Link* Training Systems

TOTAL TRAINING CAPABILITY

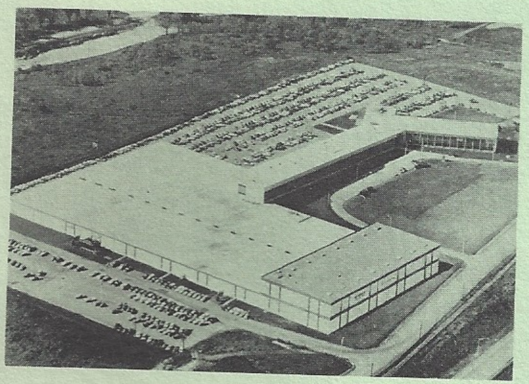
The Link Division of The Singer Company is the world's most experienced producer of sophisticated training systems.

The organization dates back nearly half a century. During World War II thousands of U.S. and allied pilots learned to fly in the "Blue Box," the famed *Link** instrument trainer.

Since then Link has kept pace with advances in aerospace, supplying training systems for each new type of aircraft and also for space vehicles which took men to the moon.

It also has extended its training expertise to other areas, which are as diverse as they are involved. They include industrial trainers, power plant simulators, naval and maritime training systems and railroad simulators.

Link, whose pioneering products range from fundamental part task devices to elaborate full mission systems, has earned its reputation as the organization with total training capability.



Facilities and Personnel

Link maintains four production facilities, totaling more than a million square feet, in the United States and England. It employs nearly 5,000 persons, more than a third of whom are engineering personnel.

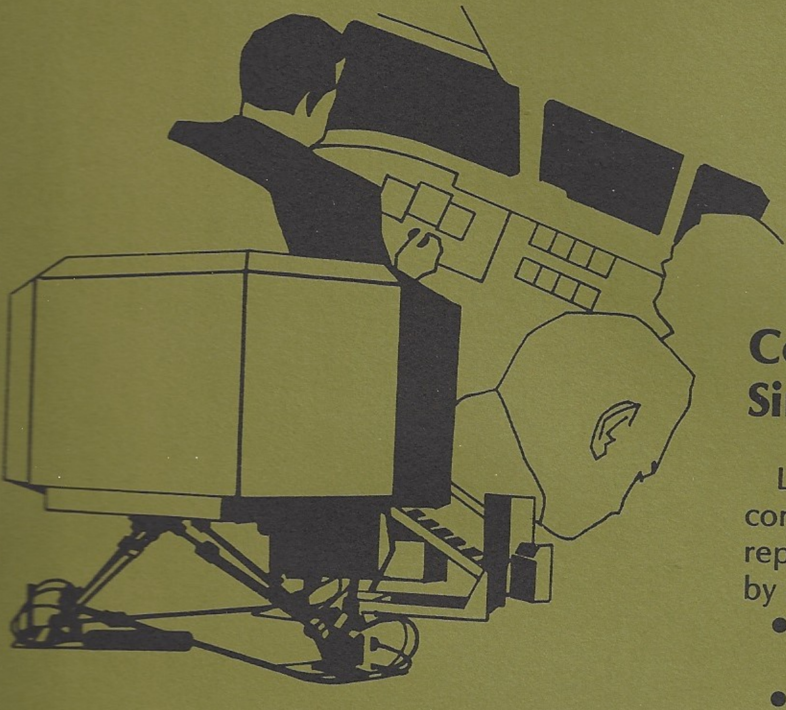
Headquarters are in Binghamton, N.Y., center of Flight Simulation Operations and various administrative and support services. Among the products of this facility, which covers 594,000 square feet, are flight and mission simulators, general aviation flight trainers and visual systems.

Additional facilities, totaling 195,000 square feet, in Silver Spring, Maryland are devoted to antisubmarine warfare, flight, naval/maritime and transportation training systems, power plant simulators and industrial trainers.

Advanced Products Operations, in Sunnyvale, California, with 152,000 square feet, is concerned with research and development as well as manufacturing. Its principal products include computer-generated visual systems and digital radar landmass simulators.

The fourth facility, covering 130,000 square feet, is Link-Miles Division of The Singer Company (U.K.) Ltd. in Lancing, Sussex, England, whose experience in aircrew training spans nearly half a century. Its products include training systems for military and commercial aircraft and tracked vehicles.

Although each facility specializes, all share in a common pool of resources. There is a continuous cross-fertilization of concepts and an interchange of techniques and systems, assuring that each customer can avail himself of Link's full training capability.



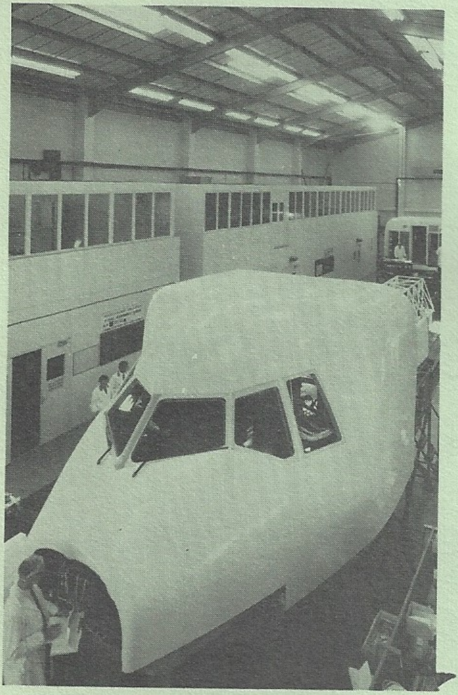
Commercial Flight Simulators

Link preeminence in the field of commercial simulation has been repeatedly reconfirmed, as evidenced by such notable achievements as:

- First commercial jet transport simulator, the DC-8, in 1958.
- First operational commercial digital flight simulator, the Boeing 727, in 1963.
- First dual simulator installation utilizing a single digital computer, a Boeing 707/707, in 1966.
- First operational wide body jet transport simulator, a Boeing 747, in 1970.
- First SST simulator exclusively for training, a Concorde, in 1975.

These achievements attest to advancements in simulator state-of-the-art. Further evidence of the quality inherent in every *Link** commercial simulator is that each is designed to meet or exceed FAA certification requirements.

Serving the World's Major Airlines



Purchasers of *Link** simulators include the best known names in commercial aviation.

In the past 10 years alone this organization has designed and built more than 100 training systems for the world's major airlines.

An indication of the universality of Link's clientele—and of the diversity of its products—can be seen in the following list of simulator sales.

BAC-111
- Allegheny

Beechcraft A-90
- Canadian government (2)

F-27
- Malaysian

FH-227
- Allegheny

Falcon 10
- FlightSafety

Falcon 20
- FlightSafety
- JAL

Learjet
- FlightSafety

Sabreliner 60
- FlightSafety

Sabreliner 75
- FlightSafety

Gulfstream II
- FlightSafety

DC-8
- Aeromexico
- Alitalia
- Delta
- Eastern
- Flying Tiger
- SAS
- United

DC-9
- Aeromexico
- Alitalia
- ATI
- Continental
- Delta (2)
- Eastern
- Iberia
- SAS (2)
- Southern
- TWA

707
- Air France
- American (4)
- BA
- Boeing
- Egyptair
- Iranair
- Northwest
- Pan Am (4)
- PIA
- Qantas (2)
- TWA (3)

720
- Continental

727
- Air France
- American (4)
- Ansett
- Braniff
- Continental
- Delta (2)
- Eastern (2)
- Iberia
- Iranair
- Lufthansa
- Mexicana
- National
- Northwest
- Pan Am (2)
- Sabena
- TWA (3)
- United (4)

737
- Malaysian

747
- Air France
- American
- BA
- Northwest
- Pan Am
- Qantas (2)
- S. African
- TWA
- United

L-1011
- BA
- Delta
- Eastern
- TWA

DC-10
- Alitalia
- Continental
- National
- Northwest
- Sabena
- SAS

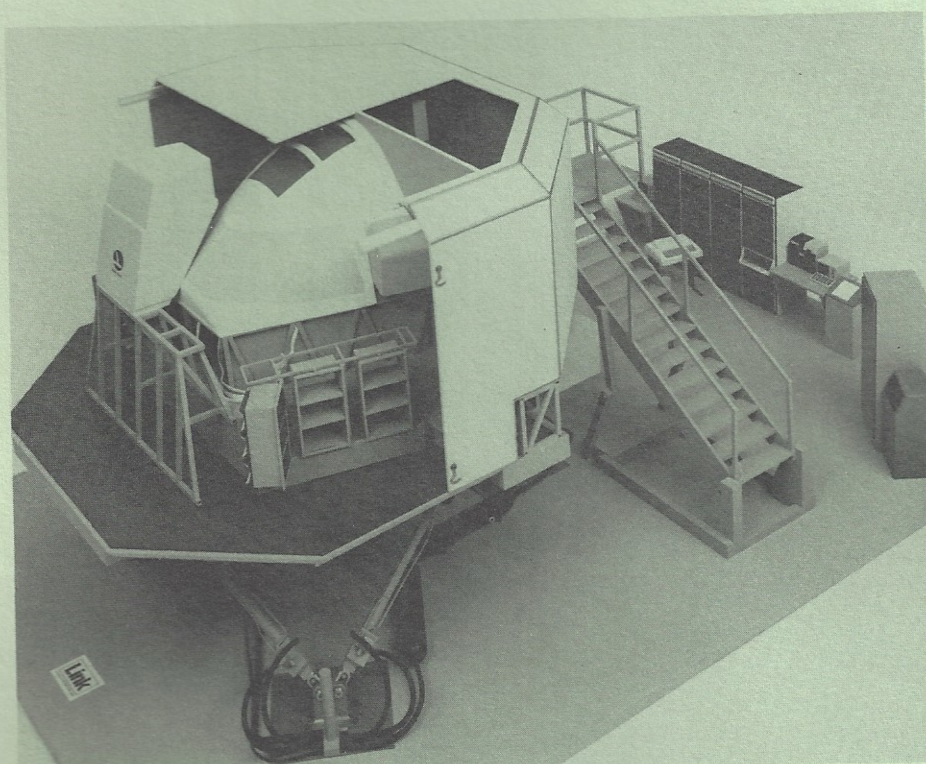
A-300B
- Iberia

Concorde
- BA

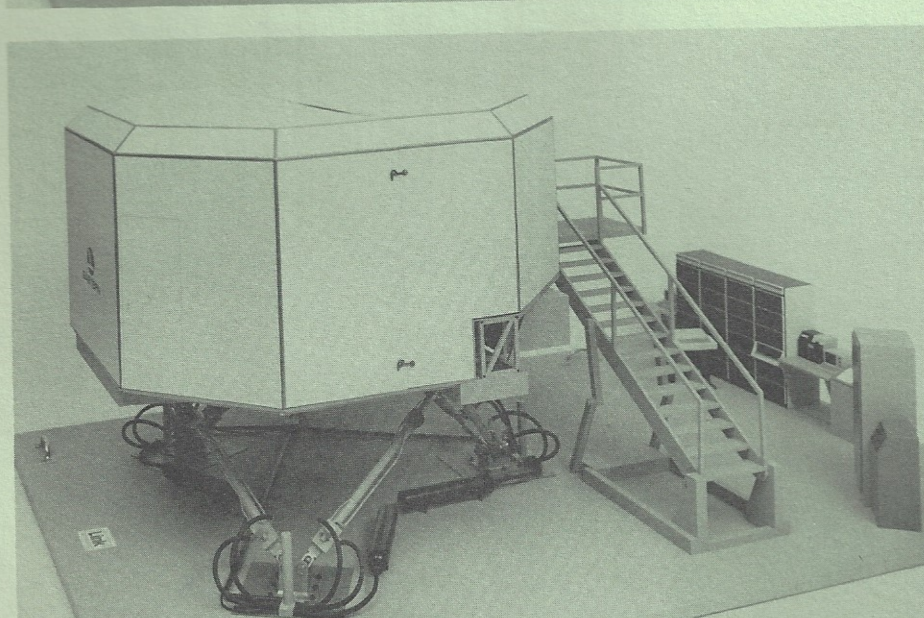
Advanced Simulation Technology

Advanced Simulation Technology (AST) is a revolutionary new approach to simulator design. It's the most significant advancement in the simulation field since development of digital devices by Link in the 1960's.

The product of an extensive three-year research and development program, AST capitalizes on the latest state-of-the-art to achieve more efficient electronic and mechanical packaging. The result is significant improvement in the performance, reliability, maintainability and life cycle cost of *Link** flight simulators.



Each of five major equipment areas was redesigned "from the ground up." New interconnection, power, aural cue, control loading and motion systems were developed.



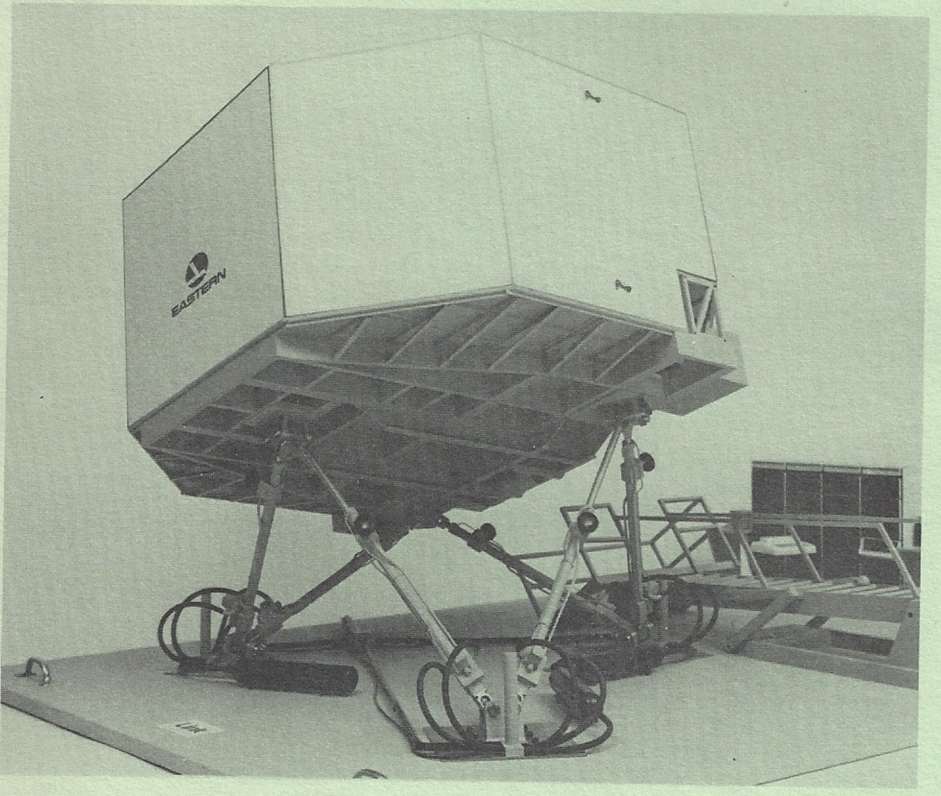
AST simulators are strikingly compact. The exterior of the simulated flight compartment no longer resembles the aircraft. (The interior, of course, is an exact replica.) The space around the cockpit is used for electronics so they'll be as close as possible to the simulator hardware they service. This streamlined design eliminates a maze of cables and interconnections, reducing electronics space requirements by 80%. It improves performance and reliability and simplifies maintenance.

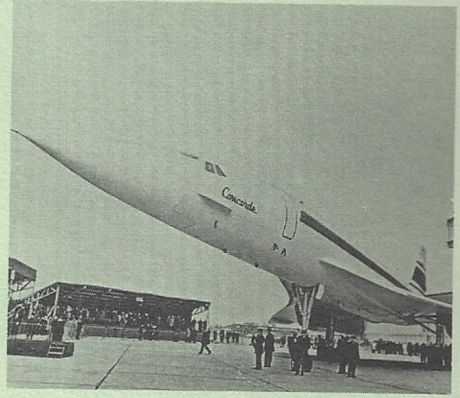
Another advantage of AST is built-in test systems that continuously check the equipment while it's being used, increasing simulator availability.

Use of new technology improves equipment performance and fidelity of simulation without attendant cost increases. AST was designed with "100% simulation" in mind.

Shortly after AST's introduction, airlines availed themselves of the new technology. Eastern Air Lines ordered a B-727 simulator and British Airways a B-747, both employing the AST concept. Later British Airways also contracted for an AST L-1011 simulator and Iberia Airlines bought an AST DC-9.

AST is also suited to military applications. The U.S. Air Force C-130 simulator program, for example, utilizes these advanced techniques.





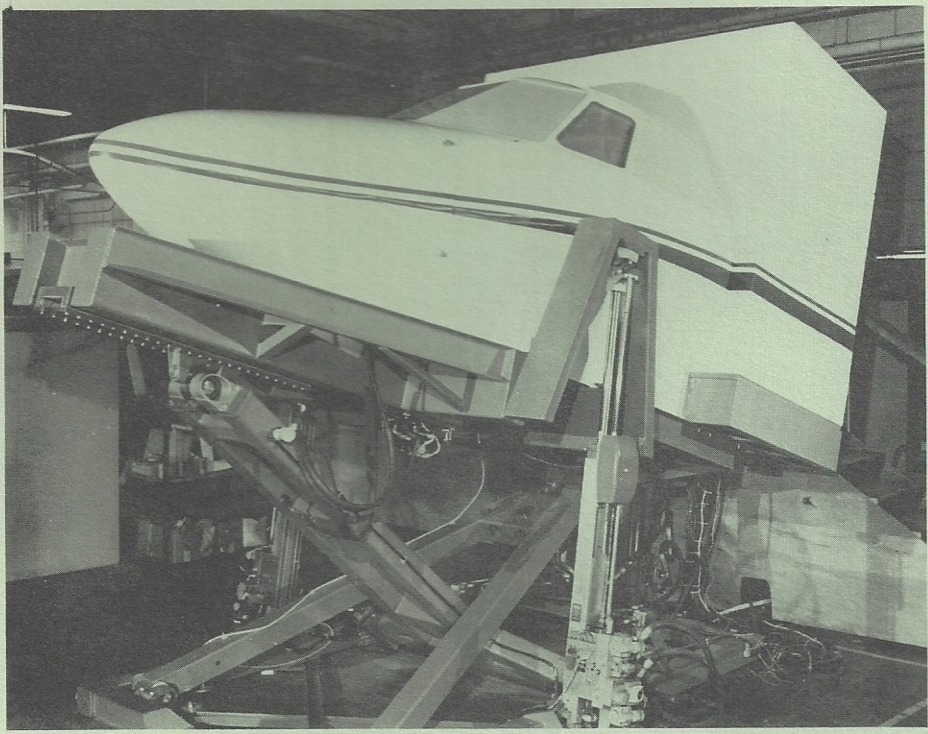
Supersonic Flight Simulator

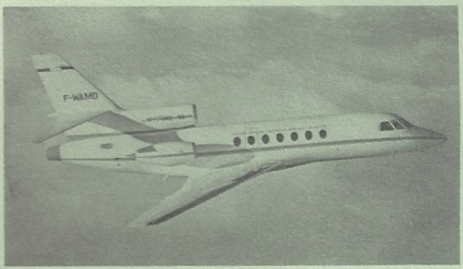
Link was awarded a contract for much of the work on the world's first supersonic aircraft simulator designed exclusively for training.

This undertaking included a full reproduction of a Concorde flight deck, mounted on a *Link**six-degree-of-freedom motion system. The flight deck includes the captain's, first officer's and third crew member's stations. Immediately behind the captain's seat is an on-board instructor's station, with sophisticated training facilities, including recorders for tracing the ground path of the simulated aircraft.

The flight deck is linked with a closed circuit color television visual display.

Link was given the additional assignment of designing the building to house the simulator.





Business Jet Simulators

Using the latest digital computer technology, Link has developed advanced training systems for business aviation.

These devices can be equipped with visual and motion systems to permit a full range of training activity comparable to that available to major airlines.

The visual systems provide electronically-generated images, representing various approach situations and airport configurations, with highly realistic variation of cloud heights down to CAT III conditions. The systems are so flexible they can represent operating areas anywhere in the world.

Three-axis motion systems produce pitch, roll and vertical translation. Other motion and audio cues include rough air, speed brakes, flaps or gear down buffeting and associated noises.

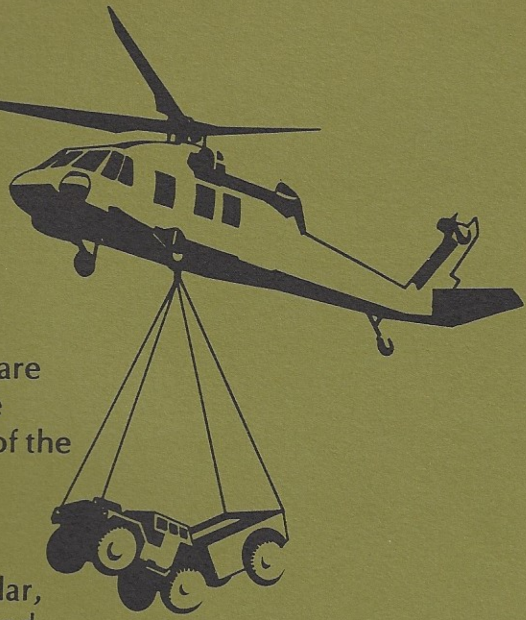
Instructors can freeze a simulator flight at any point to explain mistakes and then resume the training exercise as if no interruption had occurred. There are various degrees of freezes: the entire operation can be stopped, the simulated aircraft can be stopped but with engines and other systems continuing to function, or the simulator can remain "flyable" but with no recorded movement on the ground path recorder.

Numerous highly realistic malfunctions can be simulated: for example, subtle problems such as slow hydraulic leaks to test the alertness of trainees and traumatic failures such as flame-outs.

Simulation also includes pressurization, oxygen systems and fully functioning automatic pilot systems.

Another indication of the flexibility of these simulators is that service bulletins affecting the flight characteristics of any particular aircraft, or other modifications such as a change in thrust reverser characteristics, can be readily programmed into the digital computers which direct the simulators' performance. The computer program can also easily accommodate any navaids, such as VOR, ADF, DME, and ILS functions, as well as R-NAV.

Instructor stations are movable. From behind the pilot and co-pilot positions, the instructor's console and recording chart can be swung forward so the instructor can occupy the co-pilot seat for single-pilot training.

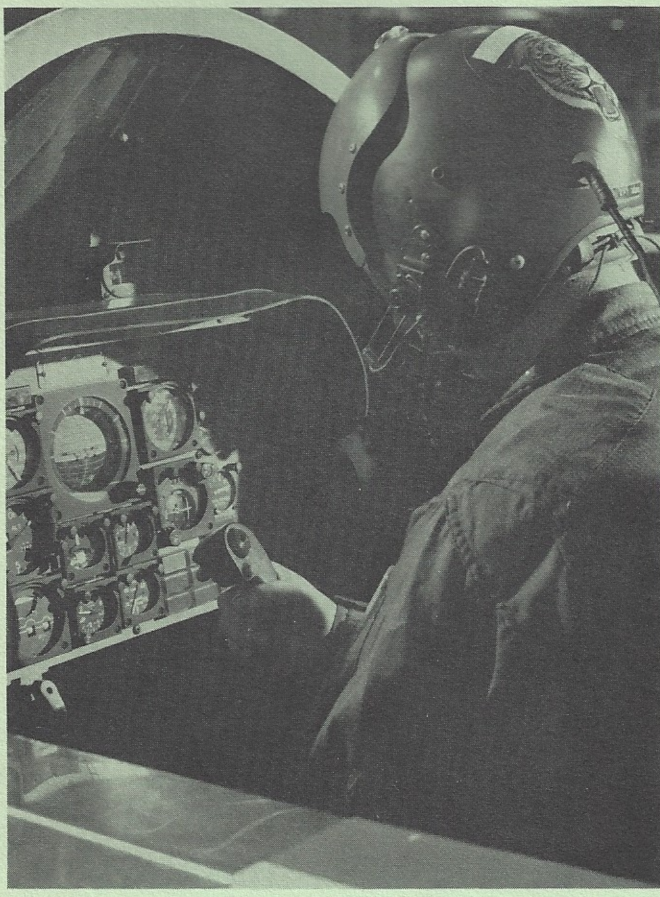


Military Simulators

Today's military simulators are highly sophisticated. They are capable of actual duplication of the flight environment of high-performance jet fighters and bombers. In addition they realistically reproduce the radar, electronic countermeasures and weapon delivery systems of a total weapons system.

The modern military simulator depends upon a digital computer complex to provide the pilot and weapon operator with flight and tactical situations closely resembling those confronted in actual combat. The digital computer is the brain of the simulator, interfacing with the pilot cockpit, instructor station, motion system, radar landmass systems, radar homing and warning system, and the various missile and weapon delivery systems.

The full military simulator product line covers a broad spectrum: fighter/attack aircraft such as the F-4 series, F-111 series, F-5E, F-14A and Swedish AJ-37; antisubmarine warfare aircraft such as S-3A and P-3C series; training aircraft such as the T-2C, T-37 and T-38; helicopters such as the UH-1H, CH-47C, AH-1Q and UTTAS; cargo aircraft such as the C-130; and tanks such as the British Chieftain.



Aircraft Simulated

The full range of Link's experience in military training is indicated by the following list of military aircraft, each of which it has simulated:

BOMBER
- A-3D
- A-3J
- AD-5N
- B-47
- B-57B
- B-58

FIGHTER
- A-7A
- AJ-37
- Buccaneer
- F2H2
- F-2H3
- F-3D
- F-4C
- F-4D
- F-4D-IR
- F-4E
- F-4F
- F-4J
- F-5E
- F-8A
- F-8C
- F-8E
- F-8U
- F8F-1
- F9F2
- F9F5
- F9F6
- F11F
- F-14A
- F-86D
- F-86L
- F-89
- F-101B
- F-102
- F-104A
- F-104J
- F-105D
- F-106
- F-111A
- F-111C
- F-111D
- F-111E
- F-111F
- FB-111
- Harrier
- J-35
- Jaguar
- Tornado (MRCA)

HELICOPTER
- AH-1Q
- CH-47C
- Sea King
- Sea Vixen
- UH-1H
- UTTAS

ASW
- Breguet 1150
- P2V5
- P2V7
- P-3A
- P-3B
- P-3C
- P-5M
- S2E
- S2F1
- S2F3
- S-3A

CARGO
- C-130B
- C-130E
- C-130H
- C-130K
- C-135B
- C-141A
- KC-130F
- KC-135A

TRAINER
- SNJ
- T-2C
- T-28B
- T-37
- T-38
- T-39

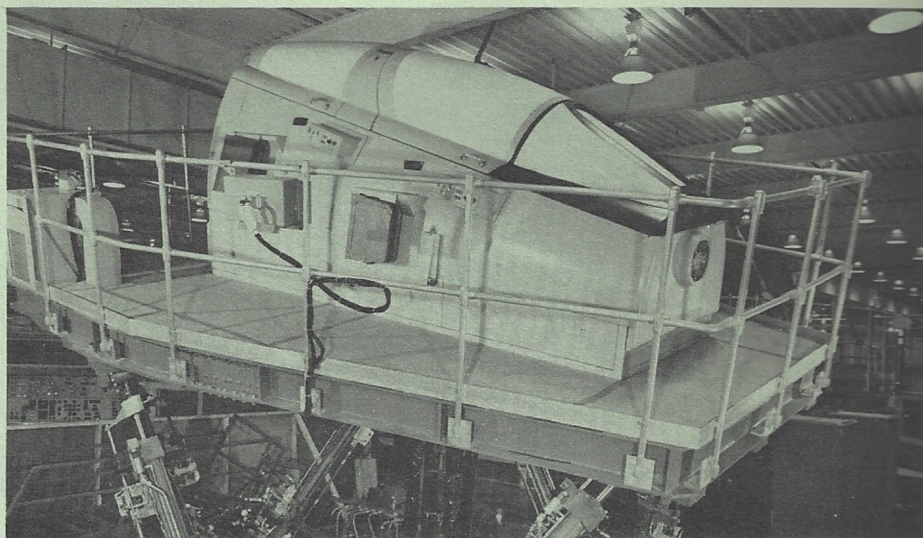
RECONNAISSANCE
- A-5A
- RA-5C
- RB-66
- RF-4C
- RF-4E
- SR-71

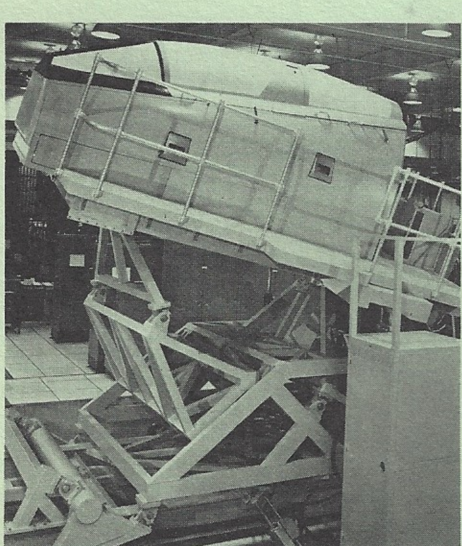
F-4 Weapon System Trainers

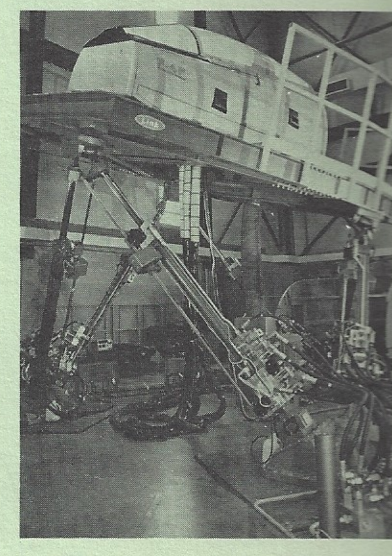
Link has produced more than 70 weapon system trainers (WST's) in the F-4 series.

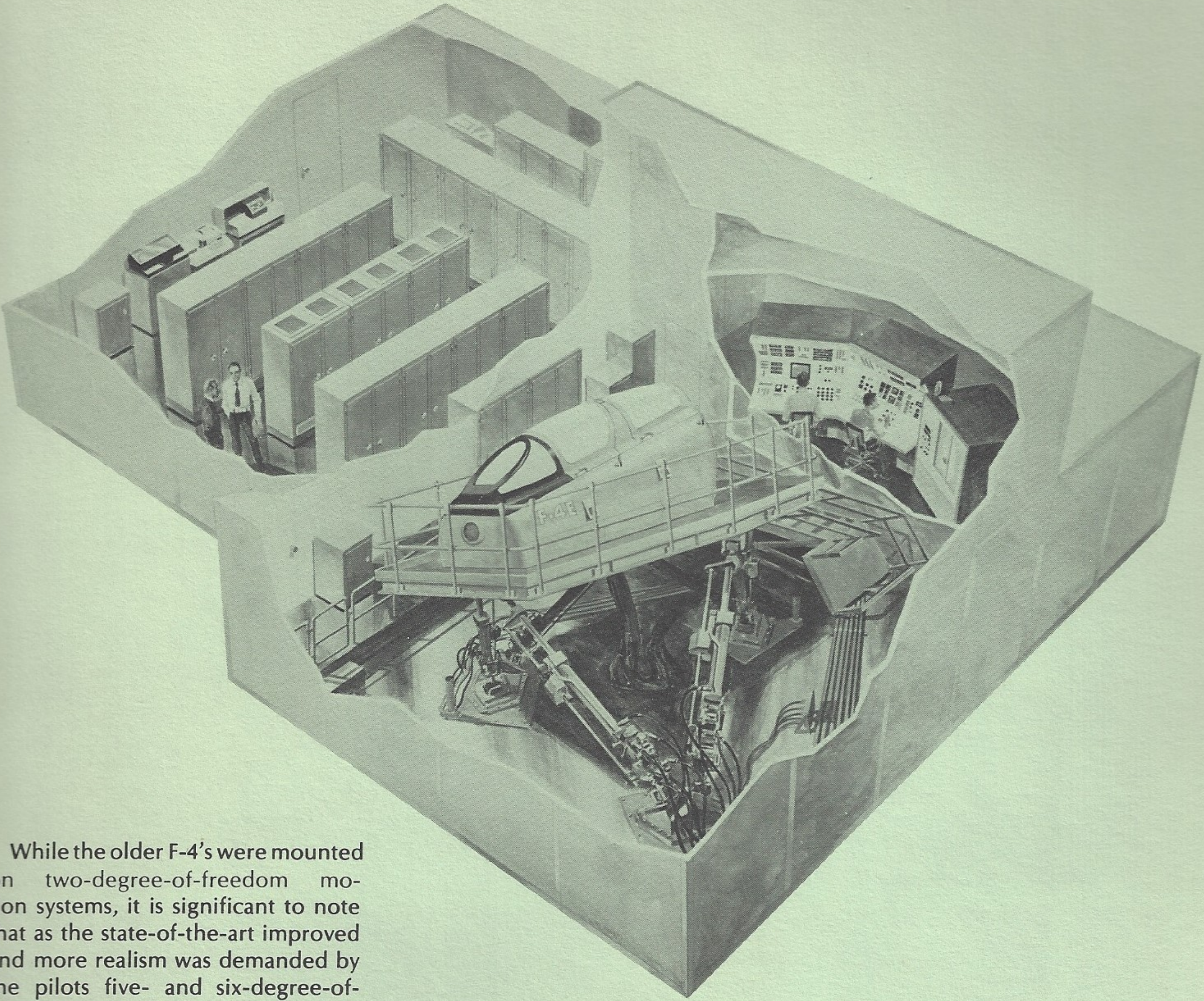
These have been provided for the U.S. Air Force, U.S. Navy and U.S. Marine Corps, as well as international customers.

All include a motion system, computer complex, trainee cockpit, instructor station and radar landmass. Radar homing and warning systems and various missile and weapon delivery systems also were simulated and tailored to the specific WST.





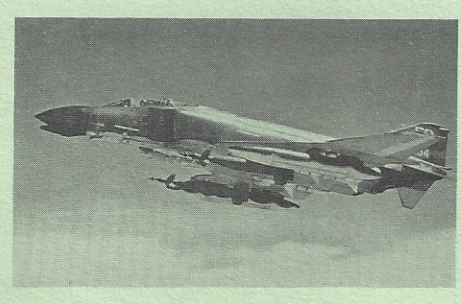


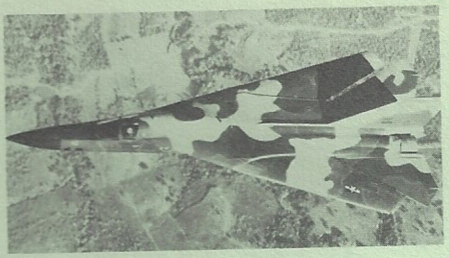


While the older F-4's were mounted on two-degree-of-freedom motion systems, it is significant to note that as the state-of-the-art improved and more realism was demanded by the pilots five- and six-degree-of-freedom motion systems were provided, along with visual systems in specific cases. The F-4F and the most recent F-4E WST's have the new *Link** digital radar landmass system.

The most recent F-4 WST's employing full digital simulation have demonstrated improved reliability and maintainability. They also have proven their versatility, through modification and updating of software.

The versatility of F-4 WST design is evidenced in the selection by the USAF Aeronautical Systems Division of two F-4 simulator cockpits as the basic modules of the Simulator for Air-to-Air Combat. Both F-4 cockpits are capable of being reprogrammed to represent flight performance of any other fighter aircraft.





F-111 Weapon System Trainers

Another major military weapon system trainer accomplishment of Link was the design and manufacture of F-111 simulators for the U.S. Air Force.

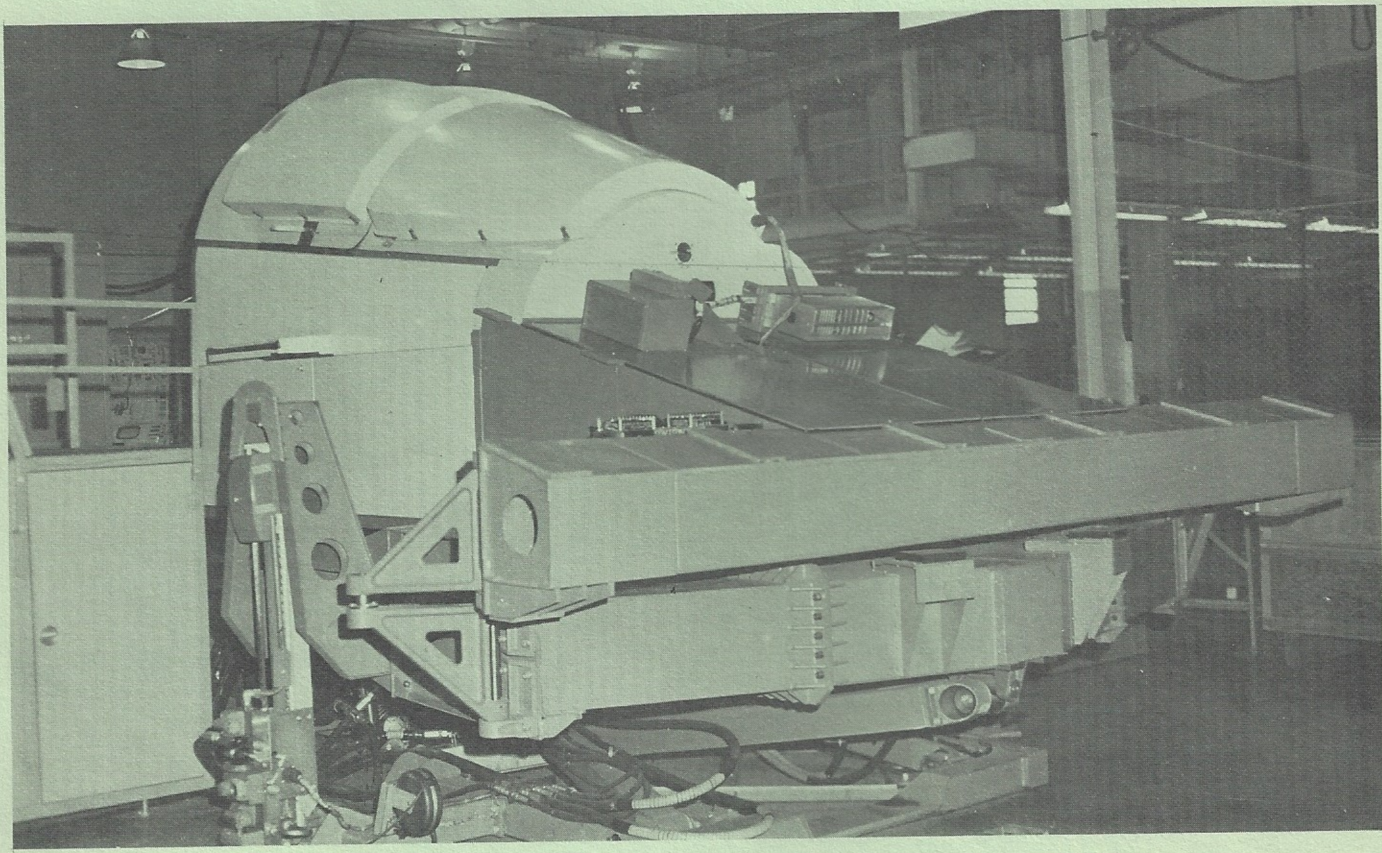
These provide an integrated air-to-air and air-to-ground training capability in all phases of the radar and armament systems.

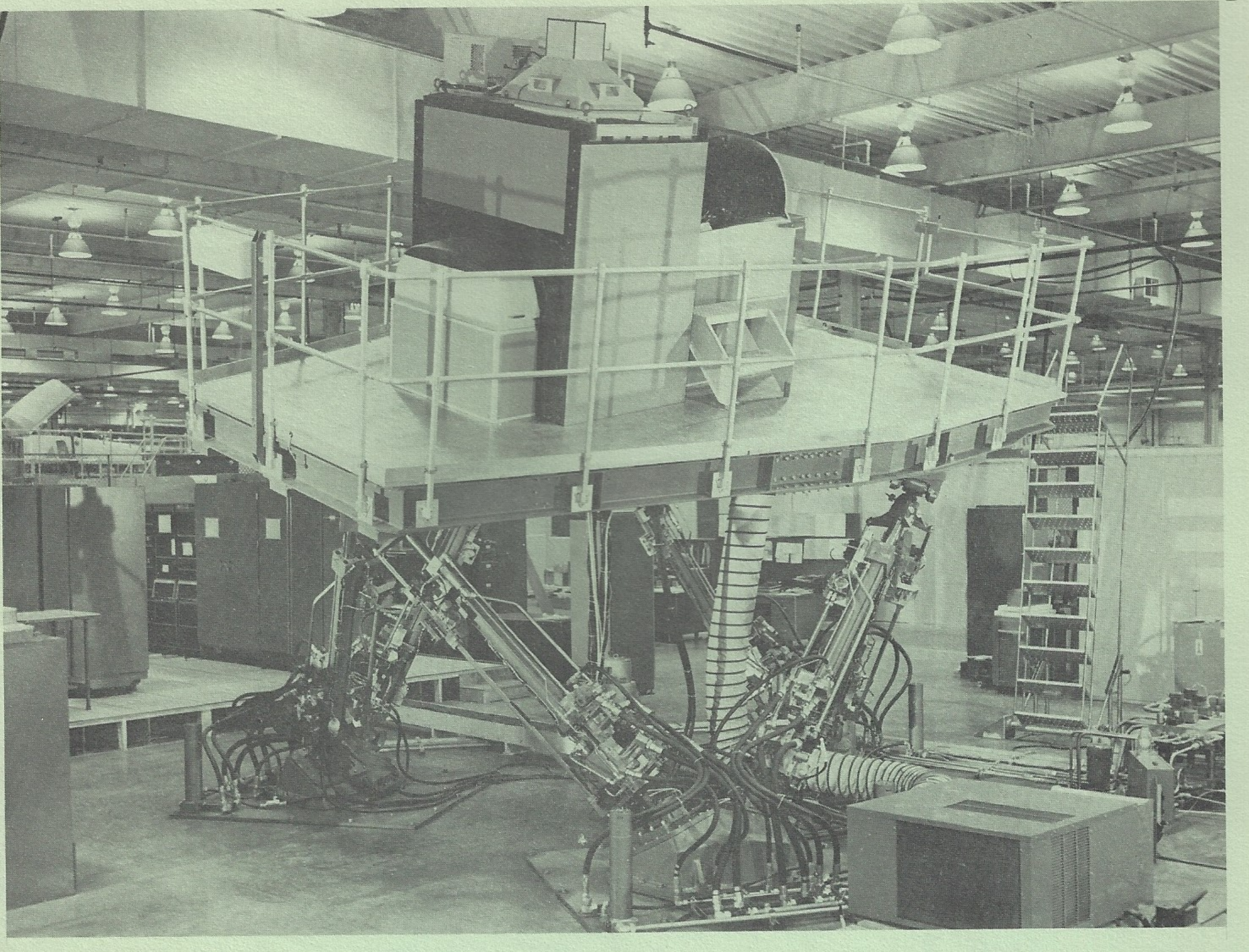
The major features are radar landmass simulation, air target generation, jamming and chaff generation, and GAR-8, GAM-83 and Shrike missile simulation, as well as conventional and nuclear weapons.

Typical of the F-111 family is the F-111A which is designed to accomplish the total ground-based curriculum—systems, procedural and complete mission training.

Its target generation capabilities include six air targets with provision for expansion to 12, 10 ground targets, 12 chaff bundles, 16 jammers and one decoy drone.

Radar simulation includes air-to-air, ground mapping (landmass), fix-taking, terrain following, and terrain avoidance capabilities.

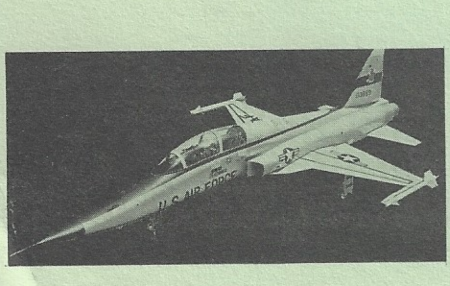




F-5E Weapon System Simulators

F-5E Weapon System Simulators are compact low-cost units, with modular design which reduces production and testing time and simplifies maintenance.

Each simulator consists of three major sub-assemblies: an instructor station, electronics cabinets and a trainee cockpit mounted on a motion platform. Digital computers provide simulation of flight, engine, navigation and accessory systems of this advanced aircraft.



The instructor station contains a flexible, graphic CRT display system, a keyboard console control unit and auxiliary control panels which enable instructors to control simulated training missions.

The cockpit interior realistically duplicates the flight controls and aircraft panels and instruments. Primary flight control forces are simulated by electrohydraulic control loading units which simulate control forces throughout all simulated flight regimes. A rugged, fail-safe platform provides cockpit motion in six degrees of freedom.

Reality is further enhanced by simulating the radar and visual system which furnishes air-to-air and air-to-ground weapon delivery training. The visual scene includes a terrain representation and representative air and ground targets, plus a runway presentation for straight-in landing practice.

Several options are available, including one (Computer Aided Instruction) which enables the simulator, under computer control, to fly a selected training maneuver to brief students before they attempt the same maneuver. This option also permits trainee performance to be compared automatically with preprogrammed mission profile data, informing instructors when errors occur. Since automatic playback and instructor printout are features of the basic WST, the addition of this option provides an important tool for monitoring transition of learning.

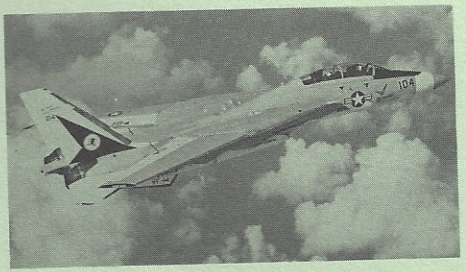
Another option provides training in use of the LN33 inertial navigation system.

F-14A Weapon System Trainers

Link designed two weapon system trainers to support the U.S. Navy F-14A program.

The trainers duplicate the total tactical and natural environment within which the F-14A Tomcat aircraft operates, ranging from carrier catapult launch to automatic weather recovery aboard ship.

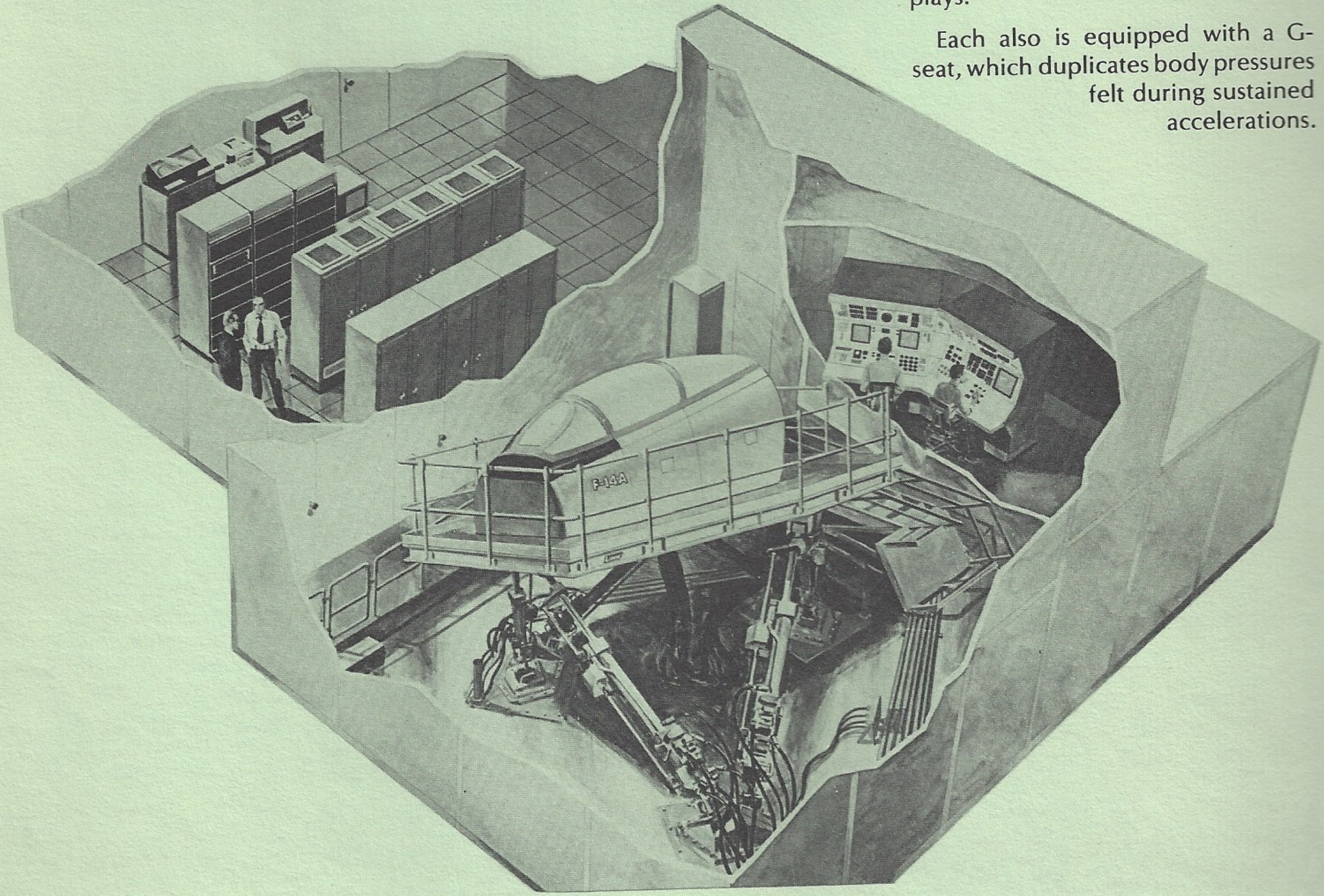
All of the onboard tactical, flight and navigational systems are simulated, in both normal and possible malfunction modes. Simulation includes electronic countermeasures, surface-to-air missile threats, and aircraft and weapons sounds.

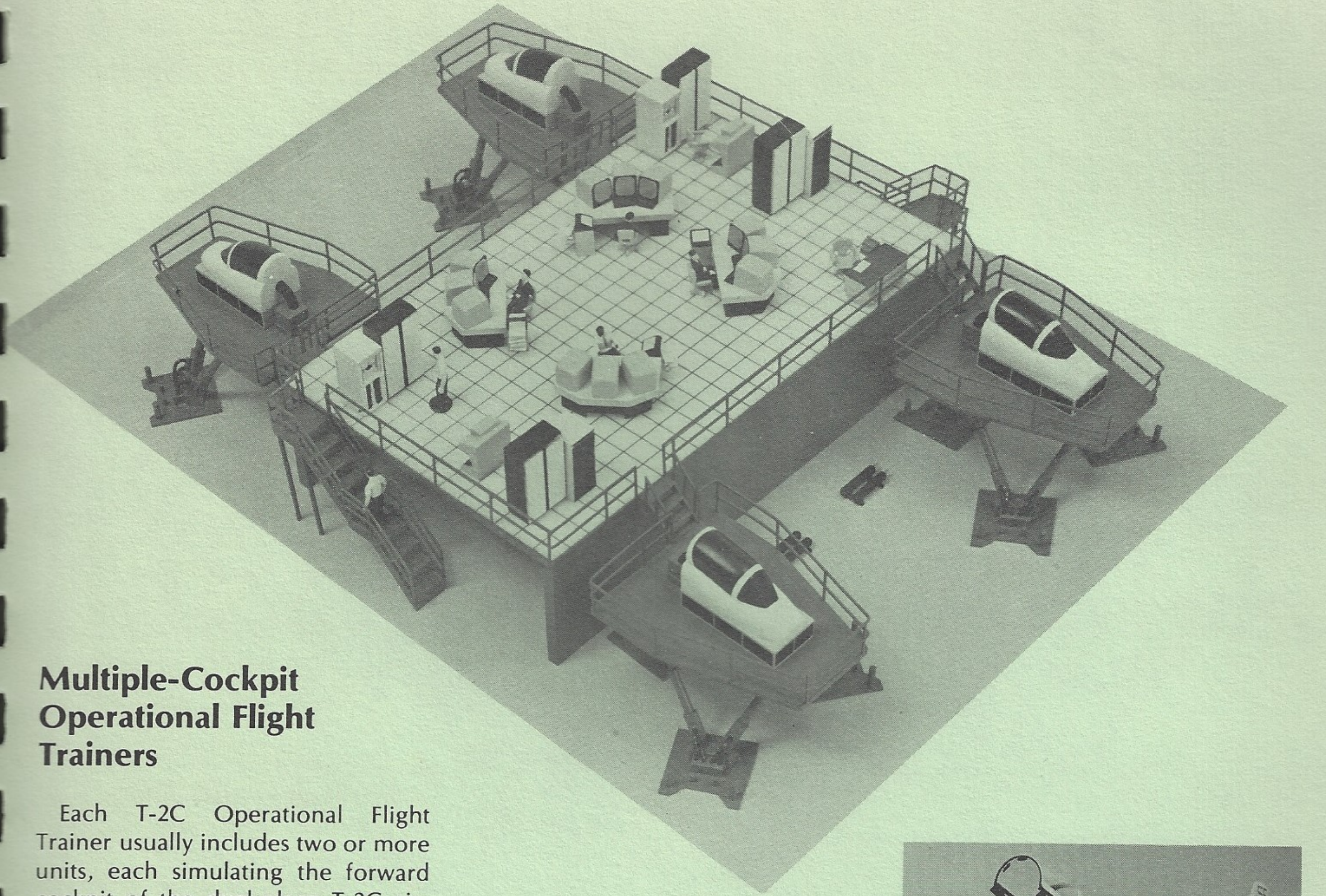


The heart of the aircraft's capability, the AN/AWG-9 Phoenix Weapons System, is fully simulated in all modes of operation.

Each trainer incorporates the Digital Radar Landmass Simulator, a major state-of-the-art advancement which generates realistic radar displays.

Each also is equipped with a G-seat, which duplicates body pressures felt during sustained accelerations.





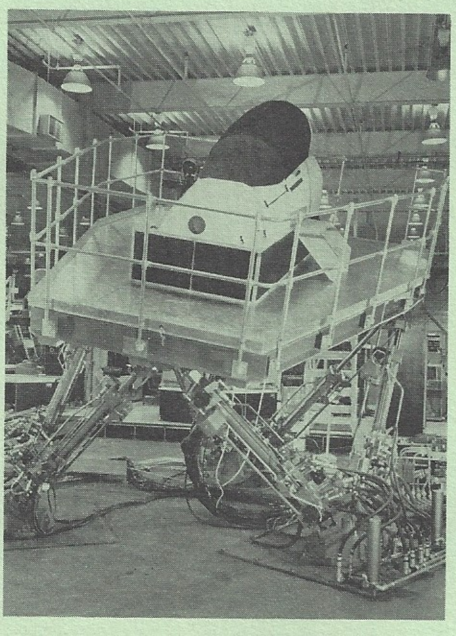
Multiple-Cockpit Operational Flight Trainers

Each T-2C Operational Flight Trainer usually includes two or more units, each simulating the forward cockpit of the dual-place T-2C aircraft.

These trainers are used by international customers and the U.S. Navy. The latter ordered seven of these systems—28 cockpits—to train pilots for both carrier-based and land-based missions. Simulation includes starting, ground handling, takeoff, climb out, cruise, flight and navigation missions, approach, landing, taxiing and shutdown.

Each of the simulated T-2C cockpits is mounted on a six-degree-of-freedom motion system. Each is connected to an instructor station equipped with three cathode-ray tubes on which trainees' performance is monitored.

A variety of operating modes are provided. Instructors can monitor standard procedures, fly programmed missions, run demonstration maneuvers or record and play back trainee performance. They can also introduce malfunctions, set up new initial conditions, record out-of-tolerance conditions, plan new maneuvers and procedures and run daily readiness checks.



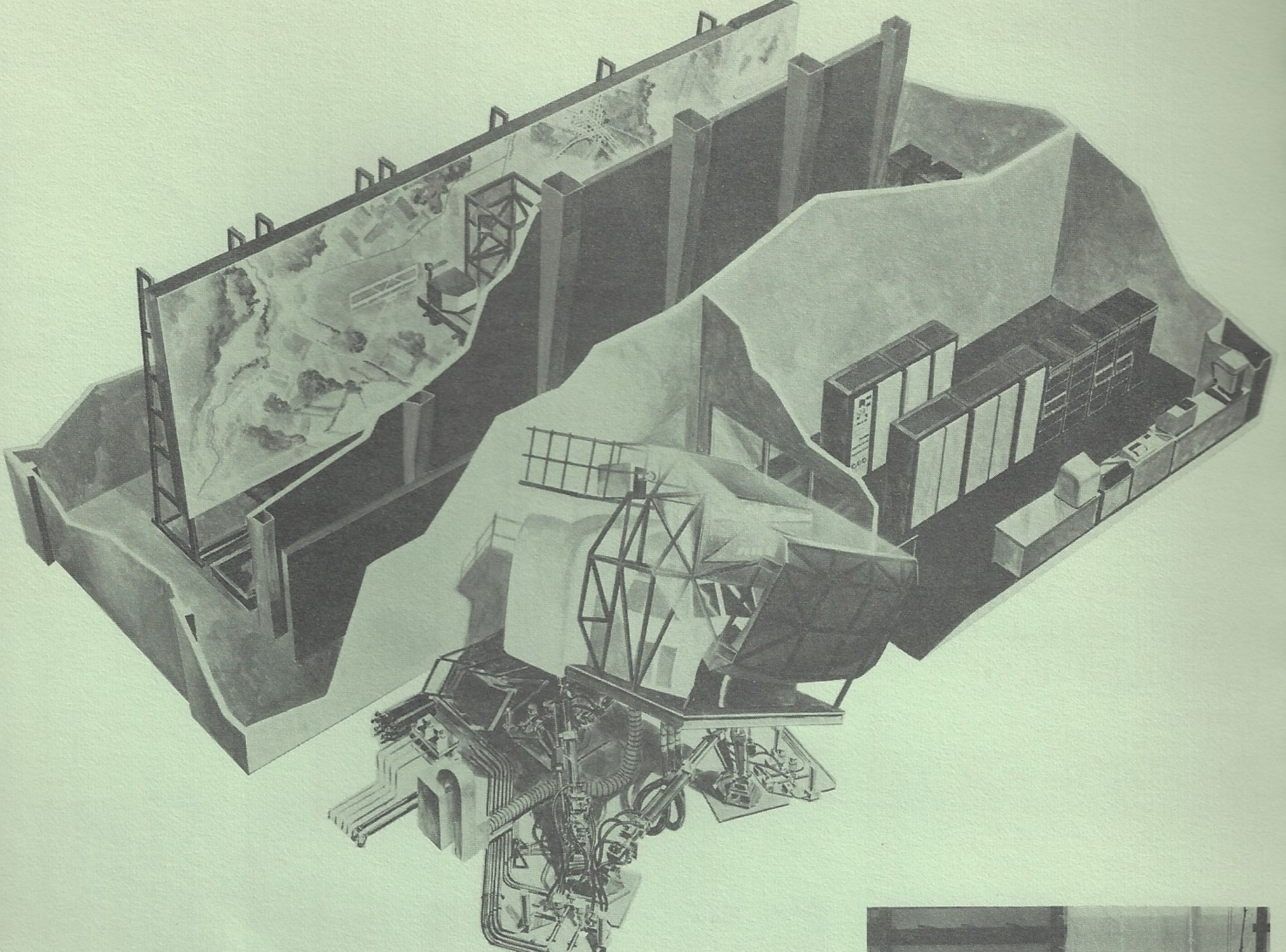
The instructor stations utilize a modern approach based on design concepts developed by Link's Human Factors Engineering Department. The display formats and operating procedures are designed to assure that instructors' workloads are reduced to a minimum. Another important feature is that this approach does not require use of aircraft in-

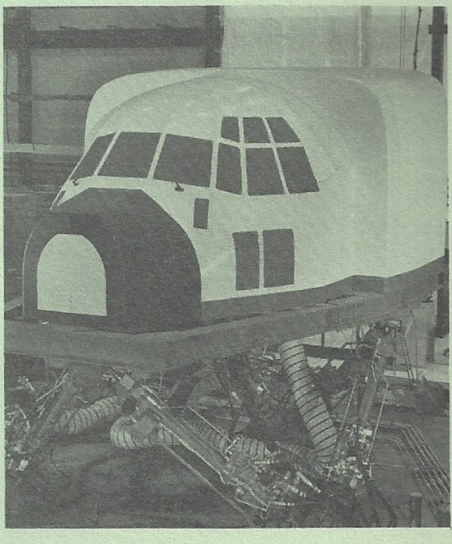
struments—a significant cost and logistics reduction.

In addition to normal operating characteristics, computer programs provide realistic simulation of numerous system malfunctions, ranging from failures of hydraulic, fuel, oil, oxygen, electrical, braking and landing gear systems to engine flameouts, hung and hot starts, fires and crashes.

The computer also contains an environmental model simulating temperature, wind and other atmospheric effects.

The T-2C design can be readily adapted to meet requirements of other customers. Since each cockpit-instructor station is an independent unit, with its own computer, similar systems can be provided in whatever aircraft configuration is required.





C-130 Flight Simulators

Link has been involved in C-130 training since the big cargo aircraft were introduced.

It has provided C-130 simulators for the United States, both Air Force and Marine Corps, and a number of other countries.

A major USAF procurement called for a complete C-130E Weapon System Trainer and two cockpit procedures trainers, with an option for nine additional units. The simulators are for training pilots, navigators and flight engineers on four types of C-130s: C-130E, C-130E AWADS (Adverse Weather Aerial Delivery System), C-130H and the HC-130P equipped with the Fulton recovery system.

The prototype utilized the newly-developed Advanced Simulation Technology which provides more efficient electronic and mechanical packaging, improving performance, reliability, maintainability and life cycle costs.

The simulator cockpit, mounted on a six-degree-of-freedom motion system, accommodates four crew members and three instructors. A complete navigator's station features the Digital Radar Landmass Simulator, which produces imagery that is more realistic and more readily reprogrammed than that of older analog-generated devices.

There also is a separate satellite navigator's station, with its own instructor, which provides independent training.

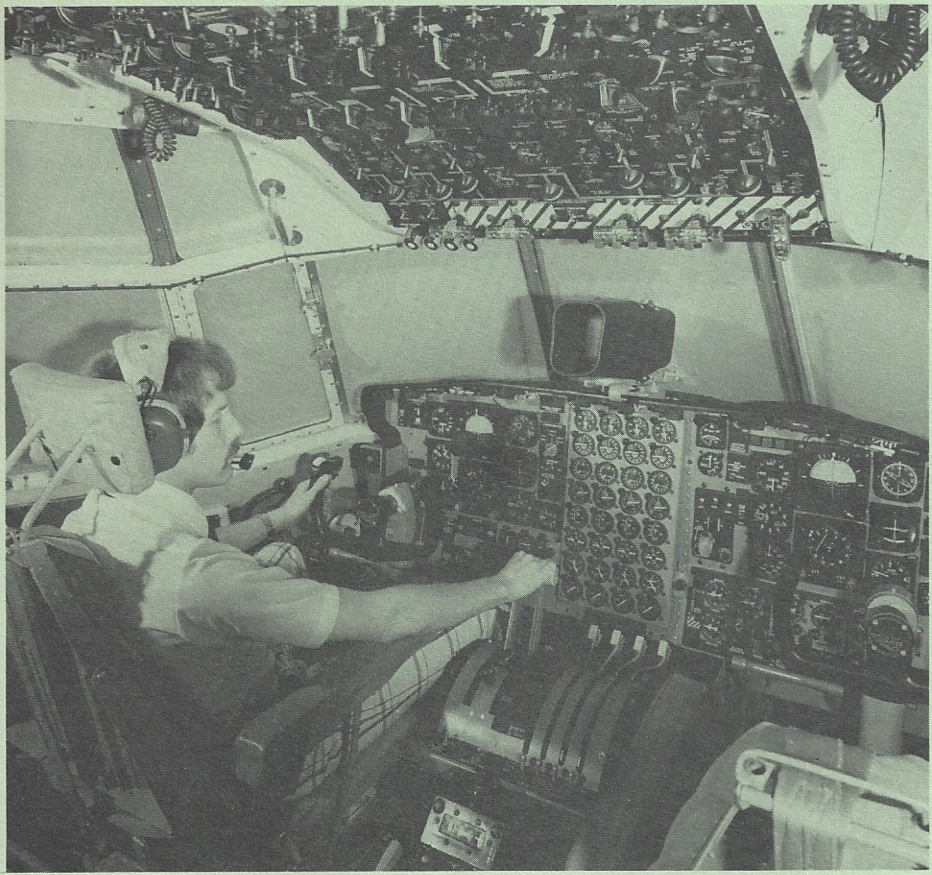
The cockpit procedures trainers are used for training pilots, copilots and flight engineers in cockpit and instrument familiarization. They also enable ground maintenance personnel to practice pre-flight mechanical checks.

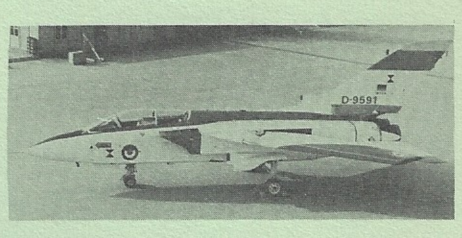
Earlier, Link designed and produced a number of C-130H simulators capable of providing virtually any level of training for flight crew personnel. They can be utilized for basic flight compartment familiarization, preflight check lists, basic instrument flight procedures, navigation and communications procedures and emergency measures.

These simulators incorporate a number of design innovations which involve use of modern, commercially-available components and subsystems to improve cost-effectiveness and reduce hardware complexity. C-130H simulators have a number of advanced training features that include demonstration maneuvers, preprogrammed missions, check-rides and trainee performance evaluation programs.

Link furnished the U.S. Marine Corps with a KC-130F operational flight trainer. Its flight compartment is similar to the layout of the C-130H, with the addition of an advanced instructor/operator station.

Advanced training techniques make the instructor's job more productive by providing him with precise, largely automated control of the training problem. Trainee performance data are displayed in real time in an easily understood format. This feature enables Marine instructors to provide training which is standardized and yet adaptable to the individual trainee's needs and accomplishments.



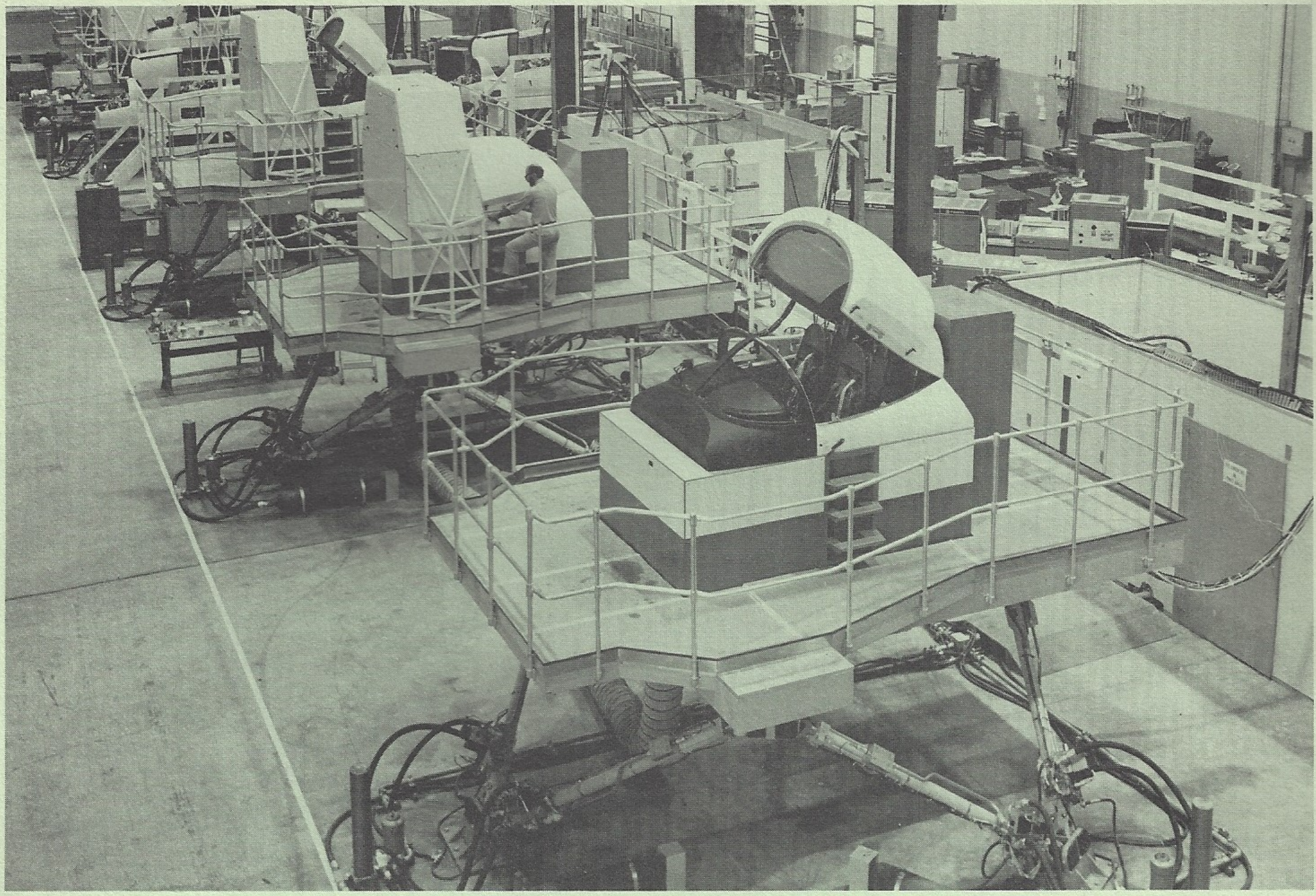


Tornado (MRCA) Simulator

Link-Miles was awarded a contract for the tactics portion of the Tornado simulation program.

The Tornado, formerly known as the MRCA (Multi-Role Combat Aircraft), is a long-range low-level terrain-following strike aircraft. The program is for the British air force.

Link-Miles simulation includes radar systems, weapons delivery, avionics, navigation, electronic countermeasures, and armament and stores management. The radar simulation utilizes the Digital Radar Landmass system developed by Link.

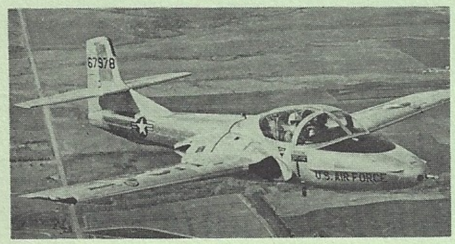


Undergraduate Pilot Training

Link was selected by the U.S. Air Force to provide T-37 and T-38 simulator complexes for training undergraduate pilots in instrument flying.

The Undergraduate Pilot Training—Instrument Flight Simulators (UPT-IFS) eventually may be used at seven Air Force bases.

Each UPT-IFS complex includes four cockpits mounted on six-degree-of-freedom motion systems, a computer complex and an instructor station. Each cockpit is integrated with a visual system procured under a separate contract.



The UPT-IFS's allow pilots to practice instrument flight in various simulated weather conditions, from clear to zero-zero, day or n ight. The realistic training environment includes air traffic control and runways, with variable lighting, ceiling and visibility conditions.

Simulator training replaces a major portion of instrument training hours flown in T-37 and T-38 aircraft used by the Air Training Command.

The simulators can be used to demonstrate instrument maneuvers, with automatic aural briefings and reset capability to allow trainees to repeat maneuvers in which they require additional training. Students can review new portions of maneuvers just completed by replaying the previous five minutes of their performance. Instructors can ride in the two-seat cockpits, as they do in the training aircraft.

The UPT-IFS enables trainees to learn to cope with emergency conditions which would be impractical or unsafe in normal operation. These include engine failures, fires, fuel starvation, blown tires and electrical system malfunctioning.

Each simulator complex is linked with two three-dimensional terrain models with color TV cameras. The model boards show airport runways, taxiways, approach lighting and surrounding terrain including cities and highways.

Supporting each cockpit are hydraulic cylinders to simulate the classical modes of aircraft motion: roll, pitch, yaw, vertical, lateral and longitudinal movement.

Link worked with the Air Force on the design of buildings to house the simulator complexes.

Synthetic Flight Training System

The Synthetic Flight Training System (SFTS) was designed and built by Link for U.S. Army helicopter training.

SFTS is the result of Link research and development work in training methods, computer technology and simulation techniques. This was undertaken as new complex helicopters were being designed, increasing the need for improved training at reduced costs.

The pioneering program was activated in 1971 when Link delivered the first of the SFTS series—a four-cockpit system for training UH-1H (Huey) pilots. This quickly won acclaim for its ability to upgrade training while reducing costs by several million dollars a year. Subsequently the Army ordered 11 similar systems.

Later the Army contracted with Link for another major component of the SFTS program. It ordered a simulator for training pilots of the CH-47C (Chinook) medium transport helicopter.

Other major milestones in the SFTS program were attained when Link was awarded contracts for AH-1Q (Cobra) and UTTAS helicopter trainers.

UH-1H Helicopter Trainer

Each unit of the UH-1H (Huey) helicopter flight training system includes four cockpit trainee stations mounted on five-degree-of-freedom motion systems, an instructor station and a high speed digital computer complex. Two-cockpit configurations also are available.

The computer "flies" the simulator realistically, responding to trainees' maneuvers and demonstrating ideal performance. It also evaluates each pilot, adjusting the degree of difficulty to match each one's progress. The system thus permits each trainee to learn at his own pace.

This automated training concept as an instructor aid is achieved by programming the digital computers with many of the routine repetitive operations traditionally assigned to instructors. The computers also implement such automatic training techniques as adaptive training, demonstration and programmed instruction. The resulting automatic training makes more efficient use of instructor skills, standardizes training programs and provides objective evaluation of trainee performance.

The computer programs include approximately 100 simulated malfunctions covering all simulated aircraft systems and flight conditions, available to instructors for use at their discretion. In addition, preselected malfunctions are automatically inserted during the checkride mode of operation.

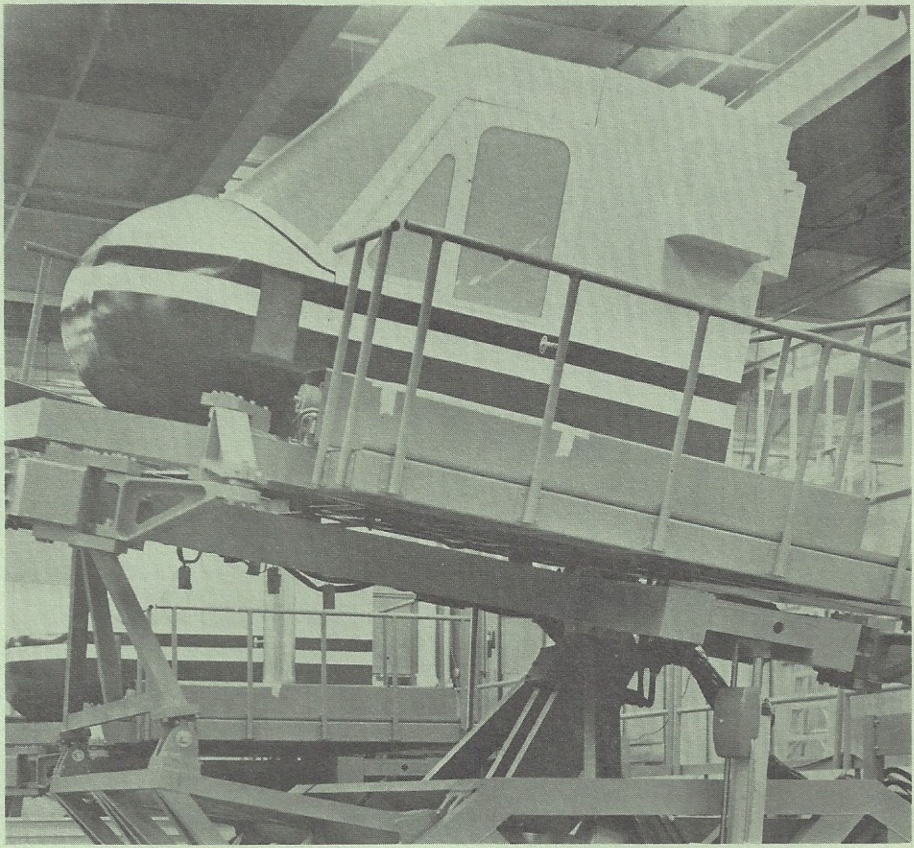
Each instructor station provides an orderly and functional presentation of information and control with which two instructors can effectively monitor and evaluate four students' performance and control training problems. The control panels are color coded—a different color for each cockpit—to facilitate identification of a particular cockpit's controls.

The simulation technique used to define rotor characteristics in flight dynamics is the Link-patented Directed Vector Approach.

In addition to simulating flight dynamics, the UH-1H trainer simulates a single Lycoming engine and its related systems. The aircraft's accessory systems are simulated to the extent necessary to provide trainees with all control and indication capabilities for systems management.

The radio communication and navigation equipment simulated includes UHF, VHF and FM communication and LF/ADF navigation systems. A total of 95 simulated ground radio communication/navigation facilities, within a gaming area of 256 square nautical miles, are provided to operate in conjunction with the simulated aircraft equipment.

Simulation of the earth's atmosphere includes barometric pressure variation, non-standard temperature, wind velocity and direction, and icing conditions. In addition, the math model admits to variations of rough air, turbulence and vibrations.



CH-47C Helicopter Trainer

The CH-47C (Chinook) is a single-cockpit installation simulating a tandem rotor helicopter. Even more advanced in some respects than the UH-1H, it is the first helicopter training device with a high-resolution color visual system.

The system employs the first high resolution (1200 line) color closed-circuit television with a three-dimensional terrain model, depicting the countryside and typical landing and drop zone areas. The model is viewed by a roving TV camera which moves in complete freedom in accordance with maneuvers of the simulator cockpit. For example, if the pilot starts to land, the camera glides closer to the terrain. The visual probe is an advanced model, providing improved depth of focus at any altitude.

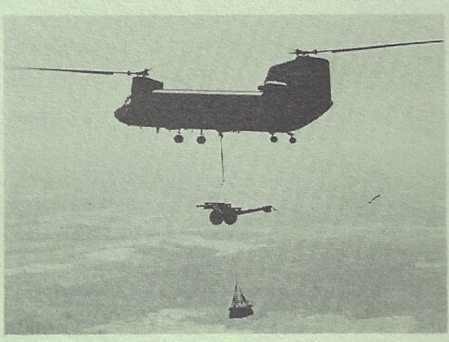
The TV camera relays images to a high resolution cathode ray tube in the cockpit window. This display also is visible to the instructor, in the cockpit behind the pilot-trainee.

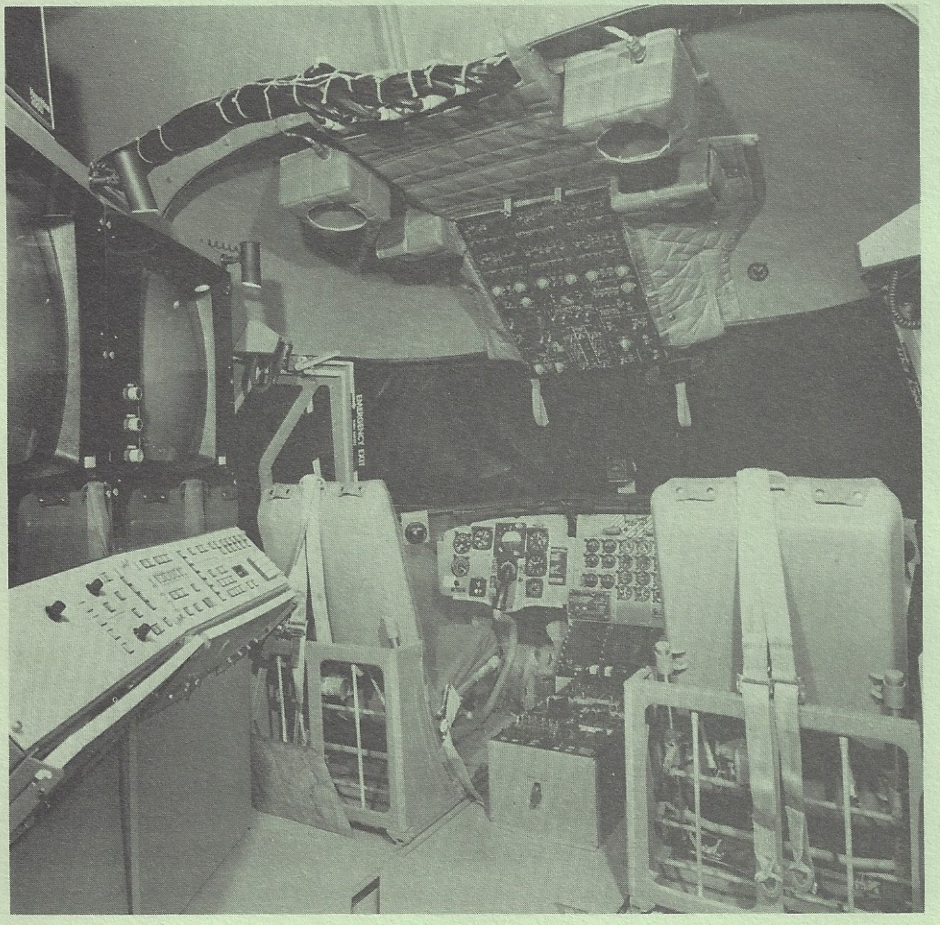
The terrain model is lighted to represent varying day and night conditions. Further realism is achieved by electronically introducing visual effects such as clouds, haze and fog.

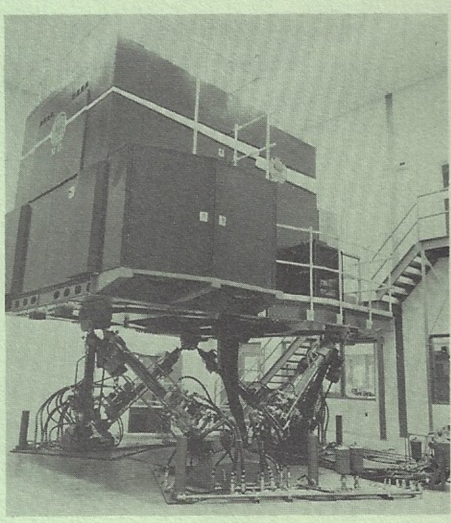
This simulator's motion system provides all six degrees of freedom: lateral, longitudinal, yaw, pitch, roll and vertical. These movements provide trainees with acceleration cues experienced in normal and emergency flight maneuvers, affording maximum simulation fidelity for a heavy aircraft such as the CH-47.

The Chinook furnishes transition training, in both instrument and contact environments. Training includes ground taxi, takeoff, hover, powered flight, standard autorotation and landing.

Also simulated with high fidelity are missed approaches and go-around, circling and 180° overhead approach, confined area landing and pinnacle and sling load operations.







AH-1Q Helicopter Trainer

Another major milestone in helicopter simulation was attained when Link was awarded a contract for an AH-1Q (Cobra) helicopter trainer for the U.S. Army.

This is a fully human-engineered training system tailored specifically to the task of providing complete crew training for both pilots and gunners. Training includes AH-1Q procedures, aircraft control, instrument procedures, engine control, emergency procedures, weapons delivery and radio navigation problems.

The AH-1Q attack helicopter is a two-place, single-rotor gunship capable of carrying a variety of weapons. The improved armament system includes helmet sights for both the pilot and gunner, a telescopic sight unit (TSU) for the gunner, and TOW missiles. Crew members share in the operational tasks, with the gunner acting as copilot and the pilot also firing weapons.

The trainer consists of two cockpits —one duplicates the pilot's aircraft station, the other the gunner's station —a computer complex and interface equipment, and a visual display system. The two trainer cockpits are operable in the integrated mode (single mission) or in the independent mode (two separate missions). Each trainee station is mounted on a six-degree-of-freedom motion system and has an instructor station located on the motion platform adjacent to it.

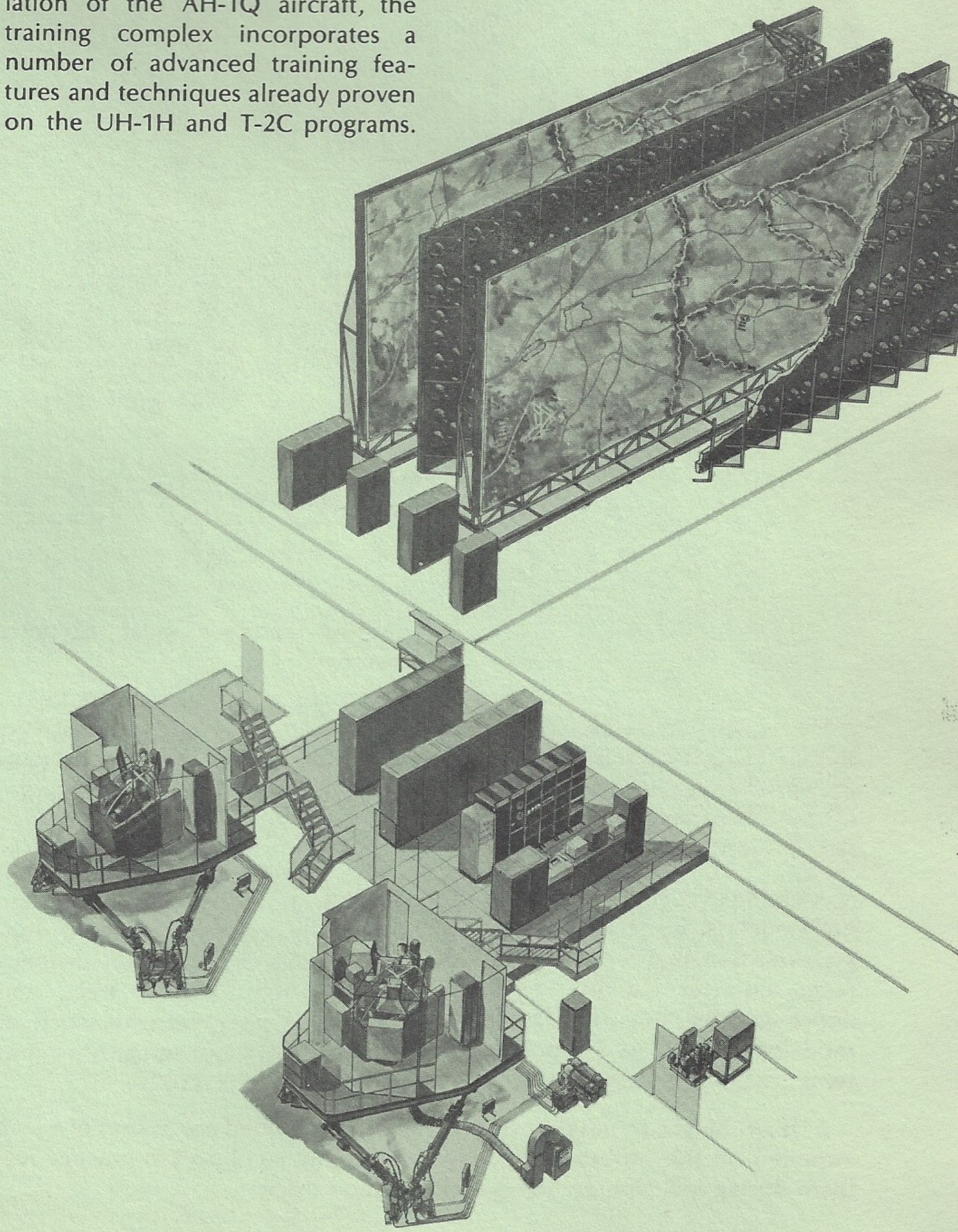
The pilot station is provided with forward- and side-window visual displays. The gunner station is equipped with a forward-window display and a telescopic sight unit which displays symbolic imagery. Weapon effects video, including display of tracers and weapon impacts, are generated and mixed with the camera-model video. The telescopic sight unit symbology provides the gunner with a visual scene including targets, weapon effects and the horizon, all correlated with the visual displays.

AH-1Q weapon system simulation includes the M28 turret system (7.62mm machine gun and the 40mm grenade launcher), Folding Fin Aerial Rocket (FFAR) launchers, M18 wing-mounted machine gun, M35 20mm cannon and the TOW missiles.

Aural cues associated with aircraft flight and ground operation are synthesized under computer control by a newly developed Poly-Voice* sound simulation system. The sounds to be simulated were tape-recorded under actual operating conditions, spectographically analyzed, math-modeled, and programmed into the PDP-11 computer. As the simulator is flown, the appropriate sounds are generated in real time, providing an exact duplication of the actual AH-1Q aircraft.

To augment the high-fidelity simulation of the AH-1Q aircraft, the training complex incorporates a number of advanced training features and techniques already proven on the UH-1H and T-2C programs. These features and techniques make the instructor's job more productive by providing him with precise, largely automated control of the training problem, and real-time display of trainee performance data in an easily understood form. They furnish the student with training that is standardized, yet adaptable to his own needs and accomplishments. The automated training features include:

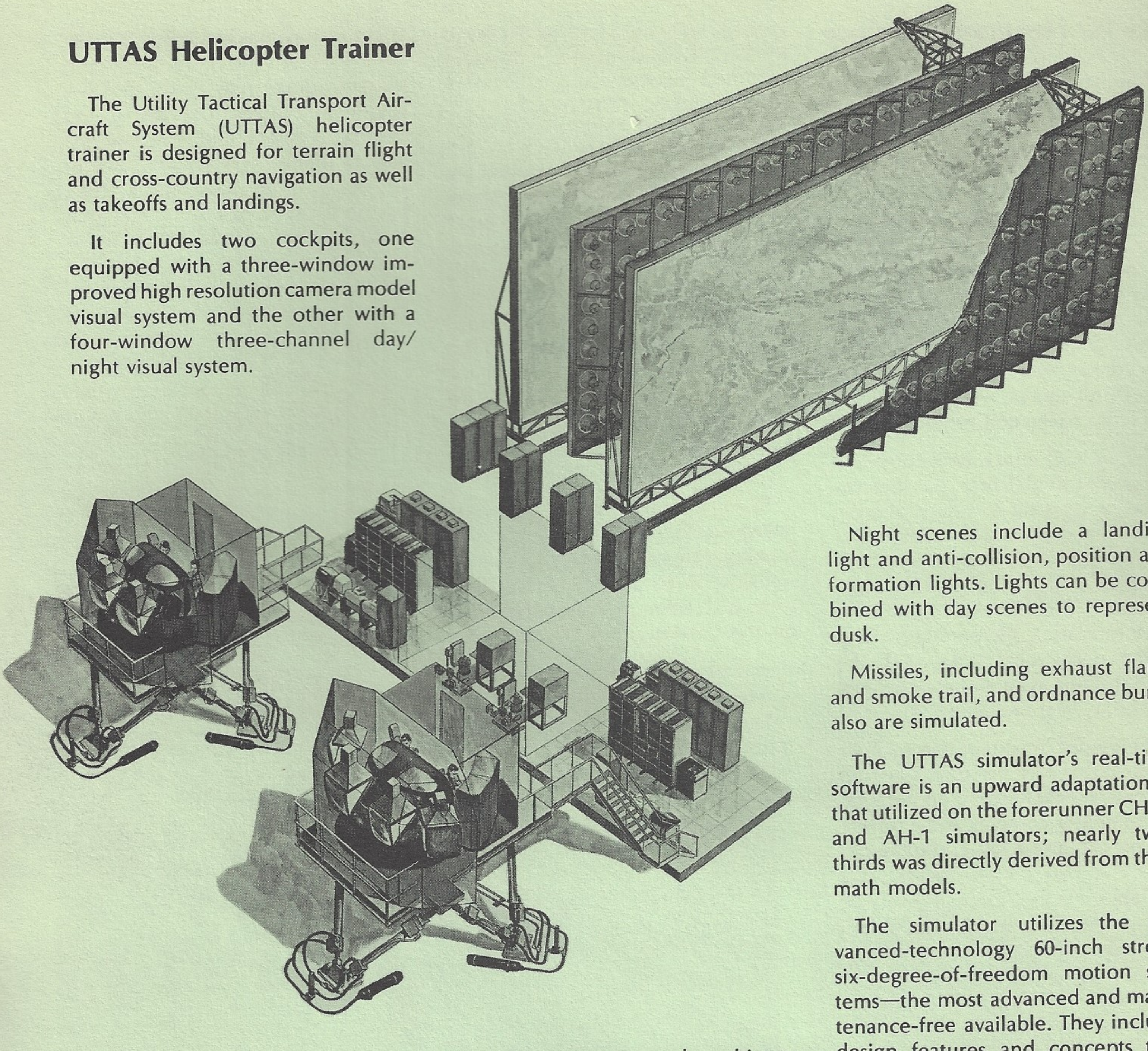
—Demonstration
—Checkrides
—Exercises
—Performance Record/Playback
—Automatic Briefings



UTTAS Helicopter Trainer

The Utility Tactical Transport Aircraft System (UTTAS) helicopter trainer is designed for terrain flight and cross-country navigation as well as takeoffs and landings.

It includes two cockpits, one equipped with a three-window improved high resolution camera model visual system and the other with a four-window three-channel day/night visual system.



The visual systems are the key to successful UTTAS simulation since they provide realistic training in nap-of-the-earth and VFR, as well as IFR, missions.

A *Visulink** High Resolution/Camera Model visual system on one cockpit furnishes visual cues and accurate radar altimeter readings over the entire gaming area. Two identical modelboards and gantry/probe systems are utilized.

A laser height-sensing device is mounted on the probes, protecting them during low altitude flights and assuring accurate radar altimeter readings.

The other cockpit has a *Visulink** Full-Scan Digital Image Generator which provides both day and night scenes over a gaming area encompassing 40 by 40 nautical miles.

The area includes four highly detailed sections in which the scene content is designed for nap-of-the-earth flights. Each section includes approximately 100,000 trees and numerous other features, such as hills, buildings and fields, which enhance training realism.

Also provided are images of a lead helicopter so pilots can practice formation flying.

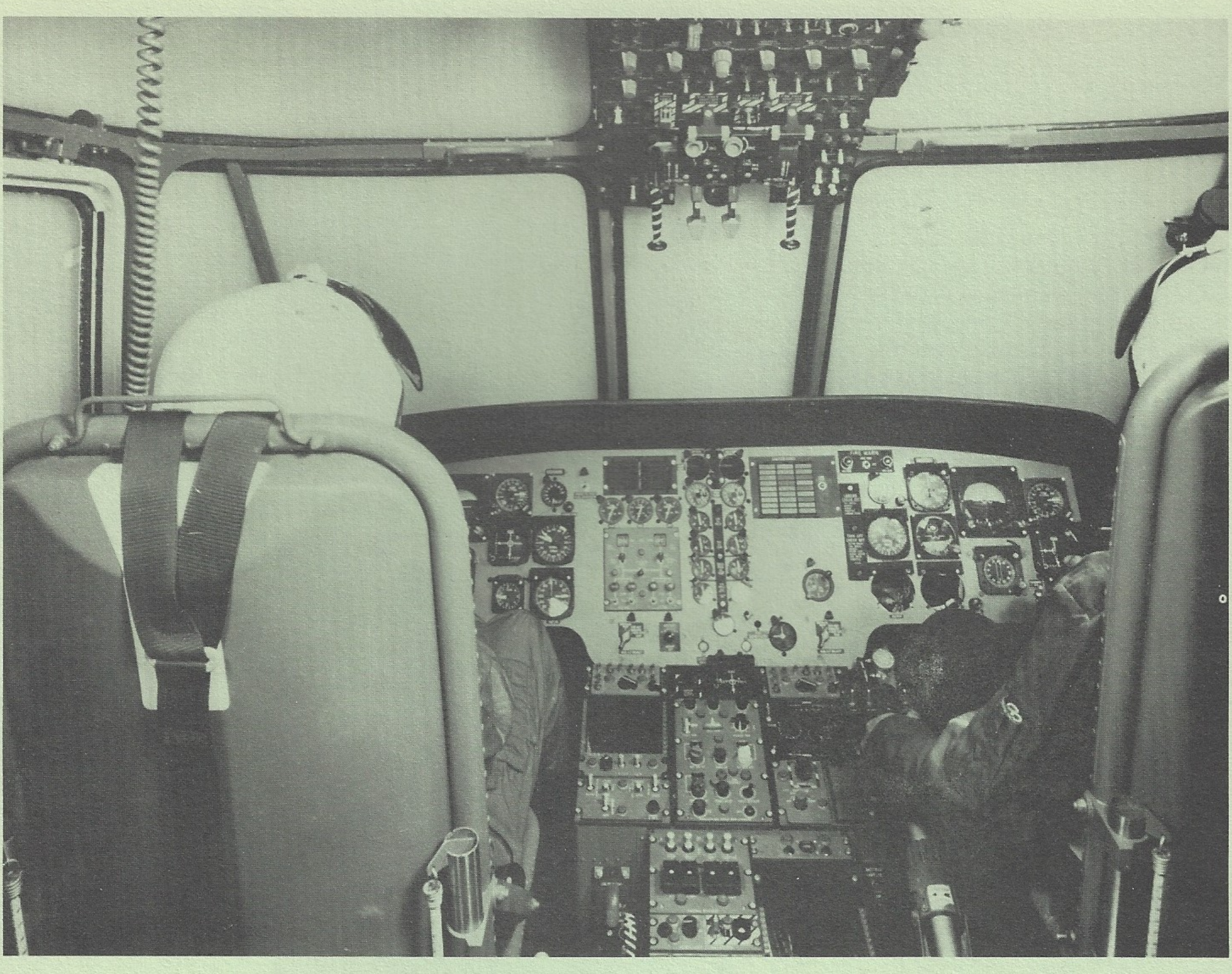
Night scenes include a landing light and anti-collision, position and formation lights. Lights can be combined with day scenes to represent dusk.

Missiles, including exhaust flame and smoke trail, and ordnance bursts also are simulated.

The UTTAS simulator's real-time software is an upward adaptation of that utilized on the forerunner CH-47 and AH-1 simulators; nearly two-thirds was directly derived from their math models.

The simulator utilizes the advanced-technology 60-inch stroke six-degree-of-freedom motion systems—the most advanced and maintenance-free available. They include design features and concepts that facilitate correlation between motion cues and visual cues.

All instructor and automatic training aid features represent a continued development of similar features found in earlier SFTS simulators.



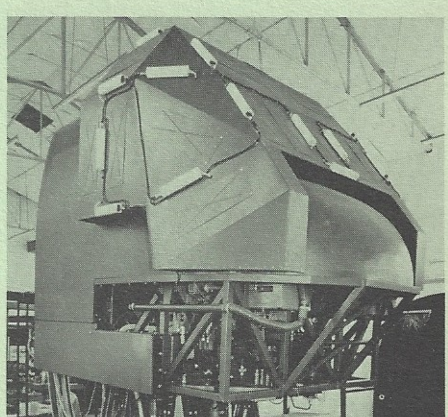
Sea King Helicopter Trainer

Another *Link** helicopter trainer is the Sea King, for training antisubmarine warfare (ASW) crews. These trainers are used by the British, Australian and Indian navies and the Egyptian Air Force.

The Sea King simulator comprises two parts: a reproduction of the flight compartment mounted on a three-axis motion system, and a static crew station, each under the control of its own instructor station. Thus pilots and flight crews can either conduct independent training exercises or carry out fully integrated training missions.

Full ASW missions are simulated in the Sea King, including operation of navigational doppler, search radar, transponder interrogation, radar, submersible sonar transducer and weapon release system.

The instructor station is equipped with facilities for generating target information and for setting a wide variety of environmental conditions. A twin CRT monitoring system is also provided to display a constantly updated picture of the tactical area—aircraft, surface vessels, submarines, and details of wind, visibility and sea state.



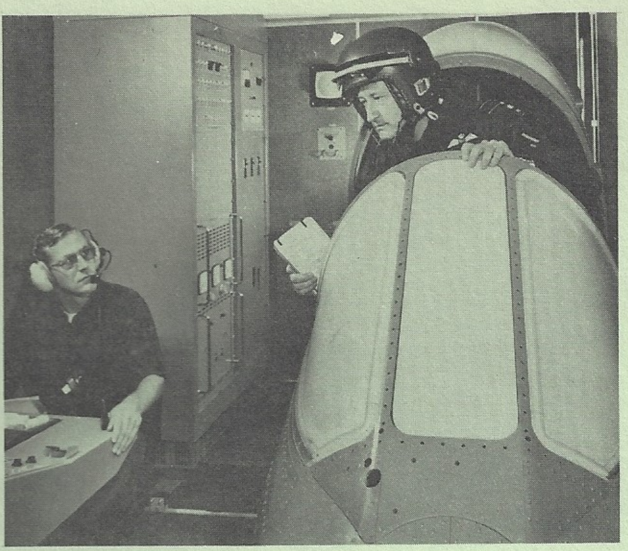
Harrier VTOL Simulator

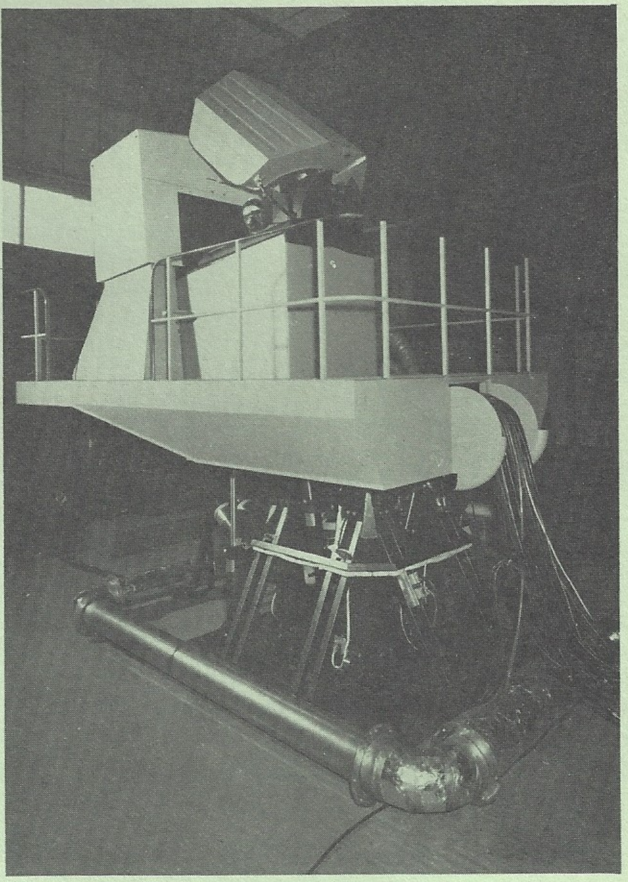
Three Harrier Vertical Takeoff and Landing (VTOL) simulators were developed and manufactured by Link-Miles for the British Ministry of Aviation Supply.

The Harrier simulator enables a pilot to carry out a full training mission, including vertical and conventional takeoff and landing, high and low altitude flight, map reading at low flight levels, and weapon attacks against specific targets. All cockpit systems are faithfully reproduced, including the head-down moving map display and head-up instrument display. The latter is integrated with the weapon aiming and release system.

An important feature of the Harrier is its full-color, closed-circuit television visual system, which utilizes three separate terrain models.

The U.S. Marine Corps also has acquired a Harrier simulator. The Marine device is used to train pilots of the AV-8A—the Marine version of the Harrier aircraft.





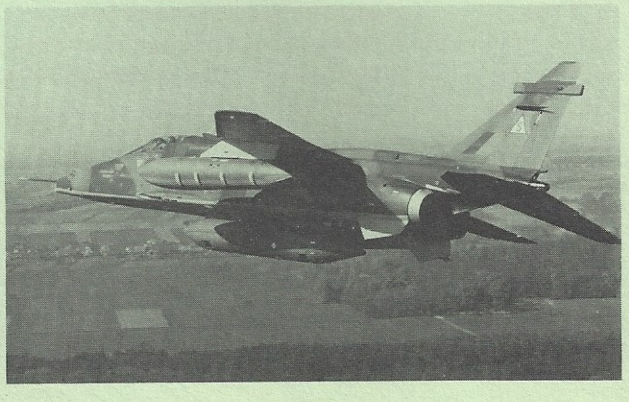
Jaguar Simulators

Five Jaguar simulators were ordered from Link-Miles by the Royal Air Force.

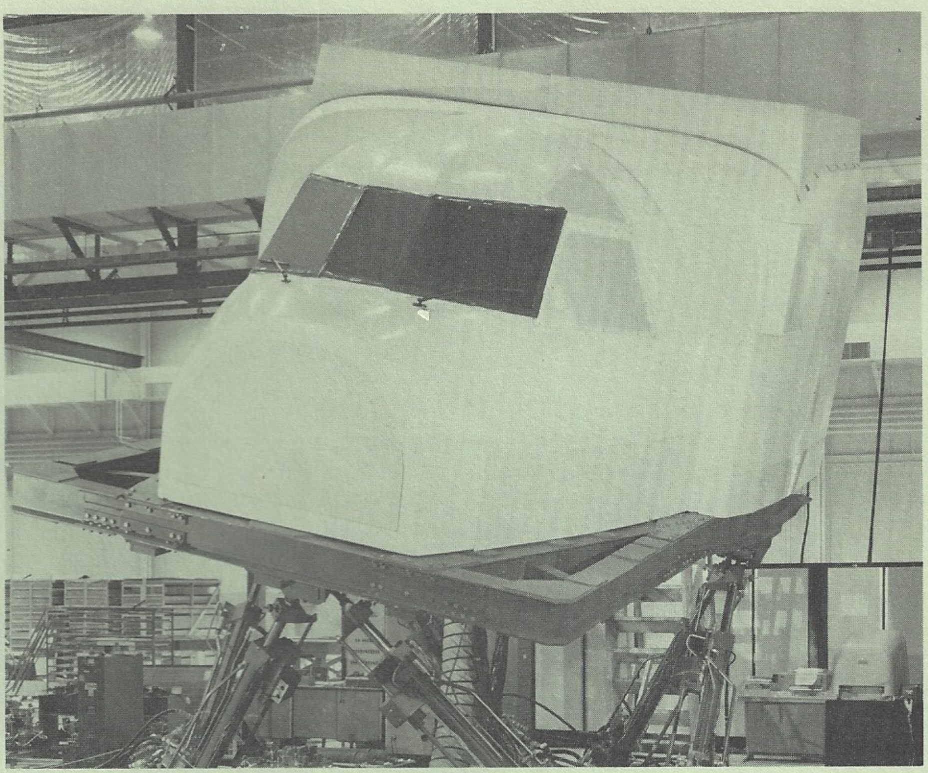
Four have full mission capability, utilizing a colored CCTV visual system with three separate terrain models of differing scales. These enable pilots to be trained in takeoff, landing, medium and low-level flying, reconnaissance and weapons delivery. The model complex is scanned by two cameras, which are rapidly interswitched to coincide with the simulator's maneuvers.

These simulators employ three-axis motion systems and *Link** GP4B computers, the latter being especially designed to meet the high speed requirements of real time simulation.

The fifth Jaguar simulator, a partial-mission version, is housed in transportable buildings to simplify installation and permit economic relocation.



Anti-Submarine Warfare Trainers



Simulation of anti-submarine warfare (ASW) aircraft involves ocean as well as flight environment.

Ocean environment is especially important as it relates to underwater sounds and sensors such as sonar and DIFAR. Link, the recognized authority in development of ASW trainers, captures the characteristics of the sea on mathematical models within digital computer systems. These models are determined by analyzing marine acoustic phenomena, such as those which cause sound paths to bend, and by calculating sound intensities and travel times.

Link has designed and built more than a score of ASW trainer configurations, including ones for the U.S. Navy's P-3C and S-3A aircraft.

P-3C ASW Trainers

The P-3C is a land-based four-engine turboprop aircraft containing complex computerized devices for seeking out and destroying enemy submarines.

Link first was asked to provide P-3C ASW tactics trainers, P-3C ASW acoustic sensor operator trainers and P-3C ASW radar/MAD (Magnetic Anomaly Detector) operator trainers. Later Link furnished P-3C operational flight trainers, including visual systems, to be integrated with the tactics trainers.

The stations and functions of the eight-man crew are realistically duplicated, enabling the Navy to train personnel both as teams and individuals.

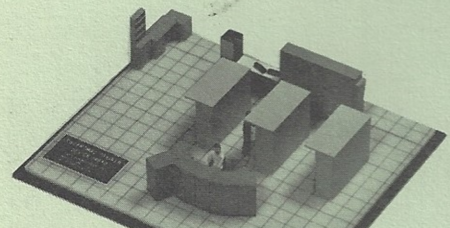
The principal elements of the operational flight trainer are:

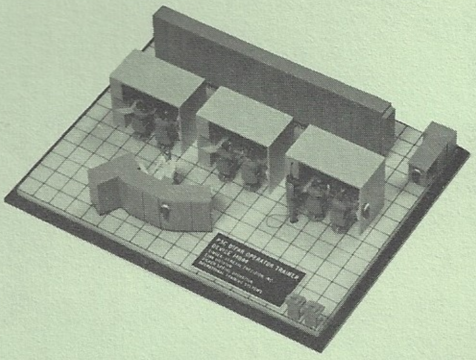
- Flight Station—An exact replica of the pilot, copilot and flight engineer stations in the P-3C cockpit.
- Instructor Station—Two interactive CRT's with keyboard and controls, in cockpit.
- Motion System—Six-degree-of-freedom.
- Computer Complex—Two PDP-11/45 central processing units.

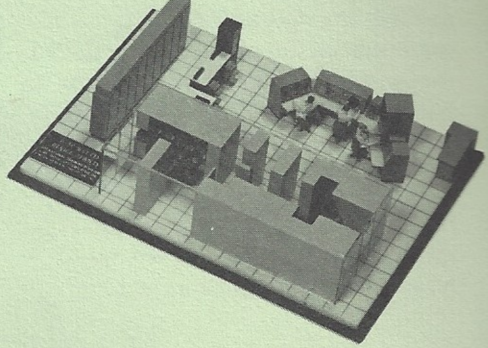
The tactics area includes:

- Tactical Coordinator (TACCO) station.
- Navigator Communication (COMM/NAV) station.
- Sensor Operator (SS-1 and SS-2) station—acoustic target sensors using simulated active and passive sonobuoys and DIFAR equipment.
- Sensor Operator(SS-3) station—non-acoustic target sensors using simulated long range radar, MAD detection equipment and the submarine anomaly detector (SAD).

The tactics trainer can operate independently to train the tactical crew alone or in an integrated mode with the operational flight trainer in a single coordinated mission. The tactics portion of the P-3C has its own computer complex (three Honeywell 516 computers) and a separate instructor/operator console.







P-3C Radar/MAD Operator Trainer

Link designed a part task trainer to provide concentrated training in the operational and tactical application of the Radar/MAD equipment for Sensor Station 3 of the P-3C Weapon System. It has three trainee and one instructor/operator positions.

The trainer provides a search radar system which simulates the actual equipment aboard the P-3C, including activation and operation of controls and video presentations of surface vessels (including snorkling and surfaced submarines), landmass shapes and atmospheric phenomena.

The MAD simulation enables proficiency training in pre-flighting associated components of this detection device and adjusting the sensitive compensator and recorder used to identify and localize magnetic disturbances caused by elusive submarine tactics. Realistic MAD signatures for display on the MAD recorder are generated in the simulation computer utilizing models of the real world parameters such as target depth, target heading versus aircraft heading and range of the day functions.

P-3C DIFAR Operator Trainer

A part task trainer developed by Link provides Acoustic Sensor Station operators with practical experience in operating Sensor Stations 1 and 2 of the P-3C Weapon System. Six trainee stations housed in three dual-position modules are exact replicas of the two sensor stations on the aircraft.

The trainer realistically simulates ocean and targets as well as equipment malfunctions and stores failures. It provides both basic and advanced training for DIFAR operators.

Tactics Trainer

This Weapon System Trainer provides realistic training for the Tactical Coordinator, Acoustic Sensor Operators, Non-Acoustic Operator and Communication Navigation Operator as a tactical integrated ASW system.

Each tactics trainer is designed to be integrated with an operational flight trainer to provide complete P-3C mission/crew training. The trainer also can be used independently, with pilot and copilot inputs provided by the tactics operator, tactics instructor or by a pilot trainee at an aircraft control console.

The U.S. Navy subsequently asked Link to update all such tactics trainers to conform with the latest changes in P-3C aircraft configuration.

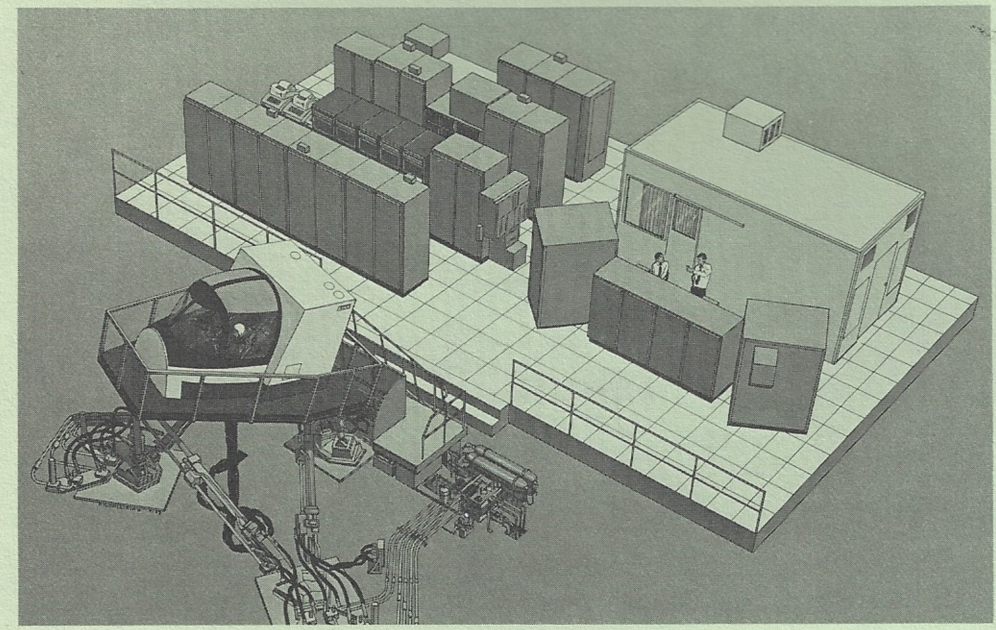
S-3A Mission Simulator

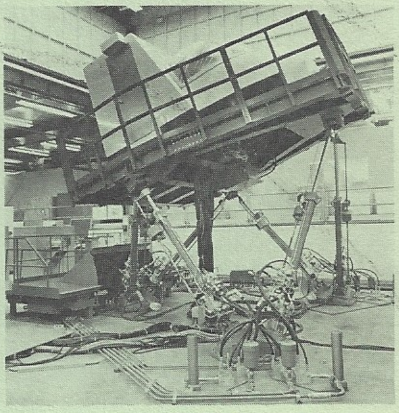
The S-3A Weapon System is a carrier-based twin-engine jet aircraft with computerized gear for locating and destroying enemy submarines.

It has a four-man crew: pilot, copilot, tactical coordinator (TACCO) and sensor operator (SENSO).

All crew stations and functions are represented in the simulator, which has four basic modes of operation:

- Flight Mode—Only the pilot and copilot stations are manned. The flight operator establishes the aircraft configuration setup via controls and a data display terminal, and the flight instructor monitors crew performance and introduces malfunctions as deemed appropriate.
- Tactics Mode—The TACCO, SENSO and pseudo copilot stations are manned and operational. Inputs normally provided by the pilot are furnished by the tactics operator, and the tactics instructor performs either "over the shoulder" monitoring for individual trainees or he can monitor the team performance utilizing the CRT plotter and PCM display.
- Simultaneous / Independent Mode—The simulator is capable of simultaneous but independent operation in both flight and tactics modes without restriction to training effectiveness. This capability is facilitated by a programming design technique that enables the simulator computer to simulate systems that are shared between the flight and tactics functions.
- Integrated Mode—All four crew stations are manned and operational, and all functions are performed normally in a single coordinated mission.

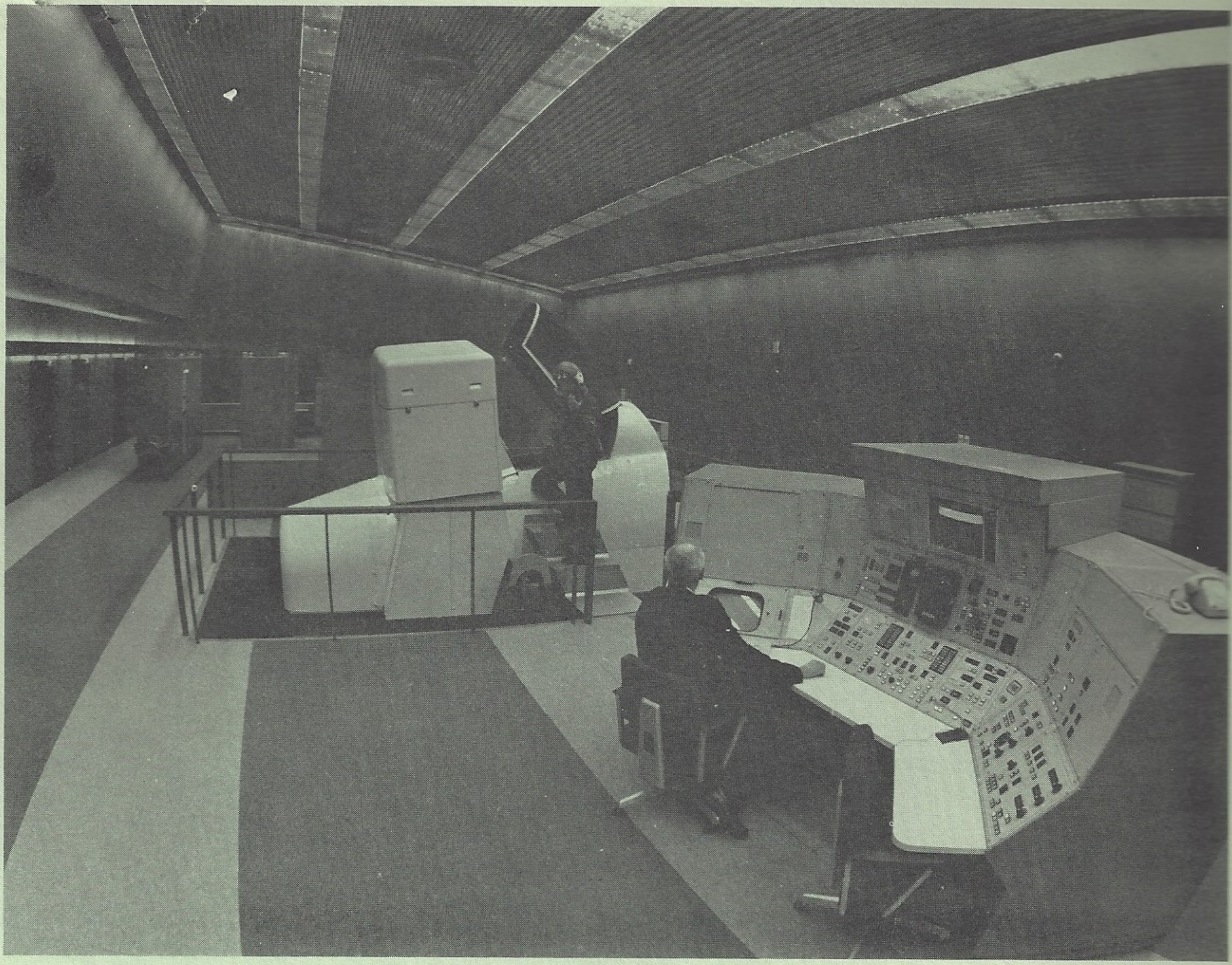




S-3A Position Trainer

Link also developed an S-3A position trainer for tactical crews of the S-3A Weapon System. The complex consists of three tactics trainee modules, each consisting of a TACCO, SENSO and pseudo copilot position.

The TACCO and SENSO are exact replicas of the aircraft stations; the pseudo copilot is a limited configuration relating solely to the tactical responsibilities of the copilot. The three modules can be operated as individual tactics team trainers or as a total position trainer where the three TACCO's, three SENSO's and three copilots train on their own problem and have no interaction with the others.



AJ-37 Weapon System Trainers

The AJ-37 trainers are used by the Swedish Air Force to instruct pilots in the procedures and techniques of flying the SAAB Viggen, a multi-mission combat aircraft.

Instruction includes use of all controls and instruments during ground operation, takeoff, landing, normal flight, various tactical maneuvers, navigation problems, tactical problems in weapons delivery and electronic countermeasure procedures, instrument approach procedures and emergency conditions.

The trainers are equipped with analog radar landmass systems and simplified visual systems. The latter provide black and white video display, 50° field of view virtual image, symbolic horizon, synthetic terrain and a symbolically-generated target that varies in size with range.

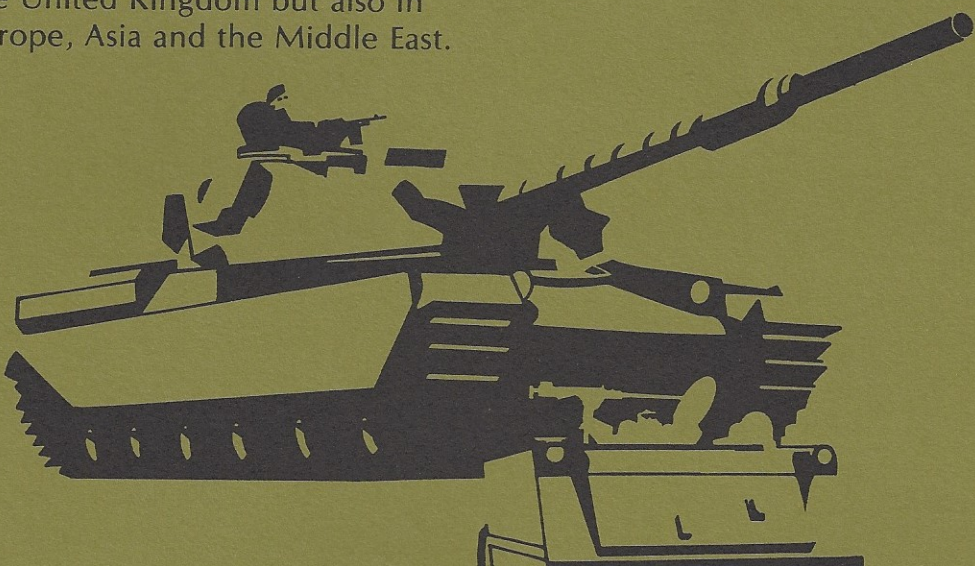
CRT display units and keyboards enable instructors to communicate with the computation system as well as depict and monitor cross-country, approach/landing, takeoff and tactical procedures and situations.

Fighting Vehicle Simulators

Link-Miles pioneered development of armored fighting vehicle simulators, from early analog models of the mid-1960's to the highly sophisticated digital complexes available today.

These simulators provide a number of advantages in training drivers of tanks and armored personnel carriers. Training can be conducted on widely varying types of terrain, which might not be readily available for actual vehicles, at all hours of day and night, regardless of weather. Emergency procedures can be practiced safely. Cost savings are appreciable.

Tracked vehicle simulators are being supplied for use not only in the United Kingdom but also in Europe, Asia and the Middle East.

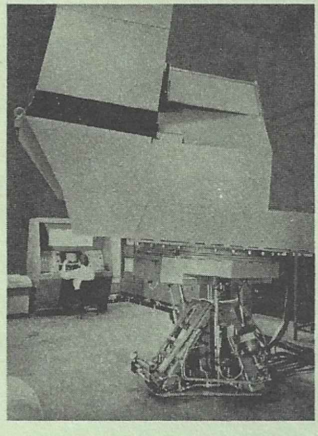


Fighting Vehicle Simulators

Link-Miles Fighting Vehicle Simulators provide wide training capability, including initial instruction, conversion and continuation practice over many types of terrain, ranging from cities to deserts.

With color visual systems that heighten realism, the simulators can reproduce the performance of any kind of wheeled or tracked fighting vehicle.

Changes in performance can easily be reprogrammed. All types of malfunctions can be duplicated in complete safety. Training can be conducted in varying kinds of weather and light conditions, at considerably less cost than in actual vehicles.



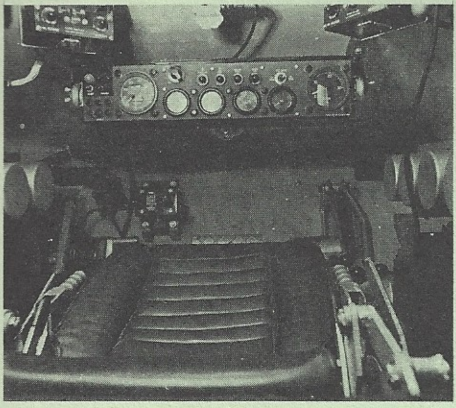
The driving compartment of each simulator is a faithful reproduction of the actual vehicle. All equipment, controls and instruments operate in the proper manner. Drivers can be trained in either head-down or head-up modes.

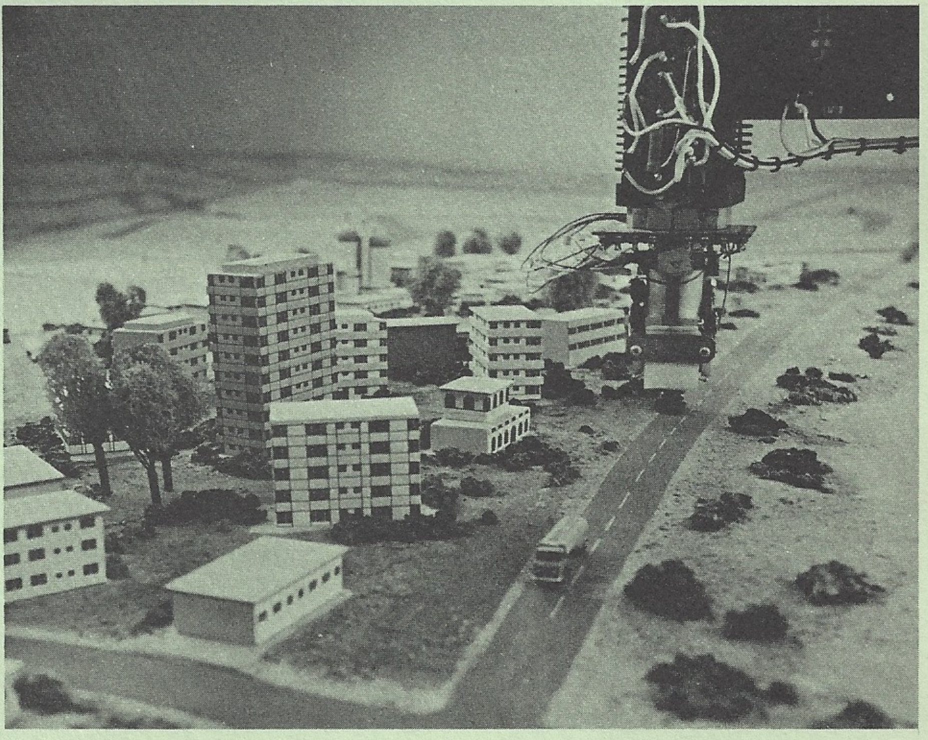
The compartment is mounted on a three-axis motion system specifically designed for tracked vehicle simulation. It provides realistic cues for pitch, roll and yaw characteristic of an actual vehicle. These cues are generated by a shoe assembly which traverses a terrain model surface, picking up ground unevenness, gradients, obstacles and other topographical characteristics. The shoe assembly is on a gantry which carries a closed circuit television camera which scans the terrain model, providing visual cues.

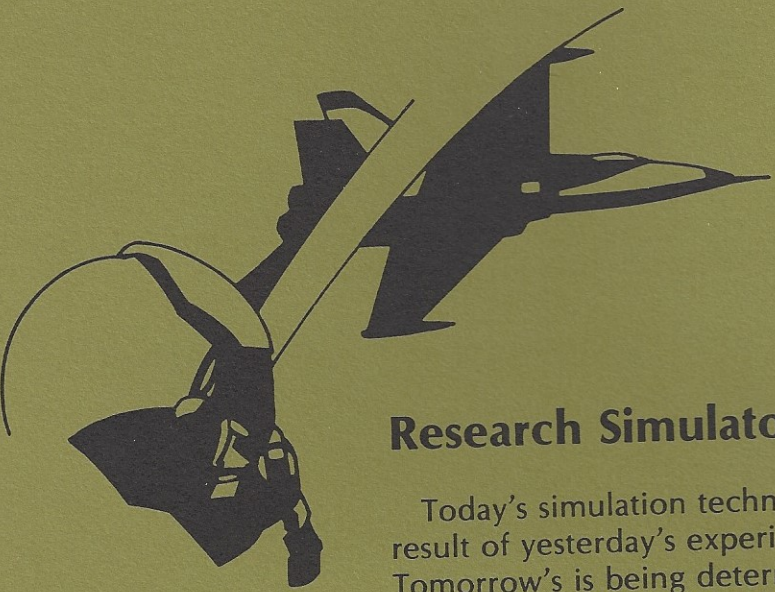
A collimated display unit, mounted on the compartment hull, uses a curved mirror and beamsplitter to process visual signals into infinity images, requiring drivers to focus their eyes some 40 feet ahead, just as they would in actual vehicles.

Each instructor's console contains all the switches, controls and instrument readouts necessary to monitor the entire exercise, plus a complete set of driving controls. The driver's view is duplicated and a translucent map with a point light source shows the vehicle's position on the terrain model at all times.

Link-Miles developed the world's first digital tank simulator, the Chieftain, and subsequently produced simulators for a number of other types of armored vehicles, including the Centurion, Leopard, Scorpion, combat engineer tractors and armored personnel carriers.







Research Simulators

Today's simulation technology is the result of yesterday's experimentation. Tomorrow's is being determined by research today.

Some of this research is being conducted on simulators especially designed for that purpose. For example Link has built three experimental U.S. military training systems. One is being used to help design trainers for the Air Force's Undergraduate Pilot Training Program; another is to develop new aircraft and flying techniques for air-to-air combat; the third is concerned with Navy aircraft carrier operations.

Link's expertise with research simulators goes beyond design and fabrication; for several years it has operated and maintained the Air Force's Crew Station Simulation Facility. This is used to evaluate new controls and displays for various Air Force aircraft.

Advanced Simulation in Undergraduate Pilot Training

The United States Air Force is developing new training techniques on a system called Advanced Simulation in Undergraduate Pilot Training (ASUPT) which was designed and built by Link.

This sophisticated research flight simulation system is being used by the Air Force Human Resources Laboratory at Williams Air Force Base in Phoenix, Ariz. The system includes twin cockpits, configured like those in the Air Force's T-37B jet trainer, on six-degree-of-freedom motion systems. Each cockpit has a seven-channel wraparound computer-generated visual display providing a 300° horizontal, 110° vertical field of view.

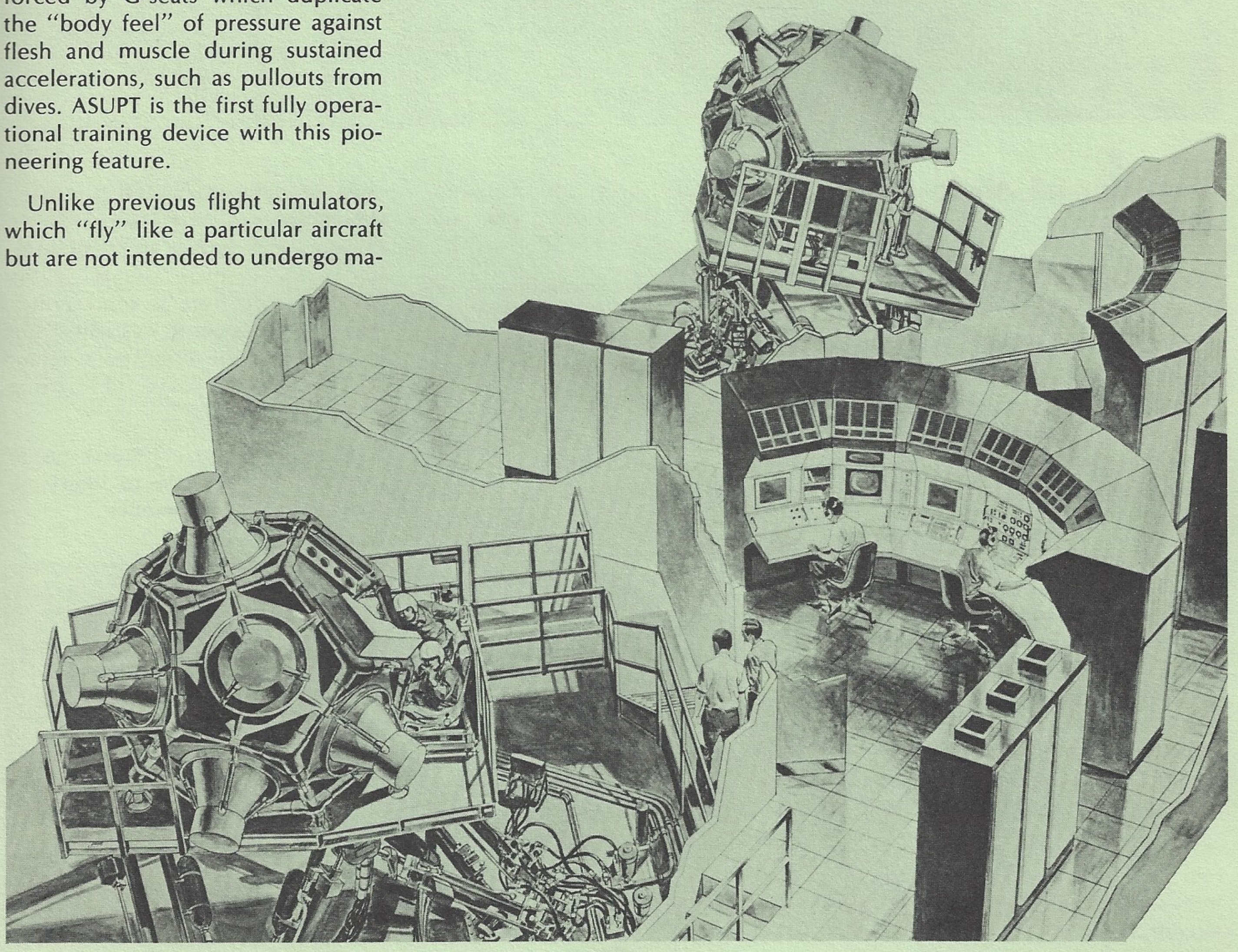
Motion and visual cues are reinforced by G-seats which duplicate the "body feel" of pressure against flesh and muscle during sustained accelerations, such as pullouts from dives. ASUPT is the first fully operational training device with this pioneering feature.

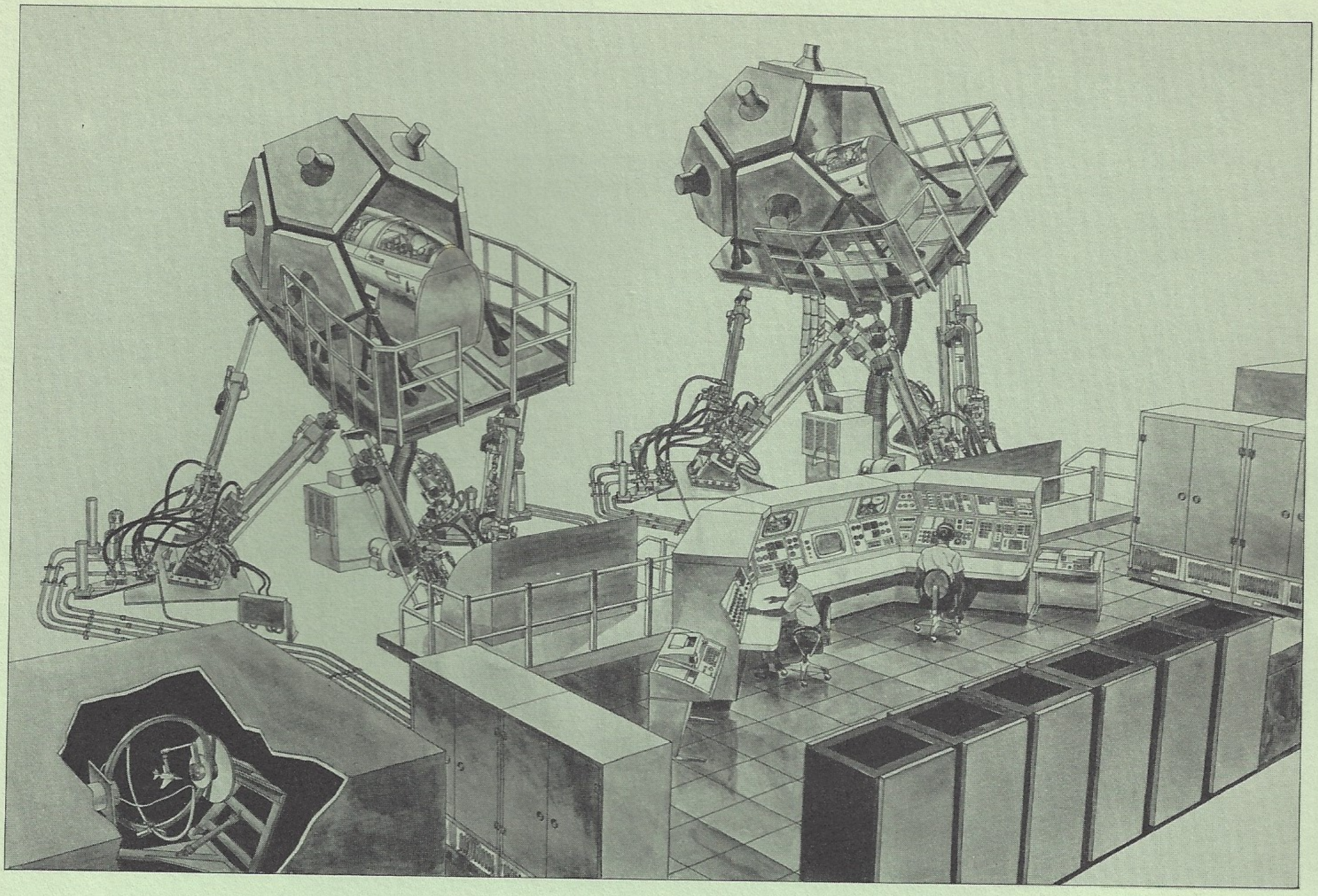
Unlike previous flight simulators, which "fly" like a particular aircraft but are not intended to undergo major modifications, the ASUPT has computer programs designed to handle a great variety of changes in aircraft performance which can be implemented through keyboard control. In conventional computation systems, changes to programs are accomplished by "patch" routines which are eventually incorporated into the new "load" by extensive and laborious programming. But as patches are entered into ASUPT simulation, the linking editor program automatically integrates them into the master program, allocates the necessary disc area and produces a "master load" copy of the updated software.

Another noteworthy feature is that ASUPT has three types of instructor stations, permitting experimentation and evaluation of different modes and techniques of instruction. They also provide flexibility in setting up experiments and in controlling, recording and interpreting trainee performance parameters.

The motion system furnishes pitch, roll and yaw rotation, plus lateral, longitudinal and vertical translation effects. ASUPT can simulate high angles of attack and sideslip associated with post stalls and spins. Pilot-trainees not only feel the pull of gravity against their seats but also can sense the center of gravity shifting as their fuel supply supposedly runs low. They can even practice formation flying, being able to see the lead aircraft and actually feel its downwash generated by high-velocity exhaust and the aerodynamic effects experienced by wing or trailing aircraft in formation.

Students hear all the sounds that can be experienced in the actual aircraft, including rain, hail and thunder.





Simulator for Air-to-Air Combat

The world's first truly realistic air-to-air combat simulator was designed and built by Link for the U.S. Air Force.

It is being used as a research tool not only for development of combat techniques but also for evaluation of fighter aircraft and tactical weapons design.

The Simulator for Air-to-Air Combat (SAAC) includes two F-4 cockpits, mounted on synergistic six-degree-of-freedom motion systems. Each cockpit is enclosed by a matrix of eight pentagonal CRT windows, affording a field of view as broad as 296 degrees. In effect each pilot sees as much from the simulator cockpit as he would from the aircraft itself.

His view includes a synthetic terrain picture (a checkerboard) and a televised image of the other pilot's aircraft, in an infinity representation. He can see operations of speedbrakes and afterburner, plus sun glints and gun and missile "hits."

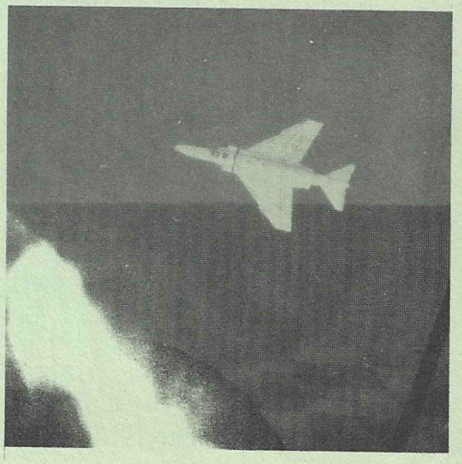
Even G forces experienced by fighter pilots are simulated. Computer-controlled pressures, supplied by G-seats and G-suits, act on the surface of the pilot's body.

G-seats duplicate the body feel during sustained accelerations, such as turns and pullouts from dives. Pressure is supplied by air forced into the seat pan, back rest, thigh panels and lap belt. Thirty-one air cells and the belt actuator are independently controlled by the computer program.

G-suit pressure is automatically activated whenever the anti-G valve in the cockpit is pressed or predetermined parameters are exceeded. Blackout conditions are represented by dimming cockpit lights.

Although configured initially as F-4 aircraft, the simulator is capable of representing various other fighter craft. Two types can be simulated simultaneously, enabling pilots to develop and perfect air-to-air combat tactics. Even aircraft still in the planning stage can be represented, making it possible to evaluate flight characteristics of tomorrow's fighter craft before they leave the drawing board.

A scoring system computes missile and gunfire trajectories to determine pilots' combat competence.



Aviation Wide-Angle Visual System

The Aviation Wide-Angle Visual System (AWAVS) was developed by Link for U.S. Navy research to determine training requirements for aircraft carrier takeoffs and landings.

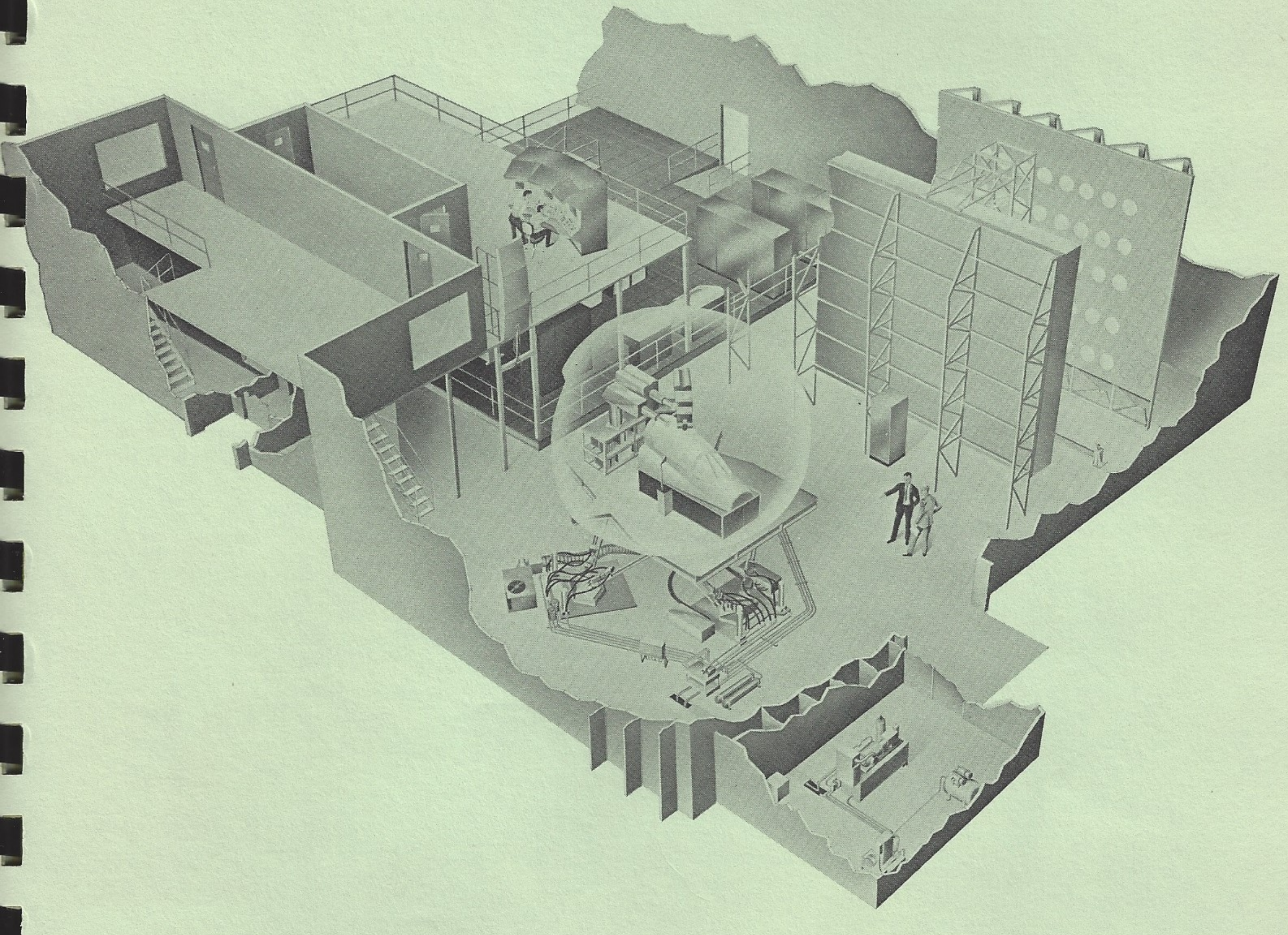
The carrier image originates from a three-dimensional model, mounted on a gimbal mechanism to provide roll, pitch and heave motion. The carrier model is viewed by a TV camera and optical probe on a movable gantry, positioned in accordance with the location and attitude of the simulated aircraft.

The image of the carrier and its wake is projected on a wraparound spherical screen on which also is displayed a televised wide-angle seascape.

Enclosed in the spherical screen is a simulator cockpit from which pilots get realistic views as they practice catapult takeoffs, circling and landing under various daylight, dusk and night conditions.

The seascape background image is generated electronically using a photographic image and flying spot scanner and is projected over a 160° x 80° field of view. A special scene keying camera also views the projected scene and "subtracts" the carrier image from the background to eliminate any "bleed through" effects.

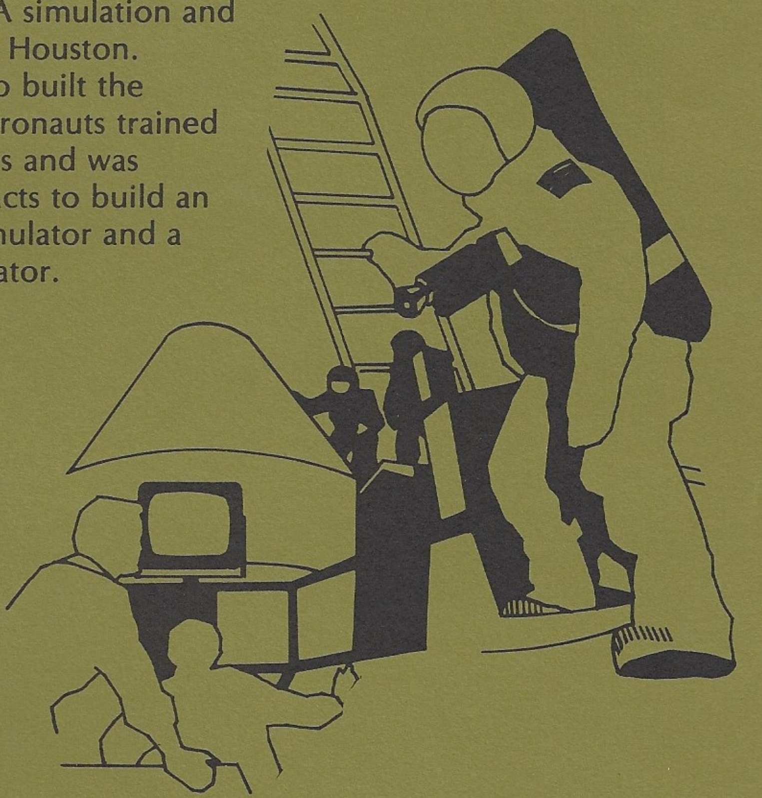
A special effects generator also electronically embellishes the scene, creating such impressions as restricted visibility, overcast ceiling and above-cloud flight.



Space Simulators

Link has been actively involved in the U.S. space program since 1962 when it employed simulation techniques to help train astronauts for pioneering Gemini flights. Later, in 1964, Link provided a space flight trainer for Edwards Air Force Base and shortly thereafter designed and built the three Command Module Simulators and two Lunar Module Simulators in which Apollo astronauts trained for their successful moon missions. These simulators also were credited with helping avert disaster during the aborted Apollo 13 flight.

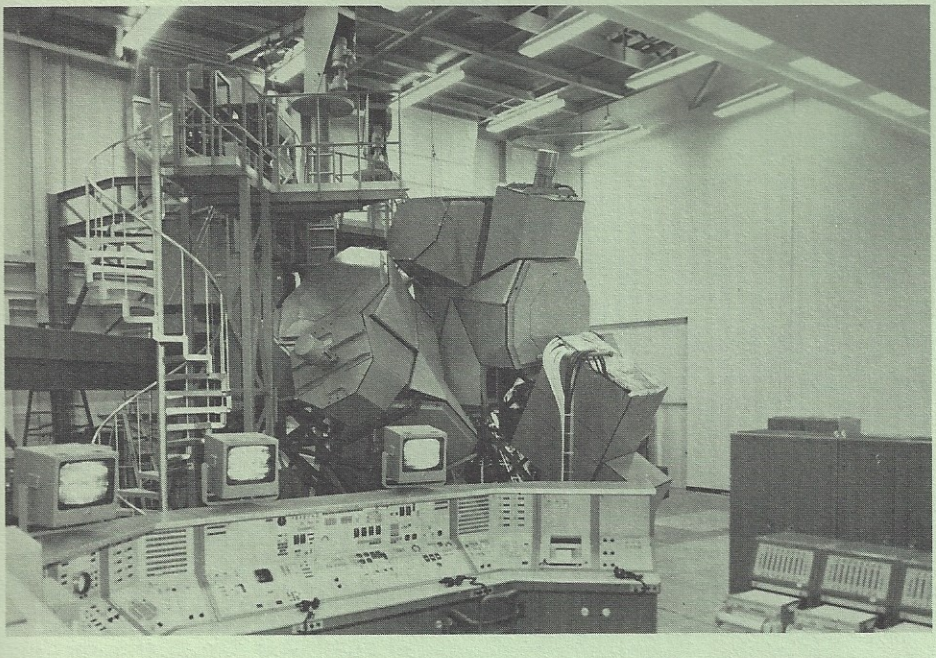
Since 1965 Link also has been charged with the responsibility of maintaining and updating all NASA simulation and training equipment at Houston. Subsequently Link also built the simulator in which astronauts trained for the Skylab missions and was awarded NASA contracts to build an Orbiter Aeroflight Simulator and a Shuttle Mission Simulator.



Apollo Command Module Simulators

The Apollo Command Module Simulators were the largest most complex training installations ever built. Each was 30 feet high and weighed approximately 40 tons. One was installed at the Manned Spacecraft Center in Houston, Texas, and two were placed at the Kennedy Space Center, Fla.

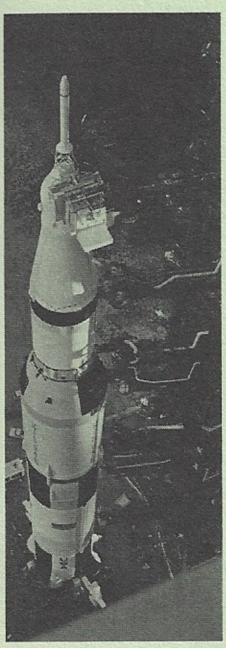
These facilities, which were completed in 1968, were used to train astronauts for every phase of the Apollo missions, from prelaunch through lunar module separation and rendezvous to earth reentry and landing.

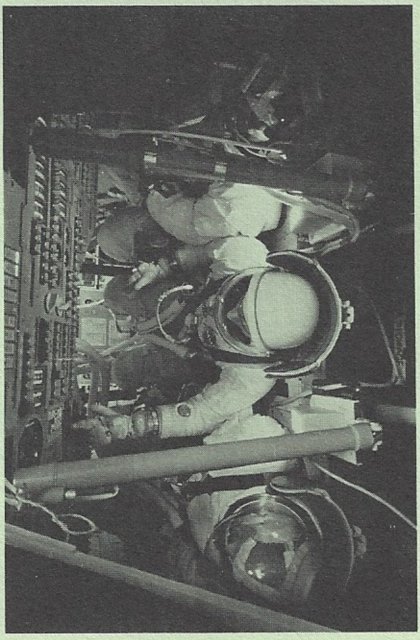


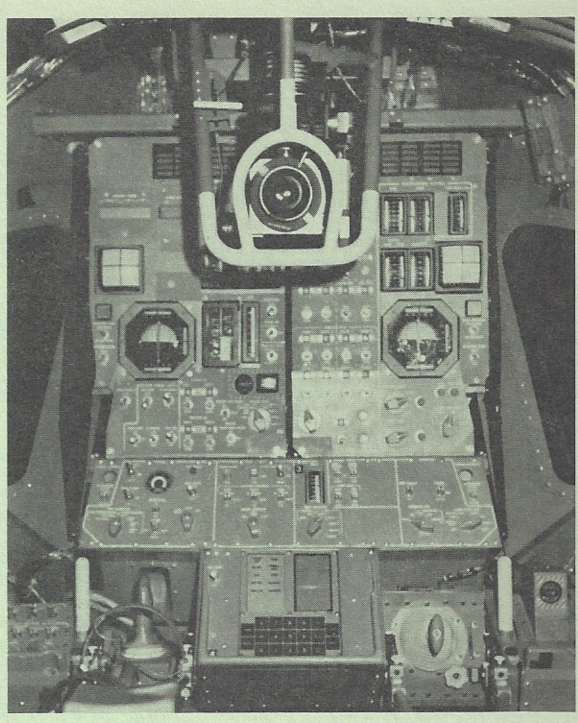
The simulators provided space lighting effects, enabling crews to see representations of the earth and moon. Realistic rendezvous and docking views were furnished by high-resolution closed-circuit television. Also simulated were food, water and waste systems, sound effects, and reentry heat changes.

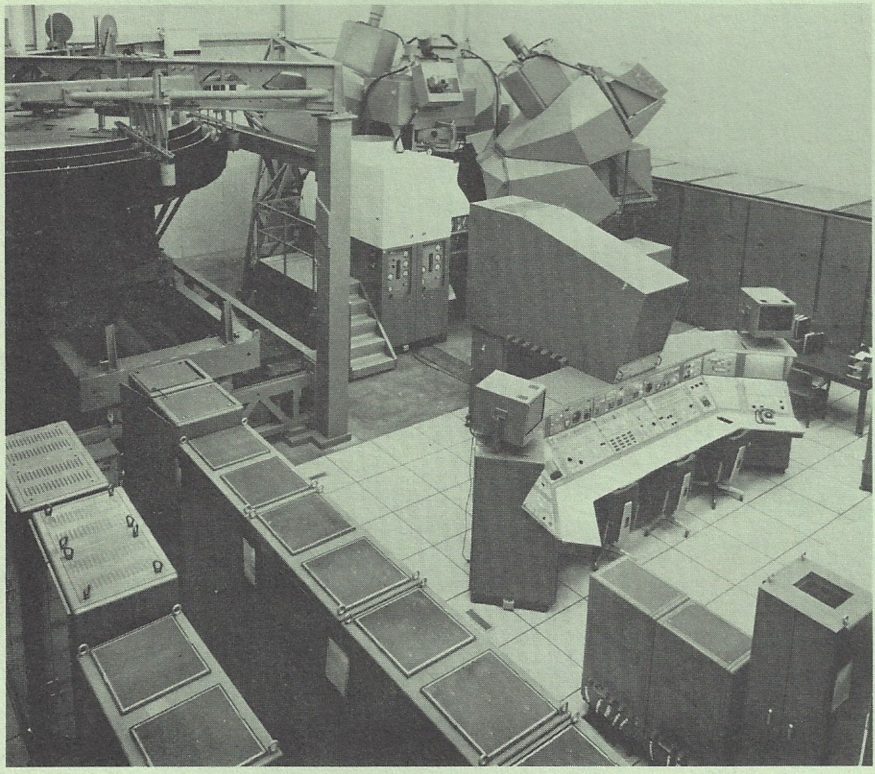
The simulators were integrated with the Manned Spacecraft Control Center, placing the astronauts in contact with the real-world network of monitoring stations.

The indispensability of the simulators was dramatically demonstrated during the flight of Apollo 13 when the crew was rescued following an explosion in space. Emergency measures were tested on the simulators before being tried aloft.









Lunar Module Simulator

Link also designed and built for the National Aeronautics and Space Administration two Lunar Module Simulators. They were integrated with two of the Command Module Simulators—one at the Manned Spacecraft Center and the other at Kennedy Space Center.

Each Lunar Module Simulator consisted of a crew station, instructor station, equipment cabinets and an external visual display system. The latter employed film, optics, models and TV to present the lunar surface, earth, star-field, sun and Command Module.

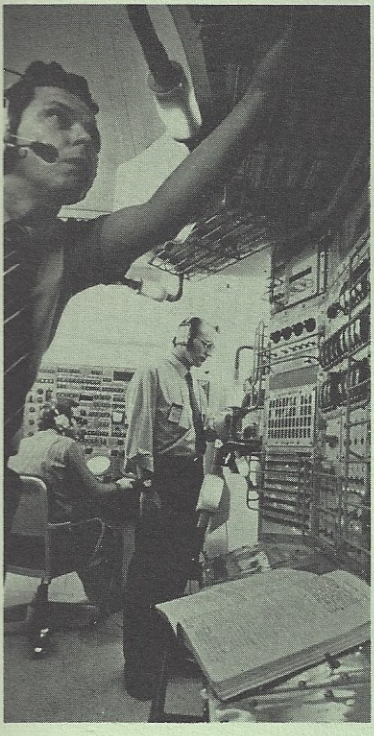
The interior of the crew station was a replica containing all equipment found in the actual vehicle, either operational or as mock-ups.

As many as five persons could work in the instructor station, with additional room for observers. Instructors could freeze an exercise in order to discuss it with the crew and could also conduct missions faster than real time.

The Lunar Module Simulators often operated in integrated missions, exchanging data with the Command Module Simulators and the Mission Control Center.

Skylab Simulator

The National Aeronautics and Space Administration also turned to Link to prepare for the next phase of the U.S. space exploration program. NASA awarded the concern the contract to design and build a simulator to train crews of Skylab—the orbiting laboratory whose missions included studying the sun.



This project presented new challenges because close-up views of the sun were not available, as they had been of the moon. Acquisition of such film was difficult because of the intervening earth's atmosphere but this finally was accomplished, achieving maximum simulator realism.

The Skylab Simulator was comprised of the following components:

—A crew station enclosure which housed the orbital assembly's control and display panels.

—An instructor/operator station which enabled as many as six men to control and monitor a simulation exercise.

—An image generation system which created the solar images.

—A computer complex and associated peripheral equipment.

—A software package that included the operating systems and the real-time program which represented the Skylab subsystems, the solar and earth resource experiments and the equations of motion.

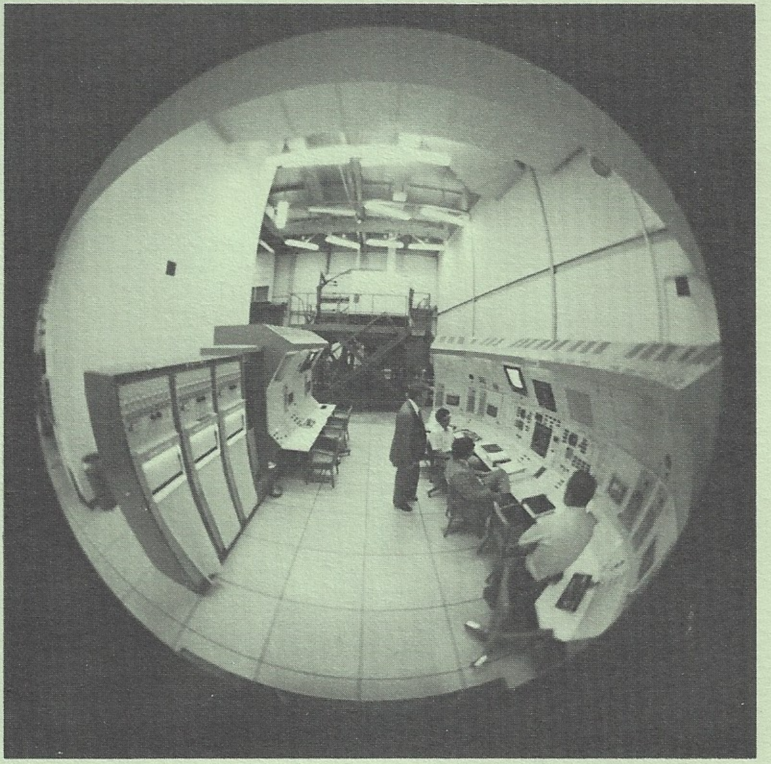
The simulator interfaced with a Command Module Simulator and Mission Control Center, maximizing the training capability.

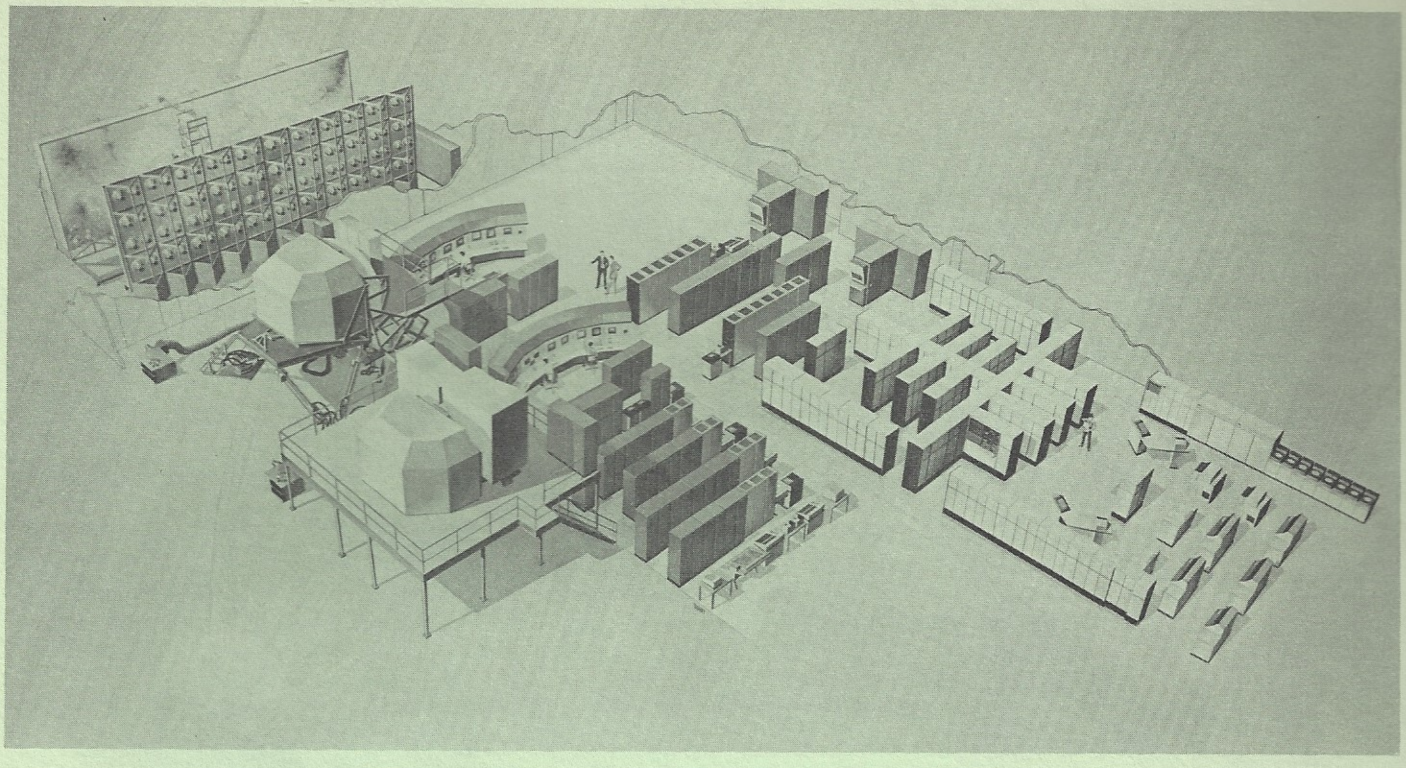
Orbiter Aeroflight Simulator

Link's dominance in space simulation again was reaffirmed when it was selected by the National Aeronautics and Space Administration for another major project.

NASA awarded the contract for an Orbiter Aeroflight Simulator (OAS) for the Space Shuttle program. The OAS is for training astronauts in the sub-orbital operation of space shuttle vehicles.

The simulator includes a crew station, color visual scene, a motion base and a flight computer-simulator interface for simulating orbiter flight dynamics and motion during the atmospheric phase of shuttle operations.





Shuttle Mission Simulator

Link's next contribution to the space effort was development of a Shuttle Mission Simulator (SMS).

The simulator consists principally of a motion base crew station and a fixed base crew station, integrated with a *Visulink* Full/Scan Digital Image Generator System and a *Visulink* High Resolution/Camera Model Visual Display System.

It is designed to train crews and flight controllers in all mission phases of the Space Shuttle Orbiter Vehicle, including launch, orbital insertion, orbital operations, re-entry and landing.

The Space Shuttle is a space transportation system for various gravity-free experiments in earth orbit. After each mission, the reusable orbiter lands like an airplane.

One visual system furnishes computer-generated images of the Shuttle flying. It also shows the Shuttle with cargo bay doors open and satellite payload in place, enabling astronauts to practice cargo manipulation with the vehicle's remote arms.

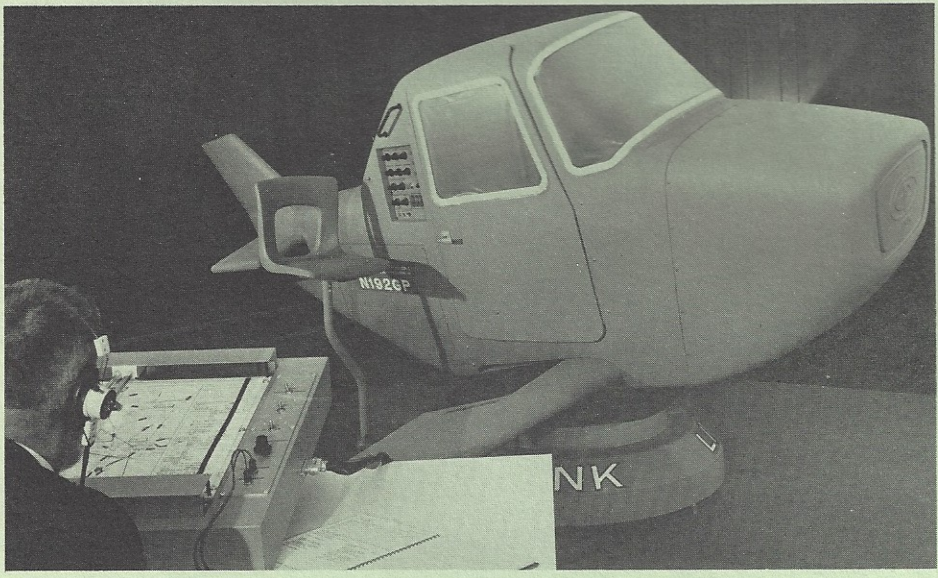
General Aviation Trainers

Link has applied the technology that produced sophisticated commercial and military aircraft simulators to meet the needs of general aviation.

Link has developed trainers that are economical enough to be purchased by high schools and colleges, flying schools and private flying clubs.

It also has designed a companion device for low-cost helicopter training.

GAT-1 General Aviation Trainer



The GAT*-1 General Aviation Trainer simulates the performance of a typical light single-engine propeller-driven aircraft.

It is equipped and performs like a real airplane. Students working the controls feel the actual motion of climbing, diving, turning and banking. All maneuvers are faithfully reflected by the cockpit instruments.

This realism is further enhanced by the sound of the engine, the swish of the slipstream and the screech of the tires touching the runway. Students are even jolted by "rough air."

Thanks to a built-in solid-state computer, the GAT-1 General Aviation Trainer performs realistically in response not only to all pilot controls but also to atmospheric, aerodynamic and ground effects introduced by the instructor.

It provides instruction in takeoffs, stalls, traffic pattern flying, landings, radio navigation, instrument approaches, communications and emergency procedures. Automatic radio aids permit solo instrument practice.

The GAT-1 trainer is mounted on a three-degree-of-freedom motion system, providing pitch, roll and yaw. All three axes of motion can be selected individually, enabling students to master one maneuver element before proceeding to the others and eventually coping simultaneously with all three.

GAT-1 trainers have become increasingly popular in high schools and colleges, not only to teach flying but also to motivate students to master related subjects such as astronomy, mathematics, physics, electronics and computer technology. They also are used by aviation research institutes, commercial air carriers, the U.S. armed forces, the U.S. Federal Aviation Administration and a number of other military agencies and governments around the world.

GAT-2 Flight and Navigation Trainers

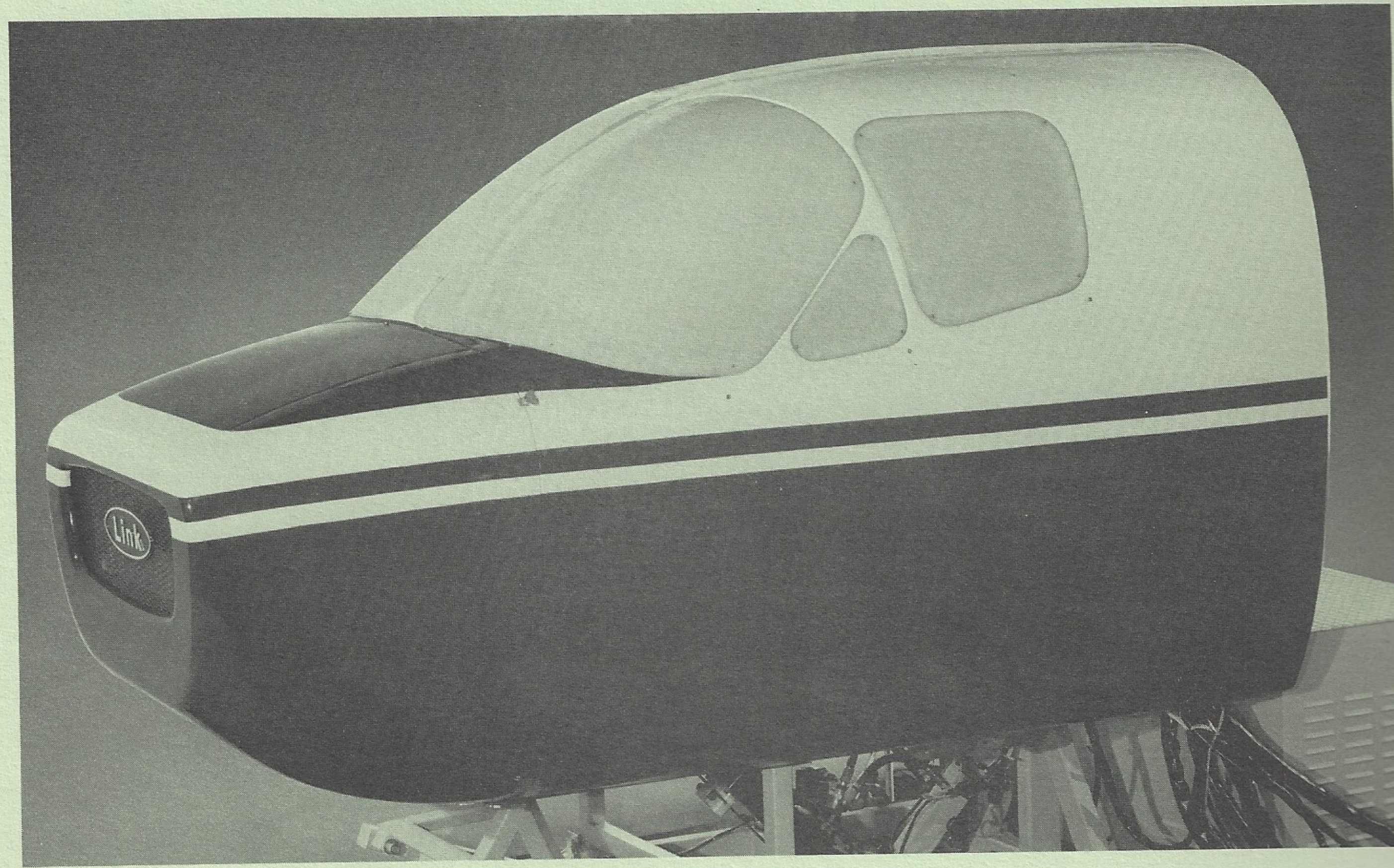
GAT*-2 Flight and Navigation Trainers simulate twin-reciprocating-engine aircraft.

Each trainer is configured to meet training requirements for a particular type; the one shown here was designed for the Argentine Army's T-42A.

GAT-2 trainers simulate flight, engines, aircraft systems, environment and radio communication/navigation. They are intended for use in a variety of training programs, including multi-engine familiarization and handling, navigation and communications procedures, instrument approaches, basic instruments and emergency procedures.

The trainers can be operated solo, with the trainee in the left seat, or dual, with the flight instructor in the right seat.

The design features complete solid-state electronics, microcircuitry and plug-in printed circuit cards. This modular approach facilitates maintenance and modification.



*A Trademark of THE SINGER COMPANY

Helicopter Operational Trainer

The Helicopter Operational Trainer (HOT) develops the basic skills necessary to control a typical single-rotor helicopter.

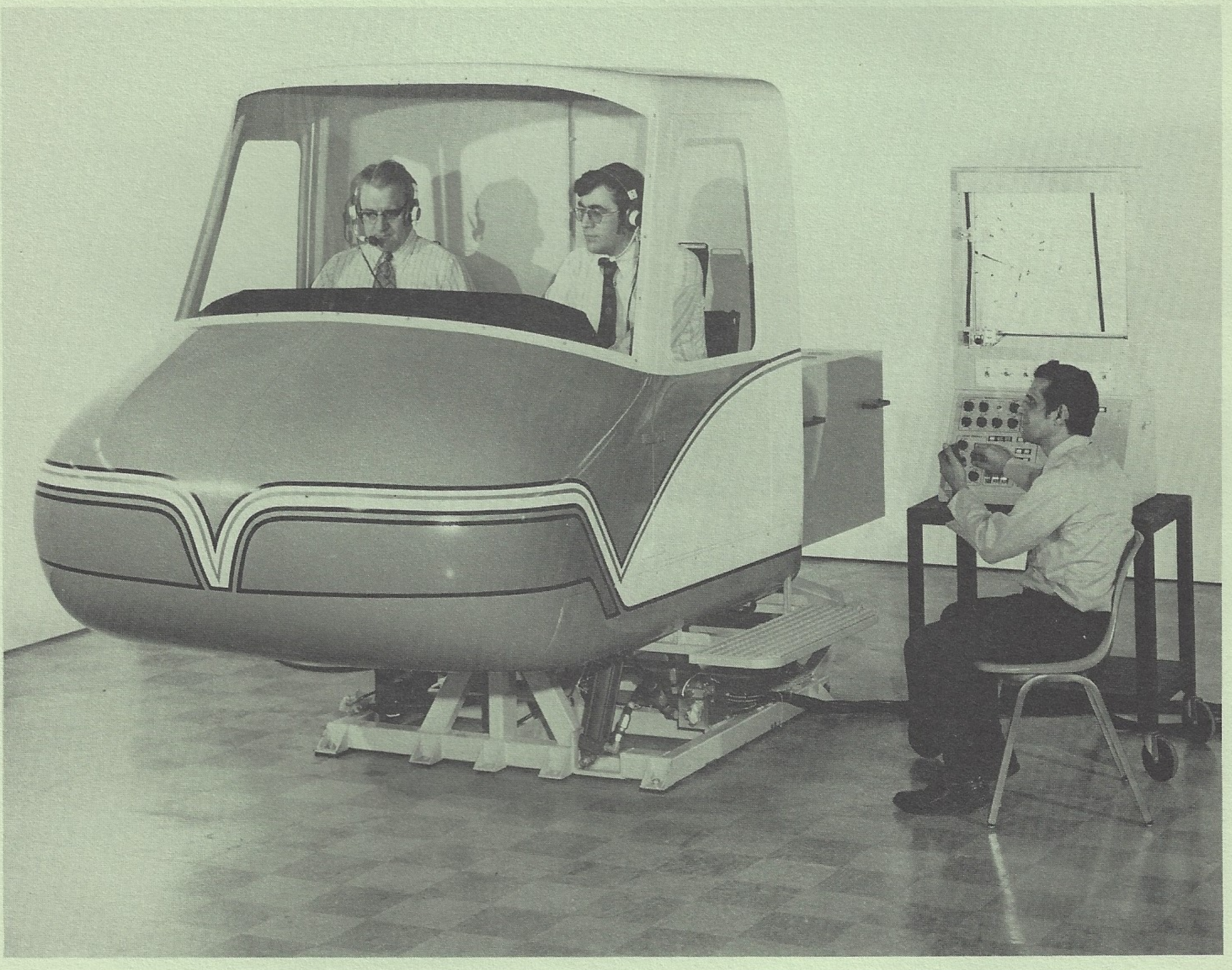
In its basic configuration, the trainer consists of a cockpit with a simulation computer mounted on a two-axis motion system. The instructor rides in the cockpit as he would in an operational helicopter.

Trainees learn to control the aircraft during take off, hovering flight, transition to and from hover, forward and backward flight, and landing. A single set of flight instruments is provided for the trainee and dual controls (cyclic, collective and directional) are furnished for both the student and instructor.

Motion cues consist of pitch and roll movement, plus the effects of rough air, landing impact and rotor-induced vibration. Sound simulation duplicates engine and transmission noise under varying load conditions.

Optional equipment includes a complete radio aids package, additional flight instrumentation, a remote instructor station, and a relative motion display system. The radio aids option comprises NAV/COMM, VOR/ILS, ADF, a ground path recorder and 16 simulated radio facilities, adding cross-country instrument flight to the training capability.

Engine and flight handling characteristics can be programmed for either reciprocating or turbine-powered engines and simulation fidelity extends even to the effects of mechanized coupling to the rotor system.



Naval and Maritime Training Systems

Nautical training systems are becoming increasingly indispensable as vessels become larger and more complex.

Today's ships rival many industrial plants and aircraft in complexity and sophistication. Fast-paced naval and maritime technology has spawned such advancements as nuclear and gas-turbine drive, electronic fire control, automated bridge control, and automatic cargo handling—all of a complexity undreamed of a few years ago.

These advancements require operational personnel with highly developed skills—skills difficult to acquire by hit-or-miss shipboard training. The solution is shore-based training on simulation devices which realistically duplicate at-sea experience.

Cargo Operations Training Systems

The high level of skill required to handle today's large shipboard cargos, both dry and liquid, can be attained by using *Link** simulation systems.

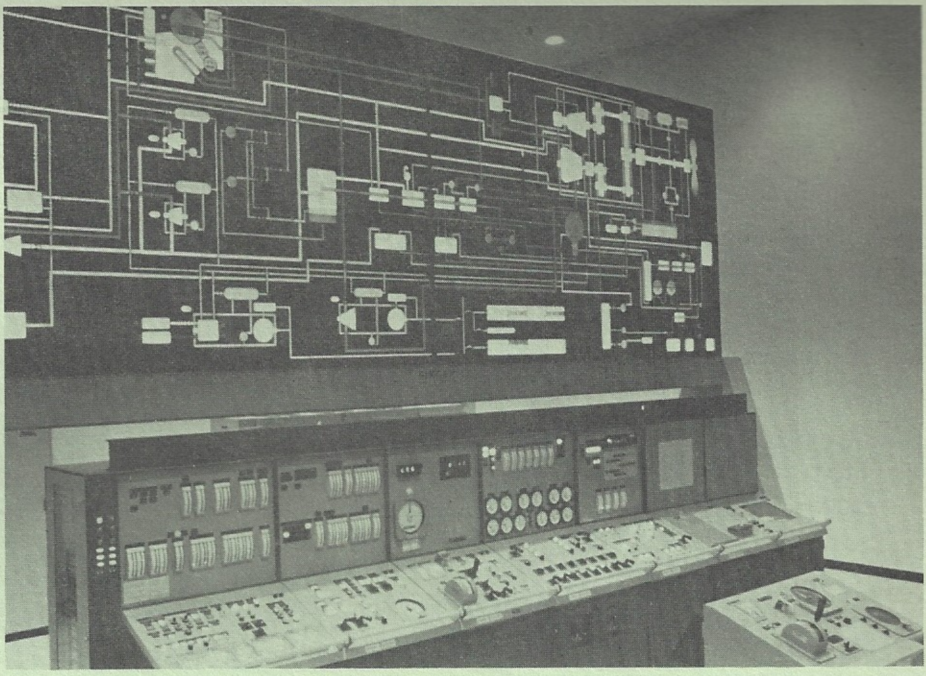
Such training is invaluable as a means of reducing the likelihood of operational errors, which can be extremely costly, as for example oil pollution accidents.

The Liquid Cargo Operations Trainer (LCOT) permits deck officers to practice handling methods and emergency procedures safely and to learn the consequences of improper actions.

The LCOT simulates a hypothetical tanker with a configuration of cargo tanks and piping designed to assure maximum flexibility of the training system.

Individual students develop operational skills by practicing normal and emergency procedures in real time. A large group of students can monitor the training exercises by watching an animated pictorial display board above the cargo and ballast control panel. This feature also enables the instructor to conduct group demonstrations of improper operations as well as correct procedures.

The trainer also can be used for research and development projects, such as evaluating loading plans for specific ships or analyzing ship construction plans.



Ship Propulsion Plant Simulator

The primary purpose of the Ship Propulsion Plant Simulator is to upgrade deck officers' knowledge of modern automated ship propulsion systems and to help engineering officers learn to efficiently operate and troubleshoot a modern automated propulsion system.

Systems and effects simulated include:

- Boiler system and associated components.
- Propulsion system and associated components.
- Service systems.
- Component effects on systems operations.
- Interaction between systems.
- Alarms (causes and effects).
- Malfunctions (causes and effects).

The major components are:

- Bridge and engine room consoles.
- Pictorial display board—animated schematic representation of monitored systems.
- Instructor's trainer control box.
- Hybrid simulation computer.

Collision Avoidance Radar Simulator

The Collision Avoidance Radar Simulator (CARS) is designed to train Merchant Marine deck officers in radar usage for piloting. It has eight trainee cubicles and two instructor consoles.

Each trainee cubicle contains two pedestal-mounted radar displays, an own-ship control console, two plotting tables and a reference table. The equipment is arranged to represent the area of a ship's bridge or wheelhouse.

Both instructor consoles are mounted in modular racks which serve two specific purposes:

(a) House computer interface equipment, power supplies, and logic units required to simulate operational radar equipment or drive meter-movement-type indicators at the trainee stations.

(b) Provide the instructor with control and monitoring panels as well as a suitable writing shelf.

The instructor's pedestal mounted radar display unit enables him to monitor any of the trainees' radar displays.

CARS' features include:

- Eight independently maneuverable own-ships.
- Eight target vessels, maneuverable either by the instructor or automatically by computer.
- Seven programmed harbors: New York, San Francisco, Dover Straits, Rotterdam, Atlantic approach to Panama Canal, Yokahama and Chesapeake Bay entrance.
- Unlimited open sea gaming area.
- Eight relative and eight true motion 16-inch PPI and two relative motion 12-inch PPI radar displays.
- Ship's horn simulation for signalling.
- Ship to ship and ship to shore VHF communications.

Collision Avoidance Radar Trainer

The flexibility of Link design is evident in this system which was updated to include LORAN, ADF, and RDF two years after its installation. The updating was accomplished merely by programming the computer and adding only the hardware necessary to control the new training problems and to interface with the new training stations.

Major components of the Collision Avoidance Radar Trainer (CART) are:

Instructor Station

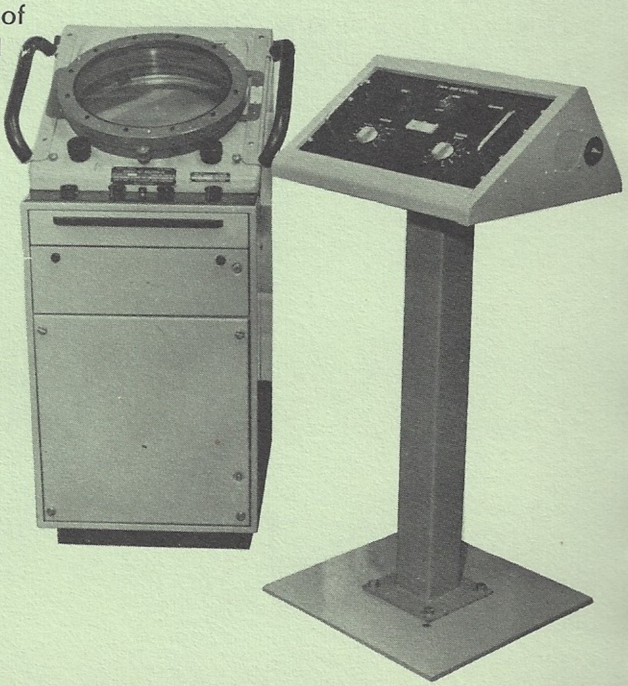
- General purpose digital computer.
- Training problems controls located on front of interface equipment cabinet.
- Tape reader and ASR-33 computer terminals.

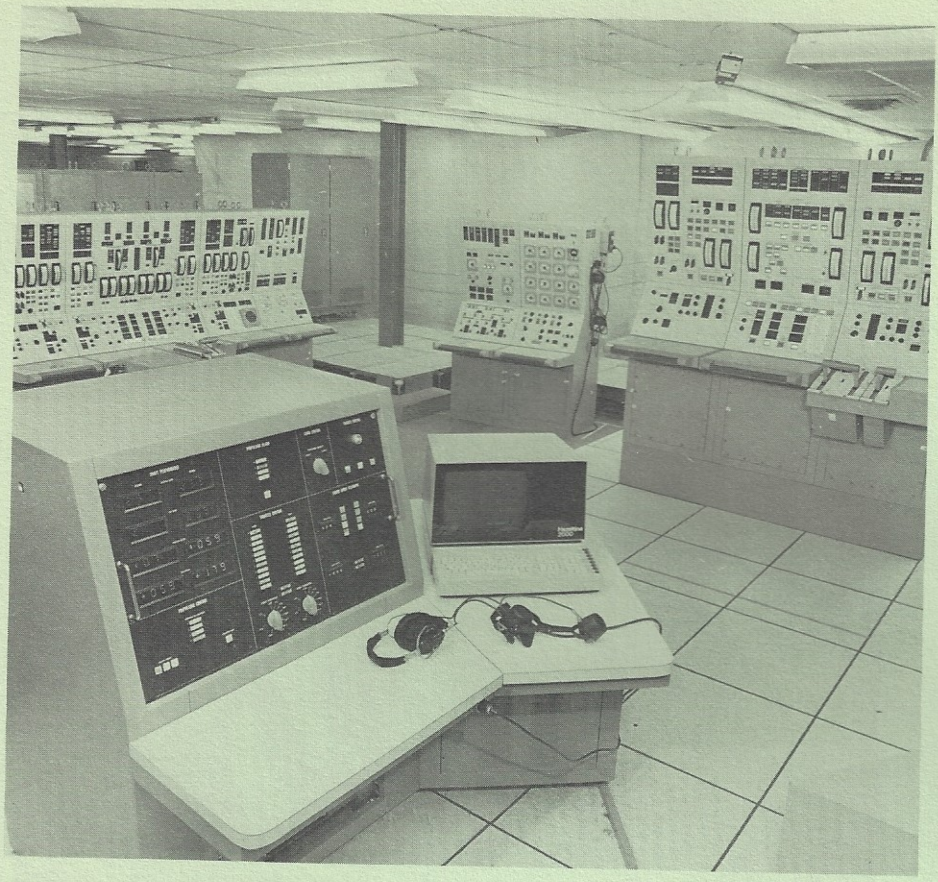
Radar Trainee Stations

- Two own-ship radar PPI displays.
- Four PPI repeaters (two slaved to each own-ship PPI).
- Two own-ship maneuver control panels.
- Plotting tables adjacent to all six radar displays.

Electronic Navigation Trainee Stations

- Two LORAN A receivers.
- Four receivers capable of receiving both LORAN A and C signals.
- Four RDF receivers.
- Two ADF receivers.





Central Control Station Operator Trainer

This system is a versatile expandable training complex for engine control room personnel of the U.S. Navy's DD963 destroyers.

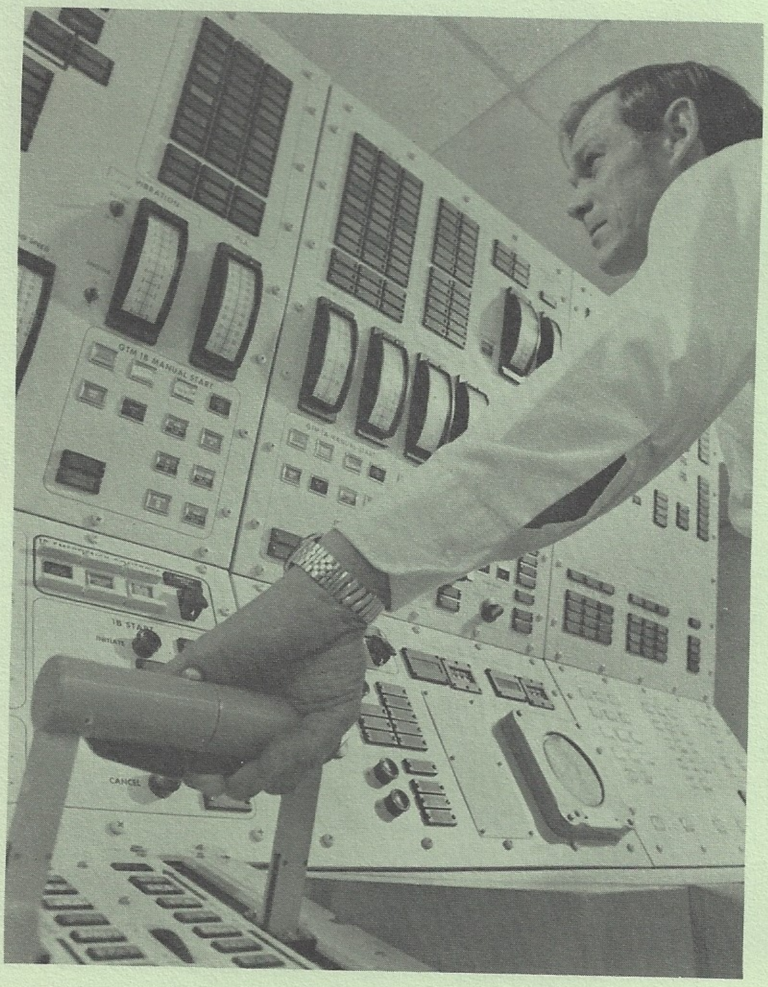
It provides real-time simulation of normal and emergency conditions for the DD963 engine performance, ship systems and environmental effects.

To assure that the training system can be changed to meet requirements of the developing DD963 operational system, the simulator employs one of the most advanced minicomputer designs in the industry.

The trainer simulates both the port and starboard engine rooms and the four gas turbine engines.

Ship systems which are simulated include:

- Ship dynamics.
- Bleed air system.
- Combustion air system.
- Compressed air system.
- Electric plant turbines (3).
- Electric power generation.
- Electric power distribution system.
- Reduction gear, brake and clutch system.
- Shaft and bearings system.
- Variable pitch propeller system.
- Fuel oil system.
- Lube oil system.
- Throttle control systems.
- Waste heat boiler system.
- Distillation system.
- Sewage system.



Danish Navy Tactical Simulator

A complex naval tactics simulation system was designed by Link for the Royal Danish Navy. It provides training in radar interpretation and navigation, plotting and navigation decision making, communications procedures, target and weapons selection, tactics procedures and tactics decision making.

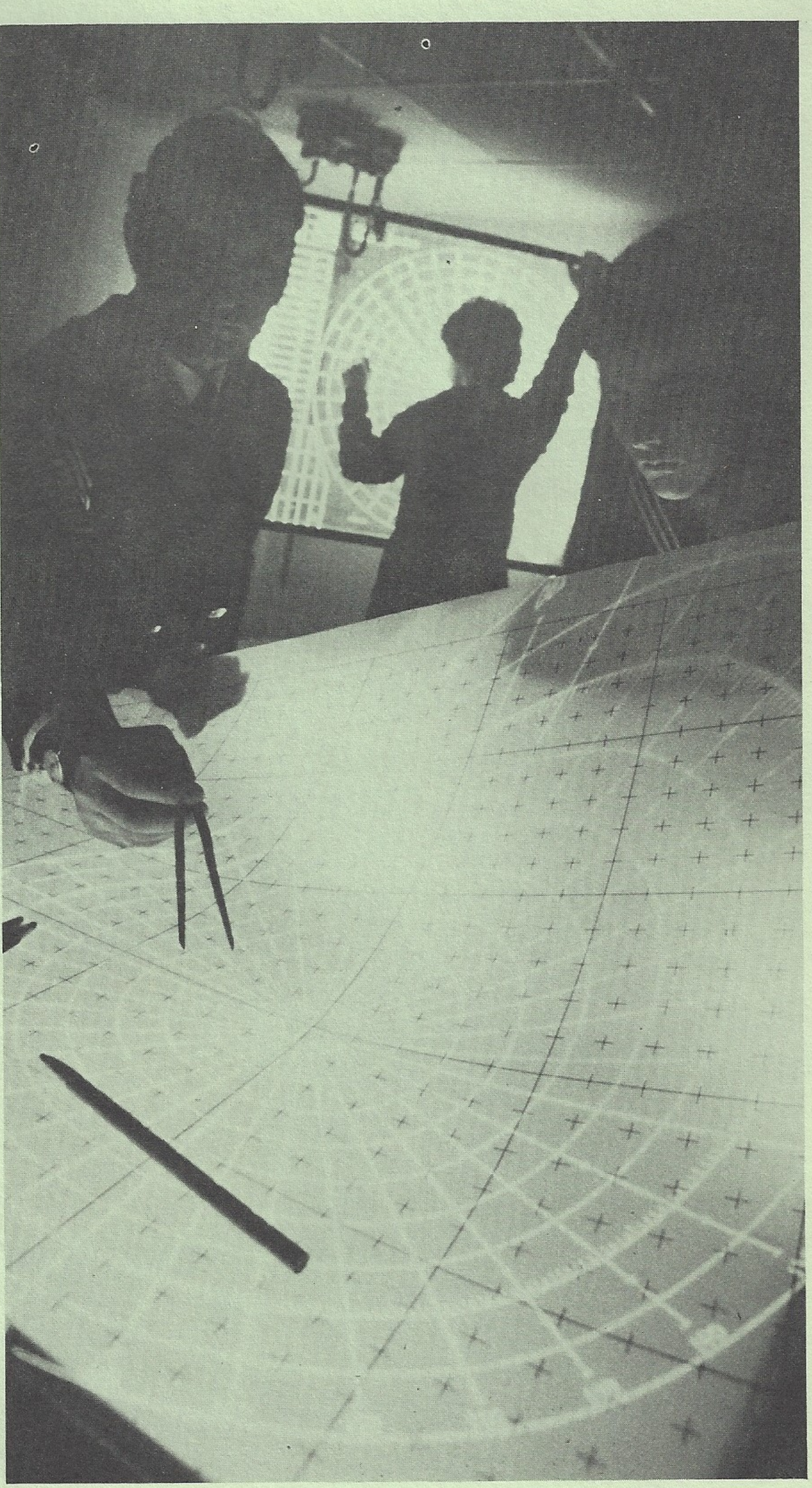
Major components of the simulator complex include:

- Twelve own-ships CIC/operations room cubicles.
- Two maritime headquarters (MHQ) cubicles.
- Exercise control and analysis facility.
- General purpose computer complex.

The computer complex determines the dynamics and relative positions of all targets and own-ships and generates all coastline, target, and IFF/SIF radar video in response to input data from the own-ship cubicles and MHQ's. Target and own-ship position computations and radar range resolution of coastline video are accurate within 50 yards.

This system once again demonstrates the flexibility of simulation as a training tool. It provides 48 targets, each of which can be designated as a frigate, mine-layer, patrol vessel, submarine, helicopter, fighter bomber or guided missile.

The system later was expanded to provide SONAR training against a variety of submarine and surface targets. This training can be conducted separately or as an integral part of the full simulator operation.



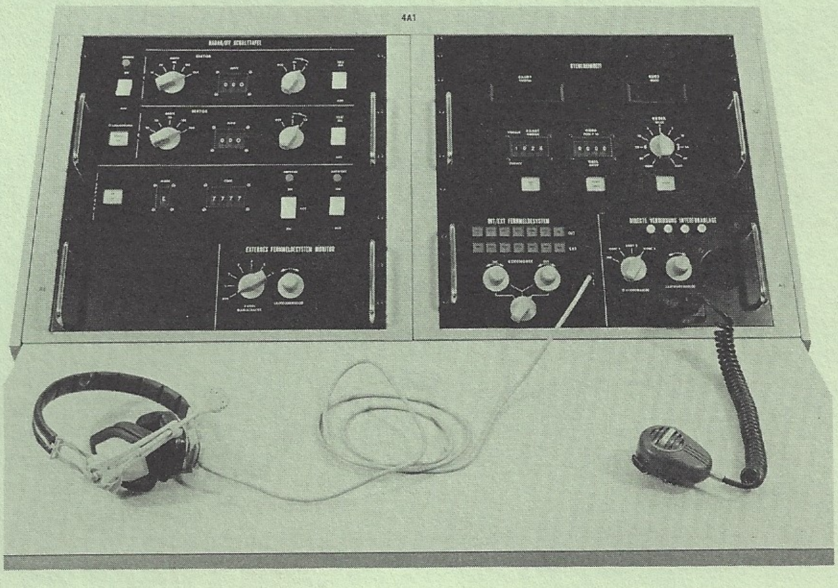
Naval Tactics Procedure Trainer

The mission of this system, designed and built for the defense forces of the Federal Republic of Germany, is to train Combat Information Center Teams in tactical procedures using radar and other sensors. The trainer consists of nine rooms: six cubicles configured as own-ship student stations, an auditorium which serves as exercise control center, a simulation equipment room and a power equipment room.

The training system is driven by a high-speed digital computer which provides the flexibility of real-time change and periodic updating. Digital simulation includes radar returns from shoreline, targets, and own-ship vehicles.

The broad simulation capability includes:

- Six own-ships of eight different types, which can be designated as underwater, airborne or surface vehicles.
- 57 targets of eight different types—underwater, airborne or surface.
- Gaming area: 200 x 200 nautical miles.
- Full capability for free maneuvering of all ships simultaneously in the gaming area.
- Radar coastline detailed for five harbor areas on the North Sea coast of Germany and the Baltic Sea—with the capability of simulating any other gaming area in the world.
- Maneuvering of ships individually, in convoys, or under preprogrammed control.
- E and I Band radar.
- ECM detection system.
- True and relative motion radar displays.
- Plotting table drive system.
- Six-channel, two-net communication system.
- Six-channel internal communications system.
- Direct line instructional intercom system.



Action Speed Tactics Trainer

The Action Speed Tactics Trainer was designed and built by Link for the defense forces of the Federal Republic of Germany.

The ASTT trains Combat Information Center command teams in decision making during tactical situations. It also can be used to develop new tactics for projected weapon systems and ships.

The trainer is comprised of 17 rooms, 14 of which are cubicles containing control, display, and communications equipment for each of 14 CIC's. One room is configured as a Maritime Headquarters (land-based) and the remaining two rooms are for computing equipment and an auditorium/control room area.

The system is driven by a high speed digital computer complex which provides the flexibility of real-time changes and periodic updating.

Also provided is a color large screen display system with exercise record and playback capability. An alphanumeric display system with keyboard is used for problem control and monitoring and for own-ship, weapon and sensor control. A tactical display system with alphanumeric and graphic capabilities is provided for the presentation of tactical situation information for the game players.

The system generates and presents tactical information on the cubicle displays for appropriate action by the command team members. The team members' decisions are implemented by manipulation of the control provided and by entering reactions on the alphanumeric display and tactical display keyboards. The system reacts in real time and adapts to the changing situation accordingly, presenting new situations and information realistically. This sophisticated display system includes a total of 38 tactical displays and 64 alphanumeric displays.

Training in modern shipboard electronic data handling ships operations is implemented with computer data link simulation. Essentially each ship simulated may be set up to have its own simulated data handling onboard computer.

The simulation provided includes:

- Fourteen own-ships of a wide variety of types including submersibles and airborne vehicles as well as surface vehicles.
- One hundred twelve targets of a wide variety of types submersible, airborne and surface.
- 1024 x 1024 nautical mile gaming area.
- Full capability for free maneuverability of all vehicles (own-ships and targets) simultaneously throughout the entire gaming area.
- Maneuvering of vehicles individually or under pre-programmed control.

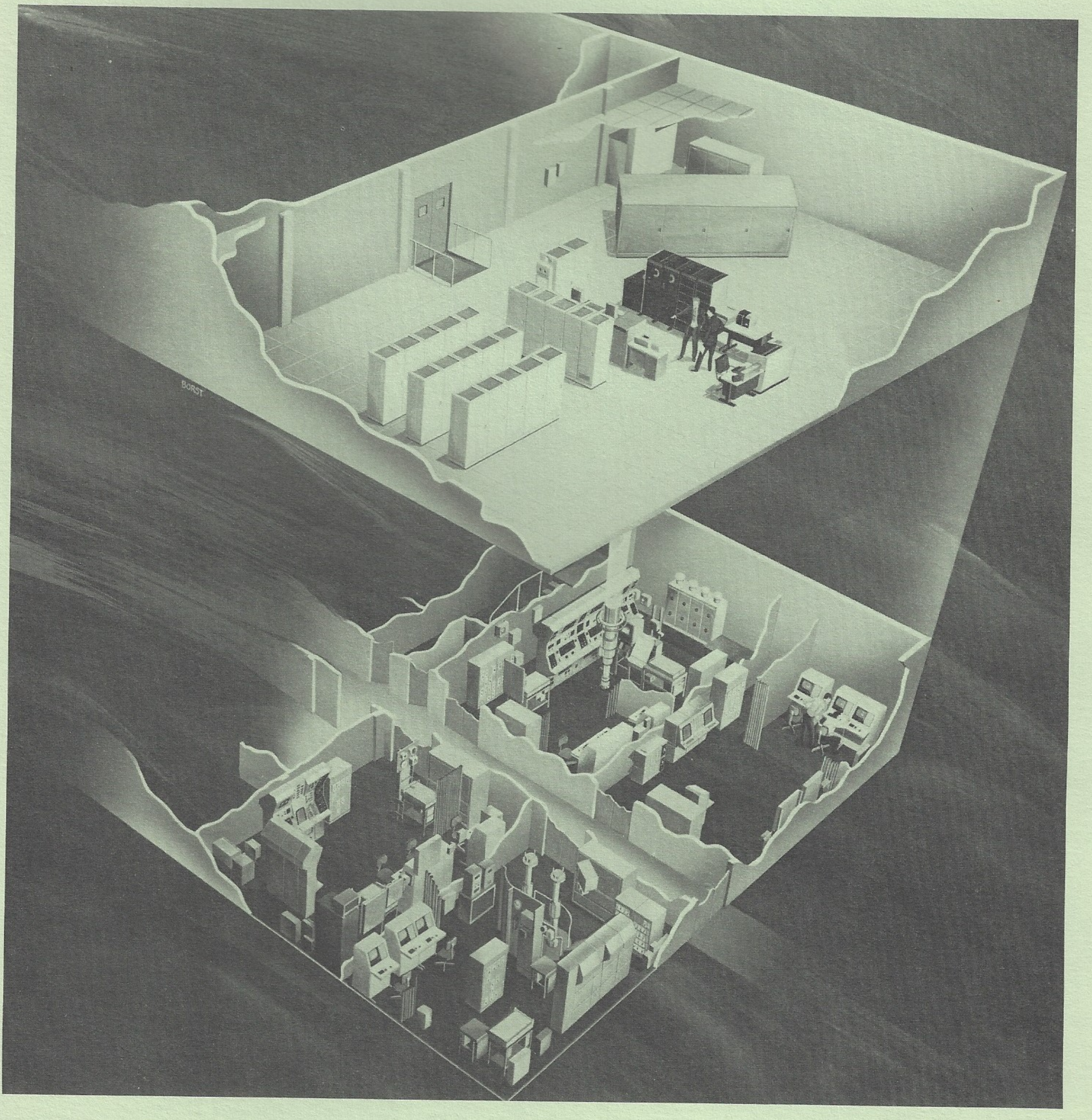
Submarine Trainers

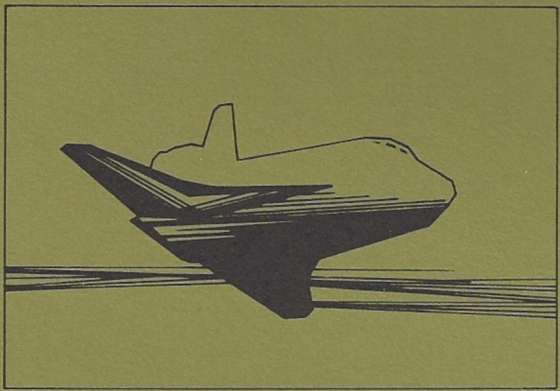
Link was awarded a contract to design and build a submarine simulator for the Norfolk Naval Base.

The simulator is to enable the U.S. Navy to train submarine crews in both offensive and defensive tactics, including the firing of torpedoes, evasive maneuvers and use of sensor equipment.

It features *Link** real-time digital signal processing and target modeling techniques whereby tactical problems are duplicated with utmost realism.

Link also was asked to modify and upgrade a training complex, encompassing four attack centers, at the Submarine School in New London, Conn. The work was planned so as to avoid major interruption of training schedules.





Visual Systems

Visual cues play a major role in providing realistic effective training.

Link has been producing visual display systems of varying types and complexities since 1942.

The earlier systems included:

- ☐ All-Electronic Night Landing System
- ☐ Day/Night Visual System (SMK-23)
- ☐ Airborne Fog Simulator
- ☐ Tactical Avionics System Simulator
- ☐ Mark IV and Mark V closed circuit television systems
- ☐ VAMP* Variable Anamorphic Motion Picture system

Recently Link introduced *Visulink** Visual Display Systems, significantly advancing the state of the art.

Link's diversity of experience provides a solid foundation of expertise for meeting today's increasingly complex visual requirements.

VISULINK Visual Display Systems

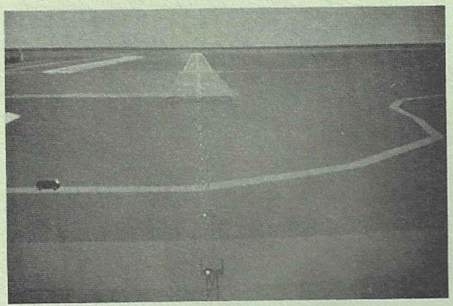
Visulink Visual Display Systems encompass a broad spectrum of visual simulation. They are the largest family of such systems available, with one to meet everyone's training requirements.

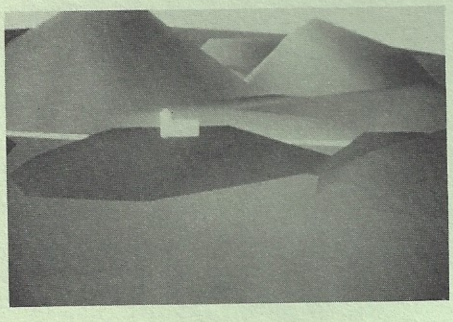
The basic components of the *Visulink* family are:

*Visulink** Full/Scan Digital Image Generator. It furnishes computer-calculated imagery faithfully representing the view from any aircraft or other vehicle—from submarine to satellite.

*Visulink** High Resolution/Camera Model Visual Display System. This employs a large terrain model and closed-circuit color television to furnish infinity displays which are strikingly realistic, even at close range.

*Visulink** Point/Scan Night Visual System. It employs more than 6,000 light points to furnish computer-generated night scenes in color.





VISULINK Full/Scan Digital Image Generator

The *Visulink* Full/Scan Digital Image Generator System (DIG) produces 1,000-line computer-composed color scenes for a wide range of training applications.

Thanks to the flexibility of digital technology, DIG is capable of generating a wide variety of operational views, involving not only aircraft but also other vehicles, including ships, submarines, tanks and spacecraft. Virtually all applications for visual systems in the training environment can be supplied by DIG.

Used with aircraft simulators, such as U.S. Air Force F-111's, DIG can perform such demanding tasks as low level flight over rolling countryside, with terrain avoidance and terrain following.

It also is being used for such sophisticated assignments as the U.S. Space Shuttle simulator where it depicts the earth below, the payloads in the cargo bay and the operation of the remote manipulator arm.

DIG works from data bases which can be readily modified, thanks to a built-in update capability. The data bases contain the locations of edges of such objects as aircraft runways and their markings, buildings, roads, rivers and fields. DIG constructs scenes in which the objects are fully colored in and displayed in perfect perspective as the onlooker moves through the scene.

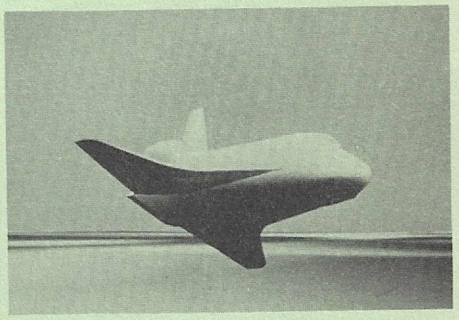
Operating in "real time," DIG can react to changes in the pilot's path in as little as 1/16 of a second, producing visual scenes with the same 30-per-second frame rate as commercial television.

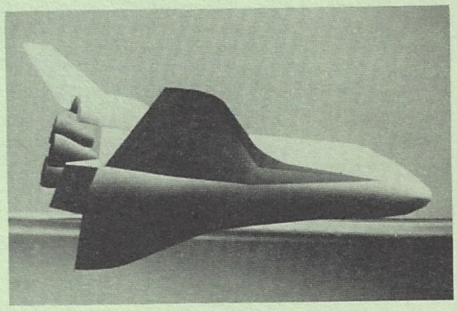
Although objects are described by edges, they need not look flat-faced. A smooth-shading feature blends the intensities across objects, imparting a delicately varying shading which changes the flat facets into a single smooth rounded contour.

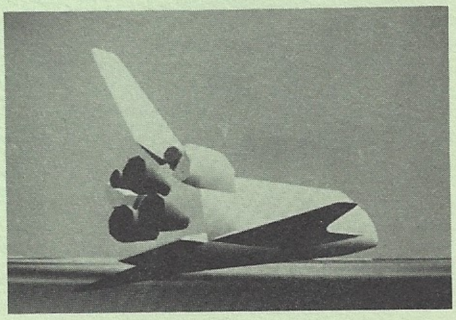
Objects respond to the illumination of the "sun," brightening on the side toward the light and darkening on the opposite side. As the sun or object moves, the shading shifts appropriately. When one object goes behind another it is hidden just as it would be in real life.

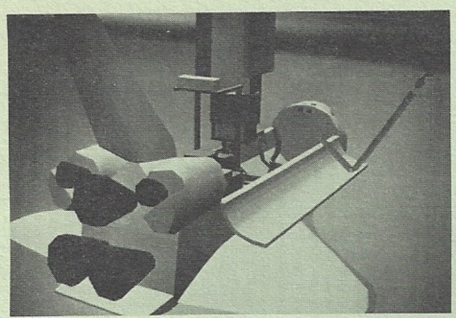
DIG can show not only solid objects but also point lights, which can be made to flash, rotate, strobe or be seen from only one direction; two-dimensional ground patterns; and even fine lines. All retain their continuity and shape as they recede into the distance.

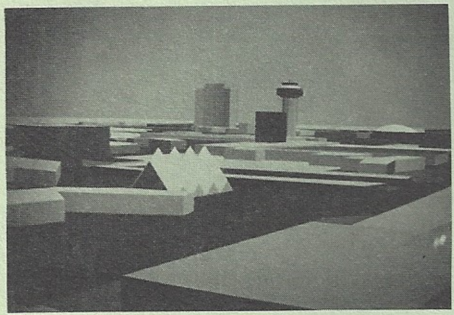
Realistic visibility effects can be introduced. The scene can be immersed in fog or haze, of desired densities, which makes them fade away into the distance. Cloud tops and bottoms can be simulated, along with the "breakout" that a pilot experiences as he drops beneath the cloud bottom. Distinct individual clouds can also be modelled, including towering cumulonimbus or thunderheads. All retain their shape and identity as the pilot flies toward them and then into them, with appropriate white-out effects. →











Perhaps the most outstanding feature of DIG is its high scene density. This advantage is especially noticeable in the presentation of cultural detail, such as that representing a high population area. This ability to process dense scenes is backed up by a magnetic disk access system that allows scene detail to be picked up gradually as the pilot flies along and dropped as it falls behind him, so only that detail in the immediate viewable vicinity loads the system.

DIG also has provisions for combatting the distracting effects commonly observed with computer image generation systems. Edge smoothing, both horizontal and vertical, is employed to eliminate the rastering or shearing noticeable in early systems as objects move past television scanlines. Anti-scintillation methods are employed to reduce the breakup of fine lines and small, pinpoint objects, which ordinarily tend to flicker and pulsate as they move through scanlines.

DIG can generate more than a million picture elements—each with its own color and shading—in each scene. To do this at the normal rate of 30 television frames a second requires extremely fast circuits in the final stages of the process, when picture elements are produced at the rate of one every forty-millionth of a second.

VISULINK High Resolution/Camera Model Visual Display System

The *Visulink* High Resolution/Camera Model Visual Display System capitalizes on the latest technological advances in the field of electro optics to meet the most exacting training requirements.

Unlike conventional systems which use commercial low-resolution television cameras and displays and terrain models which lose realism at close range, the *Visulink* system produces highly realistic scenes regardless of altitude.

This is accomplished by using a high-detail terrain model scanned by a high resolution color camera coupled to a wide angle, servo-driven Scheimpflug-corrected optical probe specifically developed for this system.

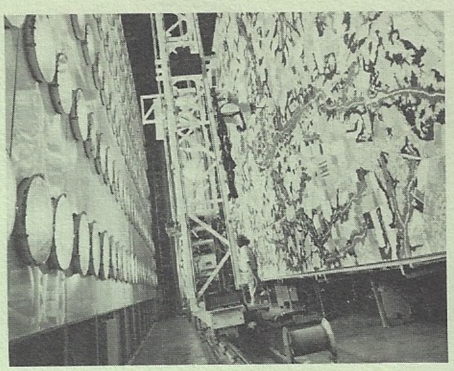
The model board is fashioned painstakingly, with rigorous adherence to correct scale factors so trainees can properly judge altitude, altitude rates, slant ranges, closure rates, etc.

Latest high fidelity modeling techniques produce exceedingly accurate detail, making the system well suited for helicopter training—including nap-of-the-earth operations below tree-top level.

A high scale factor, such as 1,500:1, increases the flying area without sacrificing detail—even individual trees stand up to close inspection.

Instructor controls permit adjustment of terrain model illumination to simulate day, dusk or night.

To meet exacting training requirements Link developed a highly sensitive, high resolution TV camera. It uses three SEC vidicons to provide relatively low resolution color information and a new two-inch intensified vidicon to provide high resolution luminance information. The use of four image-tubes minimizes misregistration problems and reduces the number of wide bandwidth channels to one, thereby increasing system reliability. The result is a cost effective color camera which requires less day-to-day maintenance than conventional three-tube cameras.



The high resolution television chain generates approximately 960,000 picture elements—four times as many as conventional systems—greatly increasing the ability to display imagery of high clarity and detail.

Contributing to this clarity is the optical probe which employs a complex and highly advanced system of optical correction, known as Scheimpflug. This preserves sharp focus down to simulated eye heights of 10 feet and permits "flying" close to vertical objects. The system is so flexible that it can operate in rugged, high-relief terrain, with sharp elevation changes of as much as 1,500 feet.

Aircraft attitudes are simulated by the probe; e.g., pitch is represented by tilting a mirror at the probe's entrance pupil and heading is simulated by rotating the pitch prism about the optical axis.

Each pilot's window has a color CRT monitor viewed through a beam-splitter and spherical mirror; the latter collimates the images so the scene appears to be at infinity throughout the range of normal head movement.

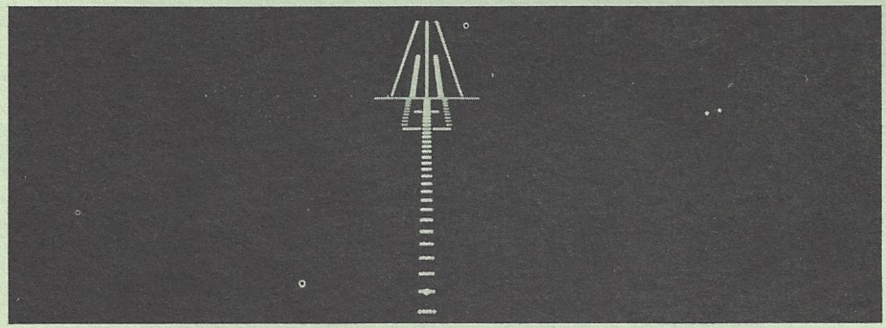
The system is used by the U.S. Air Force and U.S. Army for training fighter and helicopter pilots.

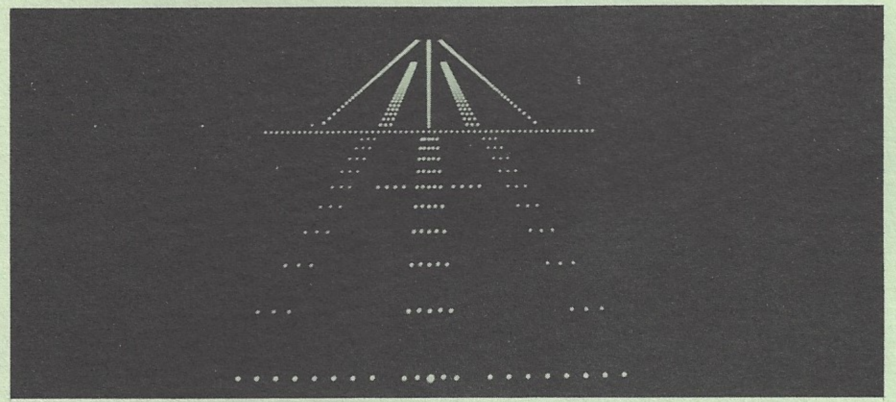
VISULINK Point/Scan Night Visual System

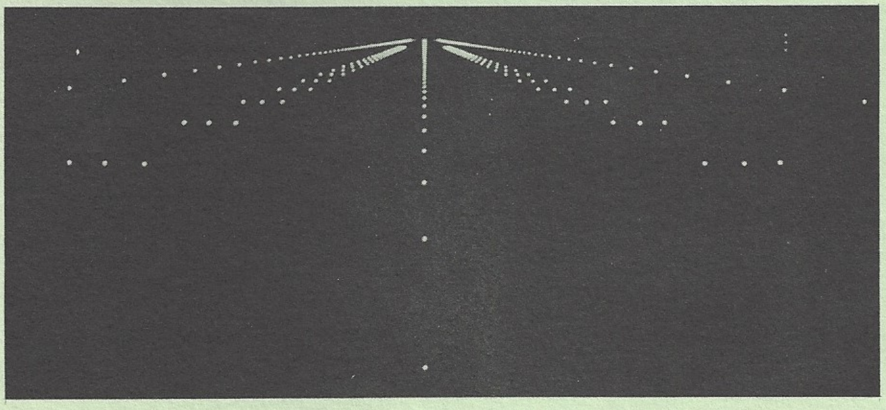
The *Visulink* Point/Scan Night Visual System (NVS) is a compact simulator attachment which provides computer-generated night scenes in full color. NVS presents a complete night visual operating environment, including a realistic dynamic representation of the landing light lobe area of coverage.

The system incorporates technological advances which make it twice as bright as other computer-based night visual systems.

The visual image is further enhanced by the fact that the picture has an update speed of 30 cycles per second which makes flickering virtually imperceptible.







Various airport scenes are furnished through computer programming. Enhancing the scenes are a realistic horizon glow and as the simulator approaches the touchdown point the runway surface texture and markings become visible.

Limited visibility and cloud effects can be inserted by the instructor. Light simulation includes real-world effects such as bi-directionality, strobing, flashing and rotation.

The system makes provision for 16 on-line data bases, each with a capacity of more than 6,000 light points in seven colors. The data bases are stored on "floppy" disks, accessible in less than two seconds.

Additional data bases, on punched cards which are easily loaded, can be obtained from the Link library. New data base masters for any airport can be custom made by Link or the user can create his own, with the aid of computer input devices and suitable source data.

The card reader supplied with the basic system allows the user to modify or update each airport scene.

Each data base permits location of light points anywhere within an area of 170 by 170 nautical miles, making possible extensive lighting surrounding the airport.

Each airport data base can be assigned to any ILS/GCA radio facility within the simulator computer; selection of an airport ILS channel therefore automatically calls up the correct visual scene.

NVS is modular so the basic two-window system can easily be expanded to as many as eight windows, providing side-window visual scenes for circling maneuvers and special vertical/horizontal configurations for helicopters or other applications.

The system can also be used for aircraft carrier training. The surface texture of the deck is shown, along with the deck edge, centerline and appropriate shipboard lights.

NVS can be integrated with virtually any flight simulator and is being widely used by commercial airlines.

SCAMP Visual System

The SCAMP (Scanned Motion Picture) Visual System is an all-electronic version of the *VAMP* Visual System.

The SCAMP is functionally the same as its parent, using films but with color television as the display medium rather than direct optical projection.

Perspective distortion is obtained through electronic computation, substantially reducing the cost of the overall system.

The only concession made to achieve this cost reduction is in resolution. The extremely high picture quality of the optical *VAMP* system, which has a 2-3 arc-minute resolution, is reduced through use of commercial TV components to approximately 10 arc minutes—equivalent to the quality provided by commercial camera/model visual simulation systems employing color television.

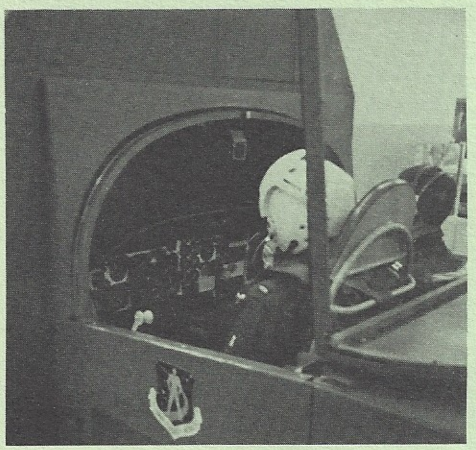
SCAMP's maneuverability is attained by taking film with wide-angle lenses which provide an 83° horizontal field of view and all of the ground imagery from the horizon to 33° below the horizon. The imagery above the horizon, held to a minimum to reduce the amount of film required, is synthetically generated to provide a uniformly lighted sky.

The film-stored field of view is used three ways:

1. To provide the imagery in the 44° by 28° field of view display.

2. To provide the imagery for vertical and lateral excursions.

3. To provide the imagery for angular maneuverability in pitch, heading and roll.



Area of Interest Visual System

The Area of Interest Visual System employs a six-window matrix of high resolution colo TV displays.

The display system encompasses a field of view large enough to contain the area of interest for most of (The area of interest is that which commands a pilot's attention during a maneuver; the AOI inset surrounds the point of interest—typically a target area or landing field.)

An infinity image provides true depth perspective and the full color allows for realistic target recognition.

The display system has the following features:

1. High resolution imagery with the AOI.

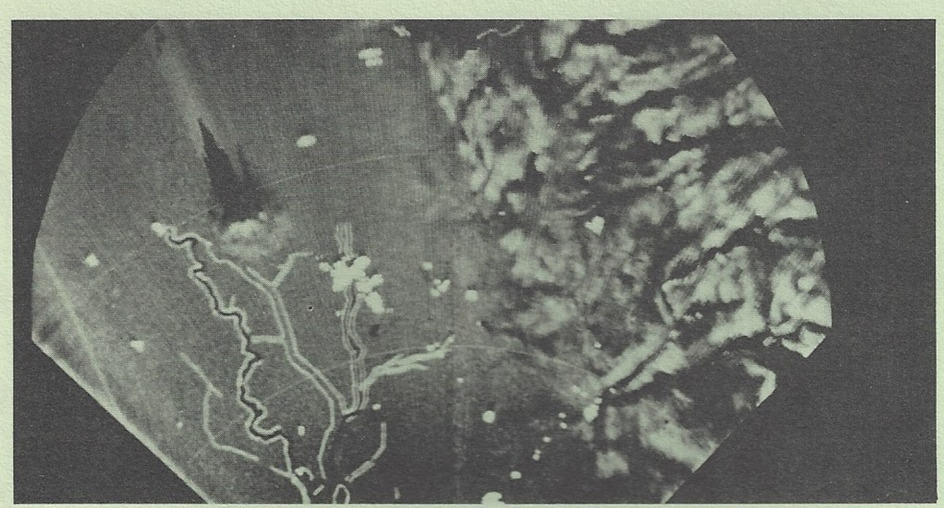
2. Capability to move the AOI anywhere within the display field of view as a function of pilot maneuvers relative to a fixed target point.

3. Peripheral imagery of comparatively low resolution in the portions of the display not filled by the AOI inset.

4. Incorporation of true perspective and motion effects into the total scene displayed.

5. Large envelope capability.

The AOI visual system can use real world film, camera model or digital computer imagery, combined with peripheral images generated by a high speed analog computer.



Radar Landmass Simulation Systems

Link has designed and built more than 100 Radar Landmass Simulators for use in military aircraft training.

Since the early 1960's Link personnel have been issued numerous patents in connection with research and development work in this highly specialized field.

After producing scores of analog radar landmass simulators, and after more than six years of research, Link developed the world's first digital radar landmass system. The new system generates radar imagery by real time computation instead of using film or terrain models as in previous systems. This method affords unlimited freedom of maneuver within the simulated operating area, encompassing thousands of square miles. Acquired from aerial photographs, the digital data needed to represent the operational area approximates one billion bits.

Another advantage of this system is that it has a built-in update capability. If a change occurs in the actual terrain being simulated—for example, a bridge is erected—the computer can be reprogrammed within minutes to include a representation of the span.

The simulated images represent a composite of many aspects, such as effects of shadowing, earth curvature and refraction, and range and atmospheric attenuation—just as in the real world.

The first such simulators were built for the Grumman Aircraft Corp. for use with an E-2C trainer and for the German Air Force, as part of Link-built F-4F Weapons System Trainers.

FLIR/LLLTV

Link conducted a simulation study for the U.S. Air Force on Forward Looking Infrared (FLIR) and Low Light Level Television (LLLTV).

Link developed an all-digital in-house FLIR and LLLTV laboratory model simulation system which operates in real-time from a data base transformed from Air Force Project 1183.

The system uses line segments and points to encode an infrared spectrum representation of the operating area for FLIR simulation and a visible spectrum representation of the operating area for LLLTV simulation. All-digital storage retrieval and processing are used for both.

Resolution as fine as 50 feet has been demonstrated in the digital image generator system. Finer detail can be encoded and processed.

Earlier Link developed a FLIR/LLLTV/RADAR part-task trainer which computes synthesized sensor imagery from aerial photographs on film strips. Different fields of view are simulated by changing lenses in the flying spot scanner optical system.

Project 1183

Link developed a special Digital Radar Landmass Simulator (DRLMS) for research by the Aeronautical Systems Division at the Tactical Air Command, Nellis Air Force Base.

Called project 1183, this DRLMS is used not only for training but also as an engineering-development test bed for radar simulation requirements on future Air Force systems.

It is a sophisticated special-purpose digital computer which produces simulated real-time images simultaneously on the attack radar and terrain following radar scopes of the host aircraft simulator.

The digitally encoded data base, which includes information on the earth's terrain relief and man-made features, has a built-in update facility. This feature, in conjunction with software control, permits experimentation with various combinations of source data at different resolutions.

Radar Predictor

The radar prediction system quickly synthesizes hard copy radar images as an aid to identification of targets and navigation checkpoints.

The system, operated in conjunction with a digital radar landmass simulator, uses a digital data base representative of the terrain, updating the data to reflect latest changes in terrain features.

It generates images nearly instantaneously and photographs of those images in a few minutes, in contrast to manual methods which require up to four hours.

The predictor flies a simulated mission in real time, noting positions at which hard copy imagery would be useful. It can be put in a freeze mode at any time to permit photography.

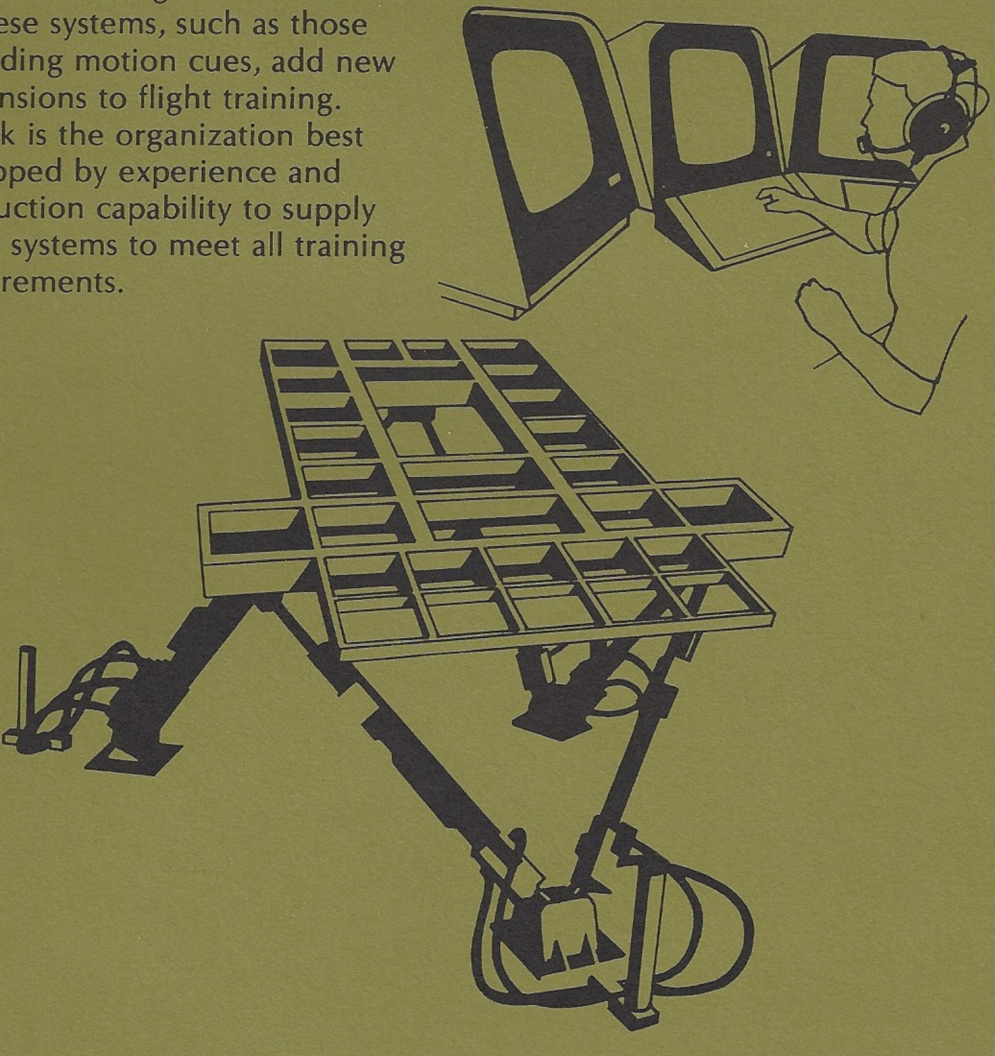
Digitally synthesized radar prediction imagery is characterized by improved realism, accuracy and repeatability as compared with earlier techniques.

Complementary Systems

The full potential of aircraft simulation can be achieved only if full advantage is taken of complementary systems which enhance training realism.

These systems, such as those providing motion cues, add new dimensions to flight training.

Link is the organization best equipped by experience and production capability to supply these systems to meet all training requirements.



Motion Systems

Motion cue generation has been an important part of flight training since the earliest days of the famed "Blue Box." The present sophisticated systems have evolved from the simple bellows type device used with the first *Link* trainers. Today's systems impart to the pilot most motion cues he will experience in an actual aircraft, faithfully reinforcing the readings of the simulator instruments. Thus a trainee "feels" and "sees" how a particular aircraft undergoes each type of maneuver.

It is generally agreed that motion cues are greatly desirable for simulator training, especially when used in conjunction with a visual system.

Of the many types of motion systems designed and built by Link the two which provide the most advanced training are the Synergistic and Cascaded systems.

Synergistic systems derive their name from Greek words meaning "working together." Half a dozen hydraulic servo actuators work in concert to provide a six-degree-of-freedom motion system which affords maximum simulation fidelity.

The actuators, in bipods joined to three floor pads, are connected at the upper end to a single movable platform. The platform is capable of simultaneous motion in six independent degrees of freedom: lateral, longitudinal, vertical, pitch, roll and yaw. These furnish trainees with acceleration cues experienced in normal and emergency flight maneuvers.

Cascaded motion systems use the "building blocks" approach. Hydraulic servo actuators provide the basic three degrees of freedom: roll, pitch and heave.

The capability of the system can be expanded by addition of modular increments. Thus customer requirements can be met for as many as six degrees.

New Synergistic System

Link has developed a six-degree-of-freedom synergistic system of an entirely new design. The result is significant improvements in performance, maintainability and safety.

The advantages include:

—Higher fidelity: The new system utilizes latest state-of-the-art components to provide higher performance parameters than conventional systems, meeting and exceeding exacting military standards.

—Improved reliability: The number of moving parts has been reduced, many being replaced with solid state electronic components, and consequently maintenance is simplified.

—Cost effectiveness: Use of standardized design and off-the-shelf parts results in lower costs, both for acquisition and upkeep.

Improvements include simplified plumbing, strengthened platforms, streamlined legs, quieter pumps and condensed electronics.

One significant technical breakthrough was development of a high-performance actuator assembly. Conventional systems had a friction problem which produced undesirable "bumps" in motion cues. Link solved this problem with a unique hydrostatic bearing which reduces static friction forces by 75%. This improves performance by ensuring smoother directional transition of the motion leg.

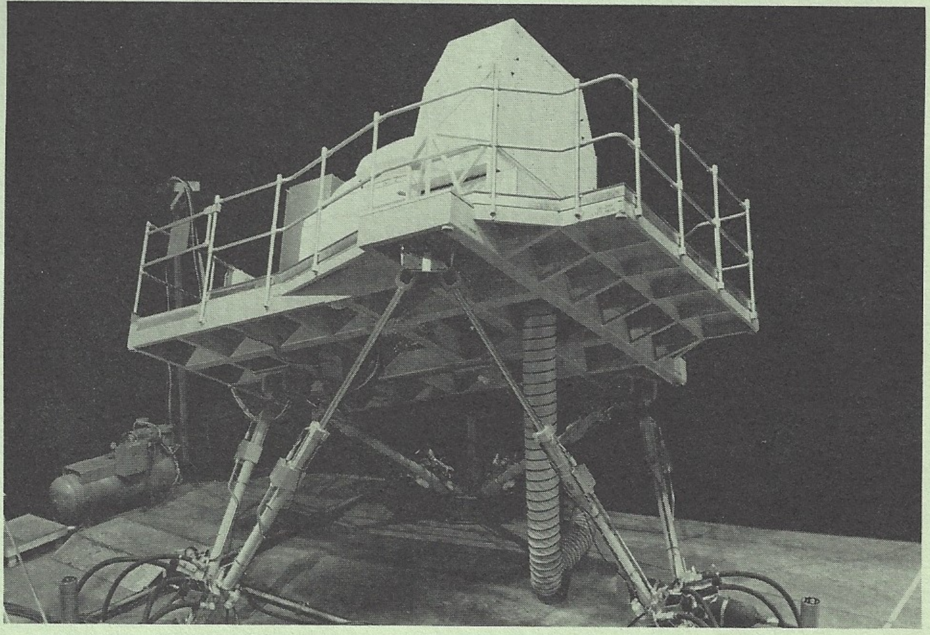
An ultrasonic linear displacement transducer eliminates all mechanical coupling and resultant play between the actuator and sensor, assuring extremely accurate position feedback.

Also unique is a major safety improvement—an ingenious device called a piccolo tube, with holes through which fluid is forced in decreasing volume as the piston moves downward. This foolproof system has no moving parts and limits maximum G forces to safely acceptable levels.

Operating pressure is considerably less than with conventional systems, permitting use of vane type pumps and significantly reducing noise levels around the motion base and in the pump room.

The plumbing has been simplified, with a 60% reduction in complexity. The motion system has a lower profile, the platform being closer to the floor because the distance between the legs has been increased, reducing forces on the actuators, joints and floor in extreme attitudes.

Electronics have been simplified and compressed so that only half a cabinet is needed instead of the customary two double-bay cabinets.



Advanced Instructor/ Operator Station

Link has developed an Advanced Instructor/Operator Station to facilitate training in today's highly complex flight simulation situations.

Through the station's keyboard and CRT's the simulator, including the visual system, can be completely monitored and controlled. Latest state-of-the-art components and techniques are utilized to provide maximum simplicity and flexibility.

The instructor is supplied with more information, with less effort and concentration on his part, than is possible with conventional instructor stations. His attention therefore can be more fully devoted to the training situation at hand and to the trainee's needs rather than operating the simulator or keeping up with the situation. This, combined with the greater amount of information easily available to him, makes him better able to utilize the simulator to its greatest capacity.

Built-in flexibility is inherent in the design of the Advanced Instructor/Operator Station. This enables users to meet constantly changing training needs and requirements and to accommodate new simulator programs without costly hardware changes.

G-Seats

Sustained G simulation is provided by cockpit G-seats.

The seats duplicate the body feel of pressure during sustained accelerations, such as turns and pullouts from dives.

The pressure is supplied by air forced into individual cells in the back rest and seat pan and along the thighs. The lap belt is also independently driven to provide cues to positive and negative accelerations.

The distribution of pressures on the surface of the pilot's body is computer-controlled to simulate his inertia as he moves during maneuvering with respect to the seat and lap belt.

Contours of the seat change to reflect even small onset cues resulting from slight aircraft movement.

G-Suits

Sustained acceleration effects also can be simulated by a G-suit system in the cockpit.

G-suit simulation provides essential cues during high G maneuvering to help prevent exceeding the aircraft operating envelope.

In an actual aircraft, G-suits exert pressure on the pilot from 1.75 G's to 10 G's. In a simulator the pilot's body does not expand into the G-suit as it does in the aircraft and therefore he is more sensitive to pressure and less is required. Pressure is supplied to the suit when the upward acceleration at the pilot's position, as computed in the equations of motion, exceeds 1.75 G, to a maximum of 15 psi.

Industrial Training Systems

Simulation techniques are proving increasingly valuable in industrial training.

The number of applications increases as industrial equipment becomes more sophisticated and as labor and materials become more expensive.

Link produces a wide variety of industrial training devices, ranging from part task and universal process trainers to more elaborate systems for railroad and power plant training.

Power Plant Simulators

One of the newest uses for simulation is training personnel to operate power-generating plants. Such simulators are highly desirable since otherwise training necessitates costly plant shutdowns.

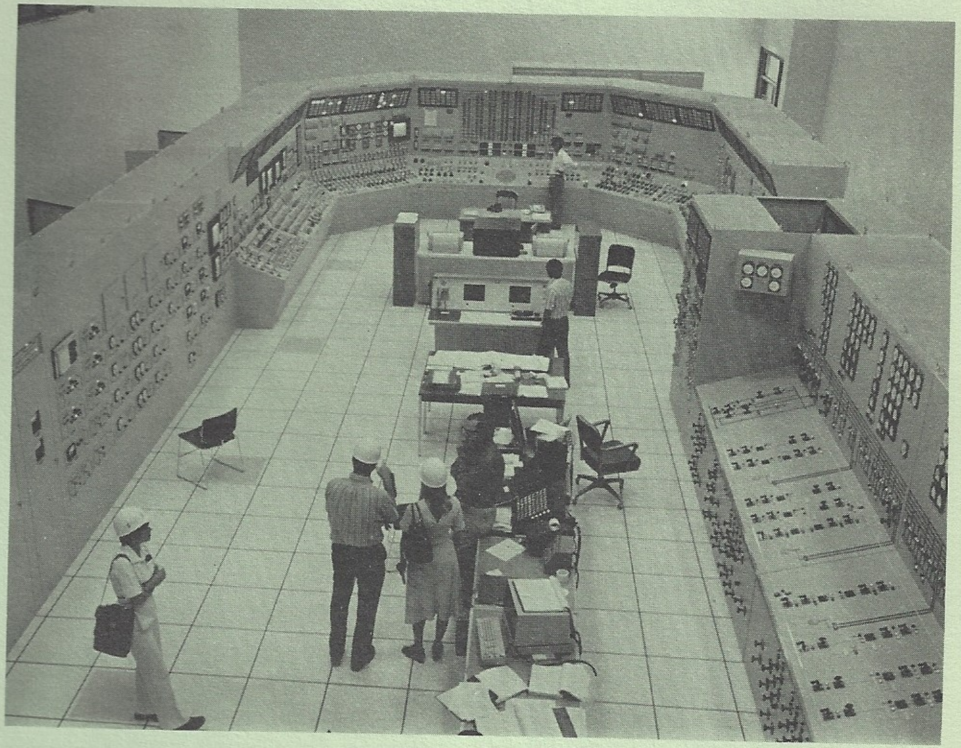
Power plant simulators, both nuclear and fossil fuel, are full-size replicas of power plant control rooms, complete with all functioning controls and instruments. The functions are represented by accurate mathematical models, including physical, electrical and aural effects, which are stored in high-speed computers providing real-time responses.

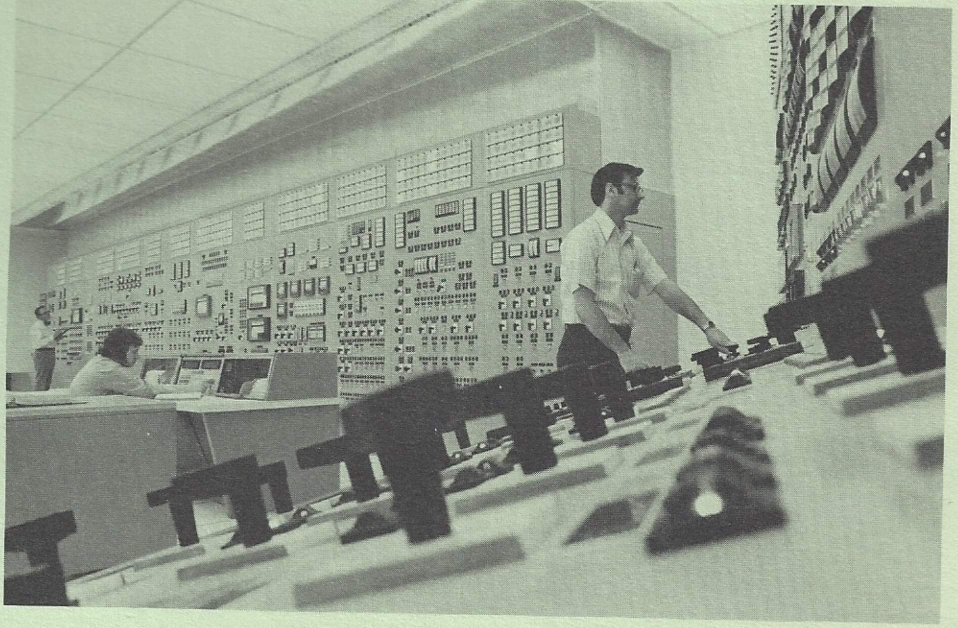
Simulations include hot and cold starts, normal operation, complete and partial shutdowns and various malfunctions and emergency drills.

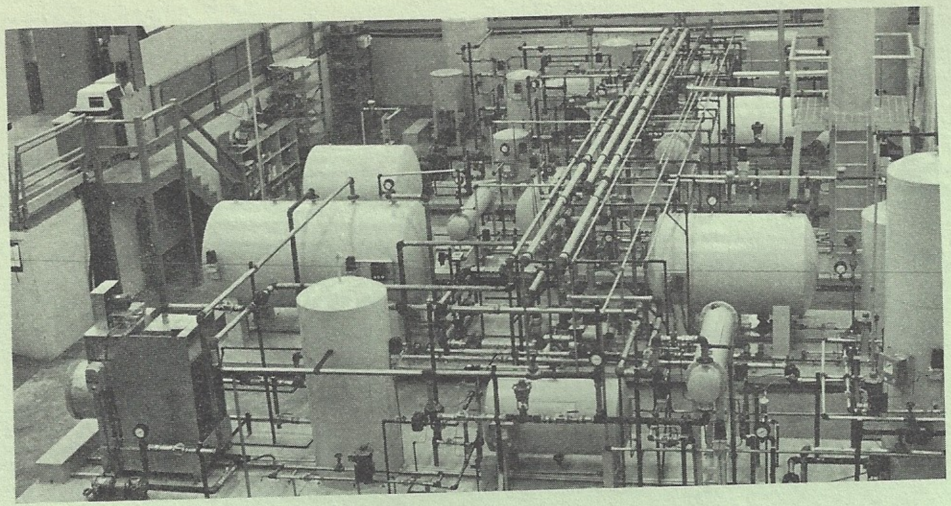
All metering, alarm and trip responses are displayed exactly as they would appear under actual working conditions. Exercises can be stopped at any point, permitting analysis and repetition of trainees' actions.

Link has simulated all types of power plants: boiling water reactor, pressurized water reactor and fossil fuel.

Customers include the Tennessee Valley Authority, Babcock & Wilcox, Combustion Engineering, Consolidated Edison, Carolina Power & Light, Duke Power, Pennsylvania Power & Light, General Electric, Kraftwerksschule, Tecnatom and Washington State.







Oil Refinery Simulator

The world's first oil refinery simulator was designed and built by Link for the Libyan Institute of Petroleum to train technicians for the country's oil and petro-chemical industries.

The training center has not only a central control room but also a representation of the remainder of the plant. The latter includes tanks, drums, piping, platforms, catwalks, steam generating boiler, heat exchanger, fuel oil pumps, cooling tower, de-aerator, pumps, compressors and so forth—all designed to appear real but with their functions simulated.

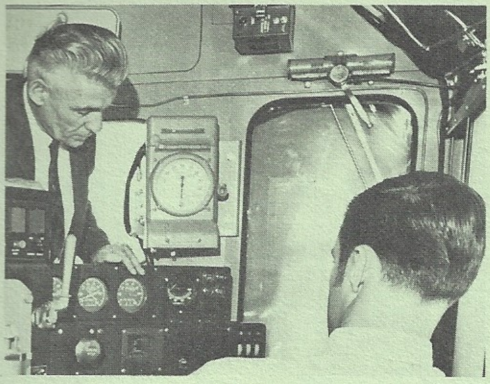
The only functional equipment provided was a standby diesel generator.

Process Operator Simulators

Link developed the Process Operator Training Simulator to provide an economic answer to the process industries requirement for more effective training.

The trainee control panel is a realistic representation of any modern process plant control room. The standard unit contains 24 instrument module positions for interchangeable process controllers, indicators, pump stations or similar devices.

Inputs to the simulator's digital mini computer include process control actions manually initiated by the trainee (as well as automatically by controllers) and parameter changes and malfunctions inserted by the instructor. The device can be reprogrammed to simulate any other process and permit training with that process even before plant construction is completed.



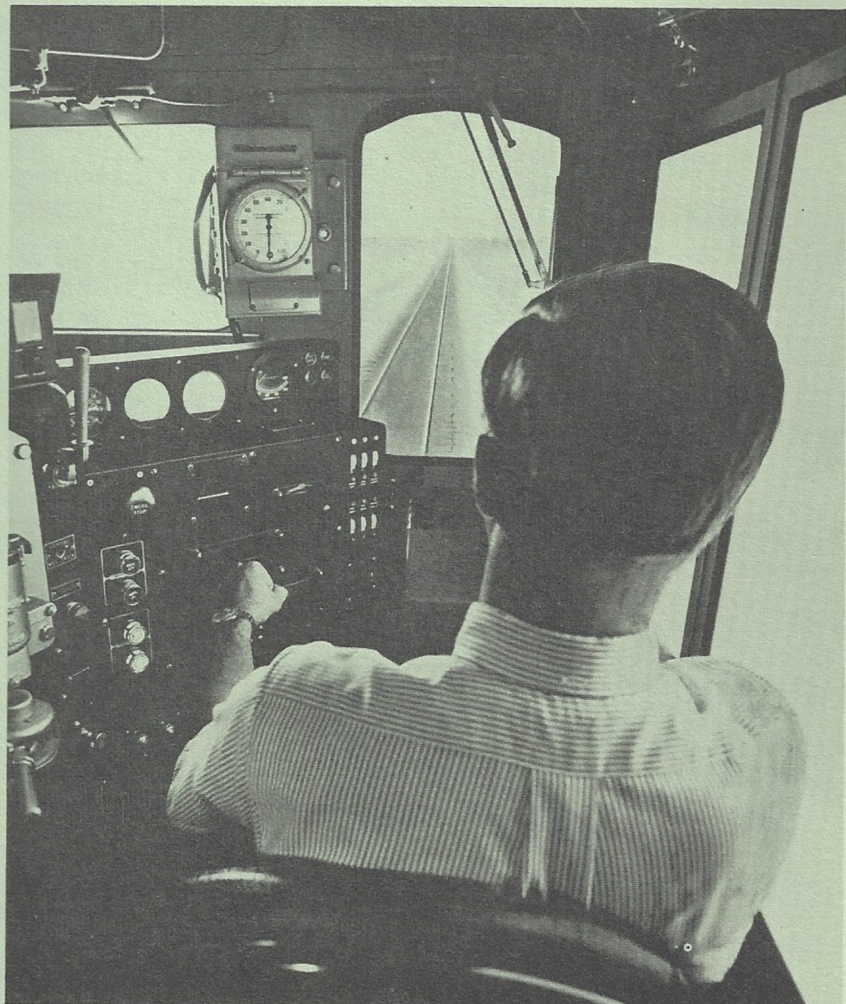
Railroad Simulators

Link built the first locomotive train simulator. It realistically reproduces the sounds, sights and movements of train operation without actually moving over the rails.

The simulator includes a full-scale mock-up of a modern diesel locomotive cab, complete with throttle, brake and other controls and gauges.

Trainees view a screen on which is projected exactly what an engineer sees during an actual run. Film sequences incorporate a selection of both routine and unusual operating situations, including signal compliance, meeting and passing other trains and other incidents requiring specific actions. Emergency situations which would be hazardous during a regular run can be simulated in perfect safety.

Also simulated, with a digital computer, are sounds and motions of train operations.



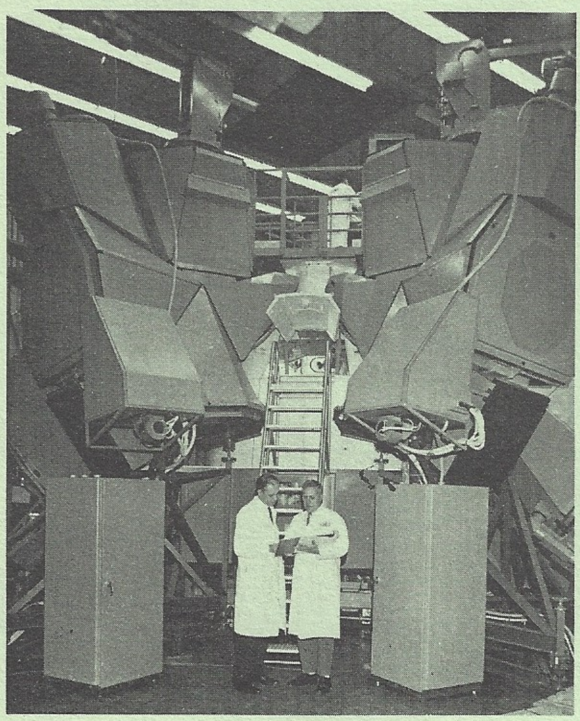
SUPPORT OPERATIONS

Link backs the systems it sells with full support—around the world, around the clock.

Experienced personnel are available day and night for telephone consultation and, if necessary, immediate dispatch to customer sites. Emergency replacement parts are quickly provided.

Link installs each system and gives instructions for its operation and maintenance. It cooperates with customers in analyzing facilities and requirements so as to make recommendations for spares provisioning.

Link also stands ready to furnish maintenance on a continuing basis. Highly qualified personnel are assigned fulltime to customers' sites, assuring maximum utilization of training devices with consequent cost savings. Link has a number of such maintenance contracts, including one with the National Aeronautics and Space Administration for total engineering support of the astronaut-training simulators.



Other on-site support programs include ones for *Link* helicopter training systems, SAAC, ASUPT and UPT programs, and the Crew Station Design Facility at Wright-Patterson Air Force Base. Depot support is provided at many Air Force bases around the world.

Link also provides its customers with modifications of existing simulation systems to capitalize on advances in the state of the art and reflect updating of various aircraft.

Technical Training

Link not only provides qualified field service personnel to support simulator installations but also has facilities for training customer personnel in simulator operation and maintenance.

The Link Training Center in Binghamton, N.Y., is furnished with all classroom equipment required to assure effective instruction. The instructors are experienced simulation-knowledgeable specialists, with proven technical academic ability and broad backgrounds in electronics and computers.

The classrooms are in the same plant where simulators are assembled and checked out, affording students the opportunity for hands-on equipment training.

Simulation Facilities Services

A Simulator Facilities Department was created to meet an increasing demand from Link customers for help in housing simulation equipment.

The department is staffed with personnel qualified in civil, mechanical and electrical disciplines related to the building industry who also are familiar with simulation equipment requirements. It can assist in the design of new buildings or ensure that existing structures are properly modified to accept simulation equipment.

Link

A DIVISION OF THE SINGER COMPANY

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