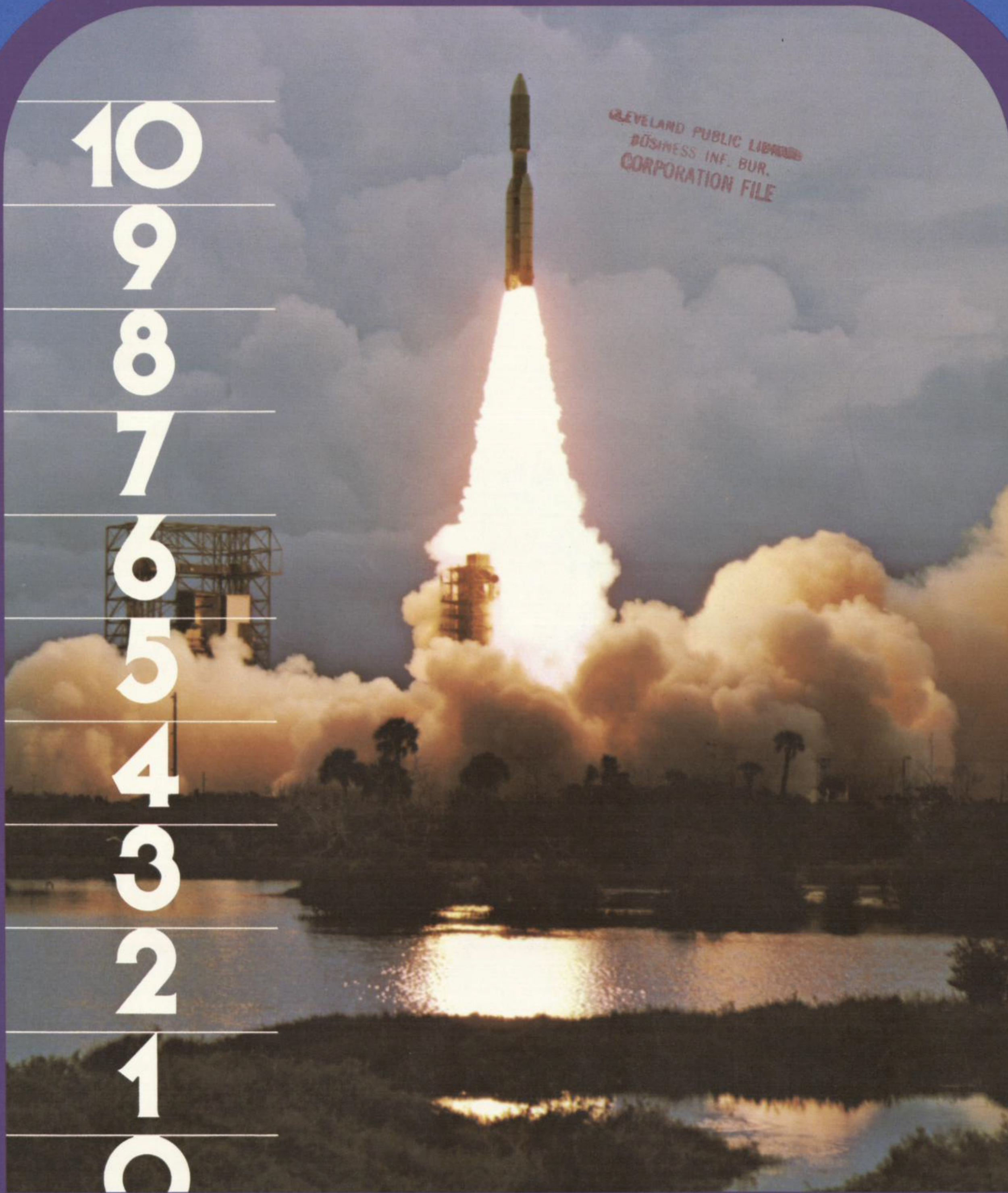
TeledyneReport

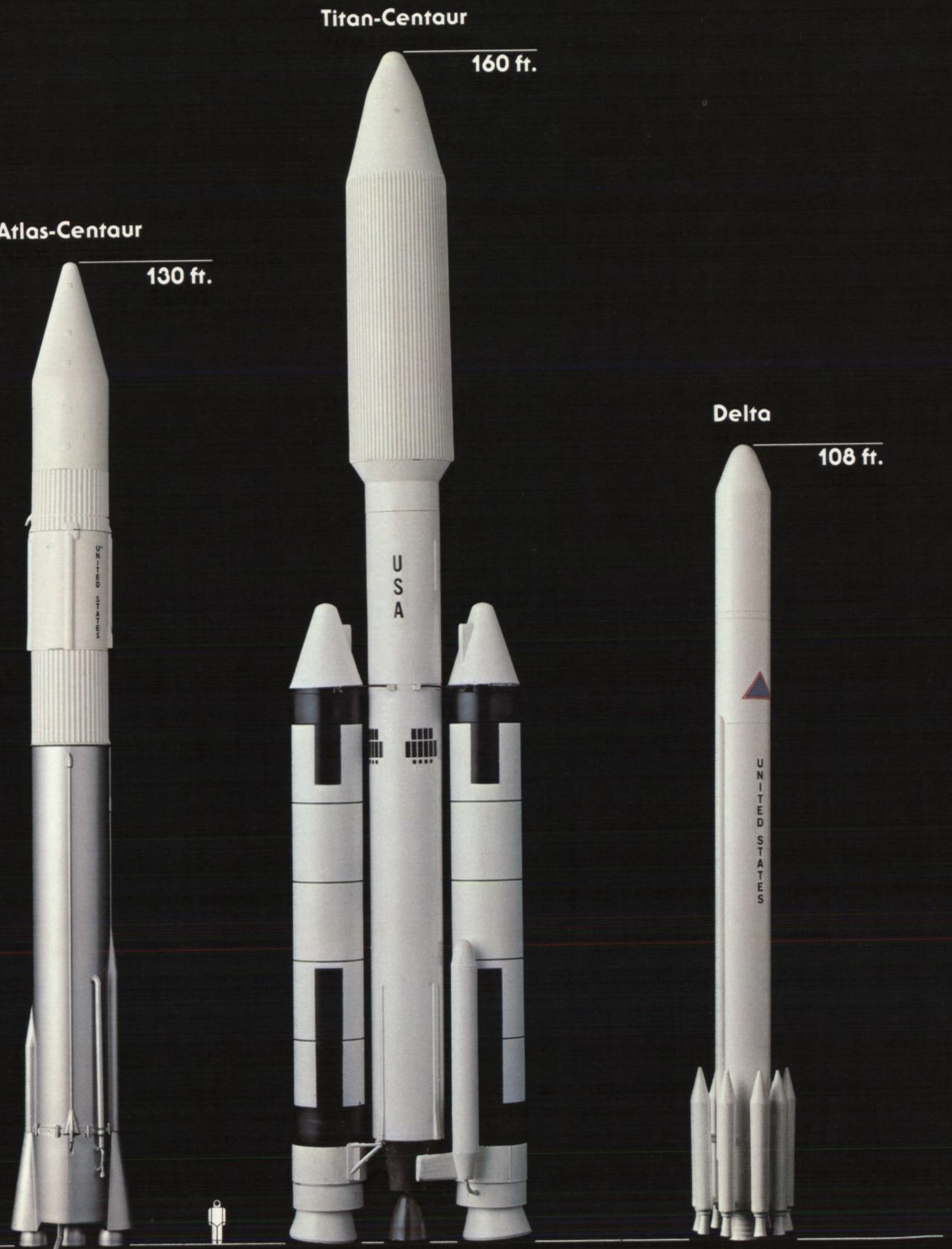
second quarter 1977

Space Navigation: Guiding the Way into Space



THE COVER: This dramatic NASA photo records the launching of the first Viking spacecraft to Mars, aboard a Titan-Centaur
unch vehicle, guided and controlled by a Teledyne on-board computer.

SA's three basic launch vehicles are used for a variety of space missions, ranging from placing communications and other
es of satellites into earth orbit, to sending exploratory probes to distant planets.



Space Navigation

Whether the payload is a spacecraft for Mars or a satellite for earth orbit, the first minutes of flight, under the guidance of an on-board computer, are the most critical to the success of the mission.

On August 20, 1975, at 5:22 P.M. EDT a 160 foot high rocket vehicle weighing 1,360,000 pounds rose into the Florida sky with an ear-shattering roar and quickly disappeared from sight. In two minutes the propellants in two solid fuel engines weighing about 1,000,000 pounds had been burned and the vehicle was over 20 miles high, traveling at a speed of nearly a mile per second.

That was the first step in a complex series of rocket motor firings, stagings, coasts, orientations and other events required to send the first Viking spacecraft on its 460 million mile, ten-month journey to intercept, orbit and eventually land on the planet Mars. The event was repeated three weeks later with the launching of the Viking "B".

Perhaps the most amazing part of these two remarkably successful feats of interplanetary marksmanship and other similar missions, is that their success is largely dependent on how precisely the launch vehicle is controlled during the relatively short launch phase of each mission. In the case of the Viking mission, for example, the powered launch phase was less than an hour on a voyage that lasted almost a year. It is during this short launch period that the spacecraft is irrevocably committed to its basic course.

Once separated from the launch vehicle, the spacecraft essentially coasts to its destination, its trajectory determined by its speed and direction at the time of separation. Some minor course corrections can be made with small on-board rocket motors, but the limited amount of fuel carried is mostly needed for other purposes.

GUIDANCE AND NAVIGATION

The heart of the system that controlled both the Viking launches, as well as many other successful space launches, was a Teledyne designed and produced Digital Computer Unit about the size of an old-fashioned bread box. This effort was initiated in 1968 under the guidance of NASA's Lewis Research Center.

Inside its armored aluminum case is an array of Teledyne hybrid microcircuits (see Teledyne Report, First Quarter 1975) that make up an advanced computer with an ability to perform up to 130,000 computing operations per second. Also in the same case is a memory that can store 16,384 words of computer information.

One primary job of the computer is the guidance and control of the launch vehicle. Input from an inertial platform tells the computer the attitude and velocity of the vehicle. Through its connection to various electrical and hydraulic systems, the computer issues commands that steer the vehicle by moving the rocket nozzles.

Another vital function of the computer is the navigation of the launch vehicle. Since there are a number of trajectories by which the vehicle can reach the desired velocity and point in space where the spacecraft must be released, the computer busily evaluates data to determine its present position and computes the best course to reach its goal, correcting and up-dating its calculations as the launch progresses.

Each launch vehicle has its own characteristics, since propellant pumps may vary slightly in output, rocket motors may vary in thrust achieved, and other factors may differ. This means that the vehicle's performance must be evaluated from live data and corrections computed and implemented while the launch is in progress.

MONITORING FLIGHT SYSTEMS

The computer also monitors the condition of various parts of the launch vehicle through three Teledyne-made multiplexer units that collect data from various points. The computer formats the data for transmission to earth for performance analysis.

A number of other steps such as propellant settling prior to firing the liquid fuel engines, chilldown of propellant pumps prior to firing, monitoring and controlling the ratio of fuel to oxidizer being used, and separation of stages by explosive disconnects are all controlled by the computer, as are the myriad valves, pumps, switches and motors that must actuate at precise times during the flight.

OTHER PROGRAMS, OTHER SUCCESSES

Viking is only one, albeit a complex and interesting one, of many space programs on which Teledyne Digital Computing Units have been used. To date Teledyne computers have controlled fifty different launches with fifty unqualified successes.

In addition to other interplanetary scientific missions such as Pioneer G which investigated Jupiter's surface and is now on its way to Saturn, the Helios probes to the sun, the Mariner Venus Mercury probes and others, Teledyne launch computers have been used for orbiting a variety of earth satellites.

These include communications satellites such as the Intelsat, Westar and Comstar series which relay telephone and television channels around the world, Landsat (ERTS) satellites which provide valuable information on earth resources, Nimbus, Itos and related weather satellites and a variety of other satellites used for various scientific purposes of great value in understanding our own planet and solar system.

THREE BASIC LAUNCH VEHICLES

Teledyne Digital Computer Units are used on all three of NASA's basic launch vehicles. These are shown in relative scale on the inside front cover of this report.

The Titan-Centaur, used to launch the Viking mission and other deep-space or large payload missions, is the largest. It consists of two solid fuel strap-on boosters that fire first. When these are expended they are jettisoned and the first stage liquid fuel engine fires. This too is jettisoned and a second smaller liquid fuel engine fires.

The Titan carries aloft the Centaur stage, which in turn carries the spacecraft to be launched. The Centaur is a very powerful, compact rocket vehicle that is fueled with liquid hydrogen and carries liquid oxygen as the oxidizer. The engine can be started, stopped and restarted many times, enabling it to carry out complex space maneuvers.

The medium-size Atlas-Centaur vehicle uses an Atlas liquid fuel rocket with two stages to carry the same Centaur vehicle. It is used in the launching of many of the larger communications satellites.

Delta is NASA's smallest basic launch vehicle. It is fundamentally a two-stage liquid fuel rocket carrying a solid fuel third stage. For additional power, sets of three, six or nine solid propellant motors may be strapped on. Delta is widely used for the launching of communications and scientific satellites.

THE INERTIAL PLATFORM

The second vital component of a complete space guidance system is an inertial reference unit. This consists of one or more gyroscopes and a related set of accelerometers.

A gyroscope is basically a small flywheel spinning at high speed. Its inherent physical characteristic is to resist having its axis of rotation changed. The same principle lets a spinning top remain balanced on its tip as long as it spins fast enough.

If a gyroscope rotor is mounted in a series of frames that are gimballed or pivoted so that the gyroscope can move freely in all three axes, the axis of the spinning rotor will always point in the same direction no matter how the outer frame is moved.

If such a gyroscope arrangement is fastened to the frame of a space vehicle, the spinning rotor, driven by an electric motor and controlled by electronics will always have its axis pointing in the same direction, no matter how the vehicle turns or twists.

Accelerometers mounted on the inner frame or platform sense changes in velocity along each of three axes of the platform caused by acceleration or deceleration of the vehicle in any direction. This information is used by the computer to calculate the exact position of the vehicle, the direction of flight, and its velocity.

STRAPDOWN GYROS

An alternative and more modern system applies the gyroscope principle in a slightly different way. The gyroscope and its motor are fastened solidly to the frame of the vehicle. The rotor is designed in such a way that it can tilt in relation to the motor's axis, much in the manner of a plate spinning on the tip of a juggler's stick. As the vehicle changes direction, the rotor tries to remain spinning in its original plane and begins to tilt in relation to the motor's axis. This tilting is sensed by electrical coils.

An electronic system then applies energy to a larger set of coils which magnetically pull the rotor back into alignment with the motor axis. The electrical current required to do this is directly proportional to the angular movement of the vehicle, and this information, plus information from a set of accelerometers allows the Digital Computer Unit to keep track of the vehicle's movement, attitude and position.

Since each gyro rotor is only free to move in two axes of rotation, two gyros are required to provide three axes of information with one redundant axis.

The strapdown system is preferable in space applications because the instrument is smaller, lighter and mechanically simpler than a gimballed navigation system. The strapdown inertial system, however, requires considerably greater computation on the part of the computer, which has been facilitated by the advent of microelectronic hybrids and the compact powerful computers they make possible.

TELEDYNE'S INTERTIAL SYSTEMS

Teledyne Systems Company has been designing and building inertial reference systems since the mid-1960's. Early models were of the gimballed variety but development and production have focused on the strapdown type since the late 1960's.

One of the most significant new programs has been the award to Teledyne Systems Company of a contract to develop a complete guidance system for the Boeing/U.S. Air Force Interim Upper Stage. This will involve flight computers and an inertial reference system organized in a redundant configuration for utmost reliability.

The Interim Upper Stage is basically a high reliability, solid propellant vehicle that can be carried aloft in the cargo bay of the Space Shuttle Orbiter. Once the shuttle is in orbit, the Interim Upper Stage, with its payload attached, will be extracted from the orbiter cargo bay and used to put the payload into a higher energy orbit.

The orbiter replaces the lower stages of present launch vehicles and is reusable, with the goal being to reduce the cost of putting payloads into orbit. Ultimately a recoverable upper stage may be developed to further reduce costs.

GUIDANCE FOR NASA

Teledyne is also currently developing a complete strapdown inertial guidance and control system for NASA's Scout launch vehicle. It is a small, four-stage, solid-propellant multipurpose vehicle for launching payloads of 300 to 500 pounds into low earth orbits. It is an economical vehicle primarily for scientific payloads.

Another very advanced program is DRIRU II, which involves the development of a standard spacecraft attitude system for NASA spacecraft. Teledyne is now developing this system featuring low power consumption and redundancy for high reliability.

The DRIRU II system consists of three totally-isolated strapdown gyros and associated electronics. Each gives two axes of reference for a total of six. Since only three are required, the system is highly failure tolerant. Even if one gyro fails completely, the system can still provide complete and accurate reference information.

The concern with utmost reliability in these systems is because of the high cost of many of the spacecraft payloads that are launched. This can range from ten million dollars to hundreds of millions, not including the costs of the launching vehicles.

REFERENCE FOR AIRCRAFT

Many of the techniques of guiding and navigating a space vehicle apply equally well to aircraft. Aircraft often must fly in overcast weather or above cloud cover that obscures visual reference points. Many navigation systems require ground based

Viking's Long Journey into Space

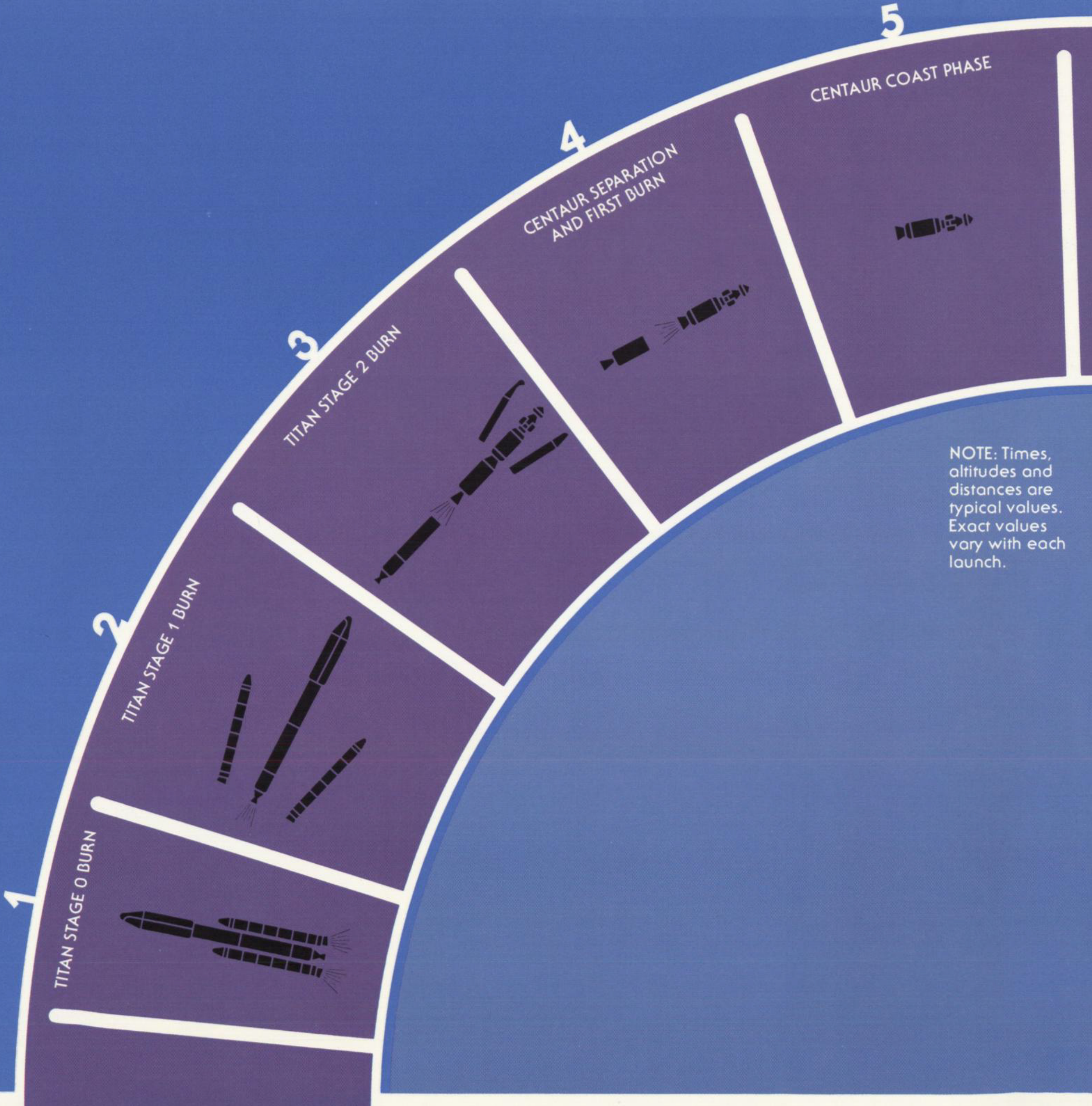
An ancient proverb has it that the longest journey begins with a single step. In no journey, however, is that first step more critical than in the launching of a space vehicle.

In the case of the two recent Viking missions to Mars, each 460 million mile voyage took almost a year to complete, but the success of each journey depended in large part on a complex sequence of hundreds of events that took place in the first 60 minutes of flight.

During that short time, from lift-off to the final release of the spacecraft for its long coast to Mars, the fate of each mission was under the control of a small white aluminum box known as the Digital Computer Unit, or DCU.

The DCU is essentially a small but powerful digital computer designed and built by Teledyne Systems Company, utilizing the company's most advanced hybrid microcircuit technology.

Drawing on a continuous stream of data from an inertial reference unit that senses and measures the launch vehi-



cle's acceleration rates and attitude, and referring to the data in its memory banks, the DCU calculates the actions necessary to put the vehicle into its proper trajectory.

It does this by controlling the angle of rocket nozzles through servo systems to steer the vehicle, and by timing the initiation and cut-off of the various rocket motor burns.

In addition, through three Teledyne produced multiplexer units it receives a constant stream of data regarding the health and proper functioning of the entire system, and formats this data for transmittal back to ground-based receiving stations for flight performance analysis.

The DCU, in addition to guiding and navigating the vehicle, also controls, times and sequences the myriad events that must occur, such as stage separations, propellant utilization, engine burns, and spacecraft orientation.

Its mission is complete shortly after the Centaur ends its retrofire sequence, and ultimately plunges with it to a fiery end as the Centaur reenters the atmosphere.

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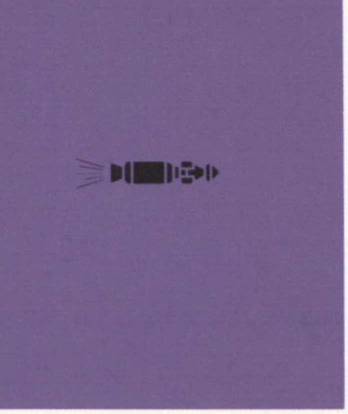
CENTAUR SECOND BURN



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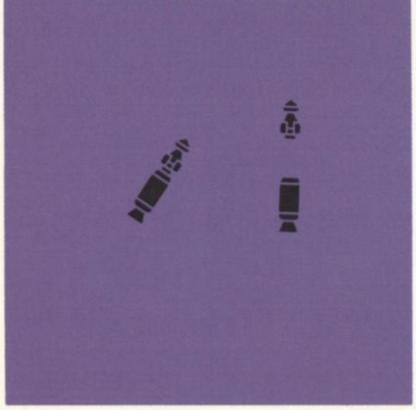
COAST, ORIENT AND SEPARATE SPACECRAFT



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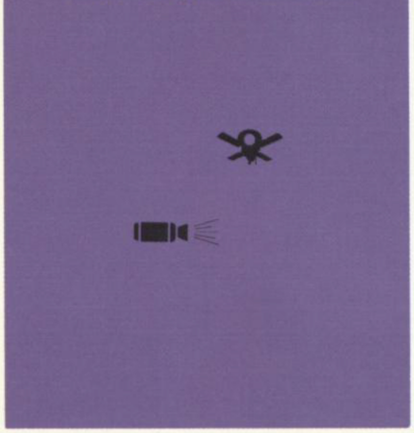
CENTAUR RETROMANEUVER



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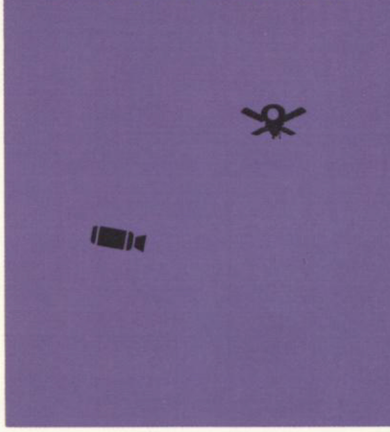
LAUNCH MISSION COMPLETE



1 Initial lift-off is accomplished by the two solid state rocket motors of Titan stage zero. Each is 10 feet in diameter and 85 feet long. Together they provide a total initial thrust of 2.4 million pounds. This thrust tapers to about 1.6 million pounds during the total burning time of two minutes. These boosters carry the vehicle to a height of 23 miles and a speed of nearly one mile per second.

2 Titan stage one is ignited just before the solid state rocket motors burn out, and shortly thereafter the spent boosters are jettisoned. Stage one uses a liquid fuel mixture of hydrazine and unsymmetrical dimethylhydrazine, burned with a nitrogen tetroxide oxidizer. It is 10 feet in diameter and 73 feet long and has a rated thrust of about 500,000 pounds. It burns for about two and one half minutes, carrying the vehicle to an altitude of 69 miles, a range of 242 miles, and a speed of over 9,000 miles per hour.

3 Titan stage one is jettisoned and Titan stage two is ignited. Also 10 feet in diameter but only 23 feet long, stage two uses the same fuel and oxidizer and produces a rated thrust of about 100,000 pounds. The protective shroud covering the payload and Centaur vehicle is jettisoned. Stage two burns for about three and one half minutes, carrying the vehicle to an altitude of 104 miles, and a speed of over 14,000 miles per hour.

4 Titan stage two is jettisoned and the Centaur main engine, fueled with liquid hydrogen and liquid oxygen, is fired for the first time for about two minutes. Its 30,000 pound thrust carries the vehicle to an altitude of 106 miles, a surface range of 1,460 miles, and a speed of 16,500 miles per hour.

5 The Centaur main engine is shut down and the launch vehicle is allowed to coast in a parking orbit for a period ranging from 6 to 30 minutes. The coast time is dependent on the exact time and date of each launch. This phase allows the vehicle to reach the proper position in its orbit around the earth for the final Centaur rocket burn which accelerates it to a speed at which it can escape earth's gravity.

6 The Centaur main engine is fired a second time when the vehicle is about 6,700 miles down range. It burns for a little more than 5 minutes, accelerating the vehicle to about 26,600 miles per hour, raising the altitude to 191 miles and placing it 8,500 miles from the launch pad.

7 The vehicle coasts for about three and one half minutes during which time it is oriented so the spacecraft will be in proper position when it is separated from the Centaur. The spacecraft is about 9,800 miles from its launch pad and at an altitude of over 600 miles when these events are completed. At this point it is separated from the Centaur.

8 After separation the Centaur stage undergoes a retro-firing maneuver to slow it down, and remove it from the vicinity of the spacecraft. It falls back into earth orbit and eventually burns up in the atmosphere.

9 The Viking spacecraft continues on its long coast to intercept Mars. Both Viking launches were so precise that only minor trajectory corrections were required to place each one in the desired orbit around Mars.

radio reference sources of various sorts, which may be subject to interference.

One major advantage of an inertial reference system is that it carries on board its own reference points in the form of one or more gyroscopes. Coupled with a modern, compact, high performance computing system, inertial reference gives the pilot an exact and constantly up-dated report of his position and heading.

These inertial systems are applicable to both rotary and fixed wing aircraft for both military and civilian use. In military applications the use of inertial systems precludes the jamming possible with other types of navigational aids.

The high inherent accuracy of these systems and freedom from interference makes them attractive in civilian applications as well. At present Teledyne Systems Company, in conjunction with Teledyne Controls, is developing a strapdown inertial navigation system for use on forthcoming commercial aircraft.

The ability of strapdown inertial gyros to measure small changes in aircraft attitude with great accuracy and resolution, provides a bonus to the designer of complex flight control systems. An on-going program with a prominent West German aerospace company illustrates the advantages of an integral navigation and flight control system employing quadruply redundant computers and strapdown sensors. In this application, a West German Air Force F-104G Starfighter is modified to fly in an aerodynamically unstable mode. The benefits are reduced fuel consumption and improved dynamics. The aircraft, however, cannot be flown by a pilot in this configuration. Instead, a strapdown inertial, digital system controls the aircraft and provides automatic navigation with high failure tolerance in this critical application.

TINY BUILDING BLOCKS

Without the existence of ultra-compact microelectronic hybrids, most of the inertial systems described would be impractical for space or aircraft use because of the weight and bulk of less advanced types of electronic packaging.

Demands for future systems are becoming more and more sophisticated with greater redundancy required to make them even more failure tolerant. Greater computer power is also required to handle more complex computations in less time.

Teledyne Microelectronics has built all of the microelectronic hybrids used in the Teledyne guidance systems described, and has supplied hybrids to many other manufacturers for use in similar systems.

Teledyne microelectronic hybrids are also used for other purposes in space and military systems. A total of more than 2,700 Teledyne hybrid microcircuits were used in the two Viking missions, for example. Teledyne's TDY-52 microcomputer has been used in the guidance system for a small solid propellant rocket, and other Teledyne hybrid devices have been chosen for use on the Space Shuttle.

SEMICONDUCTOR MEMORIES

At present, the memory arrays used in Teledyne guidance computers are of the ferrite core type. Teledyne Microelectronics is currently involved in the development of a new type of semiconductor memory that is more compact and weighs less.

The new devices are based on a CMOS semiconductor technology which offers the benefit of very low power requirements. Production of these memories is also much less labor intensive than ferrite memories which require the laborious hand stringing of thousands of microscopic cores onto fine wire grids.

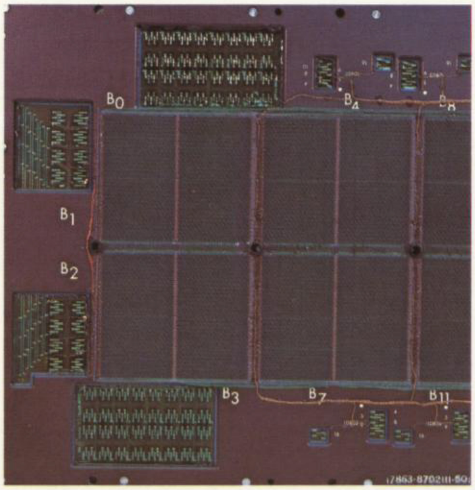
While CMOS memory devices are available in low-density packages from various sources, Teledyne Microelectronics' specialized hybrid packaging techniques provide much more compact complete memories. This means that they are easier to shield from radiation, which is an important consideration in space applications. A Teledyne Microelectronics' semiconductor memory array, very densely packaged into a three inch square stainless steel case, has already been built for use as the on-board spacecraft memory for an advanced outer planet probe.

Teledyne's expertise in the design and production of microelectronic hybrid devices, and its broad experience in designing computers and other electronic systems have made the company a leader not only in the field of space guidance and navigation, but also in aircraft inertial systems, and Loran and Omega navigation systems.

Teledyne On-Board Guidance Computers: Fifty Successes in Fifty Missions

Payload	Mission	Launch Vehicle	Launch Date
1. ERTS-A	Earth Resources Technology Satellite	Delta 89	7/23/72
2. IMP-H	Interplanetary Monitoring Platform	Delta 90	9/22/72
3. ITOS-D	Meteorological Satellite	Delta 91	10/15/72
4. TELESAT-A	Canadian Communications Satellite	Delta 92	11/9/72
5. NIMBUS-E	Weather Satellite	Delta 93	12/10/72
6. PIONEER G	Interplanetary Jupiter Probe	Atlas-Centaur 30	4/5/73
7. TELESAT-B	Canadian Communications Satellite	Delta 94	4/20/73
8. RAE-B	Radio Astronomy Explorer	Delta 95	6/10/73
9. ITOS-E	Meteorological Satellite	Delta 96	7/16/73
10. INTELSAT	Global Communications Satellite	Atlas-Centaur 31	8/23/73
11. IMP-J	Interplanetary Monitoring Platform	Delta 97	10/25/73
12. MARINER 10	Mars, Venus, Mercury Probe	Atlas-Centaur 34	11/3/73
13. ITOS-F	Meteorological Satellite	Delta 98	11/6/73
14. AE-C	Atmospheric Explorer	Delta 99	12/15/73
15. SKYNET IIA	British Communications Satellite	Delta 100	1/18/74
16. TC-1 P.F.	Titan-Centaur Proof Flight	Titan-Centaur 1	2/11/74
17. WESTAR A	Communications Satellite	Delta 101	4/13/74
18. SMS-A	Synchronous Meteorological Satellite	Delta 102	5/17/74
19. WESTAR B	Communications Satellite	Delta 103	10/10/74
20. ITOS-G	Meteorological Satellite		
OSCAR-7	Ham Radio Relay Satellite	Delta 104	11/15/74
INTASAT	Spanish Science Satellite		
21. INTELSAT	Global Communications Satellite	Atlas-Centaur 32	11/21/74
22. SKYNET IIB	British Communications Satellite	Delta 105	11/22/74
23. HELIOS A	Solar Research Probe	Titan-Centaur 2	12/10/74
24. SYMPHONIE A	French/German Communications Satellite	Delta 106	12/18/74
25. ERTS-B	Earth Resources Technology Satellite	Delta 107	1/22/75
26. SMS-B	Synchronous Meteorological Satellite	Delta 108	2/6/75
27. INTELSAT	Global Communications Satellite	Atlas-Centaur 33	2/20/75
28. GEOS-C	Earth and Ocean Physics Satellite	Delta 109	4/9/75
29. TELESAT-C	Canadian Communications Satellite	Delta 110	5/7/75
30. INTELSAT	Global Communications Satellite	Atlas-Centaur 35	5/22/75
31. NIMBUS-F	Weather Satellite	Delta 111	6/12/75
32. OSO-1	Orbiting Solar Observatory	Delta 112	6/21/75
33. VIKING-A	Mars Exploration	Titan-Centaur 4	8/20/75
34. VIKING-B	Mars Exploration	Titan-Centaur 3	9/9/75
35. INTELSAT	Global Communications Satellite	Atlas-Centaur 36	9/25/75
36. AE-E	Atmospheric Explorer	Delta 117	11/19/75
37. HELIOS-B	Solar Research Probe	Titan-Centaur 5	1/15/76
38. INTELSAT IV-A	Global Communications Satellite	Atlas-Centaur 37	1/29/76
39. NATO IIIA	NATO Communications Satellite	Delta 122	4/22/76
40. LAGEOS	Laser Earth Measurement Satellite	Delta 123	5/4/76
41. COMSTAR-I	Communications Satellite	Atlas-Centaur 38	5/13/76
42. MARISAT-B	Marine Communications Satellite	Delta 124	6/9/76
43. PALAPA-A	Indonesian Communications Satellite	Delta 125	7/8/76
44. COMSTAR II	Communications Satellite	Atlas-Centaur 40	7/22/76
45. ITOS-E2	Meteorological Satellite	Delta 126	7/29/76
46. MARISAT-C	Marine Communications Satellite	Delta 127	10/14/76
47. NATO IIIB	NATO Communications Satellite	Delta 128	1/27/77
48. PALAPA-B	Indonesian Communications Satellite	Delta 129	3/10/77
49. GEOS	Earth and Ocean Physics Satellite	Delta 130	4/20/77
50. INTELSAT IV-A	Global Communications Satellite	Atlas-Centaur 39	5/26/77

This single plane ferrite memory gives the Teledyne digital computer unit a memory of 16,384 computer words, representing information vital to the guidance and navigation of the space vehicle.

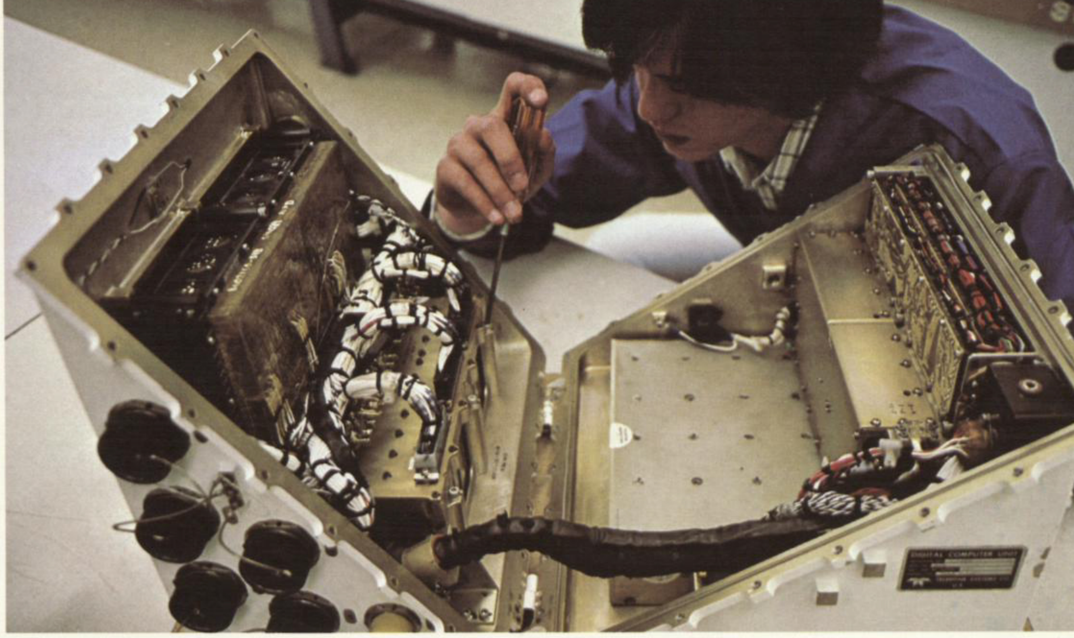


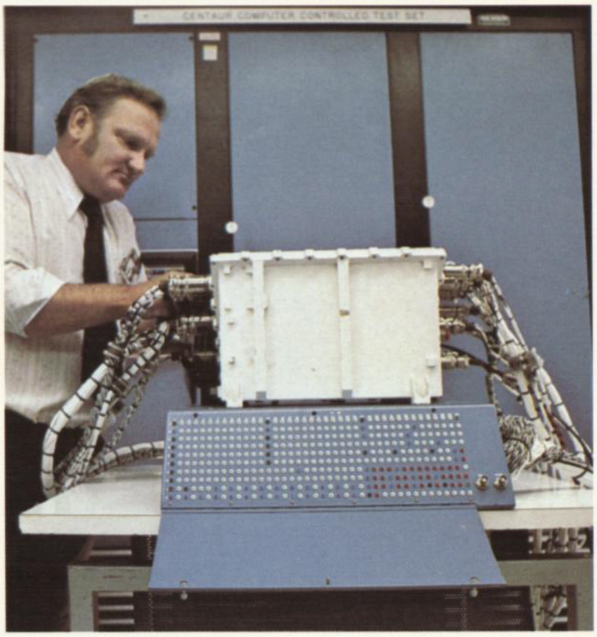
Teledyne's new inertial platform for the Interim Upper Stage of the Space Shuttle features four strapdown gyros, each giving two axes of reference for a total of eight where only three axes of reference data are required. This complete redundancy assures utmost reliability.

Teledyne's unique strapdown gyroscopes are assembled and adjusted under clean-room conditions. Each gyroscope provides information on two axes of motion.

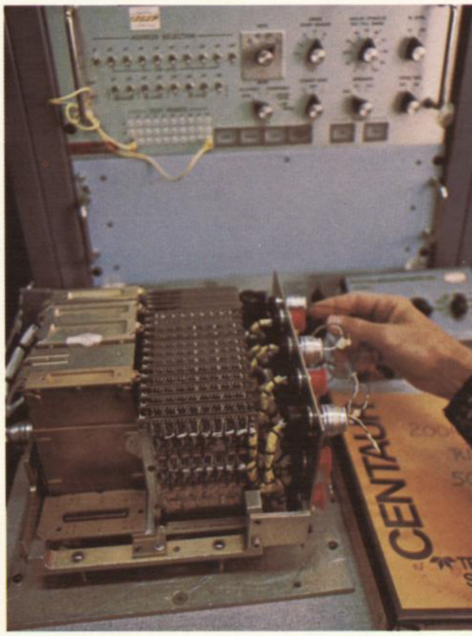
Delta launch vehicle 103 is shown here leaving the pad on October 10, 1974 carrying the Westar B communications satellite into earth orbit. Teledyne on-board computers successfully guided this and 33 other Delta launches.

Teledyne digital computer units, such as the one shown here opened for inspection, have successfully guided fifty launches out of fifty tries. Each computer contains a complex, densely packed array of Teledyne microelectronic hybrids, and a ferrite core memory.

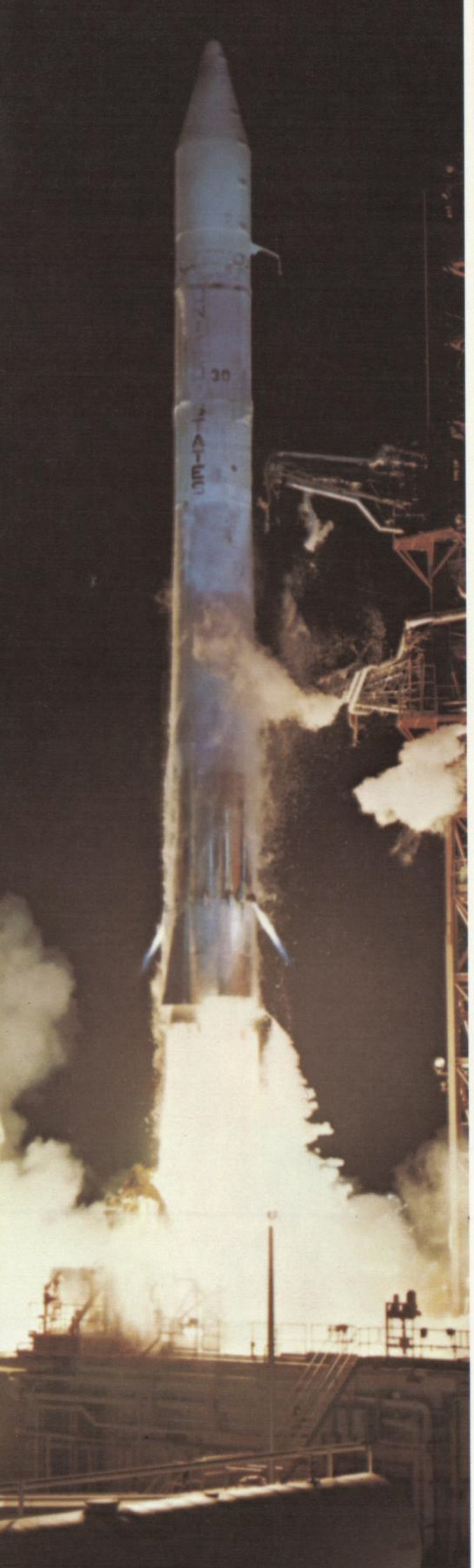




Computers are so fast it takes another computer to check them out. The full-scale blue computer controlled test set in the background is putting the white DCU through its paces and monitoring the results.



Teledyne also produces three multiplexer units, such as the one shown here under test, for each Centaur launch guidance system. These units gather data from sensors on the launch vehicle, format it and provide it to the computer as needed.



Teledyne also provided the guidance computer for the successful Pioneer G interplanetary probe which flew by Jupiter and is now on its way out of the solar system. It is shown here a few seconds after ignition on April 5, 1973 at the very beginning of its long journey.

Teledyne, Inc. and Subsidiaries

Consolidated Statements of Income

	Three Months Ended June 30		Six Months Ended June 30	
	1977	1976	1977	1976
Consolidated Sales	**$524,637,000**	$481,877,000	**$1,070,496,000**	$941,827,000
Consolidated Costs and Expenses:				
Cost of sales	**392,165,000**	361,284,000	**798,398,000**	709,789,000
Selling and administrative expenses	**66,791,000**	61,783,000	**133,571,000**	122,673,000
Interest expense	**4,166,000**	4,659,000	**8,531,000**	10,001,000
Interest income	**(2,331,000)**	(1,860,000)	**(4,948,000)**	(4,528,000)
Provision for income taxes	**32,400,000**	28,400,000	**69,300,000**	52,800,000
	493,191,000	454,266,000	**1,004,852,000**	890,735,000
Income of Consolidated Companies	**31,446,000**	27,611,000	**65,644,000**	51,092,000
Equity in Net Income (Loss) of Unconsolidated Subsidiaries, after allocated interest expense and income tax credits	**(6,161,000)**	4,261,000	**3,757,000**	14,088,000
Net Income	**$ 25,285,000**	$ 31,872,000	**$ 69,401,000**	$ 65,180,000
Net Income Per Share:				
Primary	**$2.10**	$2.53	**$5.78**	$4.78
Fully diluted	**$2.06**	$2.46	**$5.66**	$4.64

Consolidated Balance Sheet

	June 30, 1977
ASSETS:	
Current Assets:	
Cash and marketable securities	$ 192,090,000
Receivables	227,723,000
Inventories	160,108,000
Prepaid expenses	5,980,000
Total current assets	585,901,000
Investments in Unconsolidated Subsidiaries	386,651,000
Property and Equipment, less accumulated depreciation of $279,799,000	230,885,000
Other Assets	38,346,000
	$1,241,783,000
LIABILITIES:	
Current Liabilities:	
Accounts payable	$ 87,907,000
Accrued liabilities	157,882,000
Accrued income taxes	40,900,000
Current portion of long-term debt	5,616,000
Total current liabilities	292,305,000
Long-Term Debt	310,871,000
Other Long-Term Liabilities	75,933,000
Shareholders' Equity	562,674,000
	$1,241,783,000

Review

QUARTER AND FIRST HALF RESULTS

Net income for the second quarter ended June 30, 1977 was $25,285,000 compared to $31,872,000 for last year's second quarter. Per share net income for the quarter was $2.10 versus $2.53 last year. Consolidated quarterly sales increased to $524,637,000 from $481,877,000 in the 1976 period.

For the six months, net income was $69,401,000 or $5.78 per share versus $65,180,000 or $4.78 per share for six months of 1976. Consolidated sales for the six months increased to $1,070,496,000 from $941,827,000 for the first half of 1976.

In the unconsolidated subsidiaries, Argonaut Insurance Company had a loss in the second quarter, due primarily to adverse development in reinsurance assumed from other underwriters. Most of this business is in the process of being run off, and Argonaut is not currently accepting new reinsurance. Among the other unconsolidated subsidiaries, earnings at United Insurance Company of America declined in the quarter as a result of the provision of additional reserves on accident and health policies.

The second quarter loss by its unconsolidated subsidiaries brought Teledyne's 1977 second quarter earnings below the year ago level. The strike during the quarter at Teledyne Continental Motors companies had a relatively minor adverse effect, and the results of consolidated companies were ahead of last year in both the second quarter and first half.

NEW DIGITAL HEIGHT GAGE

A new precision digital measuring instrument, trademarked the Hitefinder-5, has just been introduced by Teledyne Gurley for use in critical mechanical inspection and quality assurance applications. The instrument is used on a granite surface plate to measure the height of certain datum points on the object being inspected, to a resolution of .0005 inch.

Based on Teledyne Gurley's well-established technology in optical linear encoders, the instrument provides a bright digital electronic readout, instantly switchable to provide either inch or millimeter measurements. The display module may be attached to any convenient point in the height gage column, may be hand held or may be placed on a table for convenient viewing.

The Hitefinder-5 is available in measuring ranges of 24, 30 and 36 inches.

NEW AR PROMOTION

An important new promotional effort for the Teledyne Acoustic Research line of high fidelity speakers was launched early in June of this year at the Consumer Electronics Show in Chicago. The presentation included the introduction of a new identifying logotype based on the familiar initials AR, an elegant new look for the whole line of speakers, new literature, and the addition of three new speakers to the AR line.

Redesign of the AR logotype was based on research showing that consumers identified the company and its products most closely with the initials AR. A complete set of new literature including a 4-color 16 page catalog, ads and dealer materials has been developed, emphasizing the new identification.

Introduced at the show were the brand-new AR-15 and AR-18 speakers, and a new version of the AR-17. The AR-15 is a somewhat smaller version of the well-known AR-14, featuring the new liquid-cooled high range driver that allows greater power handling capacity in a small speaker.

The AR-17 is a slightly smaller version of the AR-15, at a lower price, and the AR-18 is the smallest and the lowest priced speaker produced by AR.

A new method of displaying the entire AR seven speaker line was also introduced at the show. Known as "The Stack" it permits compact display of the line on crowded display room floors.

Other events of the show included a "live" versus "recorded" music demonstration featuring a prominent percussionist, and a demonstration of a mini-computer which calculates the ideal speaker placement for specific room dimensions and types supplied by the speaker user.

For a copy of the latest AR catalog, write: Teledyne Acoustic Research, 10 American Drive, Norwood, Massachusetts 02062.

WATER SAVING SHOWER MASSAGE

In response to water and energy shortages throughout the United States, Teledyne Water Pik has just introduced a new model of The Shower Massage that conserves both water and the energy required to heat it, while providing the same well-known stimulating massage action.

The original Shower Massage model was designed to use less water than conventional showerheads, but the new model, known as the Super Saver* goes even further. Tests have shown that on its most invigorating setting it uses less than a third the amount of water of a conventional showerhead.

At an operating pressure of thirty pounds per square inch it uses about 1.8 gallons of water per minute compared to about 5.8 gallons per minute for a standard showerhead. Based on an average shower time of five minutes, the Super Saver will use only 9 gallons compared to 29 for a standard showerhead.

A family taking an average of three showers a day can save 60 gallons of water a day or nearly 22,000 gallons each year.

Savings in energy are substantial, too. The average cost of heating water for three five-minute showers a day with an electric water heater has been estimated at about thirty-one dollars per year for the Super Saver and about one hundred dollars per year for a conventional showerhead.

The new Super Saver will be available nationally in the near future.

*TM TELEDYNE

NEW CONTRACTS FOR RYAN

Teledyne Ryan Aeronautical has recently received contracts for the design and development of equipment for two U.S. Navy programs.

The first involves the development of a new supersonic target drone designed to simulate the threat posed by Soviet anti-ship missiles. Designated the ZBQM-111A by the Navy, and known as the "Firebrand", the new aerial target will serve as a realistic enemy threat in testing Navy shipboard defense systems under simulated combat conditions. Initially, eight of the targets, each powered by a pair of ramjet engines, will be built. Six of these will be used for research and development, and two as special test vehicles. When testing is completed, an initial production quantity will be procured for operational use.

The Firebrand will be 34 feet long and weigh over 5000 pounds. It will be launched from air or surface platforms and fly at supersonic speeds.

The second contract award is for the development of a doppler radar system to be used in the U.S. Navy LAMPS MkIII program. LAMPS is an acronym for Light Airborne Multi-Purpose System. The program involves the use of destroyer-based helicopters for U.S. Navy task force protection.

Teledyne Ryan will provide nine preproduction units in the next two years. Follow-on production is scheduled to begin in late 1979 or early 1980.

ESCAPE SYSTEM FOR SPACE SHUTTLE CARRIER AIRCRAFT

NASA's modified Boeing 747 aircraft which carries the Space Shuttle Orbiter during approach and landing tests and ferry flights is equipped with an explosively actuated emergency crew escape system designed and produced by Teledyne McCormick Selph.

The system has been designed to allow crew members to safely abandon the aircraft in the event of a major emergency. It consists of an emergency escape slide, 16 feet long, connecting the aircraft flight deck with an exit port located in the forward cargo bay.

Either the pilot, co-pilot or flight engineer can activate the system by pulling one or both initiation handles located on the right and left sides of the Autopilot Control Pedestal.

Upon activation, the system first explosively fractures 30 fuselage windows located approximately amidship to allow immediate aircraft decompression. Three seconds later the emergency egress port is explosively severed and blown clear of the fuselage. After 300 milliseconds a spoiler tube is extended into the airstream to allow exiting crew members to clear the aircraft structure.

The system is ready by the time the crew members leave their seats. They then enter the escape slide by using overhead handrails, slide down out of the aircraft and activate their parachutes. Individual crew member "scramble time" to clear the aircraft is eleven seconds.

SPACE SHUTTLE TEST STRUCTURE

A 137-ton fabricated steel structure for use in the Space Shuttle testing program was recently completed in Huntsville, Alabama by Teledyne Brown Engineering. The structure is so large that a wall of the fabrication building had to be taken down in order to remove it.

It was delivered to the nearby NASA/Marshall Space Flight Center in a several hour journey on a special 32-wheel trailer with an additional 16-wheel dolly.

The doughnut-shaped 42-foot diameter structure will be installed at the 150-foot level on a giant test stand for testing a section of the Space Shuttle that includes a liquid hydrogen tank, intertank section and a liquid oxygen tank simulator.

Instruments attached to the test structure will sense and record loads and stresses applied to the Space Shuttle components in a series of tests.

LOG AMPS FOR MEDICAL DIAGNOSIS

Logarithmic amplifiers produced by Teledyne Philbrick have been chosen by a major medical manufacturer for use in a CAT (Computerized Axial Tomography) Scanner, a relatively new instrument for medical x-ray diagnosis.

CAT Scanners produce pictures of a thin section of the body, unlike conventional x-ray machines which make pictures covering a large area of the body. The scanner provides details of the anatomy that cannot be seen on conventional x-rays. The instruments are already in fairly common use for detecting tumors and internal injuries and have been developed to the point where they can provide detailed pictures of the beating human heart, heretofore one of the most difficult x-ray tasks.

Although Teledyne Philbrick has long been involved in the fast growing medical instrumentation field, CAT scanners represent an important new market because of the large number of electronic devices used. Teledyne Philbrick is supplying 128 of its logarithmic amplifiers for each scanner.

FOIL CLADDING FOR CORROSION RESISTANCE

A new line of adhesive-backed thin metal and foil in stainless steel and other alloys is now being offered by Teledyne Rodney Metals for use as corrosion-resistant cladding in a variety of applications.

A recent use involved cladding the interior of carbon-steel wine tanks with .005 and .006 inch stainless steel for corrosion resistance. Ten thousand square feet of tank surface were clad with the new Teledyne product at a small fraction of the cost of purchasing stainless steel tanks.

In another field, tests are currently being made with two foot square patches of a cupronickel alloy foil adhesively applied to the carbon steel hull of a fishing trawler. Cupronickel hulls require cleaning less frequently than carbon steel hulls, and the foil offers a far less expensive alternative to a solid cupronickel alloy hull.

The usefulness of these new cladding materials has been enhanced by the addition at Teledyne Rodney Metals of a new Sendzimir mill that can roll thin metal and foil to a full 42-inch width. The wide material minimizes the number of seams required for a given job.

Teledyne is also developing a resistance welder that will make hermetically-tight seams by welding from one side. Adhesive-backed stock intended for this type of application can be produced with an adhesive-free border for the weld area.

This Teledyne Report describes the purpose and functions of advanced space computers and inertial guidance systems, designed and built by Teledyne Systems Company. The company's on-board space launch computers have been used to guide fifty space launch missions with fifty unqualified successes. Missions include both Viking probes to Mars, the Helios sun probes, the Pioneer G Jupiter probe, the Mariner 10 Mars, Venus, Mercury probe, and a variety of satellites placed in earth orbit for communications, weather, earth resources and various scientific purposes.

Teledyne Systems Company is also currently involved in the development of strapdown inertial guidance equipment for the Space Shuttle Interim Upper Stage, for NASA's Scout launch vehicle, and the DRIRU II standard attitude measurement system for NASA spacecraft.

TELEDYNE REPORT featuring subjects of particular interest from Teledyne activities, is issued on a quarterly basis. Previous topics include:

Analytical Instruments: Detecting and measuring small amounts of specific substances in large volumes of other materials is the key to controlling many vital processes.

1776-1976: A look back at various technologies as they were two hundred years ago, compared with the technologies of today and Teledyne's involvement in them.

Life Insurance: This largest segment of the insurance industry not only provides financial security for millions of families and individuals, but is also one of the nation's major sources of investment capital.

The Refractory Twins: Two high melting point metals, tungsten and molybdenum, play versatile and vital roles in every modern industrialized society.

The Instrument Makers: Teledyne's oldest company goes back 131 years. From surveying the Old West, to moon mapping and machine tool encoders, its history is the history of the technology of measuring.

Industrial Engines: Compact portable power from gasoline and diesel piston engines has taken the drudgery out of manual labor. Now the goal is to reduce noise and emissions.

Job Corps: A decade of motivating and training a half million alienated and disadvantaged young people has produced some remarkable new teaching methods . . . and a lot of good citizens.

Friendly Explosives: Using explosives to save lives in aircraft emergencies may sound unlikely, but it's the safest, fastest, most reliable method ever developed.

Microelectronic Hybrids: From vacuum tube to transistor to integrated circuit, the history of electronics has been one of fitting more and more complex electronic circuitry into less and less space. A hybrid microcircuit is a sophisticated form of microelectronic packaging that goes a step beyond the individual large scale integrated circuit.

The Energy Options: Nuclear fuels and coal are both abundant enough to make a significant contribution to U.S. energy needs over the next several decades. Unlike many other energy sources, the technology to use them on a large scale exists today.

Workmen's Compensation Insurance: Most working people are already protected. The goal is coverage for every employed person.

Drilling for Offshore Oil: Almost half our national resources of oil and gas are believed to lie under offshore waters. The technology for getting them out is here — but it won't be easy.

The Search for Oil: With supplies dwindling and demand growing, sophisticated geophysical techniques are being brought to bear on the problem of locating new oil deposits.

High Speed Tool Steels: These precision, premium-priced alloys are vital to the production of virtually every commodity we use in modern life.

Energy Crisis in the Computer Room: As the quality of utility electrical power falls off and brownouts and blackouts become more common, the incidence of computer failures goes up. Solid-state Uninterruptible Power Systems can solve the problem.

Raydist: This ultraprecise electronic navigation system can pinpoint locations at sea with sensitivity of one and a half feet at ranges of up to 250 miles from base stations.

Welding: One of industry's most versatile production techniques, welding is used in the manufacture of virtually every type of fabricated metal product made today.

General Aviation Engines: Propeller driven aircraft powered by conventional piston engines are not only alive and well more than 30 years after the advent of the jet, they dominate air activity today.

Rubber: Rubber compounds are being called on to do new technological jobs in applications ranging from industrial tires to Teledyne's new automotive bumper system that will dissipate five-mile-per-hour impacts.

Loran: Loran was one of the first all-weather electronic navigation systems. Recent Teledyne innovations have lowered costs and greatly improved its range and accuracy.

Seismology: This relatively young science has expanded from the classic study of earthquakes to become an important tool in oil and mineral exploration, detection of underground nuclear explosions and earthquake hazard reduction.

Casting: The simple process a small boy uses when he casts a tin soldier is the basis of a high technology industry that produces items ranging from high temperature turbine blades to 90-ton steel mill rolls.

AIDS: Aircraft Integrated Data Systems keep a running record of the vital functions of the new jumbo jets and provide airlines with an important tool for lowering costs associated with maintenance, fuel management and crew proficiency testing.

Thermoelectrics: Generators that convert heat directly into electricity are providing a practical new power source for applications ranging from space exploration to remote weather stations.

Thin Metals: Less becomes more when space-age metals are rolled out into thin strip and foil. These new materials, already being used in thousands of products, are making new metal-working techniques possible.

The Reproduction of Music: Men began experimenting with methods of recording sound over 150 years ago, but it remained for electronics and some very recent developments to allow music to be reproduced with concert-hall realism.

The Crowded Spectrum: The lower portion of the radio spectrum is already overcrowded with hundreds of wireless services. Microwave devices such as the traveling wave tube are opening higher frequencies for practical use.

Science and Cinematography: Modern techniques of slow motion cinematography let scientists and engineers analyze actions and events that happen too fast for the eye to follow.

Superalloys: Materials that retain high strength at temperatures approaching 2000°F make the jet age possible.

Jets of Water for Dental Health: Studies show that high-pressure pulsed jets of water are a valuable aid in the care of teeth and gums.

The Last Eight Miles: The controlled descent to the surface of the moon was accomplished through use of a century-old principle called the Doppler effect.

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