	12,136	11,652	-3.99
Conventional Trace	12,409	12,049	-2.90
1 m.m. below	11,468	11,124	-3.00
2 m.m. below	11,229	10,836	-3.50
3 m.m. below	10,988	10,648	-3.09
4 m.m. below	10,956	10,628	-2.99
5 m.m. below	10,726	10,418	-2.87
6 m.m. below	10,460	10,142	-3.04
7 m.m. below	10,332	9,934	-3.85
8 m.m. below	10,238	9,709	-5.17
9 m.m. below	9,978	9,597	-3.82
10 m.m. below	9,690	9,415	-2.84
11 m.m. below	9,630	9,248	-3.97
12 m.m. below	9,294	8,964	-3.55
13 m.m. below	8,968	8,690	-3.10
14 m.m. below	8,694	8,568	-1.45
15 m.m. below	8,557	8,381	-2.06
16 m.m. below	8,090	7,966	-1.53
17 m.m. below	7,795	7,578	-2.78
18 m.m. below	7,570	7,451	-1.57
19 m.m. below	7,470	7,328	-1.90
20 m.m. below	7,403	7,268	-1.82
21 m.m. below	7,295	7,209	-1.18
22 m.m. below	7,221	7,184	-0.51
23 m.m. below	7,176	7,141	-0.49
24 m.m. below	7,192	7,130	-0.86
25 m.m. below	7,172	7,103	-0.96
26 m.m. below	7,097	7,002	-1.34
27 m.m. below	6,914	6,838	-1.10
28 m.m. below	6,845	6,740	-1.53
29 m.m. below	6,801	6,684	-1.72
30 m.m. below	6,319	6,210	-1.72
31 m.m. below	6,022	5,965	-0.95
32 m.m. below	5,694	5,608	-1.51
33 m.m. below	4,989	4,962	-0.54
34 m.m. below	4,448	4,382	-1.48
35 m.m. below	3,750	3,676	-1.97
36 m.m. below	2,896	2,816	-2.76
TOTAL	311,912	304,244	-2.46

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VALUES OF THE COMPLETE SERIES OF RAD

FOR THE PILOT O

PART A. MULTIPLE SECTIONS IN TERMS OF INTEGRATOR CO

Position of Tracing	Preflight Radiographs			Ra
	Film 1 (11/24/65)	Film 2 (12/1/65)	Film 3 (12/4/65)	Fi
1 m.m. above Conventional Trace	13,356	13,143	13,791	
	13,325	13,194	13,718	
1 m.m. below	13,112	12,975	12,592	
2 m.m. below	12,147	12,597	11,937	
3 m.m. below	11,884	12,360	11,838	
4 m.m. below	11,811	12,004	11,928	
5 m.m. below	11,734	11,596	11,613	
6 m.m. below	11,369	11,178	11,314	
7 m.m. below	11,077	11,024	11,214	
8 m.m. below	10,826	10,912	11,122	
9 m.m. below	10,687	10,826	10,799	
10 m.m. below	10,677	10,613	10,630	
11 m.m. below	10,376	10,247	10,394	
12 m.m. below	10,198	9,928	10,126	
13 m.m. below	9,913	9,691	9,790	
14 m.m. below	9,754	9,402	9,536	
15 m.m. below	9,576	9,233	9,280	
16 m.m. below	9,112	9,041	9,056	
17 m.m. below	8,811	8,813	8,979	
18 m.m. below	8,610	8,625	8,960	
19 m.m. below	8,419	8,191	8,222	
20 m.m. below	8,004	7,845	7,452	
21 m.m. below	7,845	7,654	7,331	
22 m.m. below	7,651	7,303	7,241	
23 m.m. below	7,309	7,065	6,893	
24 m.m. below	7,101	6,821	6,890	
25 m.m. below	6,997	6,711	6,843	
26 m.m. below	6,909	6,591	6,829	
27 m.m. below	6,750	6,530	6,645	
28 m.m. below	6,693	6,475	6,451	
29 m.m. below	6,627	6,313	6,312	
30 m.m. below	6,569	6,299	6,218	
31 m.m. below	6,516	6,174	6,090	
32 m.m. below	6,397	6,041	6,033	
33 m.m. below	6,254	5,950	5,764	
34 m.m. below	6,113	5,821	5,769	
35 m.m. below	5,841	5,732	5,452	
36 m.m. below	5,496	5,511	5,391	
37 m.m. below	5,324	5,201	4,804	
38 m.m. below	4,896	4,969	4,362	
39 m.m. below	4,212	4,852	3,714	
40 m.m. below	3,876	4,712	3,370	
TOTAL	360,154	356,163	352,693	

TABLE XV

F RADIOGRAPHS OF THE MULTIPLE OS CALCIS SECTIONS
LOT OF THE GEMINI VII MISSION
OR COUNTS

3 65)	Mean of Preflight Radiographs Mean of Films 1, 2, and 3	Postflight Radiographs				Mean of Postflight Radiographs Mean of Films 4, 5, 6, and 7
		Film 4 (12/18/65)	Film 5 (12/19/65)	Film 6 (12/29/65)	Film 7 (2/3/66)	
1	13,430	13,359	13,491	14,419	14,007	13,819
8	13,412	13,329	13,503	14,511	13,979	13,830
2	12,893	12,239	13,460	13,376	13,799	13,218
7	12,227	11,689	12,646	13,029	12,762	12,531
8	12,027	11,550	12,391	12,811	12,256	12,252
8	11,914	11,465	12,261	12,600	12,182	12,127
3	11,648	11,306	12,199	12,333	12,138	11,994
4	11,287	11,186	12,107	12,194	12,017	11,876
4	11,105	11,013	12,051	12,046	12,007	11,779
2	10,953	10,898	11,967	11,811	11,822	11,624
9	10,771	10,591	11,823	11,619	11,732	11,441
0	10,640	10,275	11,487	11,380	11,483	11,156
4	10,339	10,046	11,155	11,061	11,162	10,856
6	10,084	9,890	10,850	10,832	10,918	10,622
0	9,798	9,562	10,363	10,601	10,570	10,274
6	9,564	9,276	9,969	10,346	10,485	10,019
0	9,363	9,186	9,695	9,919	10,210	9,752
6	9,070	8,866	9,291	9,577	9,897	9,408
9	8,868	8,586	8,937	9,236	9,460	9,055
0	8,732	8,274	8,463	8,969	9,103	8,702
2	8,277	7,892	8,159	8,510	8,701	8,315
2	7,767	7,432	7,946	8,384	8,312	8,018
1	7,610	7,290	7,703	7,921	7,979	7,723
	7,398	7,168	7,481	7,610	7,611	7,467
6	7,089	6,989	7,075	7,475	7,373	7,228
0	6,937	6,843	6,814	7,238	7,198	7,023
8	6,850	6,702	6,746	7,047	7,005	6,875
9	6,776	6,503	6,610	6,910	6,912	6,734
5	6,642	6,400	6,553	6,865	6,863	6,670
	6,540	6,243	6,461	6,711	6,749	6,541
9	6,417	6,180	6,367	6,668	6,632	6,462
	6,362	6,128	6,192	6,608	6,457	6,346
0	6,260	5,910	6,066	6,594	6,251	6,208
	6,157	5,748	5,812	6,491	6,018	6,017
	5,989	5,631	5,667	6,407	5,959	5,916
	5,901	5,549	5,506	6,283	5,932	5,817
	5,675	5,319	5,421	5,965	5,697	5,600
	5,466	5,088	5,301	5,783	5,570	5,435
	5,110	4,614	4,992	5,542	5,314	5,115
	4,742	4,253	4,507	4,893	5,176	4,707
	4,259	3,637	3,928	4,677	4,841	4,271
	3,986	3,322	3,644	4,109	4,381	3,864
	356,335	343,427	363,060	377,361	374,930	364,694

TABLE X

VALUES OF THE COMPLETE SERIES OF RAD

FOR THE PILOT O

PART B. MULTIPLE SECTIONS IN TERMS OF CALIBRATION WE

Position of Tracing	Preflight Radiographs			Ra
	Film 1 (11/24/65)	Film 2 (12/1/65)	Film 3 (12/4/65)	Fi
1 m.m. above	2.4041	2.3657	2.4824	
Conventional Trace	2.3985	2.3749	2.4694	
1 m.m. below	2.3602	2.3355	2.2667	
2 m.m. below	2.1865	2.2675	2.1487	
3 m.m. below	2.1391	2.2248	2.1308	
4 m.m. below	2.1260	2.1607	2.1470	
5 m.m. below	2.1121	2.0873	2.0903	
6 m.m. below	2.0464	2.0120	2.0365	
7 m.m. below	1.9939	1.9843	2.0185	
8 m.m. below	1.9487	1.9642	2.0020	
9 m.m. below	1.9237	1.9487	1.9438	
10 m.m. below	1.9219	1.9103	1.9134	
11 m.m. below	1.8677	1.8445	1.8709	
12 m.m. below	1.8356	1.7870	1.8227	
13 m.m. below	1.7843	1.7444	1.7622	
14 m.m. below	1.7557	1.6924	1.7165	
15 m.m. below	1.7237	1.6619	1.6704	
16 m.m. below	1.6402	1.6274	1.6301	
17 m.m. below	1.5860	1.5863	1.6162	
18 m.m. below	1.5498	1.5525	1.6128	
19 m.m. below	1.5154	1.4744	1.4800	
20 m.m. below	1.4407	1.4121	1.3414	
21 m.m. below	1.4121	1.3777	1.3196	
22 m.m. below	1.3772	1.3145	1.3034	
23 m.m. below	1.3156	1.2717	1.2407	
24 m.m. below	1.2782	1.2278	1.2402	
25 m.m. below	1.2595	1.2080	1.2317	
26 m.m. below	1.2436	1.1864	1.2292	
27 m.m. below	1.2150	1.1754	1.1961	
28 m.m. below	1.2047	1.1655	1.1612	
29 m.m. below	1.1929	1.1363	1.1362	
30 m.m. below	1.1824	1.1338	1.1192	
31 m.m. below	1.1729	1.1113	1.0962	
32 m.m. below	1.1515	1.0874	1.0859	
33 m.m. below	1..257	1.0710	1.0375	
34 m.m. below	1.1003	1.0478	1.0384	
35 m.m. below	1.0514	1.0318	0.9814	
36 m.m. below	0.9893	0.9920	0.9704	
37 m.m. below	0.9583	0.9362	0.8647	
38 m.m. below	0.8813	0.8944	0.7852	
39 m.m. below	0.7582	0.8734	0.6685	
40 m.m. below	0.6977	0.8482	0.5526	
TOTAL	64.8280	64.1094	63.4310	6

E XV, CONTINUED

RADIOGRAPHS OF THE MULTIPLE OS CALCIS SECTIONS

T OF THE GEMINI VII MISSION

WEDGE MASS EQUIVALENCY (GRAMS)

	Mean of Preflight Radiographs	Postflight Radiographs				Mean of Postflight Radiographs
	Mean of Films 1, 2, and 3	Film 4 (12/18/65)	Film 5 (12/19/65)	Film 6 (12/29/65)	Film 7 (2/3/66)	Mean of Films 4, 5, 6, and 7
	2.4174	2.4046	2.4284	2.5954	2.5213	2.4874
	2.4142	2.3992	2.4305	2.6120	2.5162	2.4895
	2.3208	2.2030	2.4228	2.4077	2.4838	2.3793
	2.2009	2.1040	2.2763	2.3452	2.2972	2.2557
	2.1649	2.0790	2.2304	2.3060	2.2061	2.2054
	2.1445	2.0637	2.2070	2.2680	2.1928	2.1829
	2.0965	2.0351	2.1958	2.2199	2.1843	2.1589
	2.0316	2.0135	2.1793	2.1949	2.1631	2.1377
	1.9989	1.9823	2.1692	2.1683	2.1613	2.1203
	1.9716	1.9616	2.1541	2.1260	2.1280	2.0924
	1.9387	1.9064	2.1281	2.0914	2.1118	2.0594
	1.9152	1.8495	2.0677	2.0484	2.0669	2.0081
	1.8610	1.8083	2.0079	1.9910	2.0092	1.9541
	1.8151	1.7802	1.9530	1.9498	1.9652	1.9120
	1.7636	1.7212	1.8653	1.9082	1.9026	1.8493
	1.7215	1.6697	1.7944	1.8623	1.8873	1.8034
	1.6853	1.6535	1.7451	1.7854	1.8378	1.7554
	1.6326	1.5959	1.6724	1.7239	1.7815	1.6934
	1.5962	1.5455	1.6087	1.6625	1.7028	1.6299
	1.5717	1.4893	1.5233	1.6144	1.6385	1.5664
	1.4899	1.4206	1.4686	1.5318	1.5662	1.4968
	1.3981	1.3378	1.4303	1.5091	1.4962	1.4433
	1.3698	1.3122	1.3865	1.4258	1.4362	1.3902
	1.3317	1.2902	1.3466	1.3698	1.3700	1.3442
	1.2760	1.2580	1.2735	1.3405	1.3271	1.3010
	1.2487	1.2317	1.2265	1.3028	1.2956	1.2642
	1.2331	1.2064	1.2143	1.2685	1.2609	1.2375
	1.2197	1.1705	1.1898	1.2438	1.2442	1.2121
	1.1955	1.1520	1.1795	1.2357	1.2353	1.2006
	1.1771	1.1237	1.1630	1.2080	1.2148	1.1774
	1.1551	1.1124	1.1461	1.2002	1.1938	1.1631
	1.1451	1.1030	1.1146	1.1894	1.1623	1.1423
	1.1268	1.0638	1.0919	1.1869	1.1270	1.1174
	1.1083	1.0346	1.0462	1.1684	1.0832	1.0831
	1.0781	1.0136	1.0201	1.1533	1.0726	1.0649
	1.0622	0.9938	0.9911	1.1309	1.0678	1.0472
	1.0215	0.9574	0.9758	1.0737	1.0255	1.0081
	0.9839	0.9158	0.9542	1.0409	1.0026	0.9784
	0.9197	0.8305	0.8986	0.9976	0.9565	0.9208
	0.8536	0.7655	0.8113	0.8807	0.9317	0.8473
	0.7667	0.6547	0.7070	0.8419	0.8714	0.7688
	0.6995	0.5980	0.6559	0.7396	0.7886	0.6955
	64.1223	61.8167	65.3511	67.9250	67.4877	65.6451

TABLE XV, CONTINUED

VALUES OF THE COMPLETE SERIES OF RADIOGRAPHS OF THE MULTIPLE OS CALCIS SECTIONS FOR THE PILOT OF THE GEMINI VII MISSION

PART C. PER CENT CHANGE BETWEEN THE IMMEDIATE PREFLIGHT AND IMMEDIATE POSTFLIGHT RADIOGRAPHS

Position of Tracing	Integrator Counts		Per Cent Change
	Film 4 (Launch)	Film 5 (Recovery)	
1 m.m. above	13 791	13,359	-3.13
Conventional Trace	13,718	13,329	-2.84
1 m.m. below	12,592	12,239	-2.81
2 m.m. below	11,937	11,689	-2.08
3 m.m. below	11,838	11,550	-2.43
4 m.m. below	11,928	11,465	-3.88
5 m.m. below	11,613	11,306	-2.64
6 m.m. below	11,314	11,186	-1.13
7 m.m. below	11,214	11,013	-1.79
8 m.m. below	11,122	10,898	-2.01
9 m.m. below	10,799	10,591	-1.93
10 m.m. below	10,630	10,275	-3.34
11 m.m. below	10,394	10,046	-3.35
12 m.m. below	10,126	9,890	-2.33
13 m.m. below	9,790	9,562	-2.33
14 m.m. below	9,536	9,276	-2.73
15 m.m. below	9,280	9,186	-1.01
16 m.m. below	9,056	8,866	-2.10
17 m.m. below	8,979	8,586	-4.38
18 m.m. below	8,960	8,274	-7.66
19 m.m. below	8,222	7,892	-4.01
20 m.m. below	7,452	7,432	-0.27
21 m.m. below	7,331	7,290	-0.56
22 m.m. below	7,241	7,168	-1.01
23 m.m. below	6,893	6,989	+1.39
24 m.m. below	6,890	6,843	-0.68
25 m.m. below	6,843	6,702	-2.05
26 m.m. below	6,829	6,503	-4.77
27 m.m. below	6,645	6,400	-3.69
28 m.m. below	6,451	6,243	-3.23
29 m.m. below	6,312	6,180	-2.09
30 m.m. below	6,218	6,128	-1.45
31 m.m. below	6,090	5,910	-2.95
32 m.m. below	6,033	5,748	-4.72
33 m.m. below	5,764	5,631	-2.30
34 m.m. below	5,769	5,549	-3.81
35 m.m. below	5,452	5,319	-2.44
36 m.m. below	5,391	5,088	-5.63
37 m.m. below	4,804	4,614	-3.96
38 m.m. below	4,362	4,253	-2.51
39 m.m. below	3,714	3,637	-2.06
40 m.m. below	3,370	3,322	-1.42
TOTAL	352,693	343,427	-2.54

TABLE XVI

EVALUATION OF A SECTION ACROSS THE TALUS FOR GEMINI VII ASTRONAUTS THROUGHOUT THEIR MISSION

PART A. COMMAND PILOT

Film Numbers and Dates	Evaluations in Terms of Integrator Counts			Evaluations in Terms of Calibration Wedge Mass Equivalency (grams)
	Evaluation Number 1	Evaluation Number 2	Average of Both Evaluations	
Film 1 (11/24/65)	10,330	10,336	10,333	1.8599
Film 2 (12/1/65)	12,158	12,166	12,162	2.1892
Film 3 (12/4/65) (Launch)	10,404	10,818	10,611	1.9100
Film 4 (12/18/65) (Recovery)	9,929	9,795	9,862	1.7752
Film 5 (12/19/65)	10,077	10,477	10,277	1.8499
Film 6 (12/29/65)	11,836	11,498	11,667	2.1001
Film 7 (2/3/66)	11,116	11,108	11,112	2.0002

TABLE XVI, CONTINUED

EVALUATION OF A SECTION ACROSS THE TALUS FOR GEMINI VII ASTRONAUTS THROUGHOUT THEIR MISSION

PART B. PILOT

Film Numbers and Dates	Evaluations in Terms of Integrator Counts			Evaluations in Terms of Calibration Wedge Mass Equivalency (grams)
	Evaluation Number 1	Evaluation Number 2	Average of Both Evaluations	
Film 1 (11/24/65)	12,694	12,750	12,722	2.2900
Film 2 (12/1/65)	11,681	11,653	11,667	2.1001
Film 3 (12/4/65) (Launch)	11,948	11,940	11,944	2.1500
Film 4 (12/18/65) (Recovery)	11,415	11,517	11,466	2.0639
Film 5 (12/19/65)	11,626	11,704	11,665	2.0997
Film 6 (12/29/65)	12,784	12,770	12,777	2.2999
Film 7 (2/3/66)	12,397	12,493	12,445	2.2401

TABLE XVII

VALUES OF THE COMPLETE SERIES OF THE RADIOGRAPHS OF MULTIPLE SECTIONS OF HAND PHALANX 5-2 OF THE COMMAND PILOT OF THE GEMINI VII MISSION

PART A. MULTIPLE SECTIONS IN TERMS OF INTEGRATOR COUNTS

Position of Tracing	Integrator Counts Obtained During Densitometric Scanning of X-Rays							
	Film 1 (11/24/65)	Film 2 (12/1/65)	Film 3 (12/4/65)	Mean of Pre-Flight Radiographs (Films 1, 2, and 3)	Film 4 (12/18/65)	Film 5 (12/19/65)	Film 6 (12/29/65)	Film 7 (2/3/66)
Proximal End of Tracing	1190	1167	1161	1173	1107	1118	1117	1141
1 m.m. below	981	937	970	963	880	887	829	844
2 m.m. below	790	850	773	804	709	715	683	695
3 m.m. below	695	697	708	700	634	649	633	643
4 m.m. below	652	604	663	640	583	602	592	602
5 m.m. below	621	587	602	603	561	563	551	566
6 m.m. below	630	588	602	607	581	580	568	576
7 m.m. below	634	600	598	611	587	589	578	586
8 m.m. below	558	511	538	536	520	522	507	508
9 m.m. below	544	513	529	529	504	506	499	503
10 m.m. below	505	480	493	493	472	475	465	467
11 m.m. below	511	482	494	496	475	483	470	472
12 m.m. below	535	507	506	516	481	503	499	506
13 m.m. below	526	514	512	518	480	491	508	509
14 m.m. below	533	528	522	528	466	483	522	531
15 m.m. below	536	533	528	532	481	495	543	543
16 m.m. below	570	605	559	578	512	517	604	609
17 m.m. below	606	626	604	612	561	575	670	663
Total	11,619	11,329	11,362	11,436	10,594	10,753	10,838	10,964

TABLE XVII, CONTINUED

VALUES OF THE COMPLETE SERIES OF THE RADIOGRAPHS OF MULTIPLE SECTIONS OF HAND PHALANX 5-2 OF THE COMMAND PILOT OF THE GEMINI VII MISSION

PART B. MULTIPLE SECTIONS IN TERMS OF CALIBRATION WEDGE MASS EQUIVALENCY (GRAMS)

Position of Tracing	Film 1	Film 2	Film 3	Film 4	Film 5	Film 6	Film 7
Proximal End of Phalanx	0.107	0.105	0.104	0.100	0.101	0.101	0.103
1 m.m. below	0.088	0.084	0.087	0.079	0.080	0.075	0.076
2 m.m. below	0.071	0.076	0.070	0.064	0.064	0.061	0.063
3 m.m. below	0.063	0.063	0.064	0.057	0.058	0.057	0.058
4 m.m. below	0.059	0.054	0.060	0.052	0.054	0.053	0.054
5 m.m. below	0.056	0.053	0.054	0.050	0.051	0.050	0.051
6 m.m. below	0.057	0.053	0.054	0.052	0.052	0.051	0.052
7 m.m. below	0.057	0.054	0.054	0.053	0.053	0.052	0.053
8 m.m. below	0.050	0.046	0.048	0.047	0.047	0.046	0.046
9 m.m. below	0.049	0.046	0.048	0.045	0.046	0.045	0.045
10 m.m. below	0.045	0.043	0.044	0.042	0.043	0.042	0.042
11 m.m. below	0.046	0.043	0.044	0.043	0.043	0.042	0.042
12 m.m. below	0.048	0.046	0.046	0.043	0.045	0.045	0.046
13 m.m. below	0.048	0.046	0.046	0.043	0.044	0.046	0.046
14 m.m. below	0.048	0.048	0.047	0.042	0.043	0.047	0.048
15 m.m. below	0.048	0.048	0.048	0.043	0.045	0.049	0.049
16 m.m. below	0.051	0.054	0.050	0.046	0.047	0.054	0.055
17 m.m. below	0.055	0.056	0.054	0.050	0.052	0.060	0.060
TOTAL	1.046	1.018	1.022	0.951	0.968	0.976	0.989

TABLE XVII, CONTINUED

VALUES OF THE COMPLETE SERIES OF THE RADIOGRAPHS OF MULTIPLE SECTIONS OF HAND PHALANX 5-2 OF THE COMMAND PILOT OF THE GEMINI VII MISSION

PART C. PER CENT CHANGE BETWEEN THE IMMEDIATE PREFLIGHT AND THE IMMEDIATE POSTFLIGHT RADIOGRAPHS

Position of Tracing	Integrator Counts		Per Cent Change
	Film 3 (Launch)	Film 4 (Recovery)	
Distal End of Phalanx	1161	1107	-4.65
1 m.m. below	970	880	-9.28
2 m.m. below	773	709	-8.28
3 m.m. below	708	634	-10.45
4 m.m. below	663	583	-12.07
5 m.m. below	602	561	-6.81
6 m.m. below	602	581	-3.49
7 m.m. below	598	587	-1.84
8 m.m. below	538	520	-3.34
9 m.m. below	529	504	-4.72
10 m.m. below	493	472	-4.26
11 m.m. below	494	475	-3.85
12 m.m. below	506	481	-4.94
13 m.m. below	512	480	-6.25
14 m.m. below	522	466	-10.73
15 m.m. below	528	481	-8.90
16 m.m. below	559	512	-8.41
17 m.m. below	604	561	-7.12
TOTAL	11,362	10,594	-6.76

TABLE XVIII

VALUES OF THE COMPLETE SERIES OF THE RADIOGRAPHS OF MULTIPLE SECTIONS OF HAND PHALANX 5-2 OF THE PILOT OF THE GEMINI VII MISSION

PART A. MULTIPLE SECTIONS IN TERMS OF INTEGRATOR COUNTS

Position of Tracing	Integrator Counts Obtained During Densitometric Scanning of X-Rays							
	Film 1 (11/24/65)	Film 2 (12/1/65)	Film 3 (12/4/65)	Mean of Pre-Flight Radiographs (Films 1, 2, and 3)	Film 4 (12/18/65)	Film 5 (12/19/65)	Film 6 (12/29/65)	Film 7 (2/3/66)
Proximal End of Tracing	1147	1309	1266	1241	1139	1173	1167	1221
1 m.m. below	876	986	961	941	929	880	906	927
2 m.m. below	754	850	802	802	718	764	807	813
3 m.m. below	682	766	721	723	645	693	849	740
4 m.m. below	711	750	702	721	616	648	910	710
5 m.m. below	680	736	704	707	658	644	811	704
6 m.m. below	673	782	740	732	630	710	752	688
7 m.m. below	648	707	652	669	601	642	737	674
8 m.m. below	627	654	605	629	567	605	705	613
9 m.m. below	611	665	625	634	594	614	697	641
10 m.m. below	595	669	611	625	585	610	673	630
11 m.m. below	569	646	594	603	573	588	662	608
12 m.m. below	572	642	593	602	580	595	643	614
13 m.m. below	570	638	595	601	581	598	657	618
14 m.m. below	572	674	623	623	597	617	667	630
15 m.m. below	571	661	594	609	579	602	672	613
16 m.m. below	586	673	596	618	549	624	678	615
Total	11,444	12,808	11,984	12,078	11,141	11,607	12,993	11,059

TABLE XVIII, CONTINUED

VALUES OF THE COMPLETE SERIES OF THE RADIOGRAPHS OF MULTIPLE SECTIONS OF HAND PHALANX 5-2 OF THE PILOT OF THE GEMINI VII MISSION

PART B. MULTIPLE SECTIONS IN TERMS OF CALIBRATION WEDGE MASS EQUIVALENCY (GRAMS)

Position of Tracing	Film 1	Film 2	Film 3	Film 4	Film 5	Film 6	Film 7
Proximal End of Phalanx	0.103	0.118	0.114	0.103	0.106	0.105	0.110
1 m.m. below	0.079	0.089	0.086	0.084	0.079	0.082	0.083
2 m.m. below	0.068	0.076	0.072	0.065	0.069	0.073	0.073
3 m.m. below	0.061	0.069	0.065	0.058	0.062	0.076	0.067
4 m.m. below	0.064	0.068	0.063	0.055	0.058	0.082	0.064
5 m.m. below	0.061	0.066	0.063	0.059	0.058	0.073	0.063
6 m.m. below	0.061	0.070	0.067	0.057	0.064	0.068	0.062
7 m.m. below	0.058	0.064	0.059	0.054	0.058	0.066	0.061
8 m.m. below	0.056	0.059	0.054	0.051	0.054	0.063	0.055
9 m.m. below	0.055	0.060	0.056	0.053	0.055	0.063	0.058
10 m.m. below	0.054	0.060	0.055	0.053	0.055	0.061	0.057
11 m.m. below	0.051	0.058	0.053	0.052	0.053	0.060	0.055
12 m.m. below	0.051	0.058	0.053	0.052	0.054	0.058	0.055
13 m.m. below	0.051	0.057	0.054	0.052	0.054	0.059	0.056
14 m.m. below	0.051	0.061	0.056	0.054	0.056	0.060	0.057
15 m.m. below	0.051	0.059	0.053	0.052	0.054	0.060	0.055
16 m.m. below	0.053	0.061	0.054	0.049	0.056	0.061	0.055
TOTAL	1.028	1.153	1.077	1.003	1.045	1.170	1.086

TABLE XVIII, CONTINUED

VALUES OF THE COMPLETE SERIES OF THE RADIOGRAPHS OF MULTIPLE SECTIONS OF HAND PHALANX 5-2 OF THE PILOT OF THE GEMINI VII MISSION

PART C. PER CENT CHANGE BETWEEN THE IMMEDIATE PREFLIGHT AND THE IMMEDIATE POSTFLIGHT RADIOGRAPHS

Position of Tracing	Integrator Counts		Per Cent Change
	Film 3 (Launch)	Film 4 (Recovery)	
Distal End of Phalanx	1266	1139	-10.03
1 m.m. below	961	929	-3.33
2 m.m. below	802	718	-10.47
3 m.m. below	721	645	-10.54
4 m.m. below	702	616	-12.25
5 m.m. below	704	658	-6.53
6 m.m. below	740	630	-14.86
7 m.m. below	652	601	-7.82
8 m.m. below	605	567	-6.28
9 m.m. below	625	594	-4.96
10 m.m. below	611	585	-4.25
11 m.m. below	594	573	-3.54
12 m.m. below	593	580	-2.19
13 m.m. below	595	581	-2.35
14 m.m. below	623	597	-4.17
15 m.m. below	594	579	-2.52
16 m.m. below	596	549	-7.88
17 m.m. below	X	X	X
TOTAL	11,984	11,141	-7.03

TABLE XIX

VALUES OF THE COMPLETE SERIES OF RADIOGRAPHS OF THE MULTIPLE SECTIONS OF HAND PHALANX 4-2 OF THE COMMAND PILOT AND PILOT OF THE GEMINI VII MISSION

Position of Tracing	Command Pilot			Pilot		
	Integrator Counts from the Densitometer		Per Cent Change 12/4/65 to 12/18/65	Integrator Counts from the Densitometer		Per Cent Change 12/4/65 to 12/18/65
Distal End of Phalanx	1526	1387	-9.11	1673	1601	-4.30
1 mm below	1141	1071	-6.13	1376	1306	-5.09
2 mm below	1010	948	-6.14	1222	1186	-2.94
3 mm below	931	882	-5.26	1154	1093	-5.28
4 mm below	892	840	-5.83	1100	1012	-8.00
5 mm below	886	813	-8.24	1069	986	-7.76
6 mm below	898	832	-7.35	1102	1047	-4.99
7 mm below	893	834	-6.61	1109	1063	-4.15
8 mm below	902	842	-6.65	1082	1064	-1.66
9 mm below	932	866	-7.08	1113	1083	-2.70
10 mm below	970	890	-8.25	1089	996	-8.54
11 mm below	982	940	-4.28	1029	996	-3.21
12 mm below	941	890	-5.42	1032	951	-7.85
13 mm below	902	836	-7.32	927	878	-5.28
14 mm below	900	839	-6.78	899	884	-1.67
15 mm below	900	860	-4.44	896	875	-2.34
16 mm below	906	843	-6.95	909	879	-3.30
17 mm below	864	800	-7.41	906	882	-2.65
18 mm below	893	817	-8.51	881	897	+1.82
19 mm below	875	830	-5.14	946	906	-4.23
20 mm below	870	809	-7.01	912	916	+0.44
21 mm below	832	808	-2.88	899	881	-2.00
22 mm below	813	748	-8.00	954	947	-0.73
23 mm below	791	738	-6.70	863	845	-2.08
24 mm below	836	789	-5.62	851	827	-2.82
25 mm below	882	831	-5.78	X	X	X
26 mm below	808	762	-5.69	X	X	X
Average	24,976	23,345	-6.53	25,993	25,001	-3.82

TABLE XX

EVALUATION OF A SECTION ACROSS THE CAPITATE FOR GEMINI VII ASTRONAUTS THROUGHOUT THEIR MISSION

PART A. COMMAND PILOT

Film Numbers and Dates	Evaluations in Terms of Integrator Counts			Evaluations in Terms of Calibration Wedge Mass Equivalency (grams)
	Evaluation Number 1	Evaluation Number 2	Average of Both Evaluations	
Film 1 (11/12/65)	6,226	5,998	6,112	1.1002
Film 2 (12/1/65)	6,618	6,604	6,611	1.1900
Film 3 (12/4/65) (Launch)	6,508	6,492	6,500	1.1700
Film 4 (12/18/65) (Recovery)	6,235	6,205	6,220	1.1196
Film 5 (12/19/65)	6,542	6,566	6,554	1.1797
Film 6 (12/29/65)	7,181	7,153	7,167	1.2901
Film 7 (2/3/66)	6,715	6,729	6,722	1.2100

TABLE XX, CONTINUED

EVALUATION OF A SECTION ACROSS THE CAPITATE FOR GEMINI VII ASTRONAUTS THROUGHOUT THEIR MISSION

PART B. PILOT

Film Numbers and Dates	Evaluations in Terms of Integrator Counts			Evaluations in Terms of Calibration Wedge Mass Equivalency (grams)
	Evaluation Number 1	Evaluation Number 2	Average of Both Evaluations	
Film 1 (11/12/65)	6,797	6,759	6,778	1.2200
Film 2 (12/1/65)	7,720	7,724	7,722	1.3900
Film 3 (12/4/65) (Launch)	7,322	7,346	7,334	1.3201
Film 4 (12/18/65) (Recovery)	6,664	6,640	6,652	1.1974
Film 5 (12/19/65)	7,210	7,234	7,222	1.3000
Film 6 (12/29/65)	7,740	7,704	7,722	1.3900
Film 7 (2/3/66)	7,504	7,496	7,500	1.3500