封面格式

行政院及所屬各機關出國報告

（出國類別：~~公差~~　　）
考察

（小型商務客機關鍵技術開發赴美考察出國報告書）

服務機關：中山科學研究院第一研究所
出國人職　稱：上校/少校
姓　名：張營生/吳孟宗
出國地區：美　國
出國期間：891212 至 891218
報告日期：900515

壹、 摘要

本報告綜整赴美國考察KEARFOTT導航公司及SPORTSCOPTER飛機公司洽談航空伺服器、姿態航向導航系統細部規格及小型商務客機適航認證、次系統整合技術合作等相關事宜，並蒐集國外先進生產製造、工程設計、品管控制及FAA認證等相關技術資料以瞭解未來可能合作廠商實際研發能量及規模。

評估KEARFOTT公司之伺服致動器及具有價錢合理、性能優異市場競爭力，目前雖未被大量採用，但未來於800磅以下之無人飛機各飛行操作控制面伺服驅動器將佔有40%以上市場，國內應優先考量本項技引案或合作生產案，否則應了解其關鍵技術自行開發。

KEARFOTT之INS/GPS採用RING LASER或MICROMACHINED VIBRATING BEAM技術，使產品體積縮小、精度提高、壽命長，對各項航空器或需本身姿態及方位資訊之車、船、武器均有極大價值，由於該公司產製採垂直整合，合作空間不大，但可請待退人員前來指導，協助本院能量升級。

SPORTSCOPTER飛機公司產品未完成TYPE CERTIFICATION，單價低、性能不錯為優點，本次與相關技術支援公司研討未來認證範圍，以供本院是否協助國內廠商完成產品認證之評估參考。

貳、目　次

參、 正文

1. 參訪目的

赴美國考察 KEARFOTT 導航公司及 SPORTSCOPTER 飛機公司洽談航空伺服器、姿態航向導航系統細部規格及商務客機適航認證、次系統整合技術合作等相關事宜，以掌握小型商務客機未來市場需求，並蒐集國外先進生產製造、工程設計、品管控制及 FAA 認證等相關技術資料以瞭解未來可能合作廠商實際研發能量及規模。

2. 參訪過程

- 行程請參閱附件一 中山科學研究院出國人員工作計畫表.
- 89/12/13 KEARFOTT 公司行程請參閱附件二 會議議程.

本次參訪 kewarfott 導航公司乃由業務經理 Stephen P. Beiter 接待，該公司副總裁及相關部門負責人均到場與會，顯示該公司十分重視此次拜訪行程、及合作機會。在前往美國 kearfott 公司之前我方即將參訪目的的及需求電傳該公司，會議內容也是次我方需求的全球定位系統/精密貫性導航系統及高精度伺服攻動器為主要議題。

本次會見人員如下：

S. Beiter - Business Development

R. Poquette - System Engineering
P. Joseph - UAV System Engineering
Aldrich - Actuator Engineering
R. Zelazo (Part Time) - President, CEO

J. Gardner (Part Time) - VP Business Development & Management

公司簡介：

該公司成立於 1917 年，至今已八十餘年，在航空太空的研究成果豐碩。年產值約 2 億美元，員工總計 1619 員。產品使用包括：

- 空用：戰術飛彈導引、反艦飛彈導引、飛機貫性導航系統、飛行控制伺服致動器、感測器、指向垂直陀羅儀、航站自動導引測試系統、航電系統整合、大氣感測數據電腦、飛行導航儀表、任務顯示處理器、多功能彩色顯示器、顯示控制單元、電子飛行儀錶系統。
- 海用：軍艦、潛艇導航系統魚雷導引、潛艦飛彈發射導引、航海電子海圖顯示資訊系統、指控操控台。
- 陸用：車載榴彈砲指引導向系統、座標指引系統、載具導引系統坦克砲塔穩定系統、可攜式液晶顯示器、精密視訊系統、坦克速率感測器。

其產品均用於美國及其他國家現役各式武器裝備上。

包括：

- 挪威、企鵝反艦飛彈之導引系統 Penguin Auti-ship Missile
- 美國海軍三叉魚叉飛彈 Trident c-4/c-5 Missile
- 瑞典 Torpedo 2000 魚雷導引系統
- 美國 B-2 轟炸機導航系統
- 美國 Northrup HAWK 無人載具導航系統
- 以色列 KN4070 UAV 無人載具導航系統
- ELTA 電子公司之合成孔經雷達影像、系統、引用 KN-4072 INS/GPS 系統，

該系統可提供精密的位置速度、姿態以及增量之姿態及速度，並可和 GPS 全球定位系統混合使用於導航系統中。

3.3 參訪心得

對於該公司導航產品 AHRS KN4071/INS/SPS KN4072 及伺服致動器 K-2000 是此次參訪的主要項目，其規格如附件(二)。Interface control Document for the KN-4072 INS/GPS SYSTEM

- K 公司發展慣性導航系統由 FLOATED RATE INTEGRATING GYRO 進而研發出 DYNAMICALLY TUNED GYROSCOPES、結合雷射技術，該公司完成 SINGLE-AXIS RING LASER GYROSCOPES，隨後又縮小體積完成 MONOLITHIC THREE-AXIS RING LASER GYROSCOPES 產品，一具三軸高精度之陀螺儀體積大小比大拇指大不了多少，耗電量及安裝所需空間均極小，未來運用範圍及廣。
- 本次參觀 MONOLITHIC THREE-AXIS RING LASER GYROSCOPES 生產線，該公司進口天文望遠鏡等級之玻璃，先行切割出基本形狀，再以玻璃鑽孔機(空心具有鑽石頭之鑽頭)，由電腦控制之程式花費九小時緩慢鑽出一條條平滑之孔線，隨後進行清洗、裝電極、分光器、感測器、抽真空、灌入氦氖氣體、封口、連上高壓電路、DSP 線路，隨後進行測試，程序簡單但是具有不少關鍵技術，全程參訪中不准錄音及攝影及筆記，但允許發問，可見該公司具有相當誠意。
- 雷射陀羅導航系統於長時間使用或有訊號飄移，補償不易之問題，該中司運用全球衛星定位系統(GPS)不會因長時間使用訊號飄移，但於定環境干擾會造成資料無法獲取特性，將 GPS/INS 整合應用使其可靠度性能提

升，且精度大大提高，除本身雷射陀羅導航系統外，又增加了 GPS 全球衛星定位的功能，並於 Grounding 時可執行 Ground Alignment，此時導航系統可自行執三軸 pitch、roll、heading 校準、校正時不同的座標系統，均可適用，而嵌入式的 GPS 亦能獨立地提供導航系統所須的位置航向參數。當 INS 執行完校正後即可進入 INS、GPS 混合導航模式。

- GPS/INS 整合系統除可用以提升民航機導航準確性外，國防武器系統用途更是不可或缺，本次參訪提及希望能與該公司做技術合作，由該公司提供技術指導。我們於國內負責國內需求系統研製生產，該公司市場經理表示該項系統屬於國防精密工業，技術輸出極其困難，建議我們考量採用該公司產品、了解詳細運用、維護程序，未來適當機會再討論該項。個人認為以我國對陀螺儀系統之需求及多年經營成果，該公司製程對我們而言似乎並不複雜，國內有機會經由逆向工程協助完成類似產品。
- 獲得該公司 GPS/INS 詳細硬體介面及軟體介面、PROTOCAL 資料，供研析使用。
- K-2000 伺服致動器具有體積小、重量輕、輸出扭力大等優點也是此次參訪的目的之一，其規格如附件(二)所示。目前該型致動器，可將前端減速機構略作修改即可因應不同的阻力需求，可輸出 50、100、200 in-lb 之扭力，未來將可應用於各式飛機之翼面、煞車、鼻輪轉向等各個伺服機構上。

會議期間之會議記錄如下、相關關切事項及規格澄清亦作成書面 Action Iten，列入管制該公司並將於 2001 年元月 10 日，至本所拜訪，並針對 Action Item 提出說明。

3.4 kearfott 公司會議記錄

To: Distribution

From: S. Beiter

Subj: CSIST Visit Meeting Minutes

CSIST

Yin-Sen Chang - UAV Program Manager

Mong-Tzong Wu - UAV Engineering

Kearfott

S. Beiter - Business Development

R. Poquette - System Engineering

P. Joseph - UAV System Engineering

A. Aldrich - Actuator Engineering

R. Zelazo (Part Time) - President, CEO

J. Gardner (Part Time) - VP Business Development & Management

Summary:

1. Kearfott presented capabilities, UAV system configurations and actuator designs for UAVs.

2. The standard UAV INS/GPS data sheets for KN4070 and KN4072 were reviewed. The KN4073 was described as a new configuration having the same form factor as the KN4072 with the following modifications:

(a) Lighter weight - 9 lbs. instead of 11 lbs.

(b) P/Y code GPS instead of C/A code

3. The standard actuator for UAK (K2000) was presented. In addition, a high torque (100 inch/pounds) and integrated actuator systems were described. (See attached)

4. The total system integration (actuators & guidance) capability of Kearfott was also highlighted. This feature and capability seemed very attractive to CSIST.

5. A ROM price of $60K and 12 months lead time was verbally presented to CSIST for the KN4072. Actuator lead time for the standard actuator was identified as 2 to 3 months depending on when order is placed. Export licenses may impact the actuator delivery.

6. Based on the above, Mr. Chang indicated that Kearfott should expect an order for a single actuator early next year (Jan/Feb) and two KN4072 (March/April).

7. Only public domain data was given to CSIST. Export license application for KN4072 lease hardware and data have already been sent to the U.S. State Department for approval. I will take action to get export license request for Actuators lease and data initiated.

S. Beiter

Distr:

A. Aldrich

J. Gardner

T. Hoffmann

P. Joseph

D. Lee (AIDC)

B. McGowan

Suzane Yen (AIDC)

- 89/12/15 參訪 AMERICAN SPORTSCOPTER Inc 並由該公司經理孫博士帶領前往拜會 ATI 公司(ADVANCED TECHNOLOGIES INCORPORATED) 以瞭解該工公司在直升機主旋翼翼切形及氣動力學設計能量

2000/12/15 參訪 Sportcopter 直昇機公司

該公司經理人為華人孫錕鎮博士負責，主要業務為運動休閒直昇機銷售公司，產品包括單、雙座機型數種、其零組件係由相關衛星廠商提供，該公司僅做系統整合、組裝，為國內緯華直昇機公司的海外分公司。

另在孫經理的帶領下參訪 ATI 公司，ATI 公司為一主、尾旋翼設計製造公司，該公司負責人 C. Harry Parkinson 早年曾為波音公司設計直昇機旋翼片，目前業務為接受客戶委託設計各式複材機構及主旋翼，由於主旋翼片為直昇機之關鍵技術、其設計之良窳影響直昇機氣動性能甚鉅，而國內對直昇機之設計尚無具體成效，拜訪期間也曾提到技轉及認證之可行性。

- 直昇機主旋翼技轉案協商-- 該公司目前願意將緯華公司現用直昇機 ULTRASPORT 254， ULTRASPORT 331，及 ULTRASPORT 496 之主旋翼設計及製造技術移轉，這三型直昇機旋翼屬於完全相同翼型，貼製及成化程序也相同，主要差別在它的長度，複材旋翼有使用壽命長(廠商宣稱幾無壽

限)，但同樣有複材製造時檢驗和品保如何有效達成問題，這是關鍵技術。廠商同意以約三十萬美金轉移技術及模具，初步評估緯華現需採購六十具，ATI 每具報價約八千美金(佔該型直昇機售價 25%至 35%)，如短期內達成技轉作業，則訂單轉移後即可迅速達成收支平衡並獲得技術及後續量產效益。旋翼片複材製程技術技移轉計劃書提出，相關轉時程、經費、訓練項目詳如附件二 SPORTSCOPTER 計畫書。

- 適航認證討論一本次重要目標是評估 ULTRASPORT 496 等級直昇機適航認證技術需求及基本效益，ATI 公司總裁認為技術上可行，但由於該飛機為該公司多年前設計產品，相關數據必須重新疊整，並且因應認證需求多項設計變更必須執行，該公司特別強調原先設計目的為 HOMEMADE，所以系統強調構造簡單、造價低、尤其是為了規避 LIABILITY，緯華公司海外部門施工所需工時低於全機組裝工時 50%，這是該公司設計賣點。預期認證後，由於零組件由商源即需認證，產品售價增加將超過現有唯一認證合格者(ROBISON)，將使產品失去價格競爭力，且增加公司風險(售方責任問題)，建議我們再考慮。該公司並以引擎為例：現行 UEL682R 引擎該公司採購價錢一萬美金，但如附有認證簽章之同型引擎價錢兩萬美金。

建議

- Sporteopter 公司產數型輕型直昇機，其構造簡單大小適中，其複材機體十分輕巧，載重量約為 150kg，可裝載電戰、酬載裝備，適合未來本所發展無人直昇機之機型。

- 技引複材螺旋槳為進入高技術之良好方法，本次參訪時已見到美軍APACHE 直昇機委託該 ATI 公司研製之複材主旋翼正於應力試驗中，據說已執行測驗一年餘，未來複材旋翼可能是下階段主流，廠商同意以約三十萬美金轉移技術及模具，如短期內達成技轉作業，則訂單轉移後即可迅速達成收支平衡並獲得技術及後續量產效益。建議國內可評估本項效益優先執行。

- 全機認證是我方進入國際市場必經之路，國內航太能量不足以發展大型飛機研發認證計劃，小型之直昇機案是投資不大之嘗試，雖然受訪廠商與參訪人員都不認為全機認證能使本項發展計劃賺錢，但如從產品進入國際市場及建立經驗角度，本項大約投資台幣八億左右應可完成，建議本院團隊仍本提升國內航太能量初衷，於未來建案協助國內廠家執行適航認證能量。

肆、相關附件

1. KEARFOTT MEETING AGENDA

2. ATTENDEES NAME CARD

3. KEARFOTT—GUIDANCE AND NAVIGATION CORPORATION CAPABILITIES

   PD-2035

4. K-2000 HIGH PERFORMANCE SERVO ACTUATOR SPECIFICATION

5. INTERFACE CONTROL DOCUMENT FOR KN-4072 INS/GPS SYSTEM

6. AMERICAN SPORTSCOPTER INTERNATIONAL Inc PROPOSAL

7. AMERICAN SPORTSCOPTER INTERNATIONAL Inc BROCHURE

8. ADVANCED TECHNOLOGIES INCORPORATED BROCHURE

中山科學研究院出國人員工作計畫表

姓名 張營生、吳孟宗

日期	星期	行程 出發	行程 抵達	公差地點 國名	公差地點 (州)省	公差地點 城鎮	工作項目	備考
89 12 12	二	台中	紐約	美國	紐約	紐約	搭機赴美國途中。	
89 12 13	三			美國	紐澤西	威尼	參訪 Kearfott 公司進行下述事宜 ● 考察該公司航電、次系統裝備研發能量 ● 洽談產品 AHRS、Servo Actuator 之細部規格及相關事宜 ● 蒐集其他航電裝備之相關資料	
89 12 14	四	紐約	紐波特	美國	維基尼亞	紐波特	搭機、轉機	
89 12 15	五	紐波特	紐約	美國	維基尼亞	紐波特	參訪 Sportscopter 公司進行下述事宜 ● 考察該公司飛機設計、製造、組裝及品保能量 ● 洽談技術合作及 FAA 認證等相關事宜 ● 蒐集飛機次系統裝備之相關資料	
89 12 16	六	美國	紐約				搭機回國	
89 12 17	日						搭機途中	
89 12 18	一			中華民國	台灣	台中	抵國	

中山科學研究院出國人員工作計畫表

姓名：張營生、吳孟宗

日期	星期	行程		公差地點			工作項目	備考
		出發	抵達	國名	(州)省	城鎮		
89 12 12	二	台中	紐約	美國	紐約	紐約	搭機赴美國途中。	
89 12 13	三			美國	紐澤西	威尼	參訪 Kearfott 公司進行下述事宜 ● 考察該公司航電、次系統裝備研發能量 ● 洽談產品 AHRS、Servo Actuator 之細部規格及相關事宜 ● 蒐集其他航電裝備之相關資料	
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89 12 18	一			中華民國	台灣	台中	抵國	

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Agenda

(Headquarters West, Board Room)

Wednesday, December 13, 2000

9:00 a.m.	Welcome	S. Beiter
9:15 a.m	CSIST Requirements	CSIST
9:30 a.m.	Kearfott Capabilities	S. Beiter
10:00 a.m.	GPS/INS (KN-4072)	P. Joseph
11:00 a.m.	Actuators	A. Aldrich
12:00 Noon.	Lunch	
1:00 p.m.	Tour System Lab Plant 12	R. Poquette
2:00 p.m.	Tour Plant 1	S. Reich
3:00 p.m.	Tour Plant 3	D. Arthurs
4:00 p.m.	Recap and Action Items	All
5:00 p.m.	Depart	

Attendees

CSIST
Taiwan

Yin-Sen Chang	Engineering
Mong-Tzong Wu	Engineering

Kearfott Guidance & Navigation Corporation
Wayne, New Jersey

A. Aldrich	Asheville Engineering
D. Arthurs	Manufacturing
S. Beiter	Director, Technical Marketing
P. Joseph	System Engineering
R. Poquette	Director, Systems Engineering
S. Reich	Manufacturing

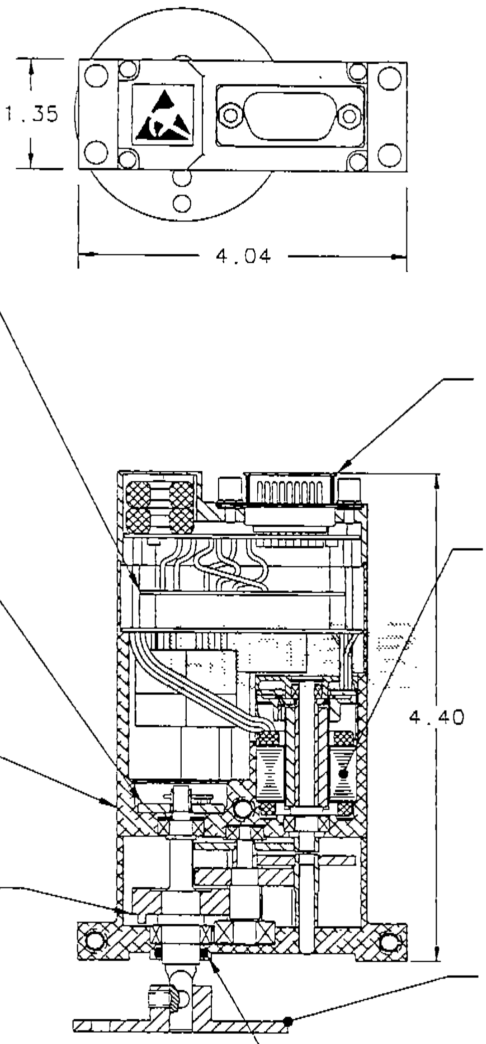
Kearfott

CAPABILITIES FOR UAV APPLICATIONS

A Presentation to:

CSIST
Taiwan

Standard K-2000



Self Contained Electronics
- Opto-Isolated Input
- Commercial Microcontrollers
- Peak by Peak Current Limiting
- High Power FETs
- Derived Velocity Feedback

Feedback
- Aerospace Quality Potentiometer
- Linearity ±0.5% MIL-R-39023

Rugged Housing
- Sealed Construction
- Three Way Mounting
- EMI Shield

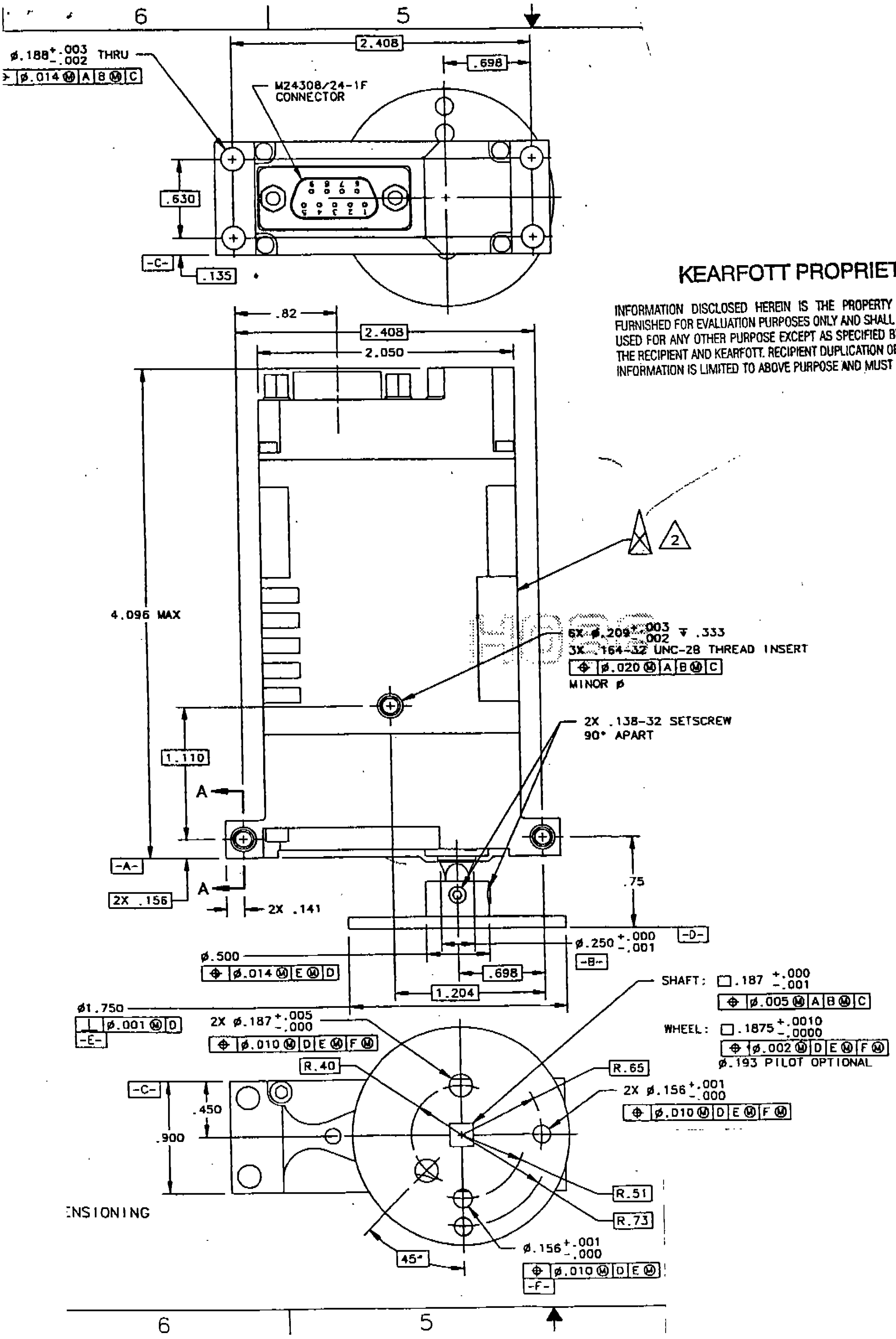
Gear Reduction
- Simple Spur Gear Configuration
- Moly Disulfide Grease (Lifetime Lubrication)
- Case-Hardened Stainless Steel Gears
- 203:1 Reduction Ratio
- Anti-friction Ball Bearing Support

M24308/24-1F Connector

High Reliability Integrated Motor
- Brushless DC Powered
- Ball Bearing Support
- 2,000 + Hour Life
- Excellent Heat Dissipation

Output Wheel* (Not included in unit weight)

Shaft Seal



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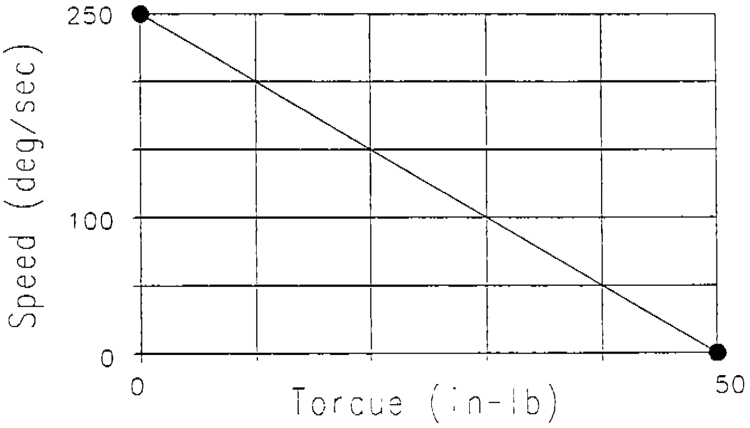
Standard K-2000

ACTUATOR CHARACTERISTICS AT 25±5°C		
TYPICAL CHARACTERISTIC @ 28 VDC	UNITS	VALUE
WEIGHT (MAX)	OZ	8
* MECHANICAL STROKE (MIN), CW & CCW	DEGREES	50
* ELECTRICAL STROKE, CCW & CW	DEGREES	45±2
OUTPUT LINEARITY (MAX) vs COMMAND	PERCENT	±6
PW COMMAND INPUT CURRENT (MAX) @ 4V	mA	5
VOLTAGE, OPERATING	V	18 TO 32
NO LOAD SPEED (MIN)	DEG/SEC	250+
PEAK TORQUE (TYP)	IN-LB	50
CURRENT @ 25 IN-LB (MAX)	AMP	0.5
POSITION FEEDBACK SCALE FACTOR (NOM)	mV/DEG	220
MECHANICAL BACKLASH (MAX)	DEG	0.5
FREQ RESPONSE GAIN (TYP) @ 20 Hz	dB	-3
TEMPERATURE, OPERATING	DEG C	-40 TO +70
TEMPERATURE, NONOPERATING	DEG C	-55 TO +85

Speed vs. Torque



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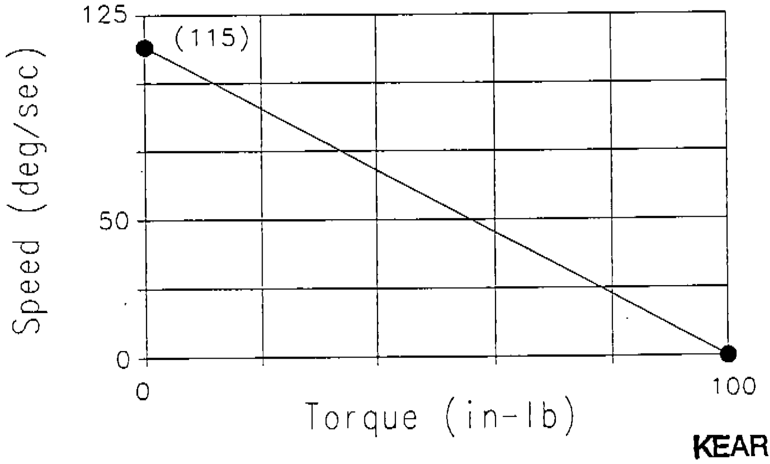
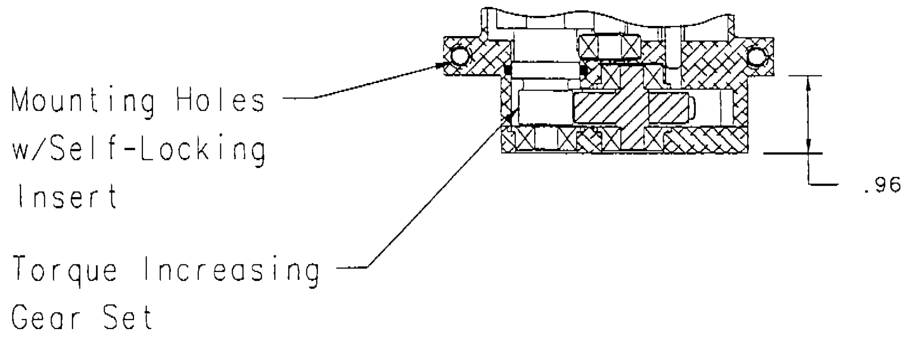
High Torque Modification

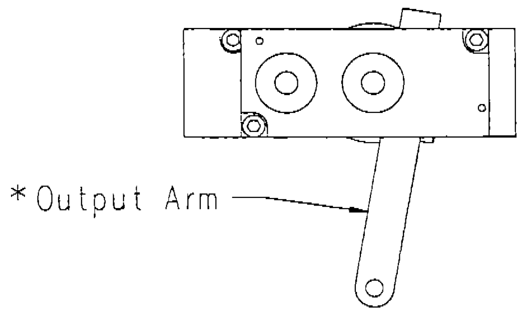
ACTUATOR CHARACTERISTICS AT 25±5°C		
TYPICAL CHARACTERISTIC @ 28 VDC	UNITS	VALUE
WEIGHT (MAX)	OZ	11
* MECHANICAL STROKE (MIN), CW & CCW	DEGREES	50
* ELECTRICAL STROKE, CCW & CW	DEGREES	45±2
OUTPUT LINEARITY (MAX) vs COMMAND	PERCENT	±1
PW COMMAND INPUT CURRENT (MAX) @ 4V	mA	5
VOLTAGE, OPERATING	V	18 TO 32
NO LOAD SPEED (MIN)	DEG/SEC	125+
PEAK TORQUE (TYP)	IN-LB	100
CURRENT @ 50 IN-LB (MAX)	AMP	0.5
POSITION FEEDBACK SCALE FACTOR (NOM)	mV/DEG	220
MECHANICAL BACKLASH (MAX)	DEG	0.5
FREQ RESPONSE GAIN (MIN) @ 10 Hz	dB	-3
TEMPERATURE, OPERATING	DEG C	-40 TO +70
TEMPERATURE, NONOPERATING	DEG C	-55 TO +85

Speed vs. Torque



High Torque Modification





* May be easily modified
to customer requirements

Note:
All dimensions are in inches.

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* Kearfott Product Bulletin *

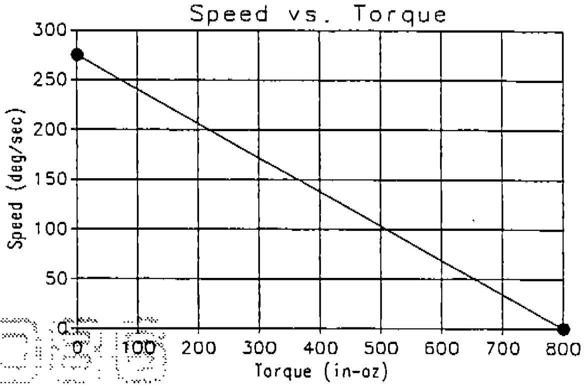
Address: Route 70, Black Mtn., NC 28711-6001 - FAX: (828) 686-5764 - TEL: (828) 686-3811

This rotary servo actuator is used in the Outrider Tactical Unmanned Air Vehicle, a unique reconnaissance aircraft featuring visible and infrared cameras, 7 hour loitering capability, quick set up and take-off, and autonomous autopilot control. Ten of these servo actuators control the throttle and all flight-control surfaces (ailerons, stabilator, rudder, and flaps). Major sub-systems include a programmed electronic controller, integrated brushless DC motor, case-hardened stainless steel spur gear train, precision position-feedback potentiometer, and sealed aluminum housings. The actuator continually receives position commands from the autopilot, and drives the output shaft to the commanded position. Dynamic response is -3dB at 7 Hz. Available modifications include: clevis arm output for direct connection to a rod end; external gear reduction for higher torque; vertical connector orientation.

TYPICAL ACTUATOR CHARACTERISTICS AT 25±5°C

CHARACTERISTIC	UNITS	VALUE
WEIGHT (MAX)	OZ	14
MECHANICAL STROKE (MIN), CW & CCW	DEGREES	95
ELECTRICAL STROKE, CCW & CW	DEGREES	90.0±3.5
BACKLASH AT OUTPUT (MAX)	DEGREES	0.6
OUTPUT LINEARITY (MAX) vs COMMAND	PERCENT	±0.5
POSITION ACCURACY AT 0 DEG	DEGREES	±1.5
PW COMMAND INPUT CURRENT (MAX) @4V	mA	17
MAX VOLTAGE, OPERATING	V	32
MIN VOLTAGE TO MEET SPEED / TORQUE	V	28
MIN VOLTAGE TO OPERATE	V	18
NO LOAD SPEED (MIN)	DEG/SEC	275
SPEED (MIN) AT 200 IN-OZ	DEG/SEC	150
PEAK TORQUE (MIN)	IN-OZ	800

Speed vs. Torque



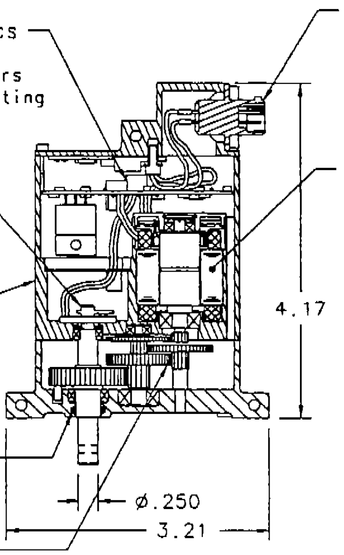
Self Contained Electronics
- Opto-Isolated Input
- Commercial Microcontrollers
- Peak by Peak Current Limiting
- High Power FETs
- Derived Velocity Feedback

Feedback
- Aerospace Quality Potentiometer
- Linearity ±0.5% MIL-R-39023

Rugged Housing
- Sealed Construction
- Three Way Mounting
- EMI Shield

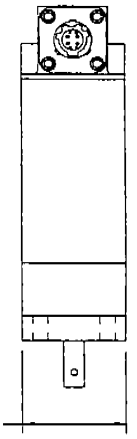
Shaft Seal

Gear Reduction
- Simple Spur Gear Configuration
- Moly Disulfide Grease (Lifetime Lubrication)
- Case-Hardened Stainless Steel Gears
- 218:1 Reduction Ratio
- Anti-friction Ball Bearing Support



Electrical Interface
- 4 Pin Connector
(Per MIL-STD-26482)

High Reliability Integrated Motor
- Brushless DC Powered
- Ball Bearing Support
- 2,000 + Hour Life
- Excellent Heat Dissipation



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05/20/98

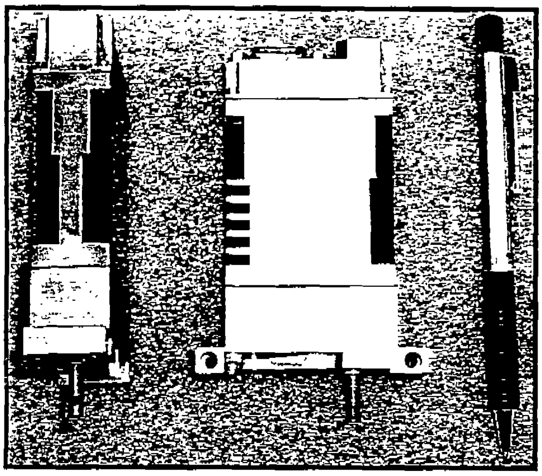
Kearfott Guidance & Navigation Corpo
A Subsidiary of Astronautics Corp. of
Black Mountain, North Carolina

ACTUATOR ASSEMBLY, ROTARY POSITION
P/N CU09660035

Introducing the K-2000

An Affordable, High Performance UAV Servo

Chosen by AAI Corp for the U.S. Army's new TUAV (Shadow 200), the K-2000 delivers high performance in a compact package..



K-2000 Features:

- 28 VDC Brushless PM Motor
- MIL-STD-461D Electronics
- High Torque - 700+in-oz
- Low weight - 8oz
- 0.9in. thick

For Information Contact:
Kearfott, Guidance & Navigation Corp.
Rte. 70, Black Mountain, NC, 28711 USA
PH 828.686.3811 Ext.285 • FX 828.686.3567
uav@asheville.kearfott.com

Introducing the K-2000 Series UAV Servo Actuator

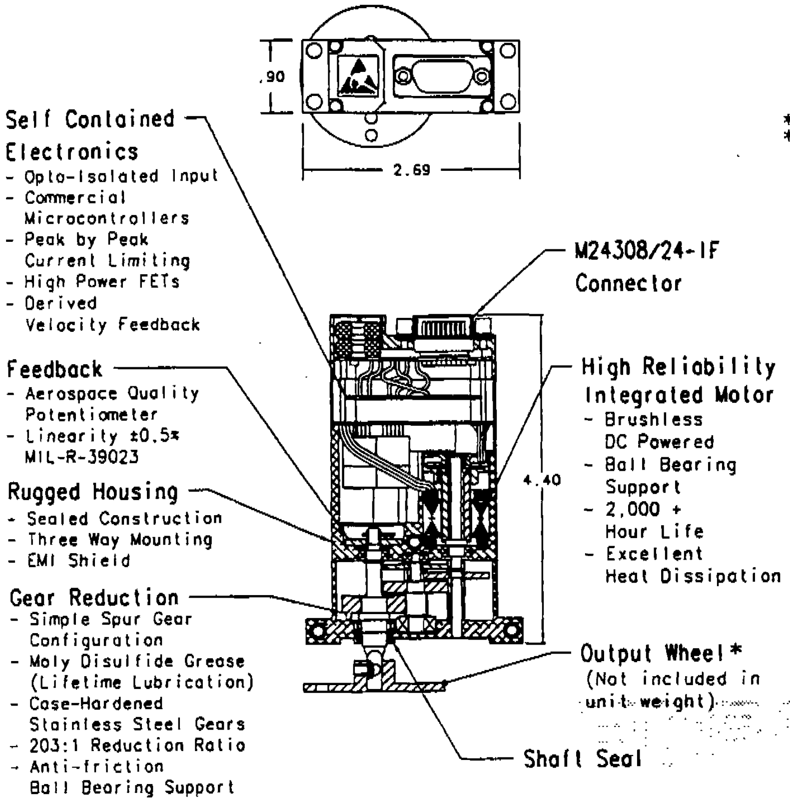
The K-2000 Series UAV Servo Actuator provides UAV manufacturers with a high performance, low weight, compact servo actuator at a reasonable price. The K-2000 Series Actuator is optimized for UAV's in the 150 to 900 pound class. The actuator is designed to comply with the latest FAA/CAA requirements for UAV's in the area of EMI and reliability.

Kearfott's K-2000 Series is based on a modular concept that utilizes a common 28 volt DC powered brushless electric motor as the prime power source. The electronic control, power module and position feedback system are also common to all actuators. Modifications to software, torque/speed ratios, input/output signals, and mechanical/ electrical interfaces can be accommodated.

Kearfott designed the K-2000 series to be a customizable, commercial, off-the-shelf (CCOTS) actuator available with short lead times. A limited quantity of the basic model K-2000 is available 2 weeks ARO. Larger quantities are available within 10 weeks ARO. Custom modified units are available 5-20 weeks ARO depending on modification requirements.

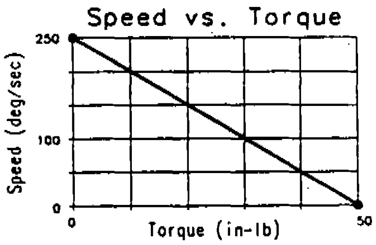
The reverse side of this sheet characterizes two K-2000 actuator configurations. 1) The standard rotary servo, typically used for throttle, nose wheel steering, and most flight control surfaces. 2) A high-torque modification of the rotary unit, providing higher torque levels for applications such as flaps and landing gear retraction.

Standard K-2000

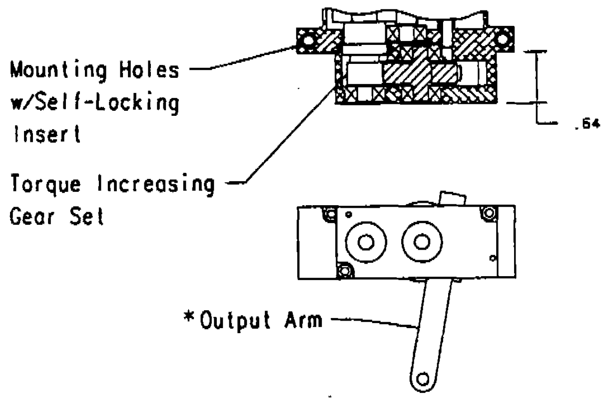


Standard K-2000

ACTUATOR CHARACTERISTICS AT 25±5°C		
TYPICAL CHARACTERISTIC • 28 VDC	UNITS	VALUE
WEIGHT (MAX)	OZ	8
* MECHANICAL STROKE (MIN), CW & CCW	DEGREES	50
* ELECTRICAL STROKE, CCW & CW	DEGREES	45±2
OUTPUT LINEARITY (MAX) vs COMMAND	PERCENT	±6
PW COMMAND INPUT CURRENT (MAX) @ 4V	mA	5
VOLTAGE, OPERATING	V	18 TO 32
NO LOAD SPEED (MIN)	DEG/SEC	250+
PEAK TORQUE (TYP)	IN-LB	50
CURRENT @ 25 IN-LB (MAX)	AMP	0.5
POSITION FEEDBACK SCALE FACTOR (NOM)	mV/DEG	220
MECHANICAL BACKLASH (MAX)	DEG	0.5
FREQ RESPONSE GAIN (TYP) @ 20 Hz	dB	-3
TEMPERATURE, OPERATING	DEG C	-40 TO +70
TEMPERATURE, NONOPERATING	DEG C	-55 TO +85

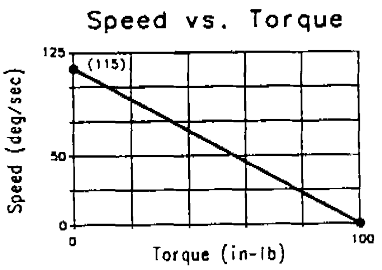


High Torque Modification



High Torque Modification

ACTUATOR CHARACTERISTICS AT 25±5°C		
TYPICAL CHARACTERISTIC • 28 VDC	UNITS	VALUE
WEIGHT (MAX)	OZ	11
* MECHANICAL STROKE (MIN), CW & CCW	DEGREES	50
* ELECTRICAL STROKE, CCW & CW	DEGREES	45±2
OUTPUT LINEARITY (MAX) vs COMMAND	PERCENT	±1
PW COMMAND INPUT CURRENT (MAX) @ 4V	mA	5
VOLTAGE, OPERATING	V	18 TO 32
NO LOAD SPEED (MIN)	DEG/SEC	125+
PEAK TORQUE (TYP)	IN-LB	100
CURRENT @ 50 IN-LB (MAX)	AMP	0.5
POSITION FEEDBACK SCALE FACTOR (NOM)	mV/DEG	220
MECHANICAL BACKLASH (MAX)	DEG	0.5
FREQ RESPONSE GAIN (MIN) @ 10 Hz	dB	-3
TEMPERATURE, OPERATING	DEG C	-40 TO +70
TEMPERATURE, NONOPERATING	DEG C	-55 TO +85



* May be easily modified to customer requirements

Note:
All dimensions are in inches.

07/05/00

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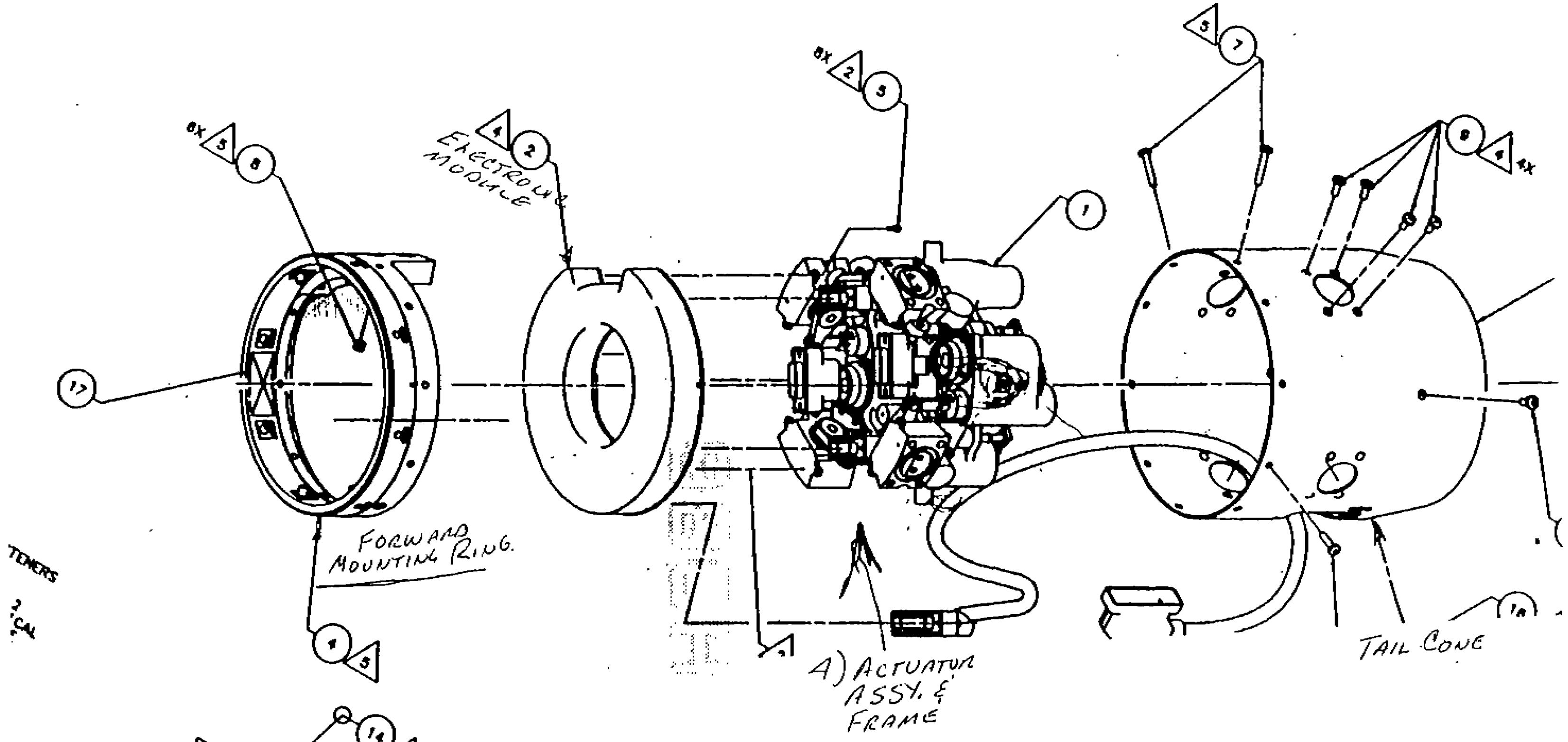
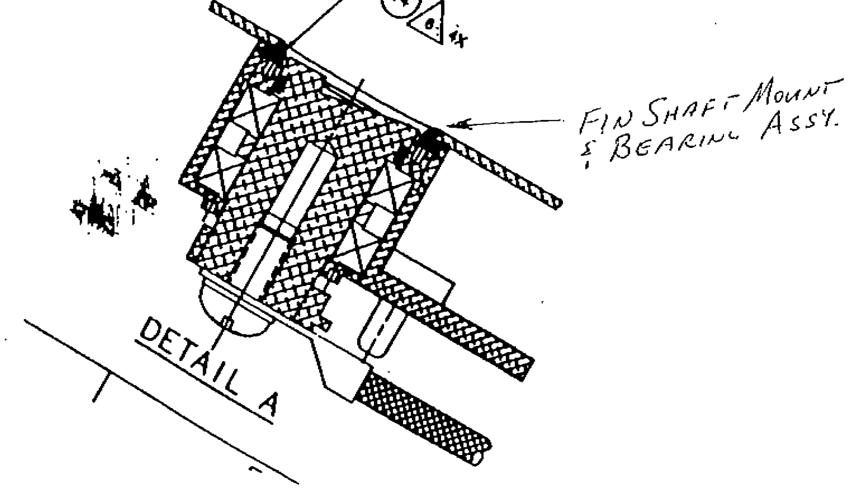
Black Mountain, North Carolina 28711





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REFERANCE PAGE 1

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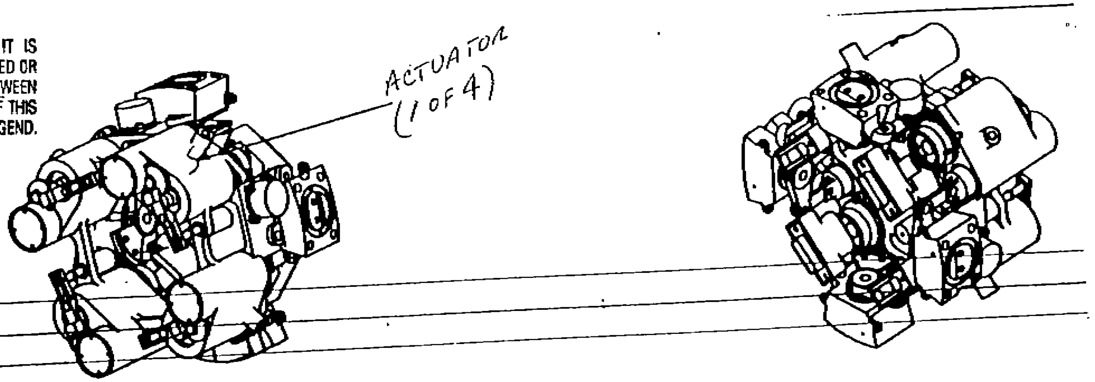

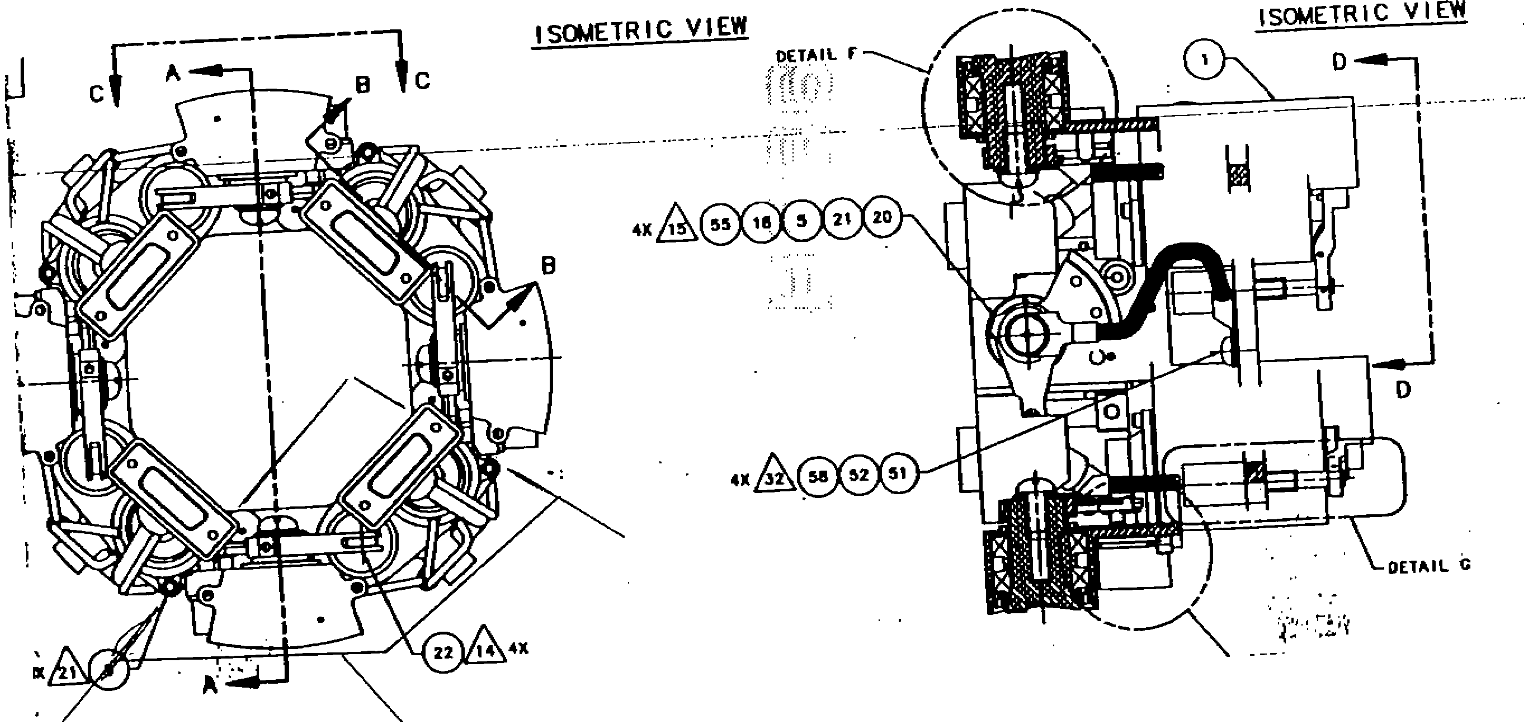

1 OF 4 ACTUATOR
& FIN SHAFT MOUNT
ASSEMBLY

REFERANCE PAGE 2

11 —

047 modified using a 320 ° feedback for 180° output sweep.

Time domain input. The input command for the modified '047' actuator is an R/C model compatible command format. The input is actually the input diode of the opto-isolator and requires a drive current of approximately 5 mAmps at 5Vdc. The position command is defined as the pulse length from 1mSec (-90 degrees ccw from 0) to 2mSec (90 degrees cw from 0). The internal position feedback is based on a 10 bit digital design, thus a 1 microSecond command change will yield a step change of approx. .18 degrees. When driven by an 8 bit control system, the output have a stepping action of approximately 0.72 degrees. The use of this actuator with a control surface with an 8 bit command will result in a very rough sounding surface movement.

The actuator control section uses an interrupt driven approach to service the input command. The input can be updated at a 20 Hz to 80 Hz rate. The control section is configured to return to 0° position if the input is lost or if the input timing goes out of the legal range. The legal range extends beyond the 1mSec to 2mSec range by 100microSec barrier. The actuator will not recognize position information as a request while in the 100microSec barriers.

Differential position output signal. The output position will be provided via a two wire analog differential signal. The position + (High) will vary from +3.453 Vdc to +16.542 Vdc for the mechanical range for a -90 ° to +90 ° mechanical change(1 mSec to 2 mSec command). The position -(Low) will vary from +16.542 Vdc to +3.453 Vdc for a -90 ° to +90 ° mechanical change (1 mSec to 2 mSec command). The 0 position is defined when both outputs are equal to +10Vdc. Thus the differential output voltage is +13.1 Vdc to -13.1 Vdc when measuring position + (High) relative to position -(Low).

Y202A150 REV-
CAGE CODE 88818

DATE 19 APR 00

Kearfott Guidance & Navigation Corporation
A Subsidiary of Astronautics Corporation of America
Corporate Headquarters, 150 Totowa Road, Wayne, New Jersey 07474-0944

INTERFACE CONTROL DOCUMENT
FOR THE
KN-4072 INS/GPS SYSTEM

P. Joseph
PREPARED BY:
P. JOSEPH, ENGIN. MANAGER
S. TOLEP, SYSTEMS ANALYSIS

4-19-2000
DATE

RELEASED BY:
J. R. DAVIES
ENGINEERING & PRODUCT SERVICES

4/19/00
DATE

APPROVALS:

F. E. Psota
F. PSOTA, MANAGER
INERTIAL SYSTEMS ANALYSIS

4/19/00
DATE

P. Joseph
P. JOSEPH
ENGINEERING MANAGER

4-19-2000
DATE

R. Poquette
R. POQUETTE, DIRECTOR
SYSTEM DEVELOPMENT

4/19/00
DATE

DRR K10127P

TOTAL PAGES 64

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PAGE	COVER		OTHER PAGES

REVISION STATUS OF PAGES

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TABLE OF CONTENTS:

Y202A150 REV-
CAGE CODE 88818

INTERFACE CONTROL DOCUMENT

FOR THE

KN-4072 INS/GPS SYSTEM

This document defines the digital data exchanged between the INS/GPS and the host via the RS-422 or the MIL-STD-1553 multiplex (MUX) data bus interface . This document includes the definition of all **messages** and **words** for the KN-4072 interface, the **Operational** description and the frame format for RS-422.

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1. KN-4072 INS/GPS SYSTEM - GENERAL OPERATION DESCRIPTION

This document references to the message addresses of the MUX; The equivalent Message ID for the RS-422 is found in the the Message Summary tables. For example: message 22/R (for the MUX) is message ID 12 (for the RS-422) or message 22/T (MUX) is message ID 09 (for RS-422).
R - stands for messages received by the INS/GPS system from the vehicle/host, T - stands for messages transmitted by the INS/GPS system to the vehicle/host.

1.1 Idle Mode

After applying power to the system, the system will automatically enter the Idle mode.

1.2 Ground Alignment (GA) Mode

A command to enter GA mode should be issued (22R/2="GA") where the inertial system will determine roll, pitch, and heading alignment.

In order to entry GA mode valid position must be available from the embedded GPS navigation solution or from operator entry (22R/19,20,21,22) and (22R/5/15) . Position may be entered in either geographic or UTM coordinates; For geographic, set UTM Zone (22R/5/1-7 = 0). Position output may be specified in either geographic or UTM coordinates(22R/5/0,9). The "vehicle on ground" and "vehicle not moving" discretes should be set to true (22R/3,4 = true) .

During this mode, the system determines roll and pitch using sensed earth gravity. The system determines heading using magnetometer input , if available, or by using sensed earth rotation rate (gyrocompassing) if magnetometer input is not available. Magnetometer heading input is entered in (22R/26) and (22R/5/11).

The system provides Attitude Data (Roll, Pitch and True heading) in Subaddress 2T. Data is tagged valid only after completing Coarse Align. Alignment status and quality are output in Subaddress 22T. The embedded GPS navigation solution is provided independently in Subaddress 3T. Both GPS and system status information is provided in Subaddress 22T.

An alignment complete indication during GA mode (22T/2/6) will show the user that expected ground alignment heading accuracy has been achieved and a navigation mode (hybrid, aided, or free inertial) can be entered. Prior to the alignment complete indication, a coarse alignment complete indication will appear (22T/2/12) . The user may enter hybrid navigation mode as soon as there is a coarse alignment complete indication; however, the system heading accuracy will be degraded.

If valid magnetometer heading is entered, alignment complete will occur within 30. seconds following data entry. Heading accuracy will be within 2. degrees 1-sigma.

If magnetometer heading is not entered, a gyrocompass alignment will be performed. Alignment duration and accuracy will depend on latitude and not exceed the following:

Latitude (deg)	Coarse Align Complete (minutes)	Align Complete (minutes)	Heading Accuracy(1-sigma) (deg)
0	2.5	4	2.5
30	3	4.5	2.9
60	4	8	5.0

Following align complete, the system will remain in GA mode and continue to improve gyro calibration if the user does not command a navigation mode, or change the "vehicle not moving" or "vehicle on ground" discretes (from true to false). The system heading accuracy will remain the same.

If "vehicle not moving" is set false during GA mode, free inertial mode will automatically be entered provided coarse alignment is complete.

If "vehicle on ground" is set false during GA mode, hybrid navigation mode will automatically be entered provided coarse alignment is complete.

The user must input the status of "vehicle not moving" as well as the "vehicle on ground" at the start of GA mode and whenever the state of these conditions change

1.3 Hybrid Navigation Mode

Once hybrid navigation mode is entered (22R/2="Hybrid Nav") , the system will compute valid navigation data, accepting pseudo range / delta range updates from the embedded GPS as often as every 2 seconds, provided that GPS data is available. If no embedded GPS reference data is available the system performs free inertial calculations and provides navigation, heading, and attitude data in Subaddress 2T. The embedded GPS navigation solution is provided in Subaddress 3T.

In order to speed up the initial GPS satellite acquisition, the GPS receiver should be initialized with position and time information. This will enable the GPS receiver to quickly acquire almanac data needed for satellite acquisition. This is not required if almanac data has been saved with the battery and the unit is restarted at the previous shutdown location.

Spec performance in heading (0.2 degrees 1 - sigma) during hybrid navigation mode will be achieved following the takeoff maneuver(assuming full GPS coverage).The takeoff maneuver will also serve to further improve roll and pitch accuracies and the calibration of gyro and accelerometer biases. As a result of these improvements, free inertial performance when GPS becomes unavailable will be enhanced so that spec performance can be achieved (600. meters CEP and 3. meters/sec 1-sigma after 10. minutes of free inertial operation). If full GPS coverage is not available during the takeoff maneuver, some turn maneuver (typically 45 deg. S turn or circle) is required when full GPS coverage resumes in order to achieve these improvements.

2. DETAILED OPERATIONAL INSTRUCTIONS

2.1 ACQUIRE ALMANAC*

1) Connect GPS battery.
2) Apply power to unit
3) Send EGR Control Message(2-R) to supply:

    Local Latitude/Longitude/Altitude and Greenwich Mean Time.
    2R/1 Validity Word : Position = Valid (1)
    Time = Valid (1)
    All others = Invalid (0)
    2R/3-5 Latitude
    2R/6-8 Longitude
    2R/11 Antenna Port Select : 2 = use weapon 1
    2R/13-17 Year/Day/Hour/Min/Sec
    2R/31 EGR Command Validity: All = Invalid (0)

4) Monitor INS/GPS Monitor (22T): Wait until GPS Status Nav 1 Word's Almanac Request Bit (22T/10,Bit 9) changes from a TRUE (1) to a FALSE (0).
5) Leave battery connected when unit is powered down.

* Note : This procedure required only when the embedded GPS battery is removed and reconnected.

2.2 OFF

The system is in the Off Mode when power is not applied to the unit.

2.3 IDLE MODE

During this mode, the system does not perform any navigation functions. There is full communication between the 1553B Mux or RS-422 and the embedded GPS receiver. System Nav Data is marked as invalid in 2T. The GPS navigation solution is provided in Subaddress 3T. Both GPS and system status information are provided in 22T. Conditions For Idle Mode:

22R/1 = 1 (Mode Valid)
22R/2 = 1 (Idle)

OR:

Power on (logic reset) brings the system into idle mode.

2.4 GROUND ALIGNMENT

1) Send INS Initialization and Control (22R) :

22R/1 Mode Command Validity : 1 - (Valid)
22R/2 Commanded Mode : 2 - (Ground Alignment)
22R/3 Vehicle Not Moving : 1 - (True)
22R/4 Vehicle On Ground : 1 - (True)
22R/5 Reference Valid Word :
    Position Valid = 1 (Valid), if operator entry of position
        = 0 (Invalid), if GPS initialization of position
    Altitude Valid = 1 (Valid), if operator entry of altitude
        = 0 (Invalid), if GPS initialization of altitude
    Position Output Mode Valid = 1 (Valid)
    UTM Zone = 0 for Lat/Lon Input or actual zone for UTM input
    Position Output Mode = 0(Lat/Lon) or 1(UTM)
    Heading/ Wander Angle Valid = 1, if Magnetometer Heading Valid
        = 0, otherwise
    All others = 0(Invalid)
22R/19,20 Northing or Latitude : Local Value (not required if GPS initialization of position)
22R/21,22 Easting or Longitutde: Local Value (not required if GPS initialization of position)
22R/23,24 Pressure Altitude : Local Value (not required if GPS initialization of altitude)
22R/26 Magnetic Heading (when used)

2) Monitor INS/GPS Monitor (22T): Wait until Align Complete is set (22T/2 /6 =1) before commanding a Navigation mode.

2.5 HYBRID NAV (Stationary - Vehicle On Ground & Not Moving)

1) Monitor INS/GPS Monitor (T-22) : Wait until there are at least 4 GPS Channels in State 5 (22T/13/0-2 = at least 4).

2) Send periodically INS Initialization and Control (22-R) :

22R/1 Mode Command Validity : 1 (Valid)
22R/2 Commanded Mode : 5 - (Hybrid Nav)
22R/3 Vehicle Not Moving : 1 - (True)
22R/4 Vehicle On Ground : 1 - (True)
22R/5 Reference Valid Word :
    Position Valid = 0 (Invalid)
    Altitude = 1 (Valid), if pressure altitude is available
    Altitude = 0 (Valid), if pressure altitude is not available
    All others = 0(Invalid)
22R/23,24 Pressure Altitude : Local Value

3) Monitor INS/GPS Monitor (22-T). Verify current INS/GPS Mode Word (22T/1) = 5 (Hybrid Nav).

, Monitor INS/GPS Nav Output (2-T) for results

2.6 HYBRID NAV (Vehicle Taxi)

1) Send periodically INS Initialization and Control (22-R) :
    22R/1 Mode Command Validity : 1 (Valid)
    22R/2 Commanded Mode : 5 - (Hybrid Nav)
    22R/3 Vehicle Not Moving : 0 - (False)
    22R/4 Vehicle On Ground : 1 - (True)
    22R/5 Reference Valid Word :
        Position Valid = 0 (Invalid)
        Altitude = 1 (Valid), if pressure altitude is available
        Altitude = 0 (Valid), if pressure altitude is not available
        All others = 0 (Invalid)
    22R/23,24 Pressure Altitude : Local Value

2.7 HYBRID NAV (Vehicle Liftoff)

1) Send periodically INS Initialization and Control (22-R) :
    22R/1 Mode Command Validity :1 (Valid)
    22R/2 Commanded Mode : 5 (Hybrid Nav)
    22R/3 Vehicle Not Moving : 0 (False)
    22R/4 Vehicle On Ground : 0 (False)
    22R/5 Reference Valid Word :
        Position Valid = 0 (Invalid)
        Altitude = 1 (Valid), if pressure altitude is available
        Altitude = 0 (Valid), if pressure altitude is not available
        All others = 0(Invalid)
    22R/23,24 Pressure Altitude

ADDITIONAL SCENARIOS:

2.8 FREE INERTIAL (Stationary-Vehicle Not Moving & On Ground)

1) Send periodically INS Initialization and Control (22-R) :
    22R/1 Mode Command Validity : 1 (Valid)
    22R/2 Commanded Mode : 4 - (Free Inertial)
    22R/3 Vehicle Not Moving : 1 (True)
    22R/4 Vehicle On Ground : 1 (True)
    22R/5 Reference Valid Word :
        Position Valid = 0 (Invalid)
        Altitude = 1 (Valid), if pressure altitude is available
        Altitude = 0 (Valid), if pressure altitude is not available
        All others = 0(Invalid)
    22R/23,24 Pressure Altitude : Local Value

2) Monitor INS/GPS Monitor (22-T). Verify current INS/GPS Mode Word (22T/1) = 4 (Free Inertial)
3) Monitor INS/GPS Nav Output (2-T) for results and validity.

2.9 FREE INERTIAL (Vehicle TAXI)

1) Send periodically INS Initialization and Control (22-R) :
    22R/1 Mode Command Validity : 1 (Valid)
    22R/2 Commanded Mode : 4 (Free Inertial)
    22R/3 Vehicle Not Moving : 0 (False)
    22R/4 Vehicle On Ground : 1 (True)
    22R/5 Reference Valid Word :
        Position Valid = 0 (Invalid)
        Altitude = 1 (Valid), if pressure altitude is available
        Altitude = 0 (Valid), if pressure altitude is not available
        All others = 0 (Invalid)
    22R/23,24 Pressure Altitude : Local Value

2.10 FREE INERTIAL (Vehicle LIFTOFF)

1) Send periodically INS Initialization and Control (22-R) :
    22R/1 Mode Command Validity :1 (Valid)
    22R/2 Commanded Mode : 4 (Free Inertial)
    22R/3 Vehicle Not Moving : 0 (False)
    22R/4 Vehicle On Ground : 0 (False)
    22R/5 Reference Valid Word :
        Position Valid = 0 (Invalid)
        Altitude = 1 (Valid), if pressure altitude is available
        Altitude = 0 (Valid), if pressure altitude is not available
        All others = 0(Invalid)
    22R/23,24 Pressure Altitude : Altimeter Input

Additional Notes :

1) If a Mode change is not required, INS Initialization and Control's Mode Command Validity Word (22R/1) shall be set to 0 (Invalid).

2) In order to input data in Geographic coordinates (Lat/Lon), the INS Initialization and Control Message's Reference Validity Word (22R/5) should input 0 for the UTM Zone value in place of the actual zone, Latitude in (22R/19,20) in place of Northing, and Longitude in (22R/21,22) in place of Easting.

3) The default condition for the Position Output Mode Coordinates is Geographic Coordinates.

Messages (summary):

Message:	Receive
From:	Host
To:	INS/GPS

	MUX- 1553B		MUX- 1553B and RS-422		RS-422	
Message Name	Address	# Words	Rate	Purpose	Message Length (Bytes)	Message ID
EGR(Embedded GPS) Control	02 - R	32	aperiodic	Control Embedded Receiver	68	02
Reserved (Time)	03 - R	9	(1 Hz)	(Relate UTC/GPS Time With Host/Master Time)	22	04
GPS Time Mark Block	04 - R	32	aperiodic	Initialize EGR	68	06
Static Data	09 - R	12	aperiodic	Provide Boresight Data	28	08
Reserved (Crypto Key)	12 - R	17	(aperiodic)	(Key The Receiver)	38	10
Test Command In	16 - R	32	aperiodic		68	20
INS Initialization/Control	22 - R	32	aperiodic	INS Control/Initialization	68	12
Reserved (Almanac)	24 - R	17	(aperiodic)		38	14
Reserved (Ephemeris 1)	25 - R	32	(aperiodic)		68	16
Reserved (Ephemeris 2)	26 - R	24	(aperiodic)		52	18
SIDS IMU Data (for test)	27 - R	15	50 Hz	(SIDS Test)		
Reserved (SIDS GPS PVT Data)	28 - R	25	(1 Hz)	(SIDS Test)		
Reserved (SIDS GPS TM 6a)	29 - R		(aperiodic)	(SIDS Test)		
Reserved (SIDS GPS TM 6b)	30 - R		(aperiodic)	(SIDS Test)		

Message: Transmit
From: INS/GPS
To: Host

	MUX- 1553B		MUX- 1553B and RS-422		RS-422	
Message Name	Address	# Words	Rate	Purpose	Message Length (Bytes)	Message ID
INS/GPS Nav Output	02 - T	32	50Hz	Nav Performance	54	01
EGR Time Mark 1	03 - T	32	1 Hz	EGR Performance	64	03
EGR Time Mark 2	04 - T	32	1 Hz	EGR Time Mark cont.	68	05
Reserved (EGR Fail Log)	06 - T	17	1 Hz	Verify EGR Health	38	07
Reserved(Nav IMU data) **	15 - T	8	(50 Hz)		18	21
Autopilot IMU data **	16 - T	7	100 Hz		16	23
EGR Line Of Sight Data 1 thru 6	18 - T Ch1 thru 6	32	1 Hz	EGR / LOS Status Ch1 thru 6	68	18
INS/GPS Monitor	22 - T	32	aperiodic	INS/GPS Status	52	09
Almanac	24 - T	17	aperiodic		38	11
Ephemeris 1	25 - T	32	aperiodic		68	13
Ephemeris 2	26 - T	24	aperiodic		52	15
Multiplex Test Output 1	27 - T	32	1 Hz	Diagnostic Visibility	68	25
Reserved (Multiplex Test Output 2)	28 - T	32	1 Hz	Diagnostic Visibility	68	27
INS/GPS BIT Status	29 - T	32	1 Hz	Verify INS/GPS Health	50	29

**This system will output Autopilot (16 - T) IMU data only.
If requested , Kearfott can replace message 16-T by message Nav IMU data (15-T). See the differences between the two messages described in message 15-T

MESSAGES

Message: **EGR Control (Page 1 of 2)**
Subaddress: 2 - R
Data Transfer: Host to INS/GPS
Rate: aperiodic
Word Count: 32

INPORTANT: *** 2-R message should be used only for GPS Antenna Lever Arms input**
* In some cases, if necessary, it could be used to initialize EGR position (**consult with KEARFOTT**)

Description	Word	Bit (0 Msb)	Type	Units	Comments
Validity Word	1				
Mode		0	discrete	1 - valid	To be set 0 (invalid) by user, otherwise consult KEARFOTT
Position		1	discrete	1 - valid	To be set 0 (invalid) by user, otherwise consult KEARFOTT
spare		2 thru 4			
Time		5	discrete	1 - valid	To be set 0 (invalid) by user, otherwise consult KEARFOTT
Lever Arm 1		6	discrete	**1 - valid**	**(See note 1 for Lever Arms use)**
Lever Arm 2		7	discrete	1 - valid	To be set 0 (invalid) by user
Spare		8			
Selected SV's Valid		9	discrete	1 - valid	To be set 0 (invalid) by user
Spare		10			
Constellation Type Valid		11	discrete	1 - valid	To be set 0 (invalid) by user
Uncertainty Category Valid		12	discrete	1 - valid	To be set 0 (invalid) by user
Dynamics Code Valid		13	discrete	1 - valid	To be set 0 (invalid) by user
spare		14 thru 15			
GPS Mode Select	2	0 thru 15	code	0 - Standby 1 - Init 2 - Nav 3 - Test	To be set 2(Nav) by user, otherwise consult KEARFOTT
Latitude - degrees	3	0 thru 15	signed int	lsb: 1	For use, consult KEARFOTT
Latitude - minutes	4	0 thru 15	signed int	lsb: 1	
Latitude - seconds	5	0 thru 15	signed int	lsb: 1	
Longitude - degrees	6	0 thru 15	signed int	lsb: 1	
Longitude - minutes	7	0 thru 15	signed int	lsb: 1	
Longitude - seconds	8	0 thru 15	signed int	lsb: 1	
Altitude - (WGS-84)	9,10	0 thru 31	signed int	lsb: 1 meters	
Antenna Port Select	11	0 thru 15	code	0 = EGR decides 1 = use aircraft **2 = use weapon 1** 3 = use weapon 2 4 = invalid (no change)	**Must** be set 2 (use weapon 1)
HB1 Configuration	12	0 thru 15	code	**0 = none** 1 = GPS feed 2 = Timing Pulse 3 = spare 4 = invalid (no change)	**Must** be set 0 (none)
Year	13	0 thru 15	signed int	1 = 1901	For use, consult KEARFOTT
Day of Year	14	0 thru 15	signed int	Julian Days	
Hours	15	0 thru 15	signed int	hours	
Minutes	16	0 thru 15	signed int	minutes	
Seconds	17	0 thru 15	signed int	seconds	
Lever Arm 1 - X axis	18	0 thru 15	signed int	inches, lsb: 1	**(See note 1 on page 12)**
Lever Arm 1 - Y axis	19	0 thru 15	signed int	inches, lsb: 1	
Lever Arm 1 - Z axis	20	0 thru 15	signed int	inches, lsb: 1	

Message:	**EGR Control (page 2 of 2)**
Subaddress:	2 - R
Data Transfer:	Host to INS/GPS
Rate:	aperiodic
Word Count:	32

Description	Word	Bit (0 Msb)	Type	Units	Comments
Lever Arm 2 - X axis	21	0 thru 15	signed int	inches, lsb: 1	To be set 0 by user
Lever Arm 2 - Y axis	22	0 thru 15	signed int	inches, lsb: 1	To be set 0 by user
Lever Arm 2 - Z axis	23	0 thru 15	signed int	inches, lsb: 1	To be set 0 by user
Spare	24				
Selected SV 1	25	0 thru 15	signed int	1 to 32	Not used
Selected SV 2	26	0 thru 15	signed int	1 to 32	Not used
Selected SV 3	27	0 thru 15	signed int	1 to 32	Not used
Selected SV 4	28	0 thru 15	signed int	1 to 32	Not used
Spare	29	0 thru 15			
Discrete Word	30				See note 1
L1 Only		0	discrete	0 - use L1/L2 1 - use L1	
Foliage Mode		1	discrete	0 - no foliage	
Constellation Type		2	discrete	0 - Y 1 - Mixed	
Dynamics Code		3	discrete	0 - 100 m/sec 1 - 450 m/sec	
spare		4 thru 7			
Uncertainty Category		8 thru 15	code	pos =< (3 sigma) 0 =< 100 km (default) 1 =< 300 km 2 =< 300 km 3 =< 10 km 4 =< 10 km	
EGR Command Validity	31				See note 1
Spare		0 thru 7			
Ephemeris Request		8	discrete	1 - valid	
Almanac Data Request		9	discrete	1 - valid	
Restart GPS Acquisition		10	discrete	1 - valid	
Zeroize Keys		11	discrete	1 - valid	
Erase Classified Data		12	discrete	1 - valid	
Deselect EGR Aiding		13	discrete	1 - valid	
Deselect INS Aiding		14	discrete	1 - valid	
Use Degraded GPS Data		15	discrete	1 - valid	
EGR Command	32				bit pattern same as word 31

Note 1: a) To input Lever Arms values for the GPS antenna use Lever Arms (X, Y, Z) words 18,19,20 , and set Lever Arm 1, validity word/bit 6, true(1)
b) Antenna Port Select, word 11, **must be 2** (use weapon 1)
c) Set GPS Mode Select, word 2, to 2 (Nav)
d) All other words **must be 0**

Lever Arms definition

From INS/GPS unit to antenna: Forward : +X
Left Wing : +Y
Ceiling (Up) : +Z

Message:	**Reserved (Time)**
Subaddress:	3 - R
Data Transfer:	Host to INS/GPS
Rate:	1 Hz
Word Count:	9

Description	Word	Bit (0 Msb)	Type	Units	Comments
UTC Time of Day	1 thru 2	0 thru 31	undoubleint	64 usec	
Day of Month	3	0 thru 15	unsigned int	1 thru 31	
Month of Year	4	0 thru 15	unsigned int	1 thru 12	
Year	5	0 thru 15	unsigned int	binary	Years
TFOM	6	0 thru 15	unsigned int	0 = < 1 ns 1 = < 10 ns 2 = < 100 ns 3 = < 1 us 4 = < 10 us 5 = < 100 us 6 = < 1 ms 7 = < 2.5 ms 8 = < 3 ms 9 = < 4 ms 10 = < 5 ms 11 = < 6 ms 12 = < 7 ms 13 = < 8 ms 14 = < 9 ms 15 = < 10 ms 16 = non precise time	
Time Mode	7	15	discrete	0 - Time Tag 1 - Data Latency	refers to word 8
		0 thru 14		always 0	
Time At Reset	8		unsigned int	64 usec	
Time Tag	9		unsigned int	64 usec	

Message:	**GPS Time Mark Block**
Subaddress:	4 - R
Data Transfer:	Host to INS/GPS
Rate:	aperiodic
Word Count:	32

Description	Word	Bit (0 Msb)	Type	Units	Comments
Validity Word	1				
Data Block Valid		15	discrete	1 - valid	
Spare		14			
UTC Valid		13	discrete	1 - valid UTC	
spare		0 thru 12			
GPS Time	2 thru 5	0 thru 63	dec dfloat	seconds	of the week
UTC Time	6 thru 9	0 thru 63	dec dfloat	seconds	of the week
Spare	10				
Time Mark Counter	11	0 thru 15	integer	n/a	
Latitude	12,13	0 thru 31	single float	radians	
Longitude	14,15	0 thru 31	single float	radians	
ECEF Position X	16,17	0 thru 31	single float	meters	
ECEF Position Y	18,19	0 thru 31	single float	meters	
ECEF Position Z	20,21	0 thru 31	single float	meters	
Altitude MSL	22,23	0 thru 31	single float	meters	
Altitude WGS-84	24,25	0 thru 31	single float	meters	
Velocity East	26,27	0 thru 31	single float	met/sec	
Velocity North	28,29	0 thru 31	single float	met/sec	
Velocity Up	30,31	0 thru 31	single float	met/sec	
TFOM	32	0 thru 15	unsigned int	0 = < 1 ns 1 = < 10 ns 2 = < 100 ns 3 = < 1 us 4 = < 10 us 5 = < 100 us 6 = < 1 ms 7 = < 2.5 ms 8 = < 3 ms 9 = < 4 ms 10 = < 5 ms 11 = < 6 ms 12 = < 7 ms 13 = < 8 ms 14 = < 9 ms 15 = < 10 ms 16 = non precise time	

Message:	**Static Data**
Subaddress:	9 - R
Data Transfer:	Host to INS/GPS
Rate:	aperiodic
Word Count:	12

Description	Word	Bit (0 Msb)	Type	Units	Comments
Roll Offset	1	0 thru 15	2's comp	semi circles lsb: 2^-15 msb: 2^-1	
Pitch Offset	2	0 thru 15	2's comp	semi circles lsb: 2^ -15 msb: 2^ -1	
Yaw Offset	3	0 thru 15	2's comp	semi circles lsb: 2^ -15 msb: 2^-1	
reserved	4 thru 12				

Message:	**Reserved (Crypto Key)**
Subaddress:	12 - R
Data Transfer:	Host to INS/GPS
Rate:	aperiodic
Word Count:	17

Description	Word	Bit (0 Msb)	Type	Units	Comments
Key 1	1	0 thru 15			weekly key
Key 1	2	0 thru 15			
Key 1	3	0 thru 15			
Key 1	4	0 thru 15			
Key 1	5	0 thru 15			
Key 1	6	0 thru 15			
Key 1	7	0 thru 15			
Key 1	8	0 thru 15			
Key 2	9	0 thru 15			weekly key
Key 2	10	0 thru 15			may be 0
Key 2	11	0 thru 15			
Key 2	12	0 thru 15			
Key 2	13	0 thru 15			
Key 2	14	0 thru 15			
Key 2	15	0 thru 15			
Key 2	16	0 thru 15			
Checksum	17	0 thru 15			

Message:	**INS Initialization and Control (page 1 of 2)**
Subaddress:	22 - R
Data Transfer:	Host to INS/GPS
Rate:	aperiodic
Word Count:	32

Description	Word	Bit (0 Msb)	Type	Units	Comments
Mode Command Valid	1	0 thru 15	code	1-valid	
Commanded Mode	2	0 thru 15	code	0 - reserved	
				1 - Idle	
				2 - Ground Alignment	
				3 - reserved	
				4 - Free Inertial	
				5 - Hybrid Nav	
				6 - Aided Nav	To be tested
				7 - Transfer Align	Reserved/Not tested
				8 - IN-Air Alignment	~~Reserved/Not implemented~~ ok
				9 - Initiated BIT	Not implemented
				10,11,12 - reserved	
Vehicle Not Moving	3	0 thru 15	code	1-true	
Vehicle On Ground	4	0 thru 15	code	1-true	
Reference Valid Word	5	0 thru 15			
Position Valid		15	discrete	1 - valid	See Note 1
Altitude Valid		14	discrete	1 - valid	
Geographic Velocity Valid		13	discrete	1 - valid	mutually exclusive
Body Velocity Valid		12	discrete	1 - valid	mutually exclusive
Heading/Wander Angle Valid		11	discrete	1 - valid	
Attitude Valid		10	discrete	1 - valid	
Position Output Mode Valid		9	discrete	1 - valid	
Year Valid		8	discrete	1 - valid	
UTM Zone		1 thru 7	signed int		
Position Output Mode		0	discrete	0 : Geographic 1:UTM	default = 0
North Velocity	6,7	0 thru 31	2's comp	meters/second lsb: 0.0000038147 msb: 4,096	
East Velocity	8,9	0 thru 31	2's comp	meters/second lsb: 0.0000038147 msb: 4,096	
Down Velocity	10,11	0 thru 31	2's comp	meters/second lsb: 0.0000038147 msb: 4,096	
Lateral Velocity	12,13	0 thru 31	2's comp	meters/second lsb: 0.0000038147 msb: 4,096	
Longitudinal Velocity	14,15	0 thru 31	2's comp	meters/second lsb: 0.0000038147 msb: 4,096	
Normal Velocity	16,17	0 thru 31	2's comp	meters/second lsb: 0.0000038147 msb: 4,096	
Velocity Quality	18	0 thru 15	2's comp	meters/second lsb: 0.015625 msb: 256	square root of the velocity variance

Note 1 : Position Valid = 1, means both Latitude/Northing and Longitude/Easting are valid

Message:	**INS Initialization and Control (page 2 of 2)**
Subaddress:	22 - R
Data Transfer:	Host to INS/GPS
Rate:	aperiodic
Word Count:	32

Description	Word	Bit (0 Msb)	Type	Units	Comments
Latitude / Northing(UTM)	19,20	0 thru 31	2's comp	For Latitude: semi circles lsb: 2^-31 msb: 0.5 min: -0.5 max: 0.5 For Northing: meters lsb: 1 meter	Range for Northing(UTM) : 0.0 - 1.0 x 10^7 meters
Longitude / Easting(UTM)	21,22	0 thru 31	2's comp	For Longtitude: semi circles lsb: 2^-31 msb: 0.5 min: -1 max: 1 For Easting: meters lsb: 1 meter	Range for Easting(UTM): 0.0 - 1.0 x 10^6 meters
Baro Altitude (MSL)	23,24	0 thru 31	2's comp	meters lsb: 0.0000152588 msb: 16,384	
Position Quality	25	0 thru 15	unsigned int	kilometers msb: 64 lsb: 0.0019531	square root of the position variance
Heading (Magnetic)	26	0 thru 15	2's comp	semi circles msb: 2^-1 lsb:2^-15 min: -1 max: 1	
Heading (Magnetic) Quality	27	0 thru 15	2's comp	semi circles msb: 2^-1 lsb: 2^-15	square root of the heading variance
Validity Time	28	0 thru 15	unsigned int	micro seconds lsb: 2^6 msb: 2^21	
Roll	29	0 thru 15	2's comp	semi circles msb: 2^-1 lsb:2^-15 min: -1 max: 1	
Pitch	30	0 thru 15	2's comp	semi circles msb: 2^-1 lsb:2^-15 min: -1 max: 1	
Wander Angle	31	0 thru 15	2's comp	semi circles msb: 2^-1 lsb:2^-15 min: -1 max: 1	
Year/Combo	32	0 thru 15			
Year		0 thru 7	unsigned int	1 equivalent to 1901	
Reserved (UTM Spheroid)		12 thru 15			
Reserved (Extended Zone)		10,11			
Spare		8,9			

Message:	**Reserved (Almanac - CV)**
Subaddress:	24 - R
Data Transfer:	Host to INS/GPS
Rate:	aperiodic
Word Count:	17

Description	Word	Bit (0 Msb)	Type	Units	Comments
Validity	1				
spare		0 thru 14			
Valid		15	discrete	1 - Valid	
Data ID	2	0 thru 1			
SV ID		2 thru 7	unsigned int		
Eccentricity_MSB		8 thru 15	unsigned int	2^-13	
Eccentricity_LSB	3	0 thru 7	unsigned int	2^-21	
Almanac Reference Time		8 thru 15	unsigned int	2^12 seconds	
Inclination Correction	4	0 thru 15	2's comp	2^-19 semi circles	
Rate of Right Ascension	5	0 thru 15	2's comp	2^-38 semi circles	
Satellite Health	6	0 thru 7	binary		
SQRT A_MSB		8 thru 15	unsigned int	2^5 meters ** 1/2	
SQRT A_LSB	7	0 thru 15	unsigned int	2^-11 meters ** 1/2	
Omega O_MSB	8	0 thru 15	unsigned int	2^-15 semi circles	
Omega O_LSB	9	0 thru 7	unsigned int	2^-23 semi circles	
Arg of Perigee_MSB		8 thru 15	unsigned int	2^-7 semi circles	
Arg of Perigee_LSB	10	0 thru 15	unsigned int	2^-23 semi circles	
Mo_MSB	11	0 thru 15	unsigned int	2^-15 semi circles	
Mo_LSB	12	0 thru 7	unsigned int	2^-23 semi circles	
af0_MSB		8 thru 15	unsigned int	2^-17 sec	
af1_MSB	13	0 thru 7	unsigned int	2^-35 sec/sec	
af1_LSB		8 thru 10	unsigned int	2^-38 sec/sec	
af0_LSb		11 thru 13	unsigned int	2^-20 sec	
reserved		14 thru 15		always 0	
Almanac Reference Week	14	0 thru 15		weeks	
reserved	15 thru 17				

Message: **Reserved (Ephemeris 1 (page 1 of 2))**
Subaddress: 25 - R
Data Transfer: Host to INS/GPS
Rate: aperiodic
Word Count: 32

Description	Word	Bit (0 Msb)	Type	Units	Comments
GPS Time	1 thru 4	0 thru 63	dec dfloat	seconds	of the week
Satellite ID	5	0 thru 15	integer		satellite PRN number for which this ephemeris is valid (1 to 32)
reserved	6 thru 7				
Subframe 1 data	8 thru 22			per ICD-GPS-200	
TLM Preamble	8	0 thru 7			
TLM Message_MSB		8 thru 15			
TLM Message_LSB	9	0 thru 5			
reserved for bits 23,24		6 thru 7			
HOW #1		8 thru 15			
HOW #2	10	0 thru 13			
reserved for bits 23,24		14 thru 15			
Week Number	11	0 thru 9			1 week
Code on L2 Flag		10 thru 11			
SV Accuracy		12 thru 15			
SV Health	12	0 thru 5			
IODC_MSB		6 thru 7			
L2 data Flag		8			
Subframe 1 bits 92-98		9 thru 15			
Subframe 1 bits 99-114	13	0 thru 15			
Subframe 1 bits 121-136	14	0 thru 15			
Subframe 1 bits 137-144	15	0 thru 7			
Subframe 1 bits 151-158		8 thru 15			
Subframe 1 bits 159-174	16	0 thru 15			
Subframe 1 bits 181-196	17	0 thru 15			
Group Delay Time	18	0 thru 7		2^-31 seconds	
IODC_LSB		8 thru 15		2^11 seconds	
Clock Date Ref Time	19	0 thru 15		2^4 seconds	
af2	20	0 thru 7		2^-55 seconds/sec/sec	
af1_MSB		8 thru 15			
af1_LSB	21	0 thru 7		2^-43 seconds/sec	
af0_MSB		8 thru 15			
af0_LSB	22	0 thru 13		2^-31 seconds	
reserved for bits 293,294 of subframe 1		14 thru 15			

Message:	**Reserved (Ephemeris 1 (page 2 of 2))**
Subaddress:	25 - R
Data Transfer:	Host to INS/GPS
Rate:	aperiodic
Word Count:	32

Description	Word	Bit (0 Msb)	Type	Units	Comments
Subframe 2	23 thru 32			per ICD-GPS-200	
TLM Preamble TLM Message_MSB	23	0 thru 7 8 thru 15			
TLM Message_LSB reserved for bits 23,24 HOW #1	24	0 thru 5 6 thru 7 8 thru 15			
HOW #2 reserved for bits 23,24	25	0 thru 13 14 thru 15			
IODC Crs_MSB	26	0 thru 7 8 thru 15		2^11 seconds	
Crs_LSB Delta n_MSB	27	0 thru 7 8 thru 15		2^-5 meters	
Delta n_LSB Mo_MSB	28	0 thru 7 8 thru 15		2^-43 semi circles/sec	
Mo_Middle	29	0 thru 15			
Mo_LSB Cue_MSB	30	0 thru 7 8 thru 15		2^-31 semi circles	
Cuc_LSB eccentricity_MSB	31	0 thru 7 8 thru 15		2^-29 radians	
eccentricity_Middle	32	0 thru 15			

Message:	**Reserved (Ephemeris 2)**
Subaddress:	26 - R
Data Transfer:	Host to INS/GPS
Rate:	aperiodic
Word Count:	24

Description	Word	Bit (0 Lsb)	Type	Units	Comments
eccentricity_LSB Cus_MSB	1	0 thru 7 8 thru 15		2^-33	
Cus_LSB SQRT(A)_MSB	2	0 thru 7 8 thru 15		2^-29 radians	
SQRT(A)_Middle	3	0 thru 15			
SQRT(A)_LSB Toe_MSB	4	0 thru 7 8 thru 15		2^-19 sqrt (meters)	
Toe_LSB Fit Interval Flag spare reserved for bits 293, 294 of subframe 2	5	0 thru 7 8 9 thru 13 14 thru 15		2^4 seconds	
Subframe 3 data	6 thru 20			per ICD-GPS-200	
TLM Preamble TLM Message_MSB	6	0 thru 7 8 thru 15			
TLM Message_LSB reserved for bits 23,24 HOW #1	7	0 thru 5 6 thru 7 8 thru 15			
HOW #2 reserved for bits 23,24	8	0 thru 13 14 thru 15			
Cic	9	0 thru 15		2^-29 radians	
Omega o Cis	10, 11 12	0 thru 31 0 thru 15		2_31 semi circles 2^-29 radians	
io	13, 14	0 thru 31		2^-31 semi circles	
Crc	15	0 thru 15		2^-5 meters	
Argument of Perigee	16, 17	0 thru 31		2^-31 semi circles	
Rate of Right Ascention_MSB	18	0 thru 15			
Rate of Right Ascention_LSB IODE	19	0 thru 7 8 thru 15		2^-43 semi circles 2^11 seconds	
Rate Of Inclination Angle reserved for bits 293, 294 of subframe 3	20	0 thru 13 14 thru 15		2^-43	
spare	21 thru 22				
L1 Ionospheric Delay	23	0 thru 15		2^-2 ns	0=no available value
SV ID	24	0 thru 15	un integer		satellite PRN number for which this ephemeris data is valid (1 to 32)

Message: **SIDS IMU Data**
Subaddress: 27 - R
Data Transfer: Host to INS/GPS
Rate: 50 Hz
Word Count: 15

Description	Word	Bit (0 Msb)	Type	Units	Comments
X Delta Angle (body)	1, 2	0 thru 31	single float	radians/50 hz	
Y Delta Angle (body)	3, 4	0 thru 31	single float	radians//50 hz	
Z Delta Angle (body)	5, 6	0 thru 31	single float	radians//50 hz	
X Delta Velocity (body)	7, 8	0 thru 31	single float	ft/sec/50 hz	
Y Delta Velocity (body)	9, 10	0 thru 31	single float	ft/sec/50 hz	
Z Delta Velocity (body)	11, 12	0 thru 31	single float	ft/sec/50 hz	
Valid Time Tag	13, 14	0 thru 31			
TMP Pulse	15	0 thru 15	discrete	1=TMP Pulse 0=No Pulse	Set TRUE 0.18 sec before LOS Data is Valid

Message: **Reserved (SIDS GPS PVT Data (Not Currently Implemented))**
Subaddress: 28 - R
Data Transfer: Host to INS/GPS
Rate: 1 Hz
Word Count: 25

Description	Word	Bit (0 Msb)	Type	Units	Comments
Mode Word	1	0 thru 15			
Nav Data Validity		0	discrete	1 - Valid	
Cmd Receiver Mode		1 thru 3	code	000 - reserved 001 - Init 010 - Nav 011 - Test 100 - reserved	
reserved		4 thru 11			
Lever Arm Correction Used		12	discrete	1 - Used	
reserved		13 thru 14			
Time Tag Mode		15	discrete	0 - use words 2,3 for time 1 - word 2 latency	
Time Of Validity	2	0 thru 15	unsigned int	micro seconds lsb: 2^6 msb: 2^21	
Time Of Reset	3	0 thru 15	unsigned int	micro seconds lsb: 2^6 msb: 2^21	
Reserved	4				
GPS Latitude	5, 6	0 thru 31	2's comp	2^-31 semi circles	
GPS Longitude	7, 8	0 thru 31	2's comp	2^-31 semi circles	
GPS Altitude - MSL	9	0 thru 15	2's comp	meters	above mean sea level
GPS Altitude - WGS-84	10	0 thru 15	2's comp	meters	ellipsoid
GPS Velocity East	11, 12	0 thru 31	2's comp	2^-20 ft/sec	
GPS Velocity North	13, 14	0 thru 31	2's comp	2^-20 ft/sec	
	15, 16	0 thru 31	2's comp	2^-20 ft/sec	
GPS Status & FOM	17	0 thru 15			
State 5 Operation		0	discrete	1 - State 5	
State 3 Operation		1	discrete	1 - State 3	
Incorporating < 4 meas		2	discrete	1 - < 4 meas	
GPS Data Not Valid		3	discrete	1 - Not Valid	
reserved		4 thru 8			
spare		9 thru 11			
FOM		12 thru 15	unsigned int	range 1 thru 9	
Est Horizontal Position Error	18	0 thru 15	signed int	1 feet	
Est Vertical Position Error	19	0 thru 15	signed int	1 feet	
Satellite State Summary	20	0 thru 15	unsigned int	# satellites in state 3 and state 5 track	
UTC Measurement Time	21,22	0 thru 31	unsigned int	2^-14 second	
reserved	23 thru 24				
Lever Arm Used X	25	0 thru 15	signed int	1 inch	
Lever Arm Used Y	25	0 thru 15	signed int	1 inch	
Lever Arm Used Z	25	0 thru 15	signed int	1 inch	

Message:	**INS/GPS Nav Output (page 1 of 2)**
Subaddress:	2 - T
Data Transfer:	INS/GPS to Host
Rate:	50 Hz
Word Count:	32 for MUX, 25 for RS-422

Description	Word	Bit (0 Msb)	Type	Units	Comments
Validity Word	1				
Attitude		15	discrete	1 - Valid	
True Heading		14	discrete	1 - Valid	
North/East Velocity		13	discrete	1 - Valid	
Latitude/Longitude		12	discrete	1 - Valid	
Inertial Altitude		11	discrete	1 - Valid	
Down Velocity		10	discrete	1 - Valid	
Spare		9			
Velocity Corrected		8	discrete	1 - Valid	
UTM Zone Number **		0 thru 7	integer		Range: +/- 60
Time Tag	2,3	0 thru 31	single float		
GPS Time	4,5,6,7	0 thru 63	double float		
Roll	8	0 thru 15	2's comp	semi circles lsb: 2^ -15 msb: 0.5 min: -1 max: 1	
Pitch	9	0 thru 15	2's comp	semi circles lsb: 2^-15 msb: 0.5 min: -1 max: 1	

** If UTM zone number is zero, then position outputs (words 17, 18 and 19, 20) are interpreted as latitude and longitude; otherwise they are UTM northing and easting. The UTM format utilizes the WGS-84 ellipsoid.

Message:	**INS/GPS Nav Output (page 2 of 2)**
Subaddress:	2 - T
Data Transfer:	INS/GPS to Host
Rate:	50 Hz
Word Count:	32 for MUX , 25 for RS-422

Description	Word	Bit (0 Msb)	Type	Units	Comments
True Heading	10	0 thru 15	2's comp	semi circles lsb: 2^-15 msb: 0.5 min: -1 max: 1	
North Velocity	11 12	0 thru 31	2's comp	meters/second resolution(lsb):0.0000038147 msb: 4,096 accuracy: 0.0002	
East Velocity	13 14	0 thru 31	2's comp	meters/second resolution(lsb):0.0000038147 msb: 4,096 accuracy: 0.0002	
Down Velocity	15 16	0 thru 31	2's comp	meters/second resolution(lsb):0.0000038147 msb: 4,096 accuracy: 0.0002	
Latitude /Northing	17 18	0 thru 31	2's comp	For Latitude: For Northing: semi circles meters lsb: 2^-31 lsb: 1 meter msb: 0.5 min: -0.5 max: 0.5	Range for UTM/Northing : 0.0 - 1.0 x 10^7 meters
Longitude/Easting	19 20	0 thru 31	2's comp	For Longtitude: For Easting: semi circles meters lsb: 2^-31 lsb: 1 meter msb: 0.5 min: -1 max: 1	Range for UTM/Easting: 0.0 - 1.0 x 10^6 meters
Altitude (WGS-84)	21 22	0 thru 31	2's comp	meter lsb: 0.0000152588 msb: 16,384 resolution: 0.305	
North Velocity Correction	23	0 thru 15	2's comp	meters/second resolution(lsb):0.00012207 max: 3.9624	From Kalman Filter
East Velocity Correction	24	0 thru 15	2's comp	meters/second resolution(lsb):0.00012207 max: 3.9624	From Kalman Filter
Down Velocity Correction	25	0 thru 15	2's comp	meters/second resolution(lsb):0.00012207 max: 3.9624	From Kalman Filter
spare(for MUX only)	26 thru 32				

For SA'

Message:	**EGR Time Mark W/6 Channel - Part 1**
Subaddress:	3 - T
Data Transfer:	INS/GPS to Host
Rate:	1 Hz
Word Count:	32

Description	Word	Bit (0 Msb)	Type	Units	Comments
GPS Time	1 thru 4	0 thru 63	dec dfloat	seconds	of the week
UTC Time	5 thru 8	0 thru 63	dec dfloat	always 0	
Delta T	9	0 thru 15		always 0	
Time Mark Count	10	0 thru 15	unsigned int	0 to 5	
Latitude	11 thru 12	0 thru 31	dec sfloat	radians	
Longitude	13 thru 14	0 thru 31	dec sfloat	radians	
ECEF Position X	15 thru 16	0 thru 31	dec sfloat	meters	
ECEF Position Y	17 thru 18	0 thru 31	dec sfloat	meters	
ECEF Position Z	19 thru 20	0 thru 31	dec sfloat	meters	
Altitude - MSL	21 thru 22	0 thru 31	dec sfloat	meters	
Altitude - WGS84	23 thru 24	0 thru 31	dec sfloat	meters	
Velocity East	25 thru 26	0 thru 31	dec sfloat	met/sec	
Velocity North	27 thru 28	0 thru 31	dec sfloat	met/sec	
Velocity Up	29 thru 30	0 thru 31	dec sfloat	met/sec	
reserved	31 thru 32			always 0	

Message:	**EGR Time Mark W/6 Channel - Part 2 (page 1 of 2) ***
Subaddress:	4 - T
Data Transfer:	INS/GPS to Host
Rate:	1 Hz
Word Count:	32

Description	Word	Bit (0 Msb)	Type	Units	Comments
reserved	1 thru 14		single float	always 0	
Channel 1 Status A	15	0 thru 15			
SV Number		11 thru 15	un integer	0 thru 31, 0=SV 32	
Channel Number		8 thru 10	un integer	1 thru 6, 0=none	
Y-Code		7	binary	0=P or CA, 1=Y	
Channel State		4 thru 6	unsigned	0 = no data	
				1 = CA search	
				2 = P(Y) search	
				3 = code lock	
				4 = AFC lock	
				5 = costas	
				6 = seq-synch	
				7 = reacquisition	
Code Type		3	binary	0=P, 1=CA	
Frequency		2	binary	0=L1, 1=L2	
Antenna		1	binary	0 = A/C or Weapon 1 1=Weapon 2	
Fault		0	boolean	1=true	
Channel 1 Status B	16	0 thru 15			
Jamming Signal		8 thru 15	un integer	decibels	
Carrier To Noise		0 thru 7	un integer	decibels	
Channel 2 Status A	17	0 thru 15		same as chan 1	
Channel 2 Status B	18	0 thru 15		same as chan 1	
Channel 3 Status A	19	0 thru 15		same as chan 1	
Channel 3 Status B	20	0 thru 15		same as chan 1	
Channel 4 Status A	21	0 thru 15		same as chan 1	
Channel 4 Status B	22	0 thru 15		same as chan 1	
Channel 5 Status A	23	0 thru 15		same as chan 1	
Channel 5 Status B	24	0 thru 15		same as chan 1	
Channel 6 Status A	25	0 thru 15		same as chan 1	
Channel 6 Status B	26	0 thru 15		same as chan 1	

*** Same as ID1100 from ICD-GPS-150**

Message: EGR Time Mark W/6 Channel - Part 2 (page2 of 2) *
Subaddress: 4 - T
Data Transfer: INS/GPS to Host
Rate: 1 Hz
Word Count: 32

Description	Word	Bit (0 Msb)	Type	Units	Comments
Figure Of Merit	27	0 thru 15			
FOM		12 thru 15	un integer	1 = < 26 meters 2 = 26-50 3 = 51-75 4 = 76-100 5 = 101-200 6 = 201-500 7 = 501-1000 8 = 1001-5000 9 = > 5000	
ICD-255 Erase Fault		11		1=fail	storage erase failure
reserved		8 thru 10			
AE LRU Failure		7	boolean	1=fail	
RPU Failure		6	boolean	1=fail	
Nav Data Not Valid		5	boolean	1=not valid	
ICD_255 Nav Degraded		4	boolean	1= degraded	SA not corrected
Nav Data going bad		3	boolean	always=0	Keys soon to expire
Less than 4 meas		2	boolean	1= < 4 meas	
State 3 Operation		1	boolean	1 = true	
State 4/5 Operation		0	boolean	1 = true	
Expected Horizontal Error	28	1 thru 15	un integer	meters	
spare		0			
Expected Vertical Error	29	1 thru 15	un integer	meters	
spare		0			
Equipment Available	30	0 thru 15			
INS		0	boolean	1 = available	
reserved		1 thru 3			
Heading		4	boolean	1 = available	
Attitude		5	boolean	1 = available	
reserved		6 thru 7			
spare		8 thru 15			
Equipment Used	31	0 thru 15			
INS		0	boolean	1 = used	
reserved		1 thru 3			
Heading		4	boolean	1 = used	
Attitude		5	boolean	1 = used	
reserved		6 thru 7			
UTC Data		8	boolean	1 = used	
reserved		9			
MSL Computed		10	boolean	1 = used	
spare		11 thru 15			
Time Figure of Merit	32	0 thru 3	un integer	1 to 15	
reserved		4 thru 15			

*** Same as ID1100 from ICD-GPS-150**

Message:	**EGR Fail Log**
Subaddress:	6 - T
Data Transfer:	INS/GPS to Host
Rate:	1 Hz
Word Count:	17

Description	Word	Bit (0 Msb)	Type	Units	Comments
GPS Time	1 thru 4	0 thru 63	double float	seconds	
reserved	5 thru 6				
reserved	7	0 thru 7			
DC Bias		8 thru 15	binary	1=fail	bit 0 or 8 = channel 1 bit 1 or 9 = channel 2 bit 2 or 10 = channel 3 bit 3 or 11 = channel 4 bit 4 or 12 = channel 5 bit 5 or 13 = channel 6 bit 6 or 14 = channel 6A bit 7 or 15 = channel 6B
Code NCO	8	0 thru 7	binary	1=fail	
Phase Rotation		8 thru 15	binary	1=fail	
Code Generator	9	0 thru 7	binary	1=fail	
PDI		8 thru 15	binary	1=fail	
Power High	10	0 thru 7	binary	1=fail	
Power Low		8 thru 15	binary	1=fail	
Overall BIT	11	0 thru 15	integer	0=pass, 1=fail	
Task Status	12	0 thru 15	binary	pass/fail	status of each task
Channel Status	Message:	0 thru 15	integer	pass/fail	each hw channel
RTC	14	0 thru 7	integer	0=pass, 1=fail	each port
A/D		8 thru 15	binary	pass/fail	
PPS-SM	15	0 thru 7	integer	0=pass, 1=fail	
Clock Drift		8 thru 15	integer	0=pass, 1=fail	
spare	16	0 thru 7			
Aux Power Low		8 thru 15	integer	0=pass, 1=fail	
Failure Found	17	0 thru 15	integer	0=none, 1=error	

Message: **Reserved (Nav IMU Data) [see remark 1]**
Subaddress: 15 - T
Data Transfer: INS/GPS to Host
Rate: 50 Hz
Word Count: 8 for MUX, 7 for RS422

Description	Word	Bit (0 Msb)	Type	Units	Comments
X Delta Angle (body)	1	0 thru 15	2's comp	radians (***)	LSB value = 10 E-6
Y Delta Angle (body)	2	0 thru 15	2's comp	radians (***)	LSB value = 10 E-6
Z Delta Angle (body)	3	0 thru 15	2's comp	radians (***)	LSB value = 10 E-6
X Delta Velocity (body)	4	0 thru 15	2's comp	ft/sec (***)	LSB value = 1.5 E-3
Y Delta Velocity (body)	5	0 thru 15	2's comp	ft/sec (***)	LSB value = 1.5 E-3
Z Delta Velocity (body)	6	0 thru 15	2's comp	ft/sec (***)	LSB value = 1.5 E-3
BIT/Mode Status *	7	0 thru 15			Available in 29-T message
Message count **	8	0 thru 15	2's comp		

* BIT/Mode Status Definition:
Bit 0: Spare
Bit 1: 1 = Over Temperature Fail (bad data)
Bit 2: 1 = External Sync Fail
Bit 2: 1 = External Sync Mode
Bit 4: 1 = Critical failure occurred, invalid or degraded outputs are probable
Bit 5: 1 = IMU in factory mode ; 0 = IMU in operational mode
Bit 6: 0 = startup BIT in progress; 1 = periodic BIT in progress
Bit 7: 0 = startup BIT fail; 1 = periodic BIT fail (valid only if bit 3 or bit 7 indicates failure)
Bit 8: 1 = Non-critical failure occurred, invalid or degraded data outputs are probable
Bit 9 -15: Failure code; number from 0 to 83 indicating type of failure (0 = no failure)

Remark 1 :
The NAV IMU data (15-T), 50 Hz has the following compensations that the AUTOPILOT IMU data (16-T),100 Hz does not have:

. coning correction (delta thetas)
. sculling correction (delta velocities)
. size effect correction (delta velocities)

The NAV IMU data uses these compensations to enhance the accuracy of the navigation data. The AUTOPILOT IMU data does not use these compensations because the enhanced accuracy is not required, and more importantly, the corrections can cause unwanted disturbances to the flight control process.

In addition, the NAV IMU data uses a second order low pass filter called a matching filter for both delta thetas and delta velocities, while the AUTOPILOT IMU data uses a second order low pass filter called a shaping filter for both delta thetas and delta velocities. Both matching and shaping filters are identical in form, but their parameters (natural frequency and damping) are set independently in EPROM.

** For Mux 1553 only

*** Delta Angle and Delta Velocity are changes over 10 msec interval

Message:	**Autopilot IMU Data**
Subaddress:	16 - T
Data Transfer:	INS/GPS to Host
Rate:	100 Hz
Word Count:	7 for Mux, 6 for RS-422

Description	Word	Bit (0 Msb)	Type	Units	Comments
X Delta Angle (body)	1	0 thru 15	2's comp	radians (**)	LSB value = 5 E-6
Y Delta Angle (body)	2	0 thru 15	2's comp	radians (**)	LSB value = 5 E-6
Z Delta Angle (body)	3	0 thru 15	2's comp	radians (**)	LSB value = 5 E-6
X Delta Velocity (body)	4	0 thru 15	2's comp	ft/sec (**)	LSB value = 7.5 E-4
Y Delta Velocity (body)	5	0 thru 15	2's comp	ft/sec (**)	LSB value = 7.5 E-4
Z Delta Velocity (body)	6	0 thru 15	2's comp	ft/sec (**)	LSB value = 7.5 E-4
Message count*	7	0 thru 15	2's comp		

* for Mux 1553 only

** Delta Angle and Delta Velocity are changes over 10 msec interval

Message:	**EGR Line Of Sight Data 1 thru 6 - for each channel ***
Subaddress:	18 -T word 1 ID's 1 thru 6
Data Transfer:	INS to Host
Rate:	1 Hz
Word Count:	32

Description	Word	Bit (0 Msb)	Type	Units	Comment
Counter	1	0 thru 15	unsigned int	n/a	
Multiplex ID	2	0 thru 15	Code	1 thru 6 for each channel	
Time Tag Of Data	3 thru 6	0 thru 63	double float	seconds of week	
Channel Status	7				
Satelite ID		11 thru 15	binary	0=32	
ICD 225 Corrected		10	discrete	0=SA corrected	
Antenna		9	discrete	0=Aircraft 1=Weapon	ID5300 word 5, bit 6 from ICD-GPS-150
spare		8			
Y-Code		7	discrete	1=Y-Code	
Tracking State		4 thru 6	binary	0 = no data 1 = CA search 2 = P(Y) search 3 = code lock 4 = AFC lock 5 = costas 6 = seq-synch 7 = reaquisition	
Code Type		3	discrete	0 = P(Y) Code 1 = CA Code	
Iono Correction		2	discrete	0 = Modelled 1 = L1/L2	
Weapon Antenna Used		1	discrete	0 = Antenna 1 (always) 1 = Antenna 2	ID5300 word 5, bit 14 from ICD-GPS-150
Channel BITE Status		0	discrete	1 = Fail	
Pseudo_Range	8,9	0 thru 31	integer	meters	lsb = 2**-5
Delta Range	10,11	0 thru 31	integer	meters	lsb = 2**-16
Pseudo Range Variance	12,13	0 thru 31	integer	meters squared	lsb = 2**-8
Delta Range Variance	14,15	0 thru 31	integer	meters squared	lsb = 2**-16
Satelite Position X End - ECEF	16,17	0 thru 31	integer	meters	lsb = 2**-4
Satelite Position Y End - ECEF	18,19	0 thru 31	integer	meters	lsb = 2**-4
Satelite Position Z End - ECEF	20,21	0 thru 31	integer	meters	lsb = 2**-4
Satelite Position X Start - ECEF	22,23	0 thru 31	integer	meters	lsb = 2**-4
Satelite Position Y Start - ECEF	24,25	0 thru 31	integer	meters	lsb = 2**-4
Satelite Position Z Start - ECEF	26,27	0 thru 31	integer	meters	lsb = 2**-4
Iono Correction	28	0 thru 15	integer	meters	lsb = 2**-5
Ephemeris URA Word	29				
URA (User Range Accuracy)		12 thru 15	binary	range 0 thru 256	
Availability		11	discrete	0 = no ephemeris 1 = ephemeris	
Nav Data Availability		10	discrete	0 = data valid 1 = data invalid	
Differential GPS		9	discrete	0 = CA code 1 = CA code diff corrected	
spare		8	discrete		
UDRE (User Diff Range Error)		0 thru 7	integer	meters	0 - 256 meters
Delta Range Interval	30,31	0 thru 31	single float	seconds	

*** Same as ID5300 from ICD-GPS-150**

Message: INS/GPS Monitor (page 1 of 4)
Subadress: 22 - T
Data Transfer: INS/GPS to Host
Rate: Aperiodic
Word Count: 32

Description	Word	Bit (0 MSB)	Type	Units	Comments
Current INS/GPS Mode	1	0 thru 15		0 - Startup	
				1 - Idle	
				2 - Ground Alignment Coarse	
				3 - Ground Alignment Fine	
				4 - Free Inertial	
				5 - Hybrid Nav	
				6 - Aided Nav	Reserved/Not tested
				7 - Transfer Align	Reserved/Not tested
				8 - In-Air Alignment	Reserved/Not tested
				9 - Initiated BIT	Not implemented
				10 - No Go	
				11 - Gyro Compass Restart	
				12 - Gyro Comp No Position	
Nav Status Word 2	2				
Position Measurement		0	discrete	1 - Position Update Used	data rejected when > 3 sigma of expected value
Velocity Measurement		1	discrete	1 - Velocity Update Used	data rejected when > 3 sigma of expected value
IMU Valid		2	discrete	1 - Valid	
GPS Fail Found		3	discrete	1 - Valid	ID5230 Fail Log word 91
No Go		4	discrete	0 - Go 1 - No Go	BIT Health / Startup Failure
Align In Progress		5	discrete	0 - Suspended 1 - In Progress	
Align Complete		6	discrete	1 - Valid	
Initiated BIT Status		7	discrete	1 - IBIT in progress	
UTM input error		8	discrete	1 - Error	
INS/GPS Not Ready		9	discrete	1 - Not Ready	
spare		10 thru 11			
Coarse Align Complete		12	discrete	1 - Complete	
Unauthorized GPS		13	discrete	1 - Degraded GPS Data	Not Corrected for SA
IMU Aiding Deselected		14	discrete	1 - IMU Aiding Deselected	
GPS Aiding Deselected		15		1 - GPS Aiding Deslected	
Time Of Align	3	0 thru 15	unsigned int	seconds lsb: 1	
Align Quality	4	0 thru 15	unsigned int	kilometers/hr lsb: 0.031250 msb: 1,024	estimated as the square root of the heading covariance in radians X (1,850 km/hr/rad)

Message: **INS/GPS Monitor (page 2 of 4)**
Subaddress: 22 - T
Data Transfer: INS/GPS to Host
Rate: aperiodic
Word Count: 32

Description	Word	Bit (0 Msb)	Type	Units	Comments
GPS Time	5 thru 8	0 thru 63	dec dfloat	seconds	of week
GPS Status Word 1	9	0	discrete	1 - valid	
spare		1 thru 15			
GPS Status Nav 1	10				
Nav Data Valid		0	discrete	1 - valid	
User Mode		1 thru 2	un integer	0 - Test 1 - Init 2 - Nav 3 - Standby	
BIT in progress		3	discrete	0 - in progress	
Stationary Mode		4	discrete	1 - stationary mode	
Init Data Request		5	discrete	1 - init data needed	
reserved		6			
Altitude Hold		7	discrete	1 - altitude hold on	
reserved		8			
Almanac Request		9	discrete	1 - need almanac data	
reserved		10 thru 11			
Lever Arm Correction		12	discrete	1 - lever arm used	
reserved		13 thru 15			
GPS Status SA/AS	11				
Key Good		0	discrete	1 - key verified	
Key In Use		1	discrete	1 - key in use	
reserved		2			
Bad Parity Key 1		3	discrete	1 - parity error	
Bad Parity Key 2		4	discrete	1 - parity error	
CV Alert		5	discrete	1 - key will soon expire	
Insufficient Keys		6	discrete	1 - insufficient keys	for mission duration
Zeroize Fail		7	discrete	1 - CV erase fail	
Keys Exist		8	discrete	1 - contains keys	
Mission Duration		9 thru 15	integer	days	1111111 >= 127
GPS Status / FOM	12				
State 5 Operation		0	discrete	1 - =>=4 in state 5	
State 3 Operation		1	discrete	1 - =>=1 in state 3	
Less than 4 measurements		2	discrete	1 - =<4 SV used in fix	
GPS Data Not Valid		3	discrete	1 - not valid	
RPU Fail		4	discrete	1 - fail	Receiver Processor Unit
AE Fail		5	discrete	1 - fail	Ant Electr (Preamp only)
Aux Power Fail		6	discrete	1 - fail	
reserved		7 thru 15			

Message:	INS/GPS Monitor (page 3 of 4)
Subaddress:	22 - T
Data Transfer:	INS/GPS to Host
Rate:	aperiodic
Word Count:	32

Description	Word	Bit (0 Msb)	Type	Units	Comments
GPS Status Satellite	13				
Channels in State 5		0 thru 2	un integer		
Channels in State 3		3 thru 5	un integer		
reserved		6			
spare		7 thru 11			
SV's tracking		12 thru 15	un integer	0=none	number of SV in track
GPS Status Equipment	14				
reserved		0			
RPU Fail		1	boolean	1=fail	Receiver Processor Unit
reserved		2 thru 15			
GPS Status Nav 2	15				
Dynamics Mode		0	integer	0=100 m/s, 1=450	
UE Mode		1 thru 2	integer	0=TEST 1=INIT 2=NAV 3=reserved	
reserved		3			
spare		4 thru 6			
reserved		7 thru 15			
GPS Status Word	16				
Erase In Progress		0	discrete	1 - In Progress	
Oscillator Stable		1	discrete	1 - Stable	
Almanac Stored		2	discrete	1 - Valid Almanacs Stored	
Ephemeris Stored		3	discrete	1 - at least 4 SV Ephemeris Stored	
Time Established		4	discrete	1 - Receiver Time Initialized	
Keys Zeroized		5	discrete	1 - Zeroize Passed	
Acquisition Restarted		6	discrete	1 - satellite acquisition has been restarted upon command	
Differential GPS mixture		7	discrete	1 - CA and CA diff corr mixture	
Satellites In State 5		8 thru 15	unsigned int	range 1 to 4	
Antenna Port Select	17	0 thru 15	code	0 - EGR decides 1 - Use A/C antenna 2 - Use Weapon #1 3 - Use Weapon #2	
HB1 Config	18	0 thru 15	code	0 - None 1 - GPS Feed 2 - Timing Pulse	

Message:	**INS/GPS Monitor (page 4 of 4)**
Subaddress:	22 - T
Data Transfer:	INS/GPS to Host
Rate:	aperiodic
Word Count:	32

Description	Word	Bit (0 Msb)	Type	Units	Comments
Lever Arm 1 - X Axis	19	0 thru 15	signed int	inches, lsb: 1	
Lever Arm 1 - Y Axis	20	0 thru 15	signed int	inches, lsb: 1	
Lever Arm 1 - Z Axis	21	0 thru 15	signed int	inches, lsb: 1	
Lever Arm 2- X Axis	22	0 thru 15	signed int	inches, lsb: 1	
Lever Arm 2 - Y Axis	23	0 thru 15	signed int	inches, lsb: 1	
Lever Arm 2 - Z Axis	24	0 thru 15	signed int	inches, lsb: 1	
spare *	25 thru 32				

* RS - 422 uses only 24 words; no spare

Message:	**Almanac - CV**
Subaddress:	24 - T
Data Transfer:	INS/GPS to Host
Rate:	aperiodic
Word Count:	17

Description	Word	Bit (0 Msb)	Type	Units	Comments
Validity	1				
spare		0 thru 14			
Valid		15	discrete	1 - Valid	
Data ID	2	0 thru 1			
SV ID		2 thru 7	unsigned int		
Eccentricity_MSB		8 thru 15	unsigned int	2^-13	
Eccentricity_LSB	3	0 thru 7	unsigned int	2^-21	
Almanac Reference Time		8 thru 15	unsigned int	2^12 seconds	
Inclination Correction	4	0 thru 15	2's comp	2^-19 semi circles	
Rate of Right Ascension	5	0 thru 15	2's comp	2^-38 semi circles	
Satellite Health	6	0 thru 7	binary		
SQRT A_MSB		8 thru 15	unsigned int	2^5 meters ** 1/2	
SQRT A_LSB	7	0 thru 15	unsigned int	2^-11 meters ** 1/2	
Omega O_MSB	8	0 thru 15	unsigned int	2^-15 semi circles	
Omega O_LSB	9	0 thru 7	unsigned int	2^-23 semi circles	
Arg of Perigee_MSB		8 thru 15	unsigned int	2^-7 semi circles	
Arg of Perigee_LSB	10	0 thru 15	unsigned int	2^-23 semi circles	
Mo_MSB	11	0 thru 15	unsigned int	2^-15 semi circles	
Mo_LSB	12	0 thru 7	unsigned int	2^-23 semi circles	
af0_MSB		8 thru 15	unsigned int	2^-17 sec	
af1_MSB	13	0 thru 7	unsigned int	2^-35 sec/sec	
af1_LSB		8 thru 10	unsigned int	2^-38 sec/sec	
af0_LSb		11 thru 13	unsigned int	2^-20 sec	
reserved		14 thru 15			
Almanac Reference Week	14	0 thru 15		weeks	
spare	15 thru 17				

Message:	**Ephemeris 1 (page 1 of 2)**
Subaddress:	25 - T
Data Transfer:	INS/GPS to Host
Rate:	aperiodic
Word Count:	32

Description	Word	Bit (0 Msb)	Type	Units	Comments
GPS Time	1 thru 4	0 thru 63	double float	seconds	of the week
Satellite ID	5	0 thru 15	integer		satellite PRN number for which this ephemeris is valid
reserved	6 thru 7				
Subframe 1 data	8 thru 22			per ICD-GPS-200	
TLM Preamble TLM Message_MSB	8	0 thru 7 8 thru 15			
TLM Message_LSB reserved for bits 23,24 HOW #1	9	0 thru 5 6 thru 7 8 thru 15			
HOW #2 reserved for bits 23,24	10	0 thru 13 14 thru 15			
Week Number Code on L2 Flag SV Accuracy	11	0 thru 9 10 thru 11 12 thru 15			1 week
SV Health IODC_MSB L2 data Flag Subframe 1 bits 92-98	12	0 thru 5 6 thru 7 8 9 thru 15			
Subframe 1 bits 99-114 Subframe 1 bits 121-136	13 14	0 thru 15 0 thru 15			
Subframe 1 bits 137-144 Subframe 1 bits 151-158	15	0 thru 7 8 thru 15			
Subframe 1 bits 159-174	16	0 thru 15			
Subframe 1 bits 181-196	17	0 thru 15			
Group Delay Time IODC_LSB	18	0 thru 7 8 thru 15		2^-31 seconds 2^11 seconds	
Clock Date Ref Time	19	0 thru 15		2^4 seconds	
af2 af1_MSB	20	0 thru 7 8 thru 15		2^-55 seconds/sec/sec	
af1_LSB af0_MSB	21	0 thru 7 8 thru 15		2^-43 seconds/sec	
af0_LSB reserved for bits 293,294 of subframe 1	22	0 thru 13 14 thru 15		2^-31 seconds	

Message:	**Ephemeris 1 (page 1 of 2)**
Subaddress:	25 - T
Data Transfer:	INS/GPS to Host
Rate:	aperiodic
Word Count:	32

Description	Word	Bit (0 Msb)	Type	Units	Comments
Subframe 2	23 thru 32			per ICD-GPS-200	
TLM Preamble TLM Message_MSB	23	0 thru 7 8 thru 15			
TLM Message_LSB reserved for bits 23,24 HOW #1	24	0 thru 5 6 thru 7 8 thru 15			
HOW #2 reserved for bits 23,24	25	0 thru 13 14 thru 15			
IODC Crs_MSB	26	0 thru 7 8 thru 15		2^11 seconds	
Crs_LSB Delta n_MSB	27	0 thru 7 8 thru 15		2^-5 meters	
Delta n_LSB Mo_MSB	28	0 thru 7 8 thru 15		2^-43 semi circles/sec	
Mo_Middle	29	0 thru 15			
Mo_LSB Cue_MSB	30	0 thru 7 8 thru 15		2^-31 semi circles	
Cuc_LSB eccentricity_MSB	31	0 thru 7 8 thru 15		2^-29 radians	
eccentricity_Middle	32	0 thru 15			

Message: **Ephemeris 2**
Subaddress: 26 - T
Data Transfer: INS/GPS to Host
Rate: aperiodic
Word Count: 24

Description	Word	Bit (0 lsb)	Type	Units	Comments
Eccentricity_LSB Cus_MSB	1	0 thru 7 8 thru 15		2^-33	
Cus_LSB SQRT(A)_MSB	2	0 thru 7 8 thru 15		2^-29 radians	
SQRT(A)_Middle	3	0 thru 15			
SQRT(A)_LSB Toe_MSB	4	0 thru 7 8 thru 15		2^-19 sqrt (meters)	
Toe_LSB Fit Interval Flag spare reserved for bits 293, 294 of subframe 2	5	0 thru 7 8 9 thru 13 14 thru 15		2^4 seconds	
Subframe 3 data	6 thru 20			per ICD-GPS-200	
TLM Preamble TLM Message_MSB	6	0 thru 7 8 thru 15			
TLM Message_LSB reserved for bits 23,24 HOW #1	7	0 thru 5 6 thru 7 8 thru 15			
HOW #2 reserved for bits 23,24	8	0 thru 13 14 thru 15			
Cic	9	0 thru 15		2^-29 radians	
Omega o Cis	10, 11 12	0 thru 31 0 thru 15		2^31 semi circles 2^-29 radians	
io	13, 14	0 thru 31		2^-31 semi circles	
Crc	15	0 thru 15		2^-5 meters	
Argument of Perigee	16, 17	0 thru 31		2^-31 semi circles	
Rate of Right Ascension_MSB	18	0 thru 15			
Rate of Right Ascension_LSB IODE	19	0 thru 7 8 thru 15		2^-43 semi circles 2^11 seconds	
Rate Of Inclination Angle reserved for bits 293, 294 of subframe 3	20	0 thru 13 14 thru 15		2^-43 semi circles	
spare	21 thru 22				
L1 Ionospheric Delay	23	0 thru 15		2^-2 ns	0=no data is available
SV ID	24	0 thru 15	un integer		satellite PRN number for which this ephemeris data is valid

Message: **Multiplex Test Output 1 - ISA Raw Data**
Subaddress: 27 - T
Data Transfer: INS/GPS to Host
Rate: 1 Hz
Word Count: 32

Description	Word	Bit (0 Msb)	Type	Units	Comments
Counter	1	0 thru 15	Integer		used to denote a new msg
Message Code	2	0 thru 15	Integer		1 = ISA Raw Data
Gyro Pulse Sum	3,4	0 thru 31	single float		X Axis
Gyro Pulse Sum	5,6	0 thru 31	single float		Y Axis
Gyro Pulse Sum	7,8	0 thru 31	single float		Z Axis
Accelerometer Pulse Sum	9,10	0 thru 31	single float		X Axis
Accelerometer Pulse Sum	11,12	0 thru 31	single float		Y Axis
Accelerometer Pulse Sum	13,14	0 thru 31	single float		Z Axis
Coning Correction Sum	15,16	0 thru 31	single float		X Axis
Coning Correction Sum	17,18	0 thru 31	single float		Y Axis
Coning Correction Sum	19,20	0 thru 31	single float		Z Axis
Accelerometer Bias	21,22	0 thru 31	single float		X Axis
Accelerometer Bias	23,24	0 thru 31	single float		Y Axis
Accelerometer Bias	25,26	0 thru 31	single float		Z Axis
Spare	27 thru 32				

Message: **Multiplex Test Output 1 - ISA Compensated Data**
Subaddress: 27 - T
Data Transfer: INS/GPS to Host
Rate: 1 Hz
Word Count: 32

Description	Word	Bit (0 Msb)	Type	Units	Comments
Counter	1	0 thru 15	Integer		used to denote a new msg
Message Code	2	0 thru 15	Integer		2 = ISA Compensated Data
Gyro Bias	3,4	0 thru 31	single float		X Axis
Gyro Bias	5,6	0 thru 31	single float		Y Axis
Gyro Bias	7,8	0 thru 31	single float		Z Axis
Commanded Dither Noise	9,10	0 thru 31	single float		
Dither In Phase	11,12	0 thru 31	single float		
Dither Quadrature	13,14	0 thru 31	single float		
Compensated Velocity Sums	15,16	0 thru 31	single float		X Axis
Compensated Velocity Sums	17,18	0 thru 31	single float		Y Axis
Compensated Velocity Sums	19,20	0 thru 31	single float		Z Axis
Compensated Angle Sums	21,22	0 thru 31	single float		X Axis
Compensated Angle Sums	23,24	0 thru 31	single float		Y Axis
Compensated Angle Sums	25,26	0 thru 31	single float		Z Axis
Spare	27 thru 32				

Message:	**Multiplex Test Output 1 - ISA Control Loop 1**
Subaddress:	27 - T
Data Transfer:	INS/GPS to Host
Rate:	1 Hz
Word Count:	32

Description	Word	Bit (0 Msb)	Type	Units	Comments
Counter	1	0 thru 15	Integer		used to denote a new msg
Message Code	2	0 thru 15	Integer		3 = ISA Control Loop 1
PLC Mirror Drive	3,4	0 thru 31	single float		X Axis
PLC Mirror Drive	5,6	0 thru 31	single float		YAxis
PLC Mirror Drive	7,8	0 thru 31	single float		Z Axis
PLC Integrator Term	9,10	0 thru 31	single float		X Axis
PLC Integrator Term	11,12	0 thru 31	single float		Y Axis
PLC Integrator Term	13,14	0 thru 31	single float		Z Axis
Laser Fringe Intensity	15,16	0 thru 31	single float		X Axis
Laser Fringe Intensity	17,18	0 thru 31	single float		Y Axis
Laser Fringe Intensity	19,20	0 thru 31	single float		Z Axis
Number Mode Hops	21,22	0 thru 31	single float		X Axis
Number Mode Hops	23,24	0 thru 31	single float		Y Axis
Number Mode Hops	25,26	0 thru 31	single float		Z Axis
Maximum Dither Amplitude	27,28	0 thru 31	single float		
Dither Amplitude Snapshot	29,30	0 thru 31	single float		
Spare	31,32	0 thru 31			

Message: **Multiplex Test Output 1 - ISA Control Loop 2**
Subaddress: 27 - T
Data Transfer: INS/GPS to Host
Rate: 1 Hz
Word Count: 32

Description	Word	Bit (0 Msb)	Type	Units	Comments
Counter	1	0 thru 15	Integer		used to denote a new msg
Message Code	2	0 thru 15	Integer		4 = ISA Control Loop 2
Dither Frequency Filtered	3,4	0 thru 31	single float		
Maximum Dither Command	5,6	0 thru 31	single float		
Dither Command Snapshot	7,8	0 thru 31	single float		
SW Dither Gain	9,10	0 thru 31	single float		
Gyro Temperature	11,12	0 thru 31	single float		
Accelerometer Temperature	13,14	0 thru 31	single float		A Axis
Accelerometer Temperature	15,16	0 thru 31	single float		B Axis
Accelerometer Temperature	17,18	0 thru 31	single float		CAxis
Sculling Corection Sum	19,20	0 thru 31	single float		X Axis
Sculling Corection Sum	21,22	0 thru 31	single float		Y Axis
Sculling Corection Sum	23,24	0 thru 31	single float		Z Axis
Buffered Size Effect	25,26	0 thru 31	single float		X Axis
Buffered Size Effect	27,28	0 thru 31	single float		Y Axis
Buffered Size Effect	29,30	0 thru 31	single float		Z Axis
Spare	31,32	0 thru 31			

Message: **Multiplex Test Output 1 - Nav Calibration Data**
Subaddress: 27 - T
Data Transfer: INS/GPS to Host
Rate: 1 Hz
Word Count: 32

Description	Word	Bit (0 Msb)	Type	Units	Comments
Counter	1	0 thru 15	Integer		used to denote a new msg
Message Code	2	0 thru 15	Integer		5 = Nav Calibration Data
Level Velocity	3,4	0 thru 31	single float	Feet	X Axis
Level Velocity	5,6	0 thru 31	single float	Feet	YAxis
Level Velocity	7,8	0 thru 31	single float	Feet	Z Axis
Wander Angle	9,10	0 thru 31	single float	Radians	
Roll	11,12	0 thru 31	single float	Radians	
Pitch	13,14	0 thru 31	single float	Radians	
True Heading	15,16	0 thru 31	single float	Radians	
Latitude	17 thru 20	0 thru 63	double float	Radians	
Longitude	21 thru 24	0 thru 63	double float	Radians	
Altitude	25,26	0 thru 31	single float	Feet	
Align Quality	27,28	0 thru 31			
Spare	29 thru 32				

Message:	**Multiplex Test Output 1 - BIT Data (TBD)**
Subaddress:	27 - T
Data Transfer:	INS/GPS to Host
Rate:	1 Hz
Word Count:	32

Description	Word	Bit (0 Msb)	Type	Units	Comments
Counter	1	0 thru 15	Integer		used to denote a new msg
Message Code	2	0 thru 15	Integer		6 = BIT Data

Message: **Multiplex Test Output 1 - Kalman State Vector 1**
Subaddress: 27 - T
Data Transfer: INS/GPS to Host
Rate: 1 Hz
Word Count: 32

Description	Word	Bit (0 Msb)	Type	Units	Comments
Counter	1	0 thru 15	Integer		used to denote a new msg
Message Code	2	0 thru 15	Integer		7 = Kalman State Vector 1
X Position	3,4	0 thru 31	single float	ft	
Y Position	5,6	0 thru 31	single float	ft	
X Velocity	7,8	0 thru 31	single float	ft/sec	
Y Velocity	9,10	0 thru 31	single float	ft/sec	
X Tilt	11,12	0 thru 31	single float	radians	
Y Tilt	13,14	0 thru 31	single float	radians	
Heading	15,16	0 thru 31	single float	radians	
Altitude	17,18	0 thru 31	single float	ft	
Z Velocity	19,20	0 thru 31	single float	ft/sec	
Integrated Altitude	21,22	0 thru 31	single float	ft/sec**2	
Baro	23,24	0 thru 31	single float	ft	
Clock Phase	25,26	0 thru 31	single float	ft	
Clock Frequency	27,28	0 thru 31	single float	ft/sec	
Clock Frequency Rate	29,30	0 thru 31	single float	ft/sec**2	
Spare	31,32				

Message:	**Multiplex Test Output 1 - Kalman State Vector 2**
Subaddress:	27 - T
Data Transfer:	INS/GPS to Host
Rate:	1 Hz
Word Count:	32

Description	Word	Bit (0 Msb)	Type	Units	Comments
Counter	1	0 thru 15	Integer		used to denote a new msg
Message Code	2	0 thru 15	Integer		8 = Kalman State Vector 2
X Accelerometer Bias	3,4	0 thru 31	single float	ft/sec	
Y Accelerometer Bias	5,6	0 thru 31	single float	ft/sec	
Z Accelerometer Bias	7,8	0 thru 31	single float	ft/sec	
X Gyro Bias	9,10	0 thru 31	single float	deg/hour	
Y Gyro Bias	11,12	0 thru 31	single float	deg/hour	
Z Gyro Bias	13,14	0 thru 31	single float	deg/hour	
Sin A Heading	15,16	0 thru 31	single float		
1-Cos A Heading	17,18	0 thru 31	single float		
X GPS Position Noise	19,20	0 thru 31	single float	ft	
Y GPS Position Noise	21,22	0 thru 31	single float	ft	
Z GPS Position Noise	23,24	0 thru 31	single float	ft	
X GPS Velocity Noise	25,26	0 thru 31	single float	ft/sec	
Y GPS Velocity Noise	27,28	0 thru 31	single float	ft/sec	
Z GPS Velocity Noise	29,30	0 thru 31	single float	ft/sec	
Spare	31,32				

Message: **Multiplex Test Output 1 - Kalman Covariance Matrix 1**
Subaddress: 27 - T
Data Transfer: INS/GPS to Host
Rate: 1 Hz
Word Count: 32

Description	Word	Bit (0 Msb)	Type	Units	Comments
Counter	1	0 thru 15	Integer		used to denote a new msg
Message Code	2	0 thru 15	Integer		9 = Kalman Cov Matrix 1
X Position Diagonal	3,4	0 thru 31	single float	ft	
Y Position Diagonal	5,6	0 thru 31	single float	ft	
X Velocity Diagonal	7,8	0 thru 31	single float	ft/sec	
Y Velocity Diagonal	9,10	0 thru 31	single float	ft/sec	
X Tilt Diagonal	11,12	0 thru 31	single float	radians	
Y Tilt Diagonal	13,14	0 thru 31	single float	radians	
Heading Diagonal	15,16	0 thru 31	single float	radians	
Attitude Diagonal	17,18	0 thru 31	single float	ft	
Z Velocity Diagonal	19,20	0 thru 31	single float	ft/sec	
Integrated Altitude Diagonal	21,22	0 thru 31	single float	ft/sec**2	
Baro Diagonal	23,24	0 thru 31	single float	ft	
Clock Phase Diagonal	25,26	0 thru 31	single float	ft	
Clock Frequency Diagonal	27,28	0 thru 31	single float	ft/sec	
Clock Frequency Rate Diagonal	29,30	0 thru 31	single float	ft/sec**2	
Spare	31,32				

Remark : All are sigma=(cov)1/2

Message: **Multiplex Test Output 1 - Kalman Covariance Matrix 2**
Subaddress: 27 - T
Data Transfer: INS/GPS to Host
Rate: 1 Hz
Word Count: 32

Description	Word	Bit (0 Msb)	Type	Units	Comments
Counter	1	0 thru 15	Integer		used to denote a new msg
Message Code	2	0 thru 15	Integer		10 = Kalman Cov Matrix 2
X Accelerometer Bias Diagonal	3,4	0 thru 31	single float	ft/sec	
Y Accelerometer Bias Diagonal	5,6	0 thru 31	single float	ft/sec	
Z Accelerometer Bias Diagonal	7,8	0 thru 31	single float	ft/sec	
X Gyro Bias Diagonal	9,10	0 thru 31	single float	deg/hour	
Y Gyro Bias Diagonal	11,12	0 thru 31	single float	deg/hour	
Z Gyro Bias Diagonal	13,14	0 thru 31	single float	deg/hour	
Sin A Heading Diagonal	15,16	0 thru 31	single float		
1-Cos A Heading Diagonal	17,18	0 thru 31	single float		
X GPS Position Noise Diagonal	19,20	0 thru 31	single float	ft	
Y GPS Position Noise Diagonal	21,22	0 thru 31	single float	ft	
Z GPS Position Noise Diagonal	23,24	0 thru 31	single float	ft	
X GPS Velocity Noise Diagonal	25,26	0 thru 31	single float	ft/sec	
Y GPS Velocity Noise Diagonal	27,28	0 thru 31	single float	ft/sec	
Z GPS Velocity Noise Diagonal	29,30	0 thru 31	single float	ft/sec	
Spare	31,32				

Remark : All are sigma=(cov)1/2

Message:	**INS/GPS BIT Status (Page 1 of 4)**
Subaddress:	29 - T
Data Transfer:	INS/GPS to Host
Rate:	1 Hz
Word Count:	32

Description	Word	Bit (0 Msb)	Type	Units	Comments
GPS SW Version/Date	1 thru 7	0 thru 7 8 thru 15	character character		xx.xx (Ex: ver 04.08) mm/dd/yy
IMU SW Version	8,9	0 thru 31	hex		scrriiii (see note 1)
NAV SW Version	10,11	0 thru 31	hex		00000vvv (see note 2)
spare	12,13				
Health	14				
Current BIT State		12 thru 15	code	binary	BIT Summary 0001 - Startup 0010 - Periodic 0100 - Initiated(not implemented) 1000 - Idle
Startup Failure		11	discrete	1 - fail	Same as NO-GO in 22-T / word 2 bit 4
Initiated BIT Failure		10	discrete	1 - fail	not used
Periodic BIT Failure		9	discrete	1 - fail	not implemented
Critical Failure		8	discrete	1 - fail	not implemented
Processor Good		7	discrete	1 - good	
Control Good		6	discrete	1 - good	
Task Good		5	discrete	1 - good	
EGR Good		4	discrete	1 - good	Same as GPS Fail Found in 22-T / word 2 bit 3
IMU Good		3	discrete	1 - good	
Power Good		2	discrete	1 - good	
spare		0, 1			

Note 1. sc - s = 0 for Internal Sync; s = 8 for External Sync
c = 0 for INS unit mounted with connector end facing BACK of aircraft and top end facing TOP of aircraft
= 1 for INS unit mounted with connector end facing BACK of aircraft, and top end facing RIGHT WING of aircraft
= 2 for INS unit mounted with connector end facing FRONT of aircraft, and top end facing RIGHT WING of aircraft
= 3 for INS unit mounted with connector end facing FRONT of aircraft, and top end facing TOP of aircraft
rr - Kearfott Internal SW release number
iiii - IMU SW version
Ex: 01010102 - Int Sync / Connector end backward, top end right wing / Release 1 / version 1.02
83030105 - Ext Sync / Connetor end forward, tot end up / Release 3 / version 1.05

Note 2. 00000vvv - Nav SW version
Ex: 00000104 - for version 1.04

USE OR DISCLOSURE OF THIS DATA IS SUBJECT TO THE RESTRICTION ON THE TITLE PAGE OF THIS DOCUMENT

Message: **INS/GPS BIT Status (Page 2 of 4)**
Subaddress: 29 - T
Data Transfer: INS/GPS to Host
Rate: 1 Hz
Word Count: 32

Description	Word	Bit (0 Msb)	Type	Units	Comments
SRA Fail Word	15	0 thru 15			not used
IMU BIT Status	16				direct from IMU
BIT Index		9 thru 15	hex	0 - No Failure	(see note 1)
Degraded Fail		8	discrete	1 - Fail	
Startup/Periodic Fail		7	discrete	0 - Startup Fail 1 - Perodic Fail	When Degraded Fail (bit 8) or Critical Fail (bit 4)
Startup / Periodic in progress		6	discrete	0 - Startup 1 - Periodic in progress	
Factory Mode		5	discrete	0 - Operational 1 - Factory	
Critical Fail		4	discrete	1 - Fail	
Internal / External Sync		3	discrete	0 - Internal Sync 1 - External Sync	
External Sync Fail		2	discrete		
IMU Bad Data - Temp Fail		1	discrete		
spare		0			

Note 1: IMU BIT INDEX DICTIONARY

1. RAM Fail in Startup
2. EEPROM Fail in Startup
3. Dither Amplitude in Startup
4. Dither Signal in Startup
5.
6. RAM Checksum
7. Dither Freq max in Startup
8. Dither Freq min in Startup
9. Dither Amplit max in Startup
10. Dither Amplit min in Startup
11. Dither OFF
12. PLC OFF
13. Switched to Internal Sync
14. Executive Overflow Periodic
15. External Sync Error
16.CPU Integrity
17. A/D Ready Fail
18. RAM Fail
19. Watchdog Timer
20. EEPROM Fail in Startup Chip #2
21. A/D Reference
22. A/D Offset
23.
24. Dither Freq max Periodic
25. Dither Freq min Periodic
26. Dither Amplit max Periodic
27. Dither Amplit min Periodic
28.
29. Pendulum Test Fail
30. A Accel Saturation
31. B Accel Saturation
32. C Accel Saturation
33. A Accel Consistency
34. B Accel Consistency
35. C Accel Consistency
36. A Accel Limits
37. B Accel Limits
38. C Accel Limits
39. Gyro Ballast Current
40. Laser Current Red Axis
41. Laser Current White Axis
42. Laser Current Blue Axis
43. PLC Loop Drive
44. ASIC Wraparound
45.EEPROM Read Fail
46. PLC Loop Red
47. PLC Loop White
48. PLC Loop Blue
49. Temp Reasonableness
50. Temp Reasonableness Degraded
51. Dither Loop Amplit Periodic
52. Dither Loop Signal Periodic
53. Temp Over / Under
54.
55. Red Gyro Saruration
56. White Gyro Saruration
57. Blue Gyro Saruration
58. Red Gyro Consistency
59 White Gyro Consistency
60. Blue Gyro Consistency
61. Red Gyro Limit
62. White Gyro Limit
63. Blue Gyro Limit
64. VCF Bias X
65. VCF Bias Y
66. VCF Bias Z
67. VCF Bias Alternate Channel
68. VCF Scale Factor X
69. VCF Scale Factor Y
70. VCF Scale Factor Z
71. VCF Scale Factor Alternate Channel
72. X Pendulum
73. Y Pendulum
74. Z Pendulum
75.
76. Startup Timeout
77.Dither Noise Degraded
78. Red Laser Intensity Max
79. White Laser Intensity Max
80. Blue Laser Intensity Max
81. X Accel 1 Hz Saturation
82. Y Accel 1 Hz Saturation
83. Z Accel 1 Hz Saturation

Message: **INS/GPS BIT Status (Page 3 of 4)**
Subaddress: 29 - T
Data Transfer: INS/GPS to Host
Rate: 1 Hz
Word Count: 32

IMU Temperature	17				direct from IMU
Gyro saturation Fail		15	discrete		
A Accel Temp saturatin Fail		14	discrete		
B Accel Temp saturatin Fail		13	discrete		
C Accel Temp saturatin Fail		12	discrete		
Gyro Temp reasonbls Fail		11	discrete		
A Accel Temp reasonbls Fail		10	discrete		
B Accel Temp reasonbls Fail		9	discrete		
C Accel Temp reasonbls Fail		8	discrete		
Gyro overtemp		7	discrete		
Gyro undertemp		6	discrete		
Accel overtemp		5	discrete		
Accel undertemp		4	discrete		
All Temperatures Fail		3	discrete		
spare		0-2			
IMU BIT Cumulative	18,19				direct from IMU
Executive		31	discrete		
CPU		30	discrete		
RAM Pattern		29	discrete		
RAM Sum		28	discrete		
EEPROM		27	discrete		
VCF Calibration		26	discrete		
A / D		25	discrete		
Accel Pendulum Offset		24	discrete		
Temp Reasonbleness		23	discrete		
Dither Loop		22	discrete		
Laser		21	discrete		
PLC Red		20	discrete		
PLC White		19	discrete		
PLC Blue		18	discrete		
Dither Freq		17	discrete		
Dither Amplitude		16	discrete		
Gyro Rx		15	discrete		
Gyro Ry		14	discrete		
Gyro Rz		13	discrete		
Acc Rx		12	discrete		
Acc Ry		11	discrete		
Acc Rz		10	discrete		
Watchdog Timer		9	discrete		
Temp Sensor		8	discrete		
Dither Optimum		7	discrete		
spare		6			
Gyro Limit		5	discrete		
spare		4			
Asic Wrap		3	discrete		
Acc Limit		2	discrete		
EEPROM I nterface		1	discrete		
External Clock		0	discrete		

Message:	**INS/GPS BIT Status (Page 4 of 4)**
Subaddress:	29 - T
Data Transfer:	INS/GPS to Host
Rate:	1 Hz
Word Count:	32

IMU Auxiliary Word	20,21	0 thru 31			direct from IMU
Processor Status	22				
Rom Checksum		15	discrete	1 - fail	
CPU Test		14	discrete	1 - fail	
RAM Pattern		13	discrete	1 - fail	
RAM Boundary		12	discrete	1 - fail	
Nav_EEPR Checksum Fail		11	discrete	1 - fail	
Nav_EEPR Pattern Fail		10	discrete	1 - fail	
Comm_EEPR Checksum Fail		9	discrete	1 - fail	
Comm_EEPR Pattern Fail		8	discrete	1 - fail	
spare		0 thru 7			
Task Errors	23				
Kal_Obs Overload		15	discrete	1 - true	
Kal_Filt Overload		14	discrete	1 - true	
Host_IO Overload		13	discrete	1 - true	
EGR_IO Overload		12	discrete	1 - true	
Magnetic Variation Overload		11	discrete	1 - true	
Auto Pilot Overload		10	discrete	1 - true	
NAV Overload		9	discrete	1 - true	
Control Auto Pilot Other Errors		8	discrete	1 - true	
Control NAV Other Errors		7	discrete	1 - true	
Kal_Obs Other Errors		6	discrete	1 - true	
Kal_Filt Other Errors		5	discrete	1 - true	
Host_IO Other Errors		4	discrete	1 - true	
EGR_IO Other Errors		3	discrete	1 - true	
Auto Pilot Other Errors		2	discrete	1 - true	
NAV Other Errors		1	discrete	1 - true	
Magnetic Variation Other Err		0	discrete	1 - true	
Spare *	24 thru 32				

* RS - 422 uses only 23 words; no spare

FIGURE 1. FRAME FORMAT FOR RS-422

INPUT / OUTPUT MESSAGE BYTE FORMAT (INPUT TO INS/GPS AND OUTPUT TO HOST)

F	ID	N	D1	D2	-------------------------------- --	DN	CH

NOTE:

F: FRAME START, AAHex

ID: MESSAGE ID CODE , (0-255)

N: DATA BYTE COUNT, (0-255)

D1 ------- DN: N bytes of DATA; 32 bit values are sent as 2 16 bit values, most significant first; 16 bit values are transmitted as 2 bytes, least significant first.

CH: CHECKSUM, 8 bits, each - xor of corresponding bit in all other message bytes including N, ID but excluding F

Messages are classified by TYPE as follows:

OPIN:	Operational message input, ID even, <20
OPOUT	Operational message output, ID odd, <20
TSTIN:	Test message input, ID even, ≥20
TSTOUT:	Test message output, ID odd, >20

BIT RATE (BAUD) = 115.2kb/s

FIGURE 2. DATA BIT TRANSMISSION SEQUENCE

Data is transmitted and received in 11 bit packets consisting of a start bit, 8 bits of data, a parity bit, and a stop bit. The start bit is a logic 0, the data bits are received / transmitted with the lsb bit first, the parity following the msb to create odd parity, and the stop bit is a logic 1. The bus idle state is a logic 1.
The example below shows bit numbering for all messages except except 26-R and 26-T:

START BIT	LSB B7	B6	B5	B4	B3	B2	B1	MSB B0	ODD PARITY	STOP BIT	IDLE

3. KN-4072 GPS/INS Serial message Timing

The serial output timing is based on 50 hz. interval. The 50 hz. (20 msec.) interval is broken into 4 200 hz. (5 msec) chunks.
Starting with a 50 hz. boundary, the 4 chunks are numbered 1, 2, 3 and 4 :
1 starts with the 50 hz. boundary and ends with the first 200 hz. boundary ;
2 starts with the first 200 hz. boundary and ends with the 100 hz. boundary ;
3 starts at the 100 hz. boundary and ends with the third 200 hz. boundary ;
4 starts with the third 200 hz. boundary and ends on the 50 hz. boundary.

Autopilot output message - ID23 (RS422), 16 bytes, 100 hz.
The autopilot data representing chunks 1 and 2 is output on the third 200 hz. boundary (on the end of chunk 3). The data representing chunks 3 and 4 is output on the first 200 hz.boundary in the next 50 hz. interval.

Navigation output message - ID 1 (RS422) , 48 bytes, 50 hz.
The navigation data representing chunks 1, 2, 3 and 4 is appended to the Autipilot message in the third 200 hz. boundary in the next 50 hz. interval.

Other output messages -
The 50 50hz. intervals that make up a 1 sec interval are numbered from 1 to 50.
Each “other “ message is assigned an interval number (1 -50) .
For each interval, if the message assigned to the interval is ready to send data, the message will be appended to the Autopilot message on the first 200 hz. boundary in that interval.

Note that all messages are packaged with three bytes leading the data [frame byte, message id, message length] and one byte following the data [checksum].
The phrase “messages are appended” simply means that the frame byte of the following message will immediately follow the checksum byte of the previous message - the data from the two messages is not combined in any way.

4. ELECTRICAL INTERFACE

J1	POWER CONN	MS27474T10B35P	[MATE: MS27484E10B35S,without cable strain relief]
J2	SIGNAL CONN	MS27474P16B35S	[MATE: MS27484E16B35P,without cable strain relief]
J3	GPS RF INPUT	WGX50SACJ(AIRBORN), (SMA TYPE) [MATES WITH SMA-50 OHM COAX (MALE)]	

J1 POWER CONNECTOR

PIN NO.	SIGNAL
1	+28 VDC INPUT POWER
2	+28 VDC INPUT POWER
6	28 VDC INPUT POWER RETURN
7	28 VDC INPUT POWER RETURN
9	CHASSIS GROUND

J2 SIGNAL CONNECTOR

PIN NO.	SIGNAL
25	RS-422 No. 1 DATA IN / HI
26	RS-422 No. 1 DATA IN/LOW
32	RS-422 No. 1 DATA OUT / HI
33	RS-422 No. 1 DATA OUT / LOW
47	GPS RS-422, PORT B, TEST PORT INPUT HI also for DIFFERENTIAL GPS CORR.
48	GPS RS-422, PORT B, TEST PORT INPUT LOW also for DIFFERENTIAL GPS CORR.
53	GPS RS-422, PORT B, TEST PORT OUTPUT HI also for DIFFERENTIAL GPS CORR.
54	GPS RS-422, PORT B, TEST PORT OUTPUT LOW also for DIFFERENTIAL GPS CORR.
49	DC SIGNAL AND CHASSIS GROUND
28	MUX A, LONG STUB PRIMARY HI
35	MUX A, LONG STUB PRIMARY LO
43	MUX A,SHIELD
30	MUX HWADD 00
31	MUX HWADD 01
37	MUX HWADD 02
38	MUX HWADD 03
45	MUX HWADD 04
46	HWADD PARITY
44	MUX B, LONG STUB PRIMARY HI
36	MUX B, LONG STUB PRIMARY LO
29	MUX B,SHIELD
10	WRITE PROTECT DISCRETE TEST POINT
6	POWER ON RESET DISCRETE INPUT (see remark 1)
11	EXTERNAL SYNC INPUT HI
12	EXTERNAL SYNC INPUT LOW

4	EMBEDDED GPS RECEIVER 1 PPS OUT HI
5	EMBEDDED GPS RECEIVER 1 PPS OUT LO

ALL OTHER PINS ARE RESERVED OR SPARED. DO NOT USE THIS PINS BEFORE CONSULTING WITH KEARFOTT. DAMAGE TO THE SYSTEM MAY OCCUR!!

20	RS232 OUT
21	RS232 IN

7	RS422 #2 IN HI	(spare)
8	RS422 #2 IN LO	(spare)
14	RS422 #2 OUT HI	(spare)
15	RS422 #2 OUT LO	(spare)

9	+5 VDC	(Test Point)
24	+15 VDC	(Test Point)
39	- 15 VDC	(Test Point)

13	C31 CLKDD	(Test Point)
17	C31 DR0	(Test Point)
18	C31 DX0	(Test Point)
19	C31 FSR0	(Test Point)
22	C31 FSX0	(Test Point)
23	C31 SCR0	(Test Point)

J3 GPS RF INPUT CONNECTOR

SMA COAX	RF INPUT AND +5VDC FOR ANTENNA PRE AMP, 40 ma MAX

REMARKS

1) Grounding this pin will reset all the computers within the system. Hold the line at ground for about 500 msec. is a safe time. System restart will be the same as if unit underwent a power turn on.

5. GPS RECEIVER'S BATTERY AND ANTENNA

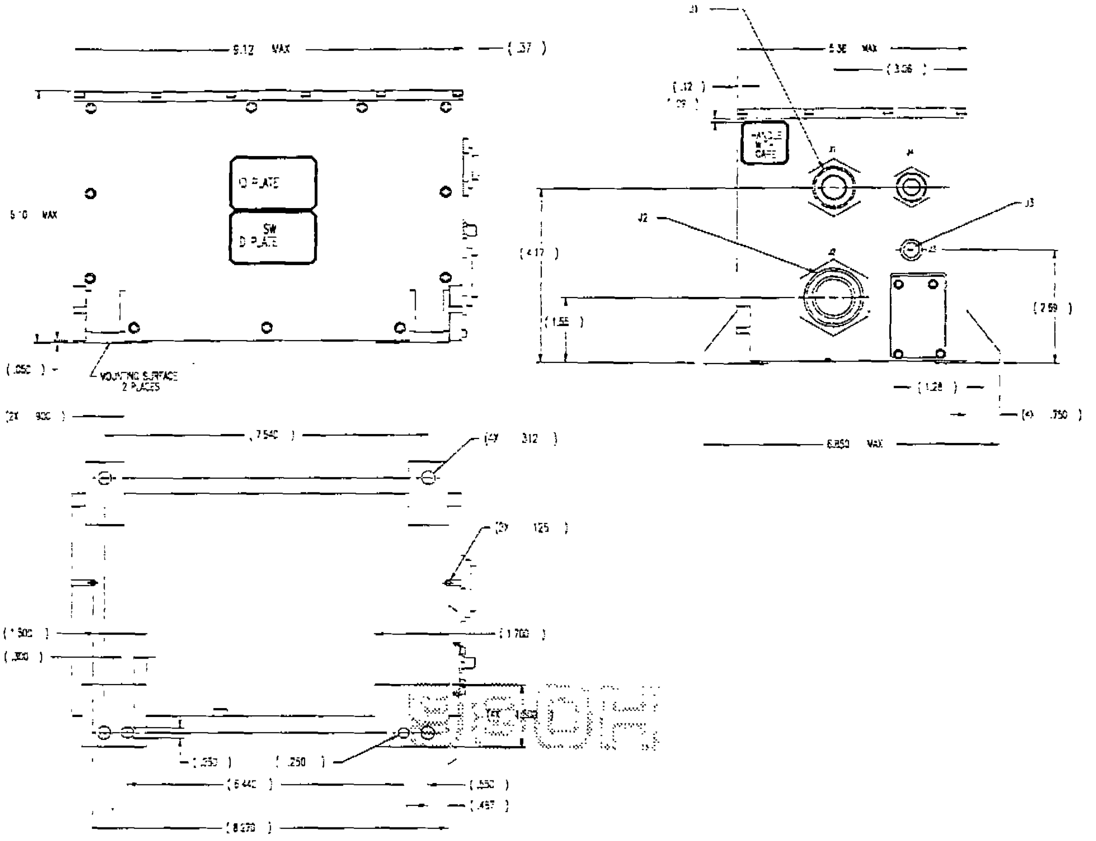
The KN-4072 INS/GPS unit has : a Trimble **GPS Receiver** 28512 -50, Force 9 Card.
Battery : 3.5 VOLT, LTC-7PN (EAGEL PITCHER) or equivalent (Lithium Th. Chloride Battery).

The GPS Antenna and Pre-Amp. (used by Kearfott for the Trimble embedded GPS) is:
Trimble GPS Antenna/Preamp P/N 16248-50.
Type : Omnidirectional, flat microstrip antenna with integral preamp.
Gain : 40 to 50 db.
5V activated antenna.

6. MECHANICAL INTERFACE

For standard mounting (flash mounted)

Note: For C/A code only receiver, J4 will not exist on chassis



0025-5
3/27/00

American Sportscopter Intn'l Inc

Keun J. Sun

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ADVANCED
TECHNOLOGIES
INCORPORATED

Phone (757) 873-3017
Fax (757) 873-3711
e-mail ati-asi.com

October 20, 2000

HeliEagle, Inc.
Newport News/Williamsburg International Airport
Hangar 21A
Newport News, VA 23602

Attention: Keum J. Sun

Subject: Composite Fabrication Technical Assistance & Ultrasport Blade Fabrication

Reference: ATI Proposal No. P-0018-007 (August 7, 2000)
ATI Letter Dated August 7, 2000 (Technical Assistance)

Dear Mr. Sun:

Per your request, Advanced Technologies, Incorporated (ATI) has revised its proposal to provide technical assistance, transfer its rotor blade fabrication technology, and manufacture (50) shipsets of Ultrasport 496 rotor systems. ATI has also prepared a price and schedule to fabricate the tooling necessary for LASI to manufacture the main rotor and tail rotor blades.

ATI has developed a training plan and schedule, which incorporates the initial rotor blade manufacturing with the technical training efforts.

Per ATI's revised price proposal for the Ultrasport 496 rotor system fabrication (dated August 7, 2000), the price quotation for (50) shipsets of main rotor blades, tail rotor blades, and tension/torsion straps is $506,000.00. The delivery schedule requires 12 weeks for the initial delivery of (10) blades, with a production rate of (20) blades per month. Overall period of performance is 8 months.

ATI utilizes a team of 5 or 6 technicians working on a two-shift schedule to achieve the (20) blades per month production rate. The training of LASI technicians will slow down the rate of production and will occur on a one-shift, 8 hour per day, work schedule.

ATI proposes the following training schedule for consideration:

Initial Class Room Training	1 week
Composite Technician Certification	1 week
On-the-Job Observation/Instruction	2 weeks (10 blades)
Hands-on Training/Instruction	4 weeks (10 blades)
LASI Blade Fabrication	8 weeks (20 blades)
Total Training Duration	16 weeks

ATI will provide LASI a copy of the blade manufacturing process manual and detail drawings in advance of the class room training. LASI personnel may study these procedures prior to starting the training.

ATI will be responsible to manufacture (80) blades, with training of LASI technicians taking place during the last (20) blades. LASI will manufacture (20) main rotor blades and (40) tail rotor blades under the oversight and supervision of ATI's personnel. ATI believes the LASI team may need to fabricate one or two "proof-of-concept" blades to develop their techniques. These blades will be physically tested, inspected, and then cut into segments to investigate interior quality of the work.

ATI will provide the blade root core material machined on the 3-axis CNC machine, the tip weight fittings, root bushings, leading edge weights, and CNC ply-cutting of composite materials. All hand labor for the blade fabrication of the last (20) blades will be performed by LASI technicians using the new tooling.

ATI will fabricate a duplicate set of main rotor blade and tail rotor blade tooling necessary for LASI to manufacture composite blades. All tools used in the blade construction will be provided. It should be noted that pieces of the foam core and weight fittings are CNC machined and the composite material is cut using a CNC ply-cut machine. ATI proposes three (3) tail rotor blade molds be provided in order to optimize the tail rotor manufacturing sequence.

PRICE PROPOSAL

ATI has developed a price proposal to manufacture (40) shipsets of main and tail rotor blades, (50) shipsets of tension/torsion straps, provide technical training of LASI technicians and supervise the manufacturing of (10) shipsets of main and tail rotor blades, and fabricate main and tail rotor blade tooling for delivery to LASI. ATI's manufacturing price includes providing all materials and hardware necessary for LASI to fabricate (10) shipsets of blades using ATI's facilities and equipment.

1.1 Rotor System Components.. $490,500.00
   80 Main Rotor Blades
   160 Tail Rotor Blades
   100 Tension/Torsion Straps

1.2 LASI Technician Training $129,500.00
   Class Room Training
   Composite Technician Certification
   On-the-Job & Hands-on Training
   Supervision of Blade Fabrication (10 shipsets)

1.3 Main & Tail Rotor Blade Tooling $124,500.00
   Main Blade OML Mold Set
   Main Blade Spar Mold Set
   Short & Long Uni-ply Compaction Fixture

Spar Core Forming Fixture
Trailing Edge Core Forming Fixture
Tail Rotor Blade OML Mold Sets (3 sets of molds)
($7,000 for the two additional tail rotor blade mold sets)

1.4 Non-Recurring Technical Assistance Fee.. $120,000.00

PAYMENT TERMS

1.1 As noted in ATI's revised price proposal, ATI will require an advance payment of $200,000.00 for materials and rotor blade manufacturing startup. This money must be received prior to ATI ordering materials.

Incremental payments for lots of (5) shipsets are required prior to delivery. The incremental payment schedule is as follows:

	Qty/Shipset	(5) Shipset Payment	Total Payments
Advance Payment			$200,000.00
Main Rotor Blades	2	$30,125.00	$241,000.00
Tail Rotor Blades	4	$ 4,000.00	$ 32,000.00
Tension/Torsion Straps	2	$ 1,750.00	$ 17,500.00
	Total		$490,500.00

Payments must be received prior to delivery.

1.2 The technical training amount of $129,500.00 is to be paid in (3) payments:

Payment #	Amount	Due	
1	$ 64,750.00	Prior to start of training	May 1, 2001
2	$ 32,375.00	Prior to start of LASI blade fabrication	July 1, 2001
3	$ 32,375.00	Completion of blade fabrication	Sept. 1, 2001
TOTAL	$129,500.00		

1.3 The $124,500.00 tooling amount is to be paid in (2) payments:

Payment #	Amount	Due	
1	$62,250.00	3 months after contract award	Jan. 30, 2001
2	$62,250.00	Completion of tooling	March 13, 2001
TOTAL			

1.4 The $120,000.00 non-recurring technical assistance fee is to be paid in 4 equal monthly increments of $30,000.00 each starting 30 days after contract award.

As an option, ATI will reduce the non-recurring technical assistance fee to $100,000.00 if payment is received in-full prior to December 15, 2000.

OTHER TERMS & CONDITIONS

All rotor system components and tooling are to be accepted and picked-up by Heli-Eagle at ATI's facility in Newport News, Virginia. ATI is not responsible for packaging or shipping the components or tooling.

All LASI technicians participating in the composite fabrication training program are to be fluent in the English language. ATI has not allowed time for translation of the technical information.

ATI has exclusive rights to manufacture all rotor blades for all UAV's sold through the Strategic Alliance.

SCHEDULE

Based on an anticipated contract award date of November 1, 2000, ATI believes the first (5) shipsets of rotor system components will be completed by February 15, 2000, assuming all composite materials are available.

ATI will make deliveries of (10) shipsets in mid-March, mid-April, and mid-May.

The LASI technician training could start in late April/early May and would last for up to 4 months. An overall program flow schedule is attached for your reference.

If you have any questions, please let me know.

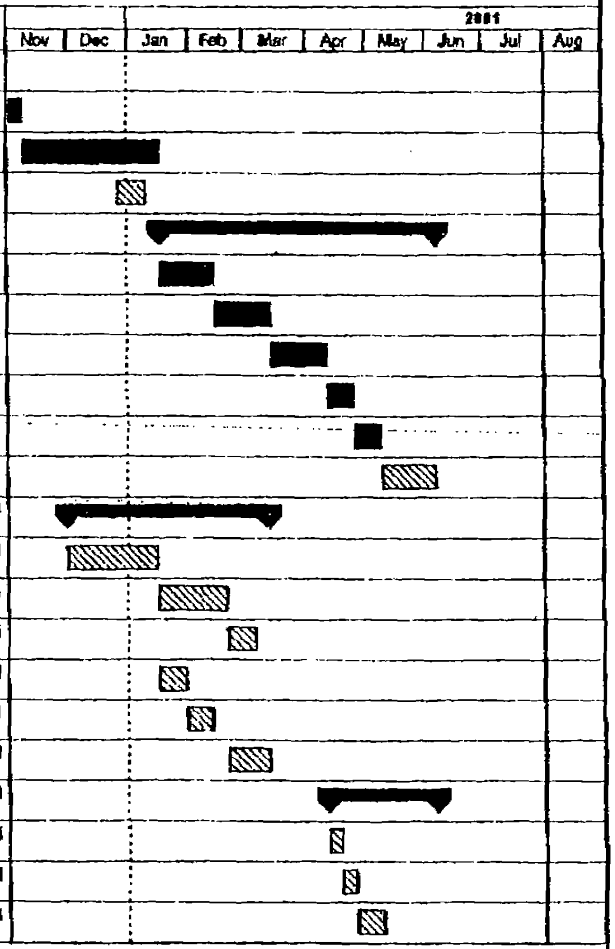
Sincerely,

R. Toby Roberts
Vice President

Rotor System Fabrication & Training

ATI Proposal No. P-0016-007

ID	Task	Duration	Pred	Start	Finish
1	Contract Award	1 day		11/01/00	11/01/00
2	Receive Advance Payment	5 days	1	11/02/00	11/08/00
3	Procure Materials	45 days	2	11/09/00	01/17/01
4	Prepare Tooling	10 days	3SS+30 days	12/27/00	01/10/01
5	**Blade Fabrication**	**100 days**		01/18/01	06/06/01
6	10 blades	20 days	3	01/18/01	02/14/01
7	20 blades	20 days	6	02/15/01	03/14/01
8	20 blades	20 days	7	03/15/01	04/11/01
9	10 blades	10 days	8	04/12/01	04/25/01
10	10 blades (observation)	10 days	9	04/26/01	05/09/01
11	10 blades (training)	20 days	10	05/10/01	06/06/01
12	**Tooling**	**70 days**		12/01/00	03/13/01
13	Main Blade OML Molds	30 days	1SS+20 days	12/01/00	01/16/01
14	Main Blade Spar Molds	25 days	13	01/17/01	02/20/01
15	Uni-pack Compression Fixture	10 days	14	02/21/01	03/06/01
16	Core Forming Fixture	10 days	13	01/17/01	01/30/01
17	Trailing Edge Forming Fixture	10 days	16	01/31/01	02/13/01
18	Tail Rotor OML Molds	15 days	14	02/21/01	03/13/01
19	**Technician Training**	**40 days**		04/12/01	06/06/01
20	Class Room Training	5 days	8	04/12/01	04/18/01
21	Composite Technician Certification	5 days	20	04/19/01	04/25/01
22	On-the-Job Observation/Instruction	10 days	9,21	04/26/01	05/09/01



Advanced Technologies Incorporated
R. Toby Roberts
5 Day Calendar

Task	▨	Milestone	◆	External Tasks	▩
Critical Task	■	Summary	▬	Project Summary	▬

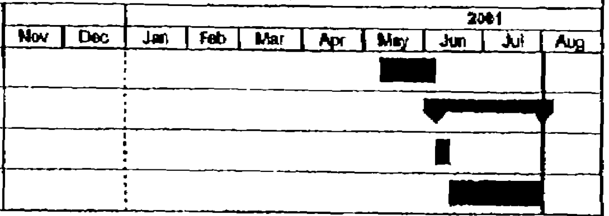
Page: 1

Date: 10/20/00

Rotor System Fabrication & Training

ATI Proposal No. P-0018-007

ID	Task	Duration	Pred	Start	Finish
23	Hands-on Training/Instruction	20 days	10	05/10/01	06/06/01
24	**LASI Blade Fabrication**	**40 days**		**06/07/01**	**08/01/01**
25	Proof-of-Process Blade	5 days	23	06/07/01	06/13/01
26	20 blades	35 days	25	06/14/01	08/01/01



Advanced Technologies Incorporated
R. Toby Roberts
5 Day Calendar

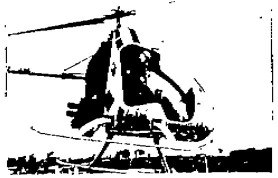
Task	▨	Milestone	◆	External Tasks	▩
Critical Task	■	Summary	▬	Project Summary	▬

Floor Mounted Cyclic

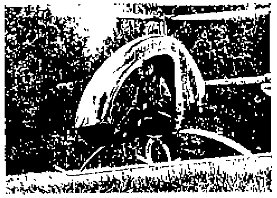
Available Now!

New Feature

Ultrasport 496



Ultrasport 254/331



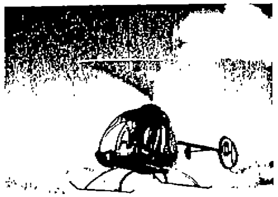
Distinctive Features

- ◆Advanced Composite Airframe
- ◆Aerospace Quality Gearboxes
- ◆Superior Autorotation Capability
- ◆Shrouded Tail Rotor System
- ◆Extra Wide Composite Landing Gear
- ◆Floor Mounted Cyclic
- ◆Low Operating & Maintenance Costs
- ◆Excellent Price-Performance Acquisition Costs

World's Most Innovative Small Helicopters Ever

Ultrasport Worldwide

Flying!



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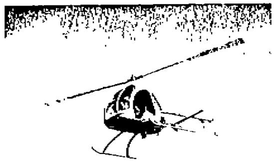
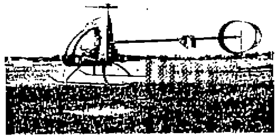


US-Virginia



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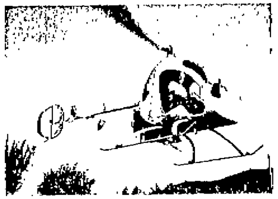
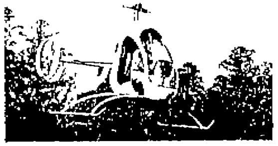
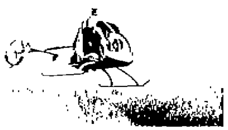


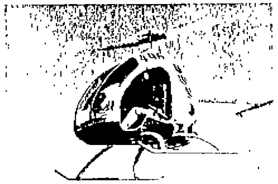
Italy



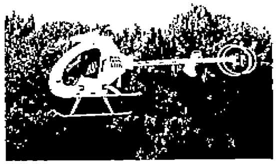
Japan



Taiwan



Korea



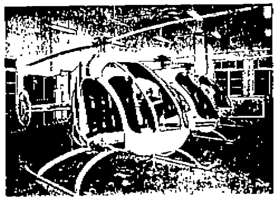
US-Virginia

US-Canada-Brazil-Guatemala-Italy-Czech-Australia
Germany-New Zealand-Japan-Korea-South Africa-Taiwan

Order Your Ultrasport Today

Enquiries Welcome

Make your dreams come true!



Aircraft Specification

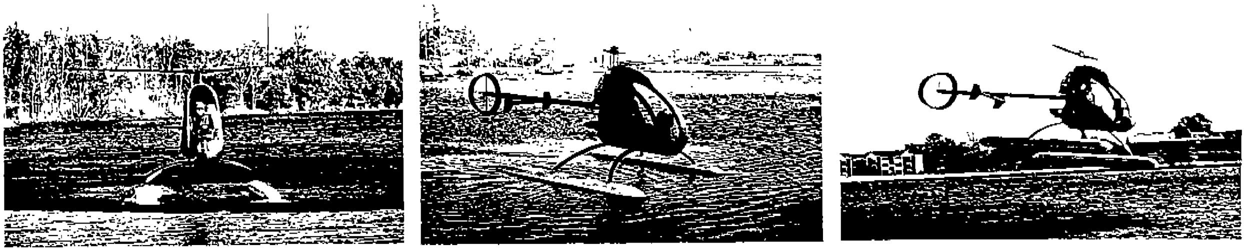
Model	Ultrasport 254 (Single-Seat Ultralight)	Ultrasport 331 (Single-Seat Experimental)	Ultrasport 496 (Two-Seat Experimental;
Engine	55hp Hirth 2703	65hp Hirth 2706	115hp Hirth F30
Transmisson	12 to 1 Planetary	12 to 1 Planetary	11 to 1 Two-Stage
Endurance	*5 Gal Fuel Tank(1 25 Hrs)	10 Gal Fuel Tank(2 5 Hrs)	16 Gal. Fuel Tank(2 5 Hrs)
Ceiling	12,000 FT	12,000 FT.	12,000 FT.
H.I.G.E.	10,800 FT.	10,800 FT.	10,800 FT.
H.O G.E.	7,000 FT	7,000 FT.	7,000 FT.
Main Rotor Blades	21'dia , 6.7"chord, composite	21'dia , 6 7"chord, composite	23'dia , 6 7"chord, compos
Tail Rotor Blades	2 6'dia . 2"chord, composite	2 6'dia , 2"chord, composite	2 6'dia., 2"chord, composi
Min. speed	Hover	Hover	Hover
Length (Cabin)	52"	52"	53"
Max Width(Cabin)	30"	30"	48"
Max Height(Cabin)	59"	59"	59"
Cruise Speed	63 MPH(101 KMH)	65 MPH(105 KMH)	69 MPH(112 KMH)
Top Speed	*63 MPH (101 KMH)	104 MPH(167 KMH)	104 MPH(167 KMH)
Empty Weight	252 LBS (115 KGS)	330 LBS (150 KGS)	540 LBS.(245 KGS)
Useful Load	273 LBS.(124 KGS)	320 LBS (145 KGS)	590 LBS.(268 KGS)
Gross Weight	525 LBS.(239 KGS)	650 LBS.(295 KGS)	1130 LBS.(513 KGS)
Width	8 FT. (2438mm)	8 FT. (2438mm)	8 FT. (2438mm)
Height	7'10" (2388mm)	7'10" (2388mm)	7'10" (2388mm)
Length	19 2" (5842mm) (blades folded)	19'2" (5842mm) (blades folded)	19'9" (6020mm) (blades folded)

*FAA Restrictions for Ultralights

http://www.ultrasport.rotor.com

The World's Most Affordable All Composite Helicopter

Now Flying With Floats

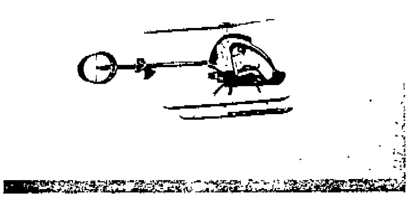


Ultrasport Floats--20 lbs. (40 lbs. total)

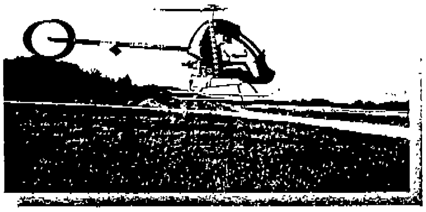
American Sportscopter International Inc.
11712 Jefferson Ave. #c228
Newport News, VA 23606, USA
Tel:(757)872-8778 Fax:(757)872-8771
E-Mail:ASII@visi.com
http://www.ultrasport.rotor.com

The World's Most Affordable and Technologically Advanced Small Helicopters

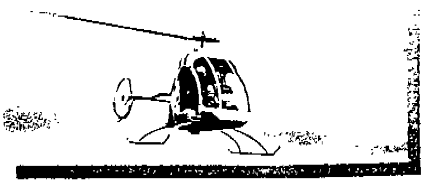
ULTRASPORT FAMILY OF HELICOPTERS



- ULTRASPORT 254 -
One-Seat Helicopter



- ULTRASPORT 331 -
One-Seat Helicopter



-ULTRASPORT 496-
Two-Seat Helicopter

ULTRASPORT

CURRENT PRICING

254

Single Seat

True Ultralight Meets FAA Part 103

Composite body, Landing gear bows, composite main rotor and shrouded tail rotor with swept tip for low noise

---

◆Engine: 55hp Hirth 2703 (Pull Start)

◆Kit Price Includes:

Hirth Engine, Pull Starter, floor mounted cyclic, airspeed indicator, engine & rotor RPM and engine CHT/EGT instruments, and all fuselage, drive train and rotor components

◆Builder Supplied Items:

- Tools and Paint
- Altitude, other gauges as desired
- Battery for Electric Start as desired
- Upholstery and seat cushion as desired
- Radios and transponders as desired

◆Options:

•Doors	$900
•Floats	$2,300
Tail Sponson	$400
•55hp Engine (Includes Electric Start)	$500
•65hp Engine Upgrade (Includes Recoil Start)	$600
•65hp Engine Upgrade (Includes Electric Start)	$900
•Raised Instrument Console	$250

◆Kit Price……………………$31,900

331

Single Seat

Experimental version of the 254
Meets the FAA Part 21.191(g)

Composite body, Landing gear bows, composite main rotor and shrouded tail rotor with swept tip for low noise

---

◆Engine: 65hp Hirth 2706 (Electric Start)

◆Kit Price Includes:

Hirth Engine, Electric Starter, floor mounted cyclic, doors, 10 gal. fuel tank, engine & rotor RPM and engine CHT/EGT instruments, and all fuselage, drive train and rotor components

◆Builder Supplied Items:

- Tools and Paint
- Airspeed, Altitude, compass, turn gauges
- Radios and transponders
- Battery for Electric Start
- Upholstery and seat cushion as desired
- Lights as desired

◆Options:

•Floats	$2,300
Tail Sponson	$400

◆Kit Price……………………$34,900

496

Two Seat

Experimental
Meets the FAA Part 21.191(g)

Composite body, Landing gear bows, composite main rotor and shrouded tail rotor with swept tip for low noise

---

◆Engine: 115hp Hirth F30 (Electric Start)

◆Kit Price Includes:

Hirth Engine, Electric Starter, floor mounted cyclic, Full Dual Controls, 16 gal. fuel tank, engine & rotor RPM and engine CHT/EGT instruments, and all fuselage, drive train and rotor components

◆Builder Supplied Items:

- Tools and Paint
- Airspeed, Altitude, compass, turn gauges
- Radios and transponders
- Battery for Electric Start
- Upholstery and seat cushion as desired
- Lights as desired

◆Options:

•Doors	$900
•Floats	$2,800
Tail Sponson	$400

◆Kit Price……………………$49,900

Pricing and Specifications Subject to Change

American SportsCopter International Inc.
NN/Wmsbg Int'l Airport, Newport News, VA23602, U.S.A
Mailing address: 11712 Jefferson Ave. #C228., Newport News, VA 23606 USA
Phone: (757) 872-8778 Fax: (757) 872-8771; e-mail: asii@visi.net www.ultrasport.rotor.com

ULTRASPORT FAMILY OF HELICOPTERS

Dear Fellow Aviation Enthusiast,

Thank you for ordering an information package on the Ultrasport Family of Helicopters! We think you will find the Ultrasport helicopters to be the best designed kit helicopter on the market.

If you have requested dealership information, we have enclosed a brief outline of our dealer program and an application form. Please fill out the form by answering the questions as best you can. Your answers will be used for information only, and are not binding.

Following is some information that may interest you that is not covered in the brochures:

- ***Where to see us?*** *You are invited to make an appointment to visit us in Newport News/*Williansburg Int'l Airport, *VA. We are also setting up a regular schedule for demonstration rides at the airport. Call to find out when is the next scheduled flight demonstration.*

- ***Ultrasport Insurance Program.*** *We now have an insurance program! It cover up to $75,000 of aircraft value and contains $1,000,000 of liability. The program is administered by Caledonian Insurance in Mercer Island, WA. To find out more, contact Mr. Larry Gregg at Caledonian Insurance at (206) 232-9870.*

- ***Financing.*** *We recommend contacting NAFCO in Lakeland, FL for financing at 800-999-4515. They specialize in loans for homebuilt-kits and ultralight aircraft.*

- ***Order More Info.*** *If you would like to order more information, the information packet is available for $5, and the Ultrasport video is an additional $25. Copies of Ultrasport Pilot Operating Handbooks and Assembly Manuals are also available for purchase(be sure to specify model#). We have included an order form.*

- ***How To Place a Kit Order.*** *Please call to request our sales contract and to make payment arrangements. We prefer a 10% deposit to initiate the order, and the final 90% just prior to shipping. Also, as a safety policy, we will withhold shipping the main rotor blades until the customer furnishes documentation of one of the following:*

  1. *A civilian or military helicopter pilot's license, OR*
  2. *A medical certificate and solo endorsement in a piston engine helicopter. This requires a medical exam and roughly 20 hours (or sometimes less) of dual instruction with a helicopter instructor, OR*
  3. *If getting a medical certificate presents a problem, obtain enough helicopter dual instruction hours such that you are proficient enough to be capable of solo flight.*

- ***Both the KITPLANES and US-AVIATOR magazines in May/99 issue pressed very nice articles on Ultrasport 496 after their test flight.***

*Feel free to call with any questions. You can also find us in the Internet for answers to many questions concerning Ultrasport helicopters at: http://*www.ultrasport.rotor.com

Sincerely yours,

JENNIFER T. YAO

Office Manager

ULTRASPORT
INFO ORDER FORM

NAME	
COMPANY	
ADDRESS	
CITY	
COUNTRY	
TEL:	FAX:

OTY	DESCRIPTION	COST EACH	TOTAL
	Information Packet	US $5	
	Ultrasport FAR 27 Airworthiness Standard	US $10	
	Ultrasport Design, Development & Testing	US $10	
	FAA Policy & Ultrasport as an Amateur-Built Rotorcraft	US $10	
	331 Pilot's Operating Manual	US $20	
	496 Pilot's Operating Manual	US $20	
	331 Construction Manual	US $100	
	496 Construction Manuel	US $100	
	496/331 Construction Manuel (color)	US $120	
	VIDEO: VHS Ultrasport Video (Sent by Airmail) includes information packet	US $30	
	PAL Ultrasport Video (Sent by Airmail) includes information packet	US $40	
		Total Amount	
		Total Due Before Delivery	

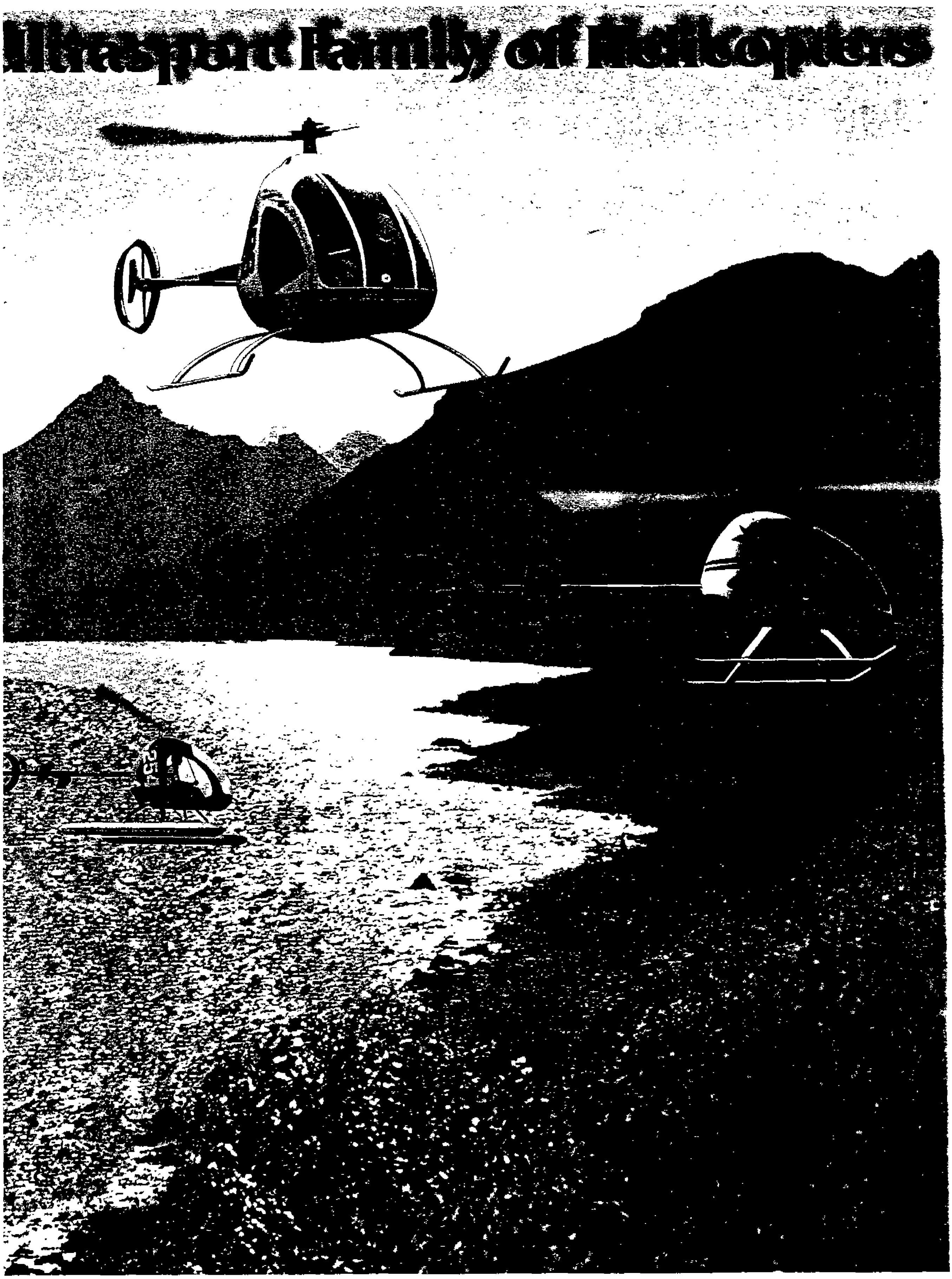
- Method Of Payment:

1. By Credit Card:____________Visa____________Master Card
   Card Number____________________________Exp. Date
2. By Check:
   Enclosed: ☐
   Will mail later: ☐

*Signature:*________________________*Date:*__________

Please Mail or FAX this order to:
American Sportscopter International Inc.
11712 Jefferson Ave. #C228
Newport News, VA 23606
Tel: (757) 872-8778 Fax: (757) 872-8771
E-mail: asii@visi.net

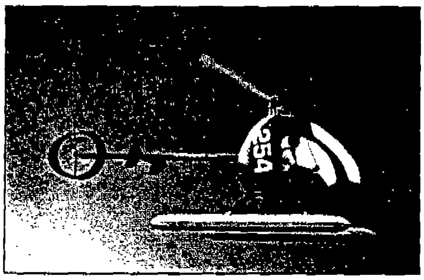
Ultrasport Family of Helicopters



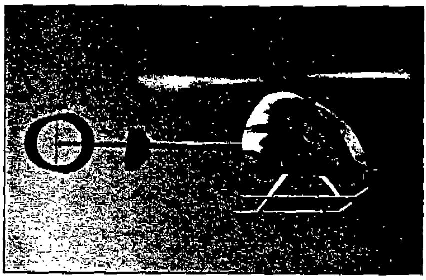
The **UltraSport** Family of Advanced S

INTRODUCTION

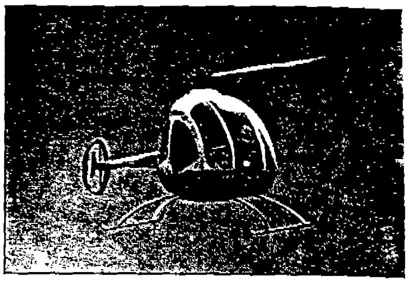
American SportsCopter is pleased to introduce the UltraSport Family of Helicopters. We call it a family because we cover full range of FAA classifications and share the high technology components and manufacturing process in each of our fami members. All of our helicopters ship as kits meeting FAA Regulation Part 21.191(g), which defines Amateur Built Aircraft



The UltraSport 254 is the lightest member of the family. This helicopter is the world's only true ultralight helicopter in full production. It complies with the FAA Part 103 ultralight regulations and is available with or without floats. Neither a pilot's license nor a registration number is required to legally fly the 254, however training is a must. The UltraSport 254 is a single seat, partially enclosed conventional helicopter. The UltraSport 254 uses a Hirth 2703 engine with a recoil starter. The Hirth 2706 engine is optional and can be used for more power and additional gross weight capability.

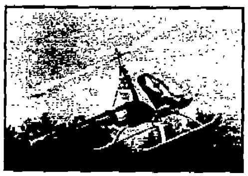


The UltraSport 331 helicopter is also single seat, and is a growth version of the 254. It is essentially a 254 with doors, electric start, room for more instruments, and a larger fuel tank. All other components are the same as in the 254. The weights of the additional components in the 331 place it in the experimental category. The 331 can be equipped for full VFR and IFR flight regulations. A helicopter pilot's license is required to legally fly the UltraSport 331. The UltraSport 331 uses a Hirth 2706 engine with electric start.



The UltraSport 496 is a two-seat enclosed conv tional helicopter containing the same features the 331, and available as experimental categor incorporates a new main rotor drive train, but lizes the same main and tail rotor components the 254/331 aircraft. Under experimental categ regulations, the 496 can be equipped to fly und both VFR and IFR flight regulations. A special two-seat ultralight version 496 is available by sp cial order. The ultralight version 496 can be exempted under Part 103 as a two seat ultraligh trainer. A helicopter pilot's license is required t legally fly the UltraSport 496. The UltraSport 4 uses a Hirth F-30 engine with electric start.

ULTRASPORT DEVELOPMENT

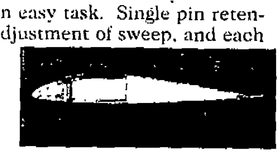


When American SportsCopter built the first two prototype helicopters, we instrumented the rotor blades, pitch links, control system and rotor shaft with strain gages. A 20 channel data recording system was installed, along with a slip ring, and 5 accelerometers on the airframe of the flight test helicopter. An experienced test pilot then performed a full flight test, and we gathered and analyzed the flight loads and performance data.

We know the loads that each component in the dynamic drive train and rotor system is subject to under the most demanding flight conditions. We have applied several factors to these loads in our production design, ensuring you will not reach a load limit of any component when flying our family of helicopters. All flight critical components are built to the same quality standards as components produced for the major aerospace helicopter companies. All are specially designed and manufactured for the UltraSport helicopters. No off-the-shelf automotive or uncertified hardware is used in our kits.

ROTOR BLADES

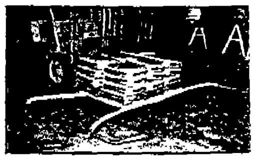
The main rotor blades are all composite construction containing a prepreg graphite and S-glass spar, nomex honeycomb trailing edge, and an outer skin of pre-preg S-glass. The blades are hand layed-up and cured in tools elevated to 260 deg F. The tail blades are similar construction except that they have rohacell foam in the trailing edge. The blades use a low drag, cambered airfoil, which delivers 14 pounds of lift per horsepower at sea level. The blades are designed to have unlimited life and a frequency placement that avoids the rotor rpm and airframe frequencies, ensuring low vibration and long life airframe and rotor system. Track and balance of the rotor system is an easy task. Single pin retention with a drag link allows full and easy adjustment of sweep, and each blade has a tip pocket for small weights for radial balance.



The most important safety feature is the blades' autorotation capability. Tungsten weights in the leading edge and 2 pound tip weights result in rotor inertia 2-1/2 times better than U.S. Army requirements and enhanced autorotation. The UltraSports have glide ratios superior to both large and small helicopters.

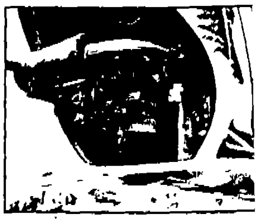
FUSELAGE

The fuselage strongback incorporates a strong torque box to which the drive train is attached. This rigid structure is lightweight but far from fragile, assembled from sandwich panels of epoxy resin, graphite fabric and nomex honeycomb core, forming a monocoque structure. The outer shell is a non-load carrying fairing. The fuselage is a one-piece assembly; there is no welding or any rivets to crack and fatigue. All hard poin attachments are installed at the factory. Taller pilots will appreciate the generous headroom in the cockpit.



The landing gear bows are sandwich structures of aluminum honeycomb with fiberglass and epoxy laminate face plies. Ply thickness is tailored to provide maximum energy absorption and impact attenua tion for 2.5 G ground contact without structural failure. The bow shape can flex and contract, thus absorbing impact far better than traditional landing gear legs. The wide bows allow the pilot to properly trim the aircraft before takeoff. The landing skids are pre-bent aluminum tubes with steel skid shoes. The extra wide skid width of 8 feet provides extra safety against dynamic rollover and enable landings on steeper slopes. The fuselage and landing gear have been structurally tested to FAA airworthiness standards Part 27.501 Grounding Loading Conditions.

THE ENGINE



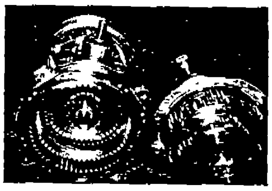
The Hirth engines provide over 20% power reserve. Two-stroke engines were chosen because of their high power versus weight ratio, and in order to vertically mount the engines onto the aircraft. Hirth's smooth power band and flat torque curve provide low pilot workload in maintaining engine speed. Virtually no throttle correction is needed. The two-cylinder engines

t Helicopters

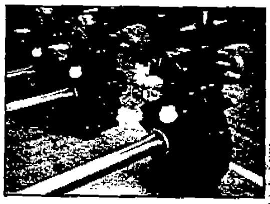
: only 40hp hovering at sea level, standard day conditions. The two-
inder engines, 55hp Hirth 2703 and 65hp Hirth 2706, are available
.h Bing or Mikuni carburetors. The four-cylinder 115 hp Hirth F-30
gine uses four Mikuni carburetors and provides a 35% power reserve at
ı level, standard day conditions. The Hirth engine now equipped with
'fuel injections is available.

IE MAIN DRIVE SYSTEM

lirect drive connects the engine to the clutches and main rotor shaft.
ere are no drive belts or chains to slip or break. The main and tail
or gears are manufactured to American Gear Manufacturing
sociation (AGMA) Class 11 Ground
ndards from 9310 carbonized steel.
ll analysis and testing of each compo-
nt have been performed to ensure high
;O and safety.



e 254 and 331 main rotor gearboxes
: a 12:1 planetary reduction gearbox,
.ed for 60hp continuous. The transmis-
ın on the 496 is a two-stage helical spur
ırbox with a 4.18 to 1 reduction, rated
· 120hp continuous. In combination with the engine's 2.64 to 1 reduc-
n gear, there is an overall 11 to 1 reduction on the two-seater. An
ternal cooler, sump and pump circulate pressurized oil through the
ırbox. Chip detector and oil pressure
itches are standard. The 496-drive sys-
n has provisions to allow installation of a
llistic parachute recovery system.



gine start up is easy due to a centrifugal
ıtch that does not engage the rotors until
: engine reaches 2000 rpm. There is
ɪo a one-way sprague clutch that enables
: rotors to continue running in autorota-
ın in the event of a loss of engine rpm.
l transmissions are manufactured under aerospace specifications by
mpanies that make rotor hubs for the Bell 206, Huey and Cobra heli-
pters, and gearboxes for the Apache and Eurocopter helicopters.

HE CONTROLS

ıe to popular demand, a conventional
ɪor mounted stick control system has
ɪw been outfitted for the helicopter. The
acious cabin and familiarity of this con-
ntional control system will enable any
ston helicopter pilot to feel comfortable
e first time he takes control of the heli-
pter. To the pilot's left are the combined
llective and throttle control. Two foot
·dals control the tail rotor collective via a
ısh/pull cable running along the tailboom.

OTOR HUB

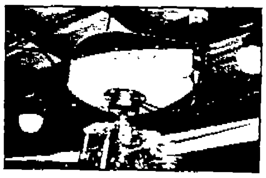
ıe main rotor hub is a two-bladed, underslung, teetering type. The hub
ɪke (main body) is one-piece CNC machined from a 2024-T4 aluminum
llet. The pitch change bearings are mounted to the yoke spindles,
clined (preconed) 3 degrees and offset
each other (torque offset), in order to
ılance the rotor control loads. The
ades are retained against centrifugal
rce not with bearings but a tension/tor-
on pack, which requires no lubrication,
ʌs infinite life and is fail-safe. The entire
ıb assembly has been structurally tested
conform to FAA FAR Part 27 levels. The one-piece hub ensures a high
ıtural frequency of the hub and blades when rotating, thus reducing air-
ame fatigue that can occur with multi-piece two-bladed hubs

AILBOOM AND TAIL ROTOR

he tail rotor gearbox is a spiral bevel type containing a 1:3/4 reduction
engine rpm, built by the same aerospace company that supplies the
ain rotor transmission. The tail rotor gearbox is driven by an
uminum shaft (again no belts!) supported by hangar bearings inside the
ilboom. The horizontal stabilizer is composite, as is the vertical ringtail
ırrounding the tail rotors. The vertical ringtail is a safety feature that
·aws attention to the moving tail blades, thus reminding the curious to stay away from that area. It also protects the tail rotor blades from damage.

SAFETY

The safety features mentioned previously bear repeating. The UltraSports have superior autorotation capability. The fuselage and strongback can absorb 2.8-G impact. The 8-foot wide bows and landing gear help with trimming the aircraft prior to takeoff, enable landings on steeper slopes, and are all proof tested to 2.5 G before they leave the factory. The UltraSports have been rigorously flight-tested Design loads have been verified during flight tests to FAR Part 27 levels of applied loads. All gearbox and drive system components are custom designed and manufactured by aerospace manufacturing companies. The hubs and blades are frequency tuned to avoid airframe vibration. There is horsepower to spare with over 20% engine power reserve. A Ballistic Parachute is a planned option on the 496. The UltraSports are easy to fly and ideal for the low time helicopter pilot.



TRAINING

As a safety policy American SportsCopter will gladly deliver a kit but withholds the main rotors until the purchaser can demonstrate helicopter proficiency. The company prefers to see a student logbook endorsed to solo signed off by a helicopter CFI. A lightweight two-seat, piston-engine trainer such as a Robinson R-22 or Hughes 269 is recommended.

ASSEMBLY, FLIGHT AND MAINTENANCE

The UltraSports ship as quick build kits, conforming to FAA Regulation Part 21.191(g). Approximately 60 to 80 hours of assembly time are all that is required using basic tools. The kits include all pre-assembled components, plus an assembly manual, pilot operating manual and full set of engineering reference drawings UltraSport components have been designed for high TBO and safety. The owner can perform all routine maintenance, such as greasing the moving parts and replacing transmission oil. An annual condition inspection is required.

AVAILABILITY

In 1996, the American Helicopter Society presented the UltraSport Family of Helicopters the Howard Hughes award for making this significant achievement in helicopter technology available to the public. The UltraSport 496 prototype also won the Reserve Grand Champion award at the PRA Convention in 1996.
Upon seeing the UltraSports in flight, aircraft enthusiasts at every air show remark that they are amazed at its maneuverability and the quality of the engineering.

If you have ever dreamed of safe helicopter flight and shedding the runway, your dream has come true! The UltraSports are lightweight and ultralight helicopters developed by heavyweight aerospace professionals using today and tomorrow's technology. Quality in the design and manufacturing have translated into safety. All three UltraSport models are available NOW! Contact the factory or your local dealer for more information such as the marketing video, assembly manuals or pilot operating handbooks.

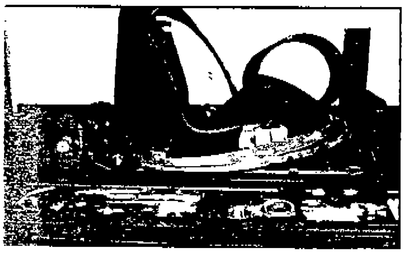
The Ultrasport Family of Helicopters

The Ultrasport 254 meets the FAA Part 103 as an Ultralight Helicopter
The Ultrasport 331 and 496 meet the FAA Part 21.191(g) as an Amateur Built Kit
The Ultrasport 496 ultralight version can be exempted under Part 103 as an Ultralight Trainer

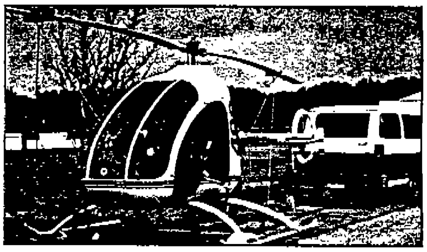
Model	Ultrasport 254 (Single-Seat Ultralight)	Ultrasport 331 (Single-Seat Experimental)	Ultrasport 496 (Two-Seat Experimental)
NGINE	55hp Hirth 2703 Pull Start, Dual Carb, Dual CDI, 2-Cylinder	65hp Hirth 2706 Electric Start, Dual Carb, Dual CDI, 2-Cylinder	115hp Hirth F30 Electric Start, Quad Carb, Dual CDI, 4-Cylinder
RANSMISSION	12 to 1 Planetary	12 to 1 Planetary	11 to 1 Two-Stage
NDURANCE	*5 Gal. Fuel Tank (1.25 Hrs.)	10 Gal. Fuel Tank (2.5 Hrs.)	16 Gal. Fuel Tank (2.5 Hrs.)
ERVICE CEILING	12,000 Ft.	12,000 Ft.	12,000 Ft.
I.I.G.E.	10,800 Ft.	10,800 Ft.	10,800 Ft.
I.O.G.E.	7,000 Ft.	7,000 Ft.	7,000 Ft.
IAIN ROTOR BLADES	21' dia., 6.7" Chord, Composite	21' dia., 6.7" Chord, Composite	23'dia., 6.7" Chord, Composite
AIL ROTOR BLADES	2.6' dia., 2" Chord, Composite	2.6' dia., 2" Chord, Composite	2.6'dia., 2" Chord, Composite
IN. SPEED	Hover	Hover	Hover
ENGTH (CABIN)	52"	52"	53"
VIDTH (CABIN)	30"	30"	48"
IEIGHT (CABIN)	59"	59"	59"
RUISE SPEED	63mph (101kmh)	65mph (105kmh)	69mph (112kmh)
OP SPEED	*63mph (101kmh)	104mph (167kmh)	104mph (167kmh)
MPTY WEIGHT	252 lbs. (115 kg)	330 lbs. (150 kg)	**540 lbs. (245 kg)
SEFUL LOAD	273 lbs. (124 kg.)	320 lbs. (145 kg.)	590 lbs. (268 kg.)
ROSS WEIGHT	525 lbs. (239 kg.)	650 lbs. (295 kg.)	1130 lbs. (514 kg.)
VIDTH	8 Ft. (2438 mm)	8 Ft. (2438 mm)	8 Ft. (2438 mm)
IEIGHT	7'-10" (2388 mm)	7'-10" (2388 mm)	7'-10" (2388 mm)
ENGTH BLADES FOLDED)	19'-2" (5842 mm)	19'-2" (5842 mm)	19'-9" (6020 mm)

FAA Restrictions for Ultralights ** Special 495 lb. empty weight ultralight version available by special order.

ll Ultrasport Helicopters have a composite body, landing gear bows, composite main rotor, and shrouded tail tor blades with swept tips for low noise. The Ultrasport Kits consist of lightweight composite materials and gh quality parts produced by rotorcraft professionals with expertise in manufacturing for the S-61, Apache, ornet, Eurocopter Dauphine, Huey, Cobra and Bell 206 Helicopters. All of this military and cutting edge helipter technology is available to you in a recreational helicopter application. Due to continuous improveents, specifications of the Ultrasport Helicopters are subject to change without notice.


he Ultrasports Ship in
uick-Build Kit Form

The Ultrasports Can be Adapted to
Police or Military Applications


Transporting the Ultrasport
is a Breeze

S.A., Canada, Mexico and South American
untries should contact:

nerican Sportscopter International, Inc.
712 Jefferson Ave #C228
wport News, VA 23606 USA
l. 757-872-8778 Fax: 757-872-8771
mail ASH@visi.net

Ultrasport Helicopter Club Membership
Online Registration

It is FREE to become an Ultrasport Helicopter Club member. Benefit of a membership?

(1) Receive new brochures about Ultrasport helicopters
(2) Receive news and future information about Ultrasport helicopters

All others should contact:

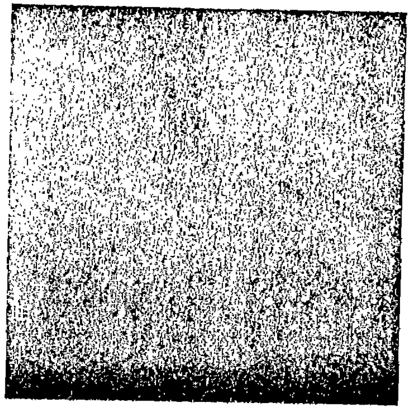
Lights American Sportscopter, Incorporated
26 Taho Street, Taichung 407, Taiwan, ROC
Tel: 886-4-311-8003 Fax: 886-4-311-8001
E-mail: ultrasport@iname.com

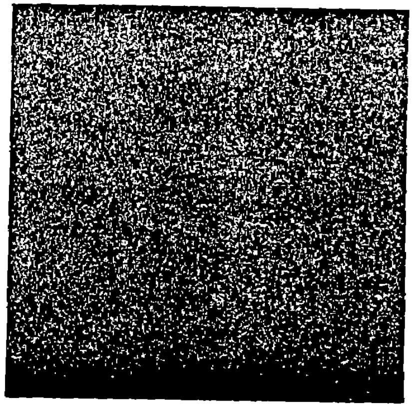
Internet Site: www.ultrasport.rotor.com

Kearfott Guidance & Navigation Corporation
A Subsidiary of Astronautics Corporation of America

KEARFOTT
GUIDANCE AND NAVIGATION CORPORATION
CAPABILITIES

PD-2035





Kearfott Guidance & Navigation Corporation
150 Totowa Road
Wayne, New Jersey 07474-0946
Telephone (973) 785-6000
FAX (973) 785-6025
Website: www.kearfott.com

KEARFOTT
GUIDANCE AND NAVIGATION CORPORATION
CAPABILITIES

Presentation Document No. PD-2035

MAY, 2000

Kearfott Guidance & Navigation Corporation
150 Totowa Road
Wayne, New Jersey 07474-0946

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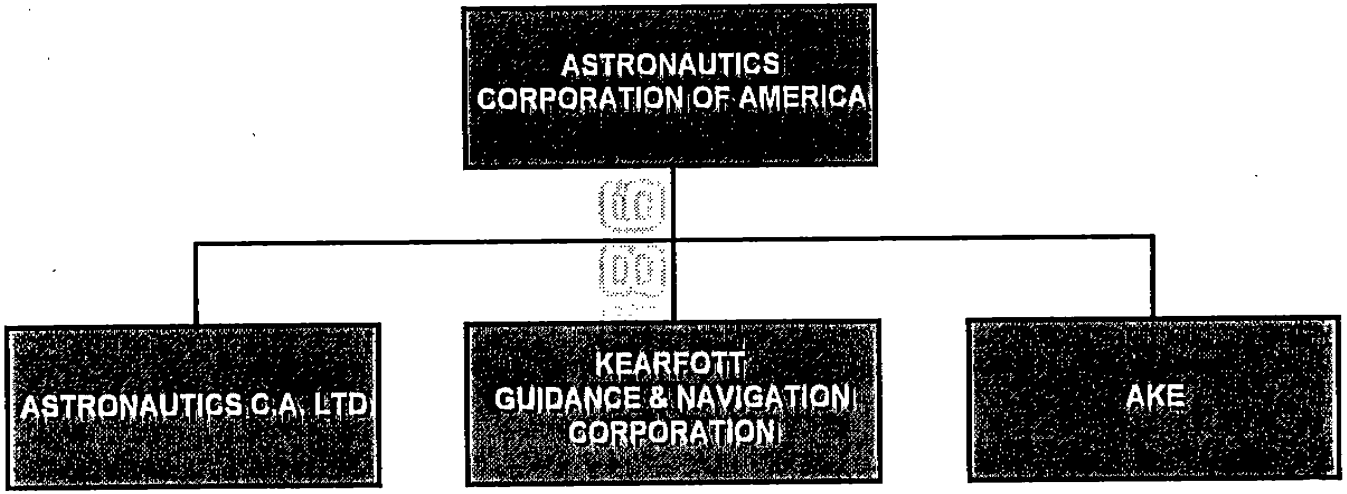
KEARFOTT GUIDANCE & NAVIGATION CORPORATION

WE HAVE THE UNIVERSE COVERED!


ASTRONAUTICS CORPORATION OF AMERICA
ASTRONAUTICS C.A. LTD
KEARFOTT GUIDANCE & NAVIGATION CORPORATION
AKE

15.95A
5/10/93

Kearfott

80 YEARS OF INNOVATION

1917
The Kearfott Company, Inc.

1952 Kearfott Division
General Precision Equipment Corporation

1959
Astronautics Corporation of America, Inc.

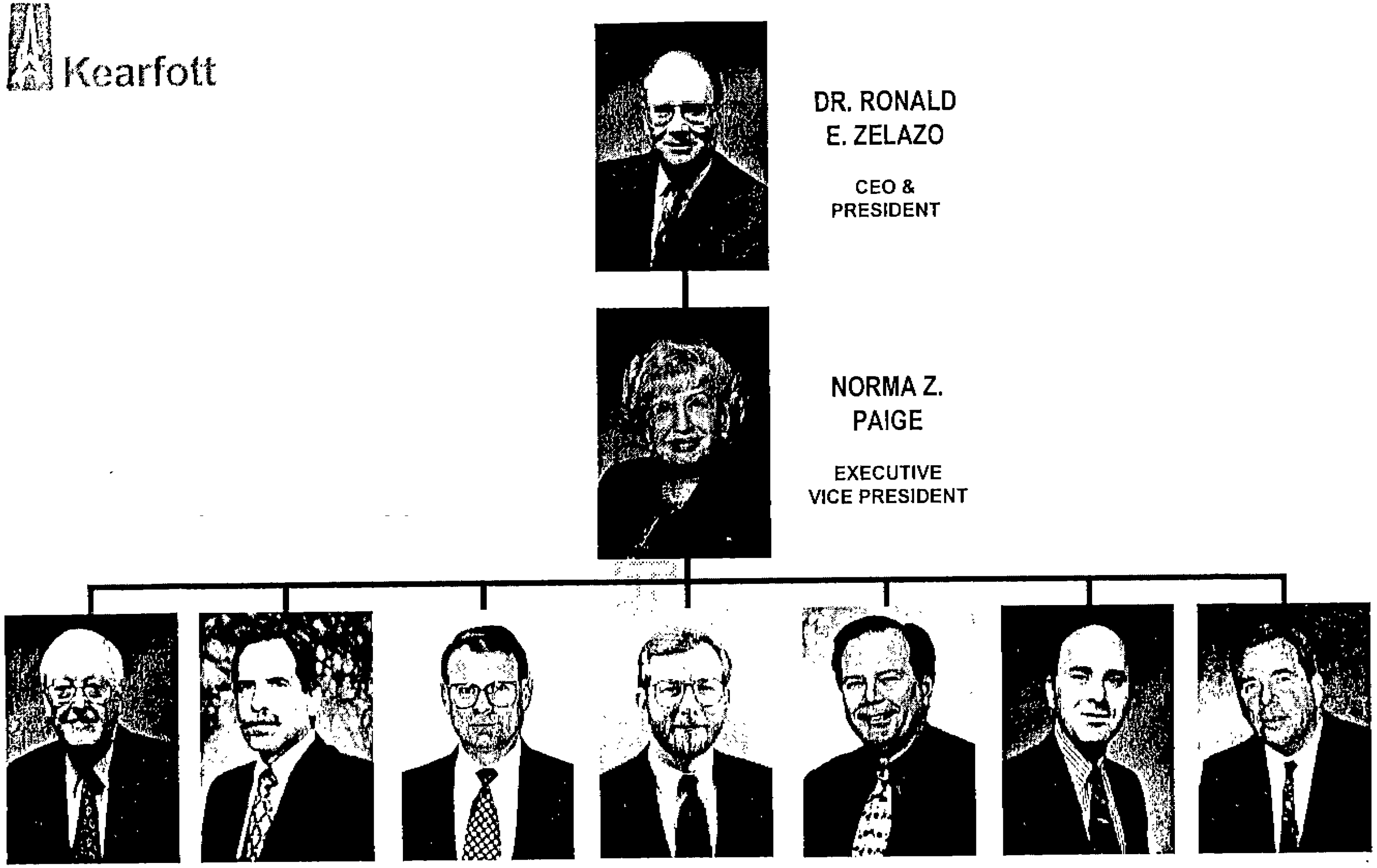
1968 Kearfott Division
The Singer Company

1987 Kearfott Guidance & Navigation Division
The Singer Company

1988 Kearfott Guidance & Navigation Corporation
A Subsidiary of Astronautics Corporation of America

10.96A
4/2/97

Kearfott



DR. RONALD E. ZELAZO
CEO &
PRESIDENT

NORMA Z. PAIGE
EXECUTIVE
VICE PRESIDENT

THOMAS J. SHANAHAN
ENGINEERING
VICE
PRESIDENT

HOWARD J. MINTZ
MANUFACTURING
VICE
PRESIDENT

ERIC FURNESS
QUALITY
ASSURANCE
VICE
PRESIDENT

R. JOSEPH POTTS
MATERIEL
VICE
PRESIDENT

DR. JAMES A. GARDNER
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DEVELOPMENT
& MANAGEMENT
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PRESIDENT

STEPHEN G. GIVANT
FINANCE
VICE
PRESIDENT

JOHN H. MIDDLETON
ASHEVILLE N.C.
OPERATIONS
VICE
PRESIDENT

11.2A
1/3/00

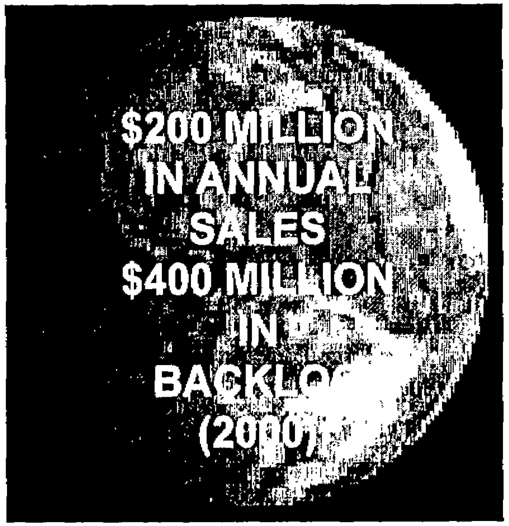
Kearfott Astronautics

SEA

- CORVETTE NAVIGATION SYSTEMS
- SUBMARINE NAVIGATION SYSTEMS
- TORPEDO GUIDANCE
- SUBMARINE LAUNCHED MISSILE GUIDANCE
- ELECTRONIC CHART DISPLAY & INFORMATION SYSTEM (ECDIS)
- COMMAND AND CONTROL CONSOLES

LAND

- MOBILE HOWITZER INERTIAL NAVIGATION & POINTING SYSTEMS
- NORTH FINDING SYSTEMS
- VEHICLE NAVIGATION SYSTEMS
- TANK GUNNER STABILIZED SIGHTS
- TANK RATE SENSOR ASSEMBLIES
- GUN TRUNNION RESOLVERS
- RUGGEDIZED CRT & LCD DISPLAYS
- DRIVER ENHANCED VISION SYSTEM



AIR

- TACTICAL MISSILE GUIDANCE
- AIRCRAFT INERTIAL NAVIGATION SYSTEMS
- ANTISHIP MISSILE GUIDANCE
- FLIGHT CONTROL SENSORS
- FLIGHT CONTROL ACTUATORS
- DIRECTIONAL/VERTICAL AIRCRAFT GYROS
- LINEAR VARIABLE DIFFERENTIAL TRANSFORMER
- AUTOMATIC DEPOT INERTIAL NAVIGATION TEST SYSTEMS
- AVIONICS INTEGRATION
- AIR DATA COMPUTERS
- FLIGHT & NAVIGATION INSTRUMENTS
- MISSION AND DISPLAY PROCESSORS
- MULTI FUNCTION COLOR DISPLAYS
- CONTROL & DISPLAY UNITS
- ELECTRONIC FLIGHT INSTRUMENT SYSTEM (EFIS)

SPACE

- MILITARY AND COMMERCIAL SATELLITE PRECISION POINTING SYSTEMS
- STAR TRACKERS
- 3-AXIS ACCELEROMETER PACKAGES
- STELLAR/INERTIAL GUIDANCE SYSTEMS

Kearfott

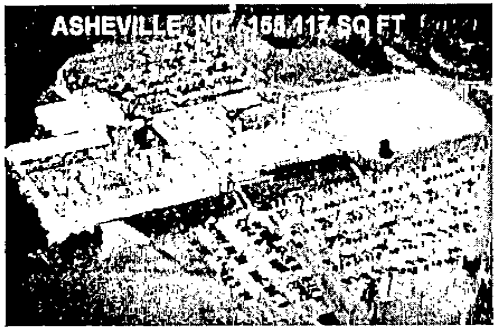
KEARFOTT FACILITIES

WAYNE, NJ 337,900 SQ FT

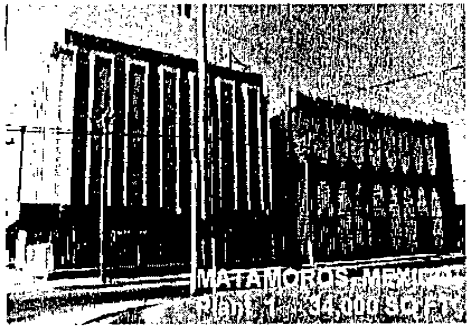
CORPORATE HEADQUARTERS
- ENGINEERING DESIGN/TEST
- ADMINISTRATION
- BUSINESS DEVELOPMENT/MGT
- TRIDENT PRODUCTION
- HUMAN RESOURCES
- LOGISTICS

PLANT 1
- INERTIAL COMPONENTS PRODUCTION
- SYSTEMS ASSEMBLY
- PRODUCTION TEST FACILITY

PLANT 3
- RLG SENSOR PRODUCTION
- RLG SYSTEM ASSEMBLY
- TECHNOLOGY CENTER
- MATERIAL & PROCESSES LABS



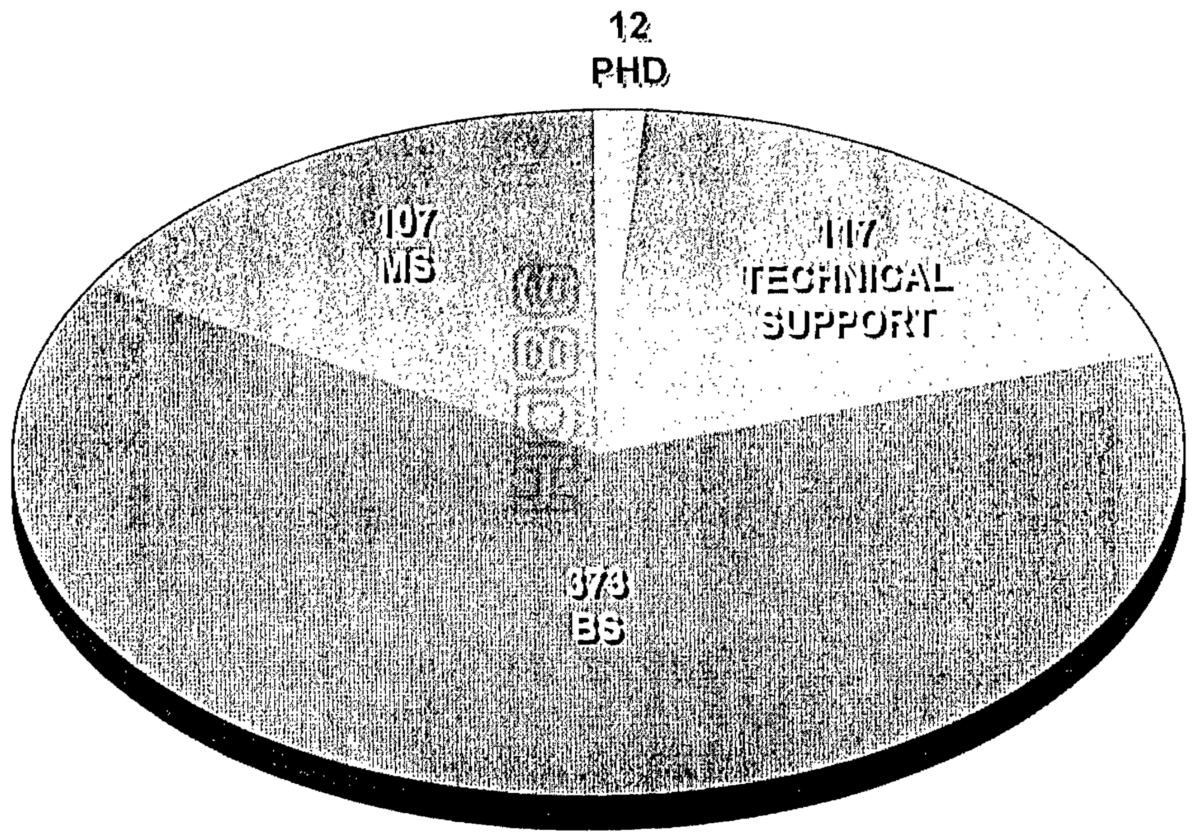
- PRECISION COMPONENT ENGINEERING
- PRODUCTION FACILITY FOR ROTATING COMPONENTS, ELECTRONICS, ACTUATORS, GYROS, ACCELEROMETERS



- PRECISION WOUND COMPONENTS
- CABLE ASSEMBLIES
- ELECTRONIC CARD ASSEMBLY

Kearfott

HUMAN RESOURCES

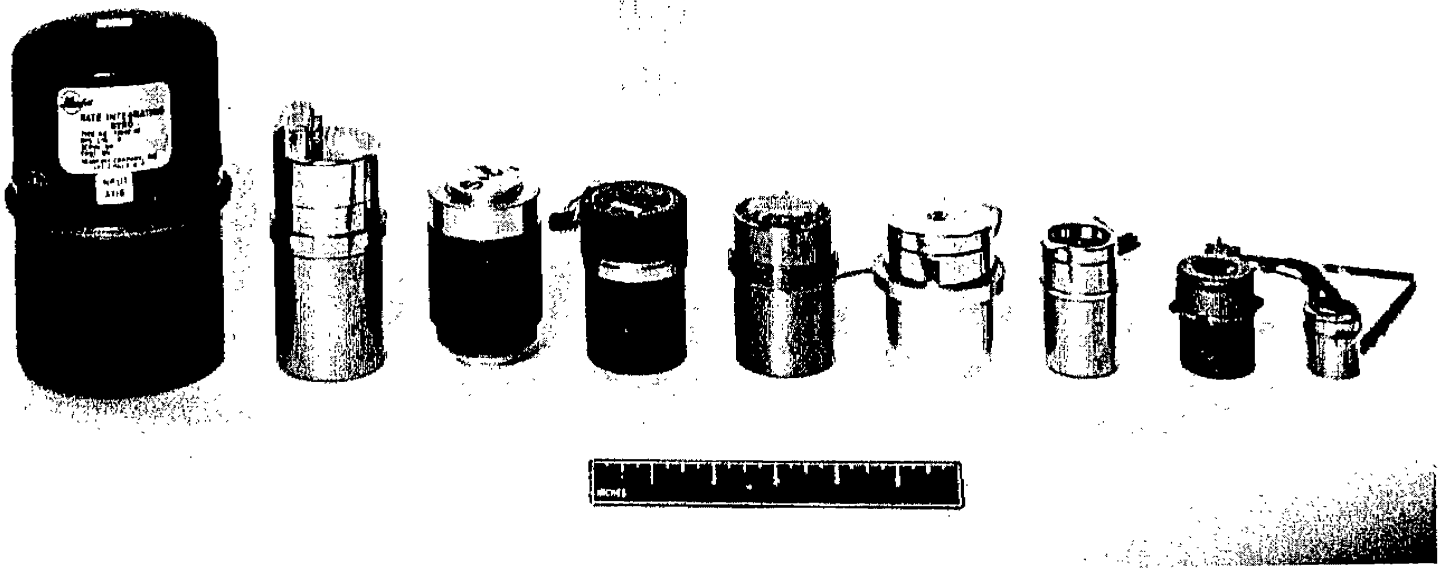


TOTAL PERSONNEL: 1,619
TOTAL TECHNICAL EMPLOYEES: 609

13.307
3/13/00

Kearfott

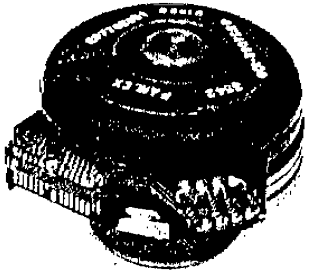
FLOATED RATE INTEGRATING GYROS



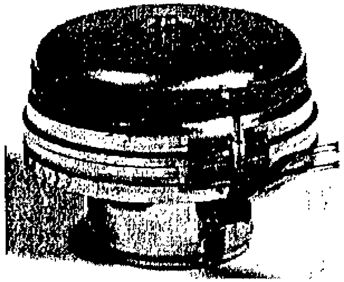
31.416
1/16/93

Kearfott

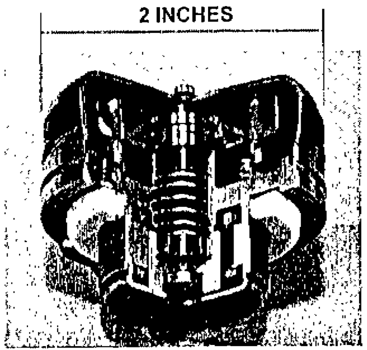
A FAMILY OF GYROS DERIVED FROM KEARFOTT'S DYNAMICALLY TUNED GYROSCOPES



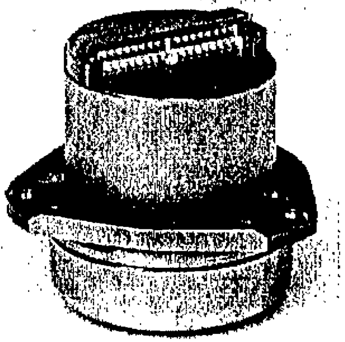
MOD II E
B-1, B-2, ACM,
SPACE SHUTTLE



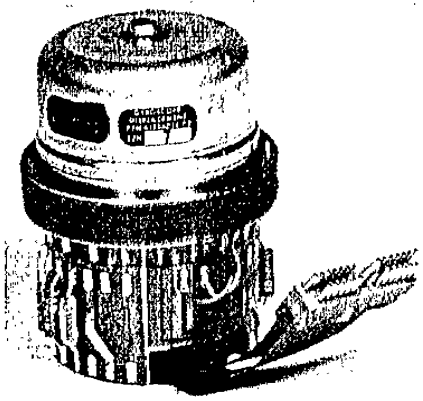
MOD II E/S
MILSTAR, TDRS,
DSCS



MOD II C
F-16, SRAM, A-7 . . .

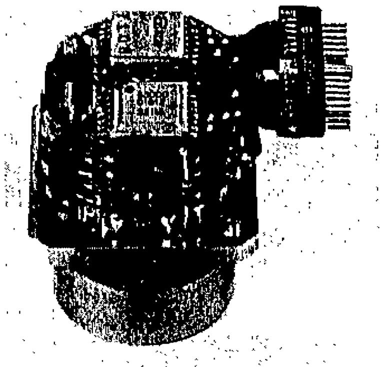


MITA 5
TRIDENT



CONEX MOD O
M1-A1, CHALLENGER, DAHA

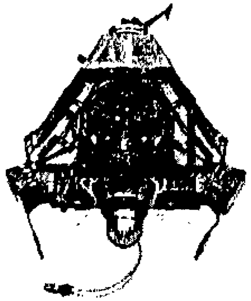
CONEX MOD I
PENGUIN, HS-601

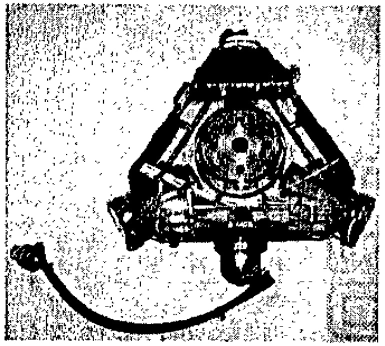


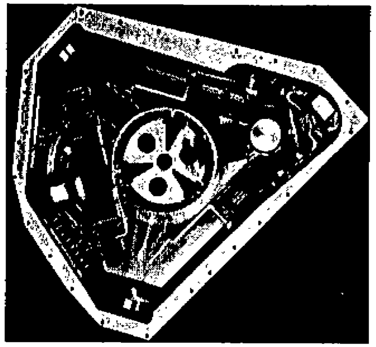
CONEX MOD II
MK-48

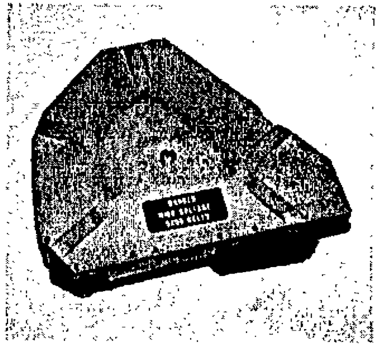
KEARFOTT'S FAMILY OF RING LASER GYROSCOPES

SINGLE-AXIS RING LASER GYROSCOPES

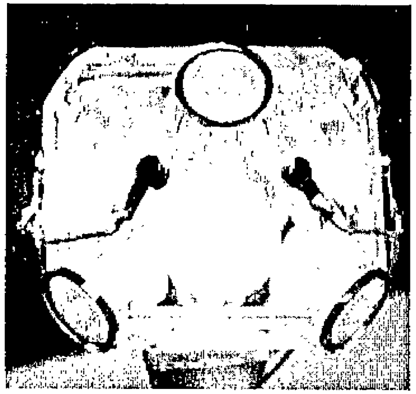

MOD IIT

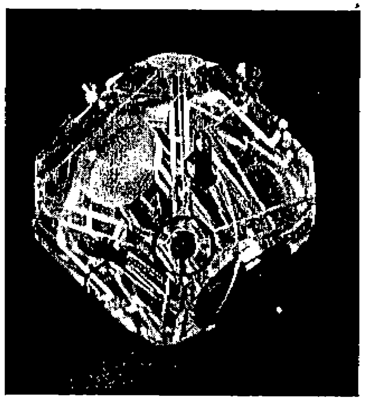

MOD IIS

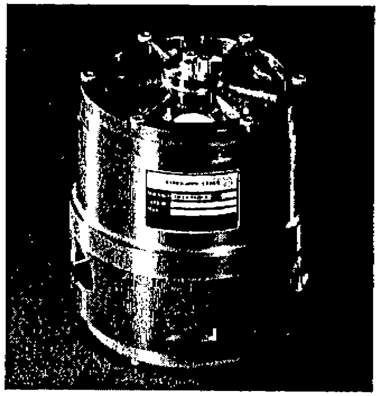

MOD IIR

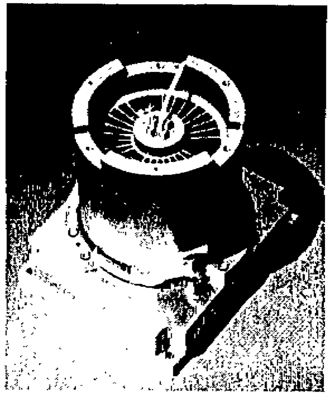

MOD IIH

MONOLITHIC THREE-AXIS RING LASER GYROSCOPES


T10

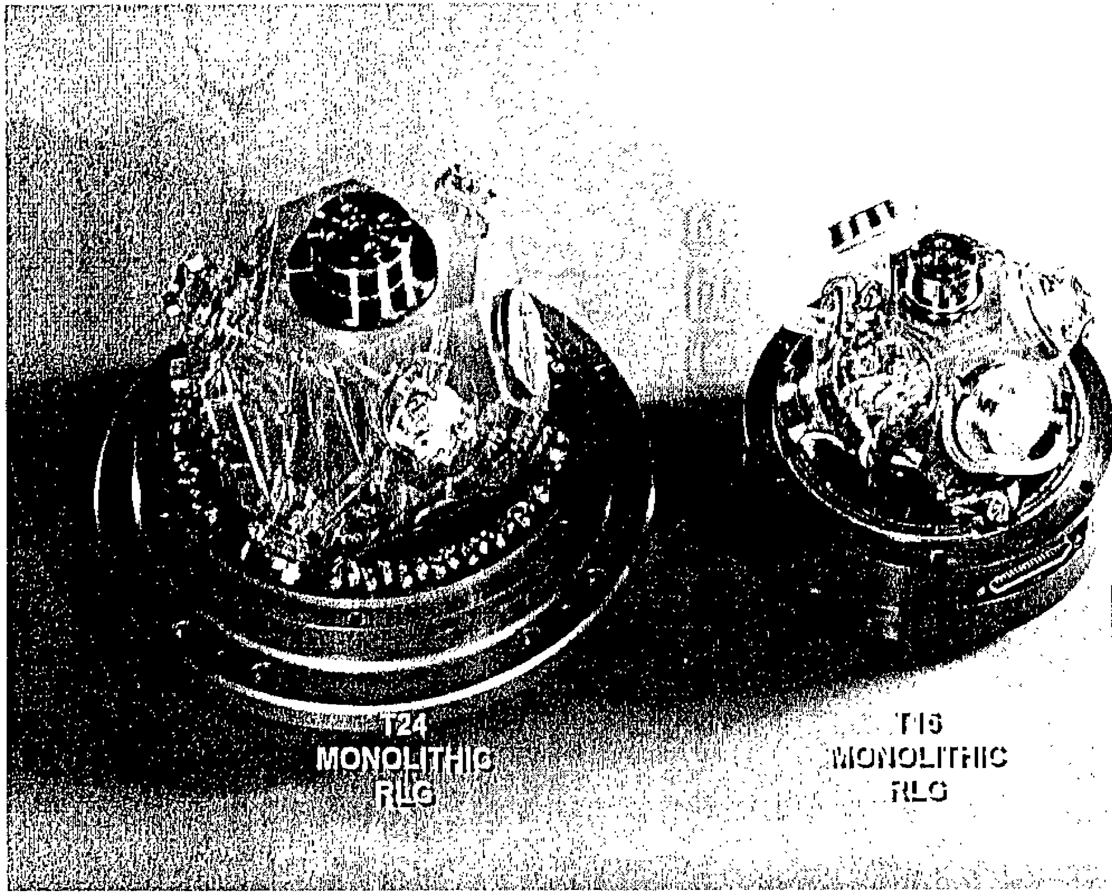

T16-E


T16-B

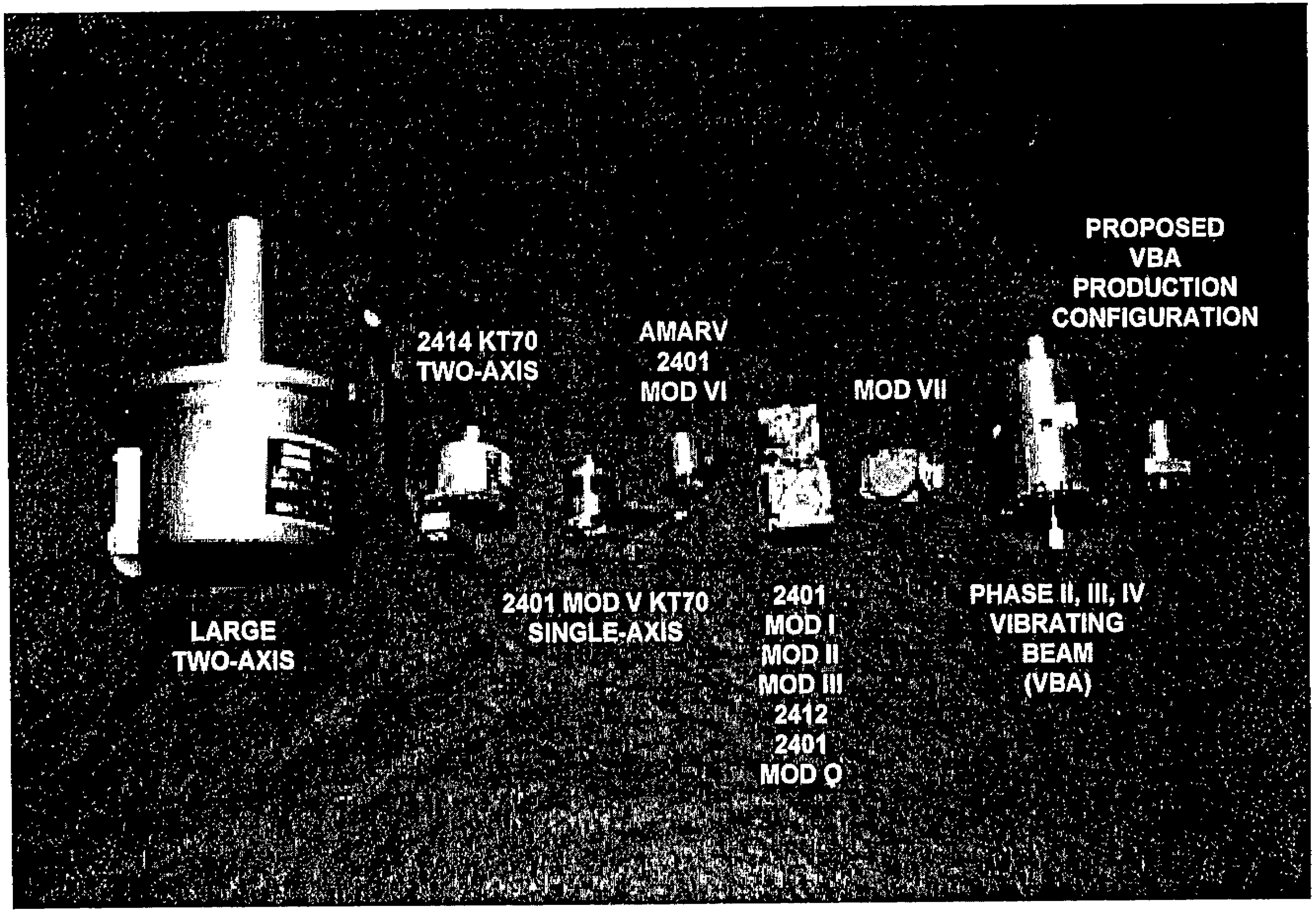

T24-E/B

Kearfott

KEARFOTT'S LATEST INVENTION WILL REPLACE SINGLE-AXIS RING LASER GYROS



KEARFOTT'S FAMILY OF ACCELEROMETERS

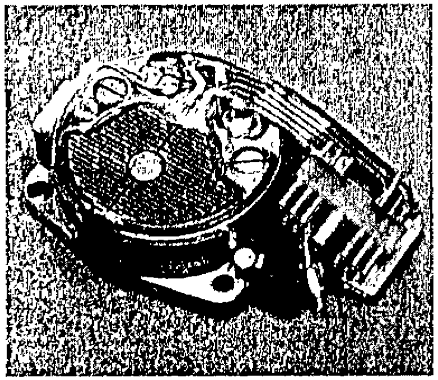


31.458
1/16/93

Kearfott

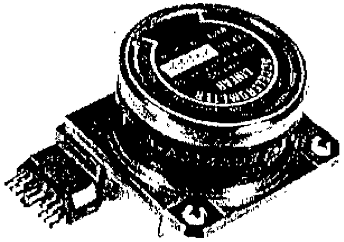
KEARFOTT MANUFACTURES ITS OWN ACCELEROMETERS

GAS-DAMPED

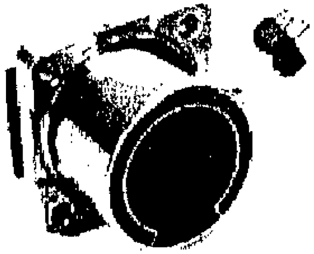


MOD VII
GIMBALLED
SYSTEM

MOD VIIS
STRAPDOWN
SPACE SYSTEM



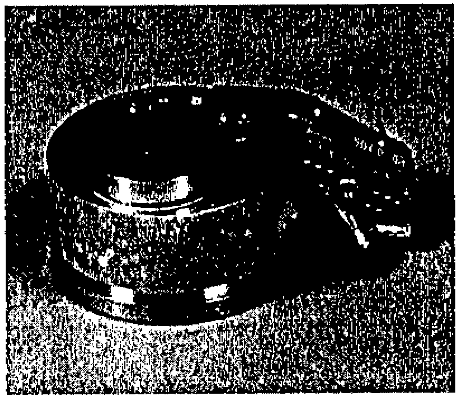
MOD VIIS, MK- 48
TORPEDOES



MOD VIIA
TACTICAL
MISSILE

LIQUID-DAMPED

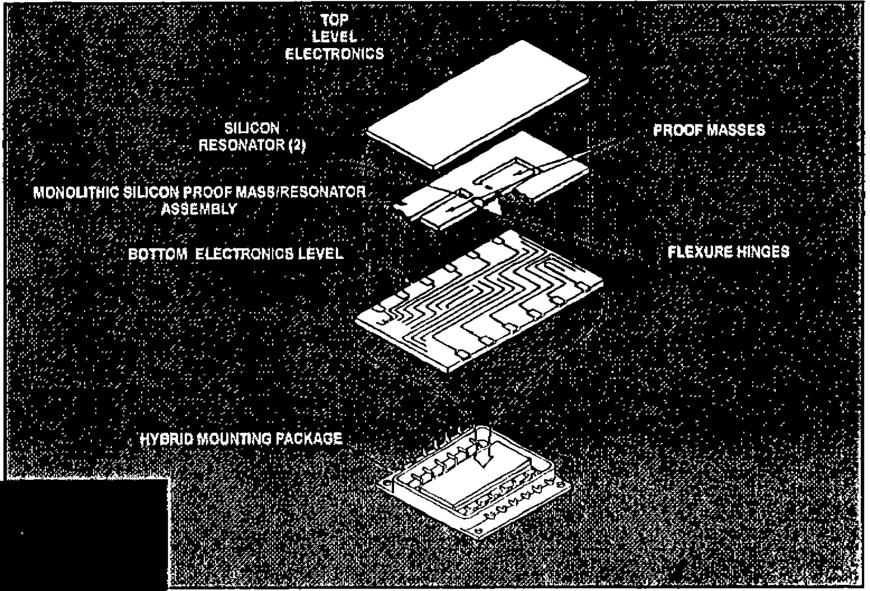
MOD VIIL - RIMU

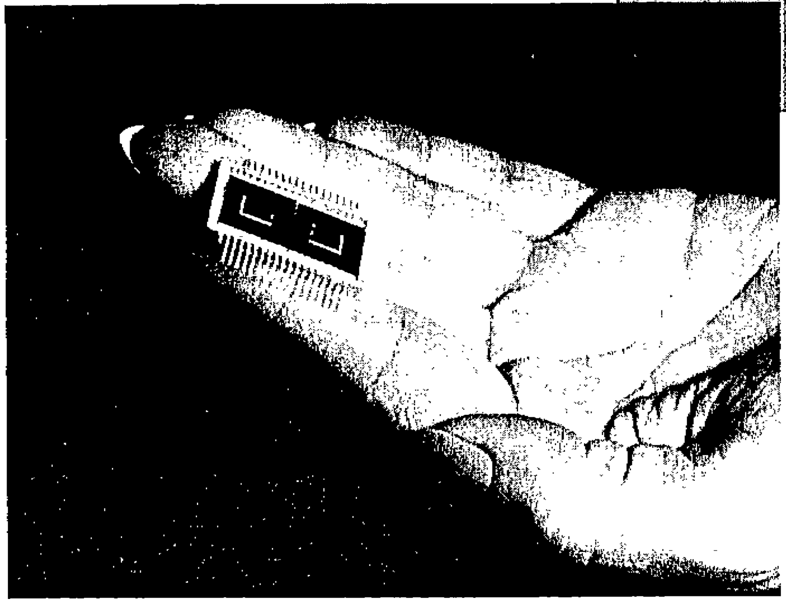


MOD VIIL - HI-G

Kearfott

MICROMACHINED VIBRATING BEAM ACCELEROMETER (MVBA)





FEATURES

- MONOLITHIC SILICON CONSTRUCTION WITH THREE-MICRON FEATURE SIZE
- VBA PRINCIPLE
- QUICK TURN ON: <1 sec
- SMALL SIZE: 0.06 in^3 (1.0 cm^3)
- LIGHT WEIGHT: 0.07 oz (2 grams)
- INTEGRAL ELECTRONICS/HIGH -*g* CAPABILITY
- LOW COST

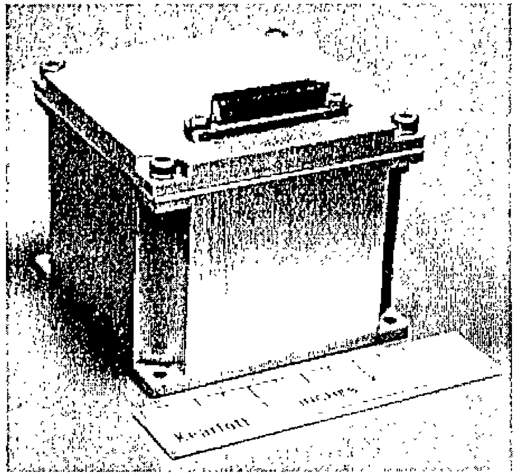
433.60
4/28/93

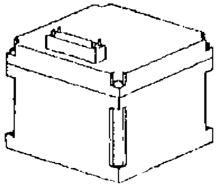
Kearfott

MICROMACHINED VIBRATING BEAM MULTISENSOR (MVBM)

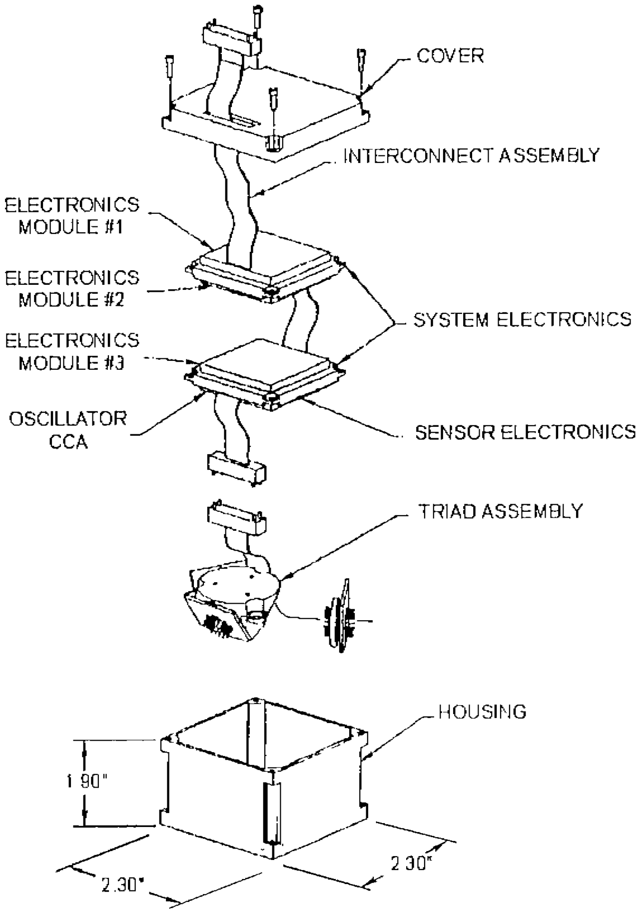
FEATURES

- MONOLITHIC SILICON CONSTRUCTION
- VBA PRINCIPLE
- MEASURES 1 AXIS OF RATE AND 1 AXIS OF ACCELERATION ON A SINGLE CHIP
- GYRO BIAS 1.5°/h
- GYRO RANDOM WALK .15°/√h
- ACCELEROMETER BIAS 300 mg
- 3 AXIS SENSOR BLOCK
- IMU (Δθ, ΔV OUTPUT) 10 in³



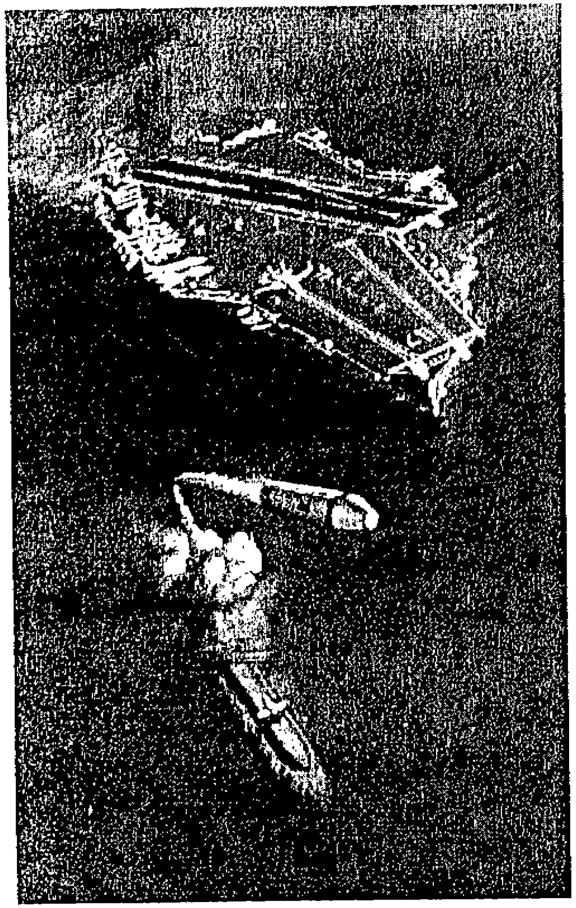


ISOMETRIC VIEW



Kearfott

WE HAVE THE UNIVERSE COVERED!

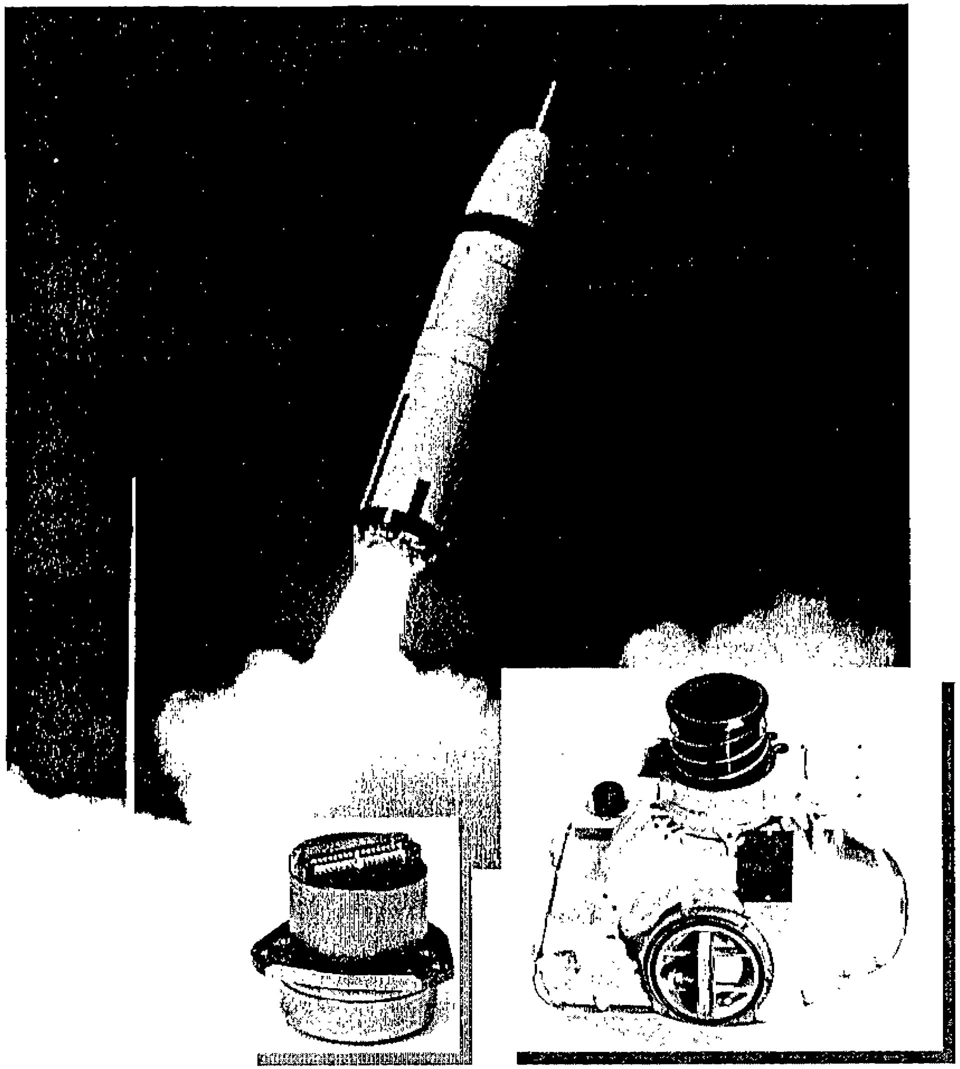


SEA PRODUCTS

- STRATEGIC MISSILE GUIDANCE SYSTEM FOR THE USN TRIDENT MISSILE
- INERTIAL REFERENCE SYSTEMS FOR USN MK-48 ADVANCED CAPABILITIES TORPEDO (ADCAP)
- NAVIGATION SYSTEMS FOR 209 CLASS SUBMARINES
- NAVIGATION SYSTEMS FOR 1200 TON CLASS CORVETTES
- POSITION SENSORS, MOTORS, GEARHEADS FOR SHIPS
- ACCURATE MARINE GYROCOMPASS SYSTEM
- POWERFUL MODULAR OPERATOR COMMAND AND CONTROL CONSOLES FOR SHIPS AND SUBMARINES
- LIGHTWEIGHT, LOW-COST HIGHLY RELIABLE STATE-OF-THE-ART MRLG SEANAV

Kearfott

KEARFOTT DESIGNS AND BUILDS STELLAR INERTIAL GUIDANCE SYSTEMS FOR STRATEGIC MISSILES



CUSTOMER/USER:

- SSPO - TRIDENT C-4/D-5 MISSILES
- CSDL
- U.S. NAVY

EQUIPMENT:

- STELLAR INERTIAL MEASUREMENT UNIT WITH KEARFOTT'S DYNAMICALLY TUNED GYROFLEX® GYRO
- KEARFOTT PURCHASES ALL IMU CRITICAL PARTS FOR ENTIRE USN PROGRAM

FUNCTION PROVIDED:

- PROVIDES THE ENTIRE GUIDANCE FUNCTION FOR THE C-4/D-5 SUBMARINE LAUNCHED TRIDENT MISSILE

PENGUIN ANTI-SHIP MISSILE

- CUSTOMER/USER:
  NORSK
  FORSVARSTEKNOLOGI
  (NFT), NORWAY
- EQUIPMENT:
  TWO-AXIS
  DYNAMICALLY
  TUNED GYROSCOPE
  (CONEX MOD I)
- FUNCTION PROVIDED:
  SENSOR FOR MISSILE
  GUIDANCE SYSTEM

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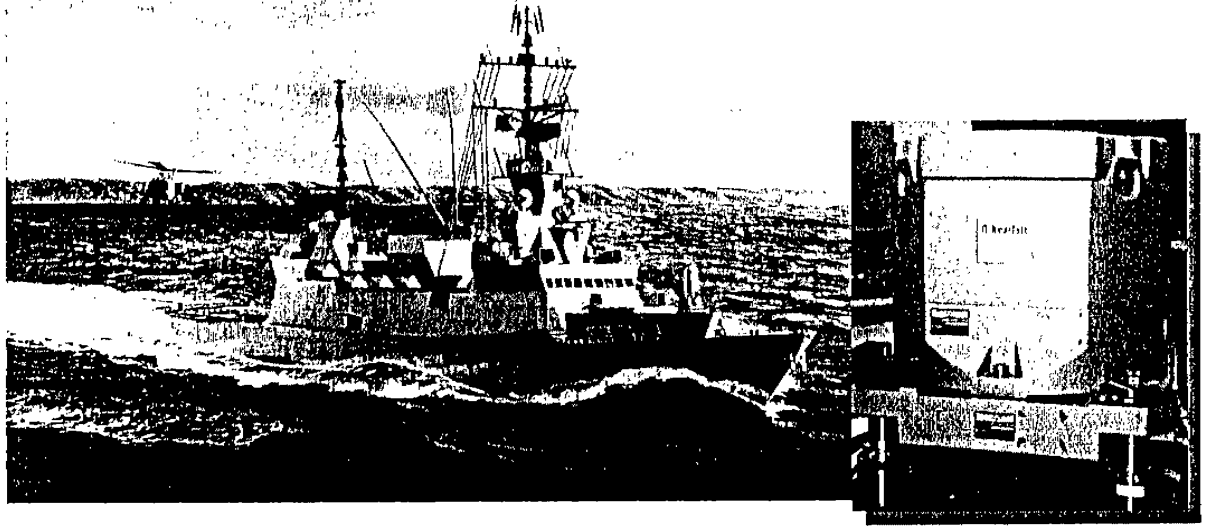
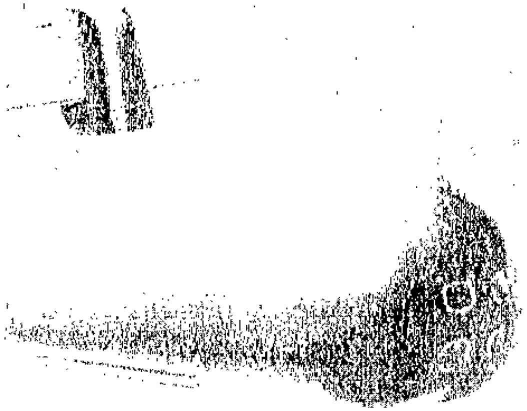
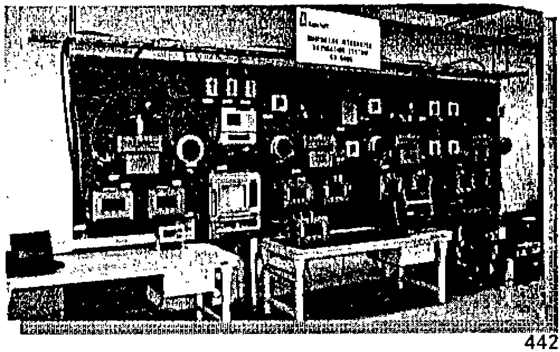
KEARFOTT INTEGRATES SHIPBOARD NAVIGATION SYSTEMS FOR 1200 TON CLASS CORVETTES AND 209 CLASS SUBMARINES







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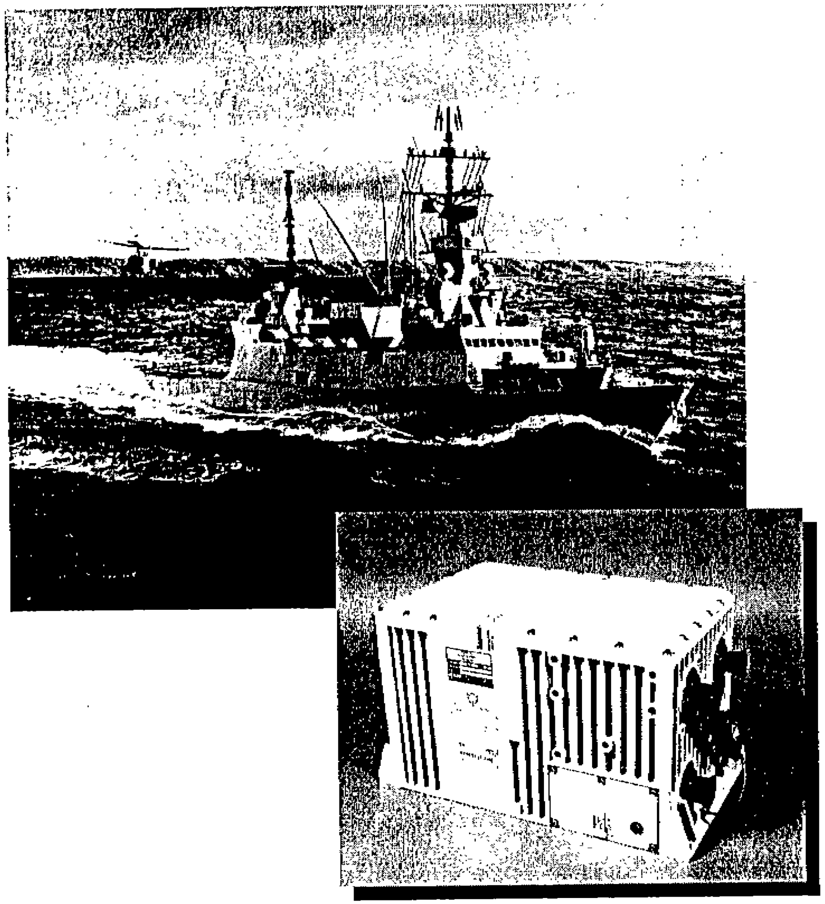
SURFACE SHIPS



- CUSTOMER/USER:
  - SPA WAR (US NAVY)
  - UNIVERSITY OF TEXAS ARL
  - XONTEC
  - TEXTRON
- EQUIPMENT:
  - SKN-5053 SEANAV
- FUNCTIONS PROVIDED:
  - POSITION, VELOCITY, ATTITUDE, ATTITUDE RATE
  - BLENDED NAVIGATION
    - GPS
- APPLICATION:
  - NAVIGATION
  - RADAR STABILIZATION

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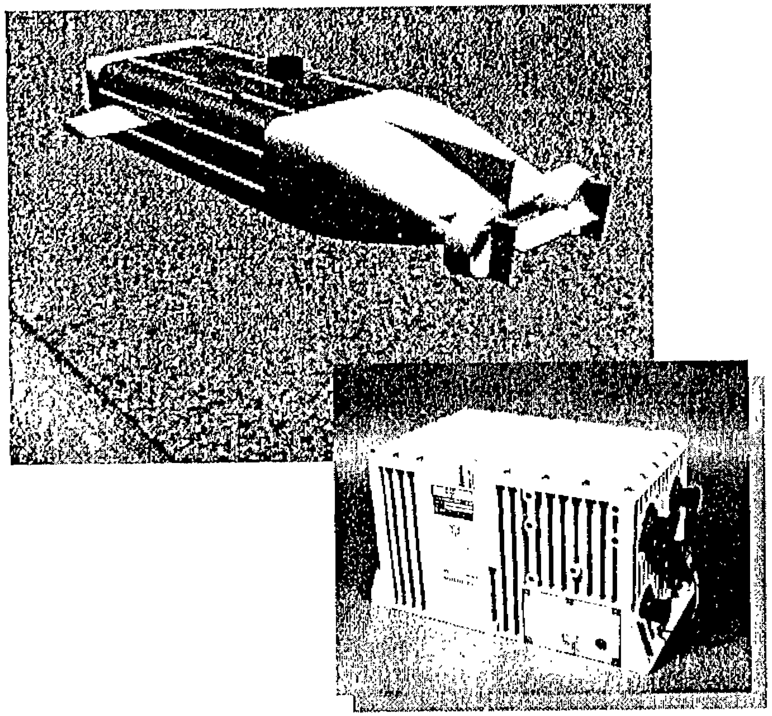
UNMANNED UNDERWATER VEHICLES

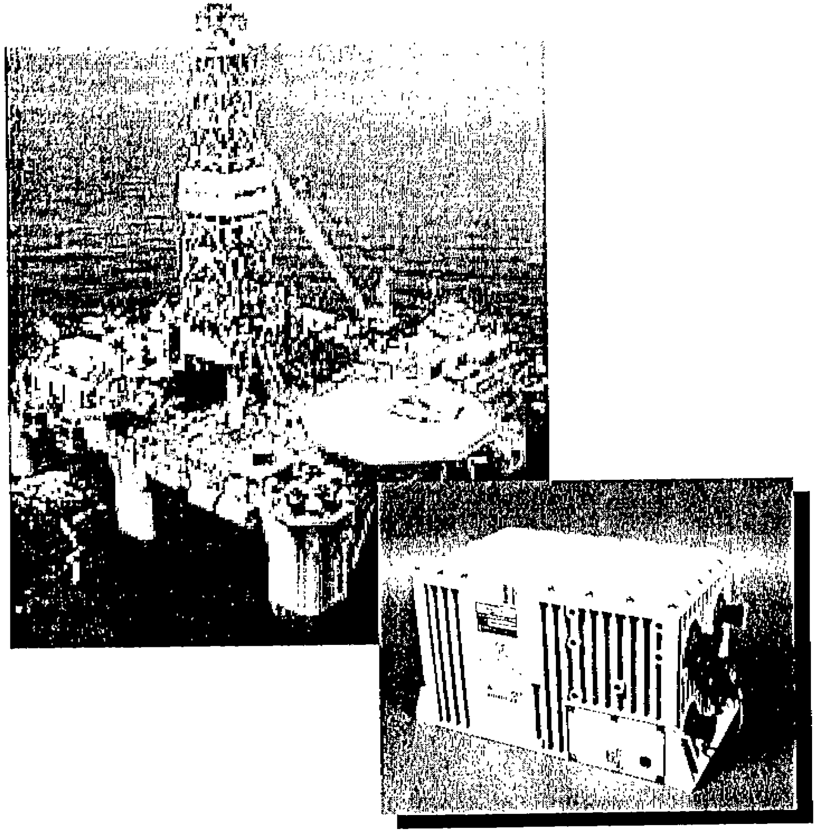


- CUSTOMER/USER:
  - MARIDAN A/S
  - PENN STATE (ARL)
  - SUB SEA INTERNATIONAL
- EQUIPMENT:
  - KN-5053 SEANAV
- FUNCTIONS PROVIDED:
  - POSITION VELOCITY, ATTITUDE
  - ATTITUDE RATE
  - BLENDED NAVIGATION SOLUTION
  - GPS, DOPPLER VELOCITY LOG
  - DEPTH ALTITUDE SENSOR
- PLANNED PRODUCTION:
  - 15 - 20/YR

SWEDISH TORPEDO 2000

- CUSTOMER/USER:
  BOFORS UNDERWATER
  SYSTEMS (SWEDEN)
- EQUIPMENT:
  T-16B THREE AXIS
  MONOLITHIC RING LASER
  GYRO (MRLG) AND
  ELECTRONICS
- FUNCTIONS PROVIDED:
  PROVIDES Δ θ & Δ V TO
  TORPEDO GUIDANCE
  COMPUTER FOR
  NAVIGATION GUIDANCE

COMMERCIAL EXPLORATION



- CUSTOMER/USER:
  - VARIOUS
- EQUIPMENT:
  - SEANAV
    - ♦ KN-5051
    - ♦ KN-5053
- FUNCTIONS PROVIDED:
  - POSITION ATTITUDE, HEADING
  - BLENDED SOLUTION WITH GPS
- PRODUCTION ANTICIPATED
  - 10 TO 20 YEARS

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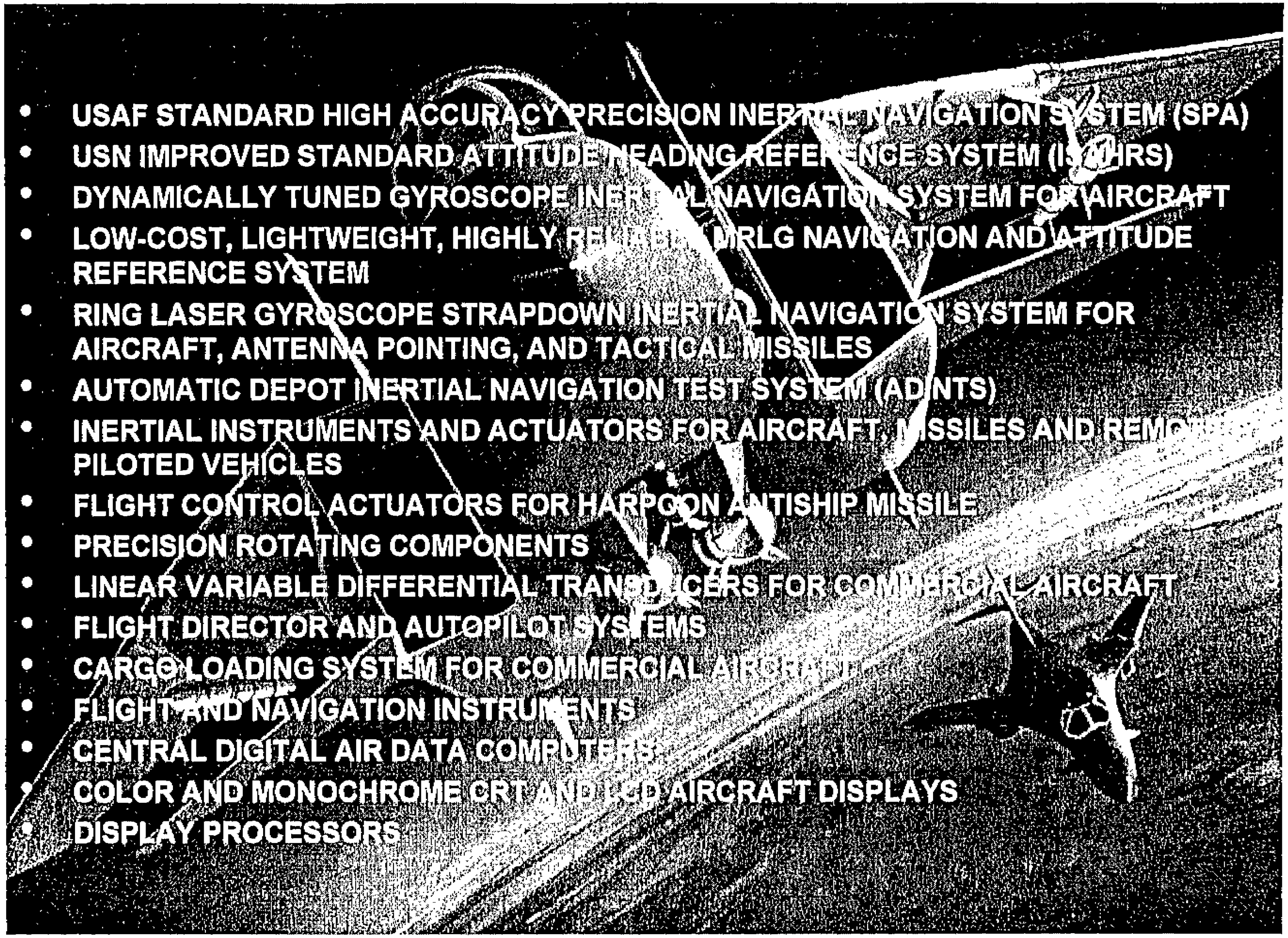
WE HAVE THE UNIVERSE COVERED !

AIR PRODUCTS



- USAF STANDARD HIGH ACCURACY PRECISION INERTIAL NAVIGATION SYSTEM (SPA)
- USN IMPROVED STANDARD ATTITUDE HEADING REFERENCE SYSTEM (ISAHRS)
- DYNAMICALLY TUNED GYROSCOPE INERTIAL NAVIGATION SYSTEM FOR AIRCRAFT
- LOW-COST, LIGHTWEIGHT, HIGHLY RELIABLE MRLG NAVIGATION AND ATTITUDE REFERENCE SYSTEM
- RING LASER GYROSCOPE STRAPDOWN INERTIAL NAVIGATION SYSTEM FOR AIRCRAFT, ANTENNA POINTING, AND TACTICAL MISSILES
- AUTOMATIC DEPOT INERTIAL NAVIGATION TEST SYSTEM (ADINTS)
- INERTIAL INSTRUMENTS AND ACTUATORS FOR AIRCRAFT, MISSILES AND REMOTELY PILOTED VEHICLES
- FLIGHT CONTROL ACTUATORS FOR HARPOON ANTISHIP MISSILE
- PRECISION ROTATING COMPONENTS
- LINEAR VARIABLE DIFFERENTIAL TRANSDUCERS FOR COMMERCIAL AIRCRAFT
- FLIGHT DIRECTOR AND AUTOPILOT SYSTEMS
- CARGO LOADING SYSTEM FOR COMMERCIAL AIRCRAFT
- FLIGHT AND NAVIGATION INSTRUMENTS
- CENTRAL DIGITAL AIR DATA COMPUTERS
- COLOR AND MONOCHROME CRT AND LCD AIRCRAFT DISPLAYS
- DISPLAY PROCESSORS

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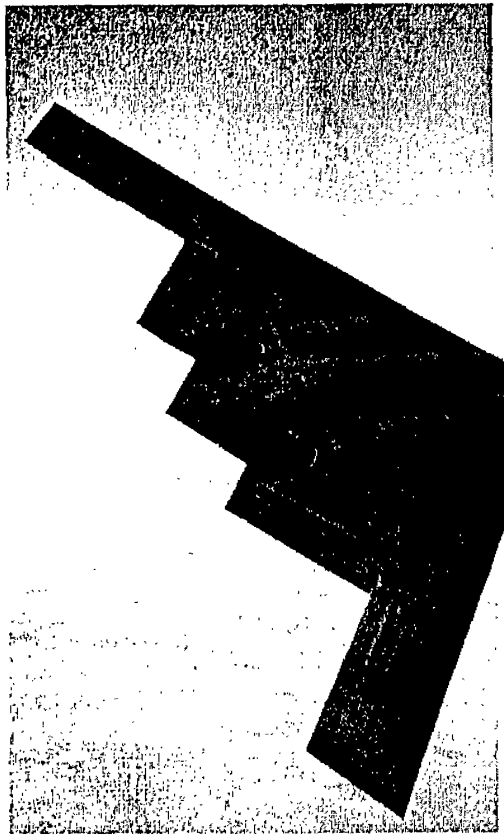
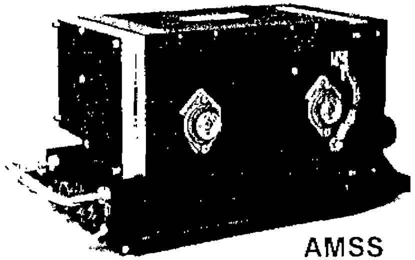
KEARFOTT EQUIPMENT SELECTED FOR THE LATEST U.S. AIRCRAFT



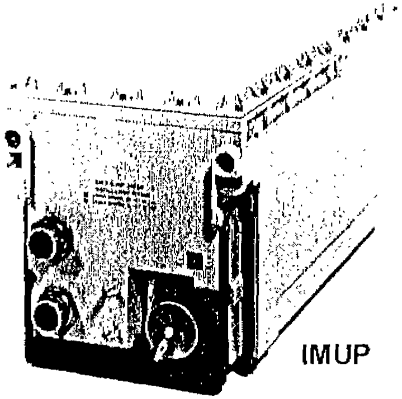
CUSTOMER/USER:
NORTHROP
B-2 DIVISION



AMSS

EQUIPMENT:
- RING LASER GYRO ATTITUDE MOTION SENSOR SET
- RACK

FUNCTIONS PROVIDED:
- EMERGENCY BACK-UP NAVIGATION (POSITION, VELOCITY, ATTITUDE)
- QUAD REDUNDANT FLIGHT CONTROL REFERENCE (ACCELERATION, ANGULAR DATA, α, $\dot{\alpha}$, β, $\dot{\beta}$)



IMUP

EQUIPMENT:
- HIGH ACCURACY INERTIAL NAVIGATION UNIT (<0.2nmi/h)

FUNCTION PROVIDED:
- STABILIZED INERTIAL VELOCITY AND ATTITUDE

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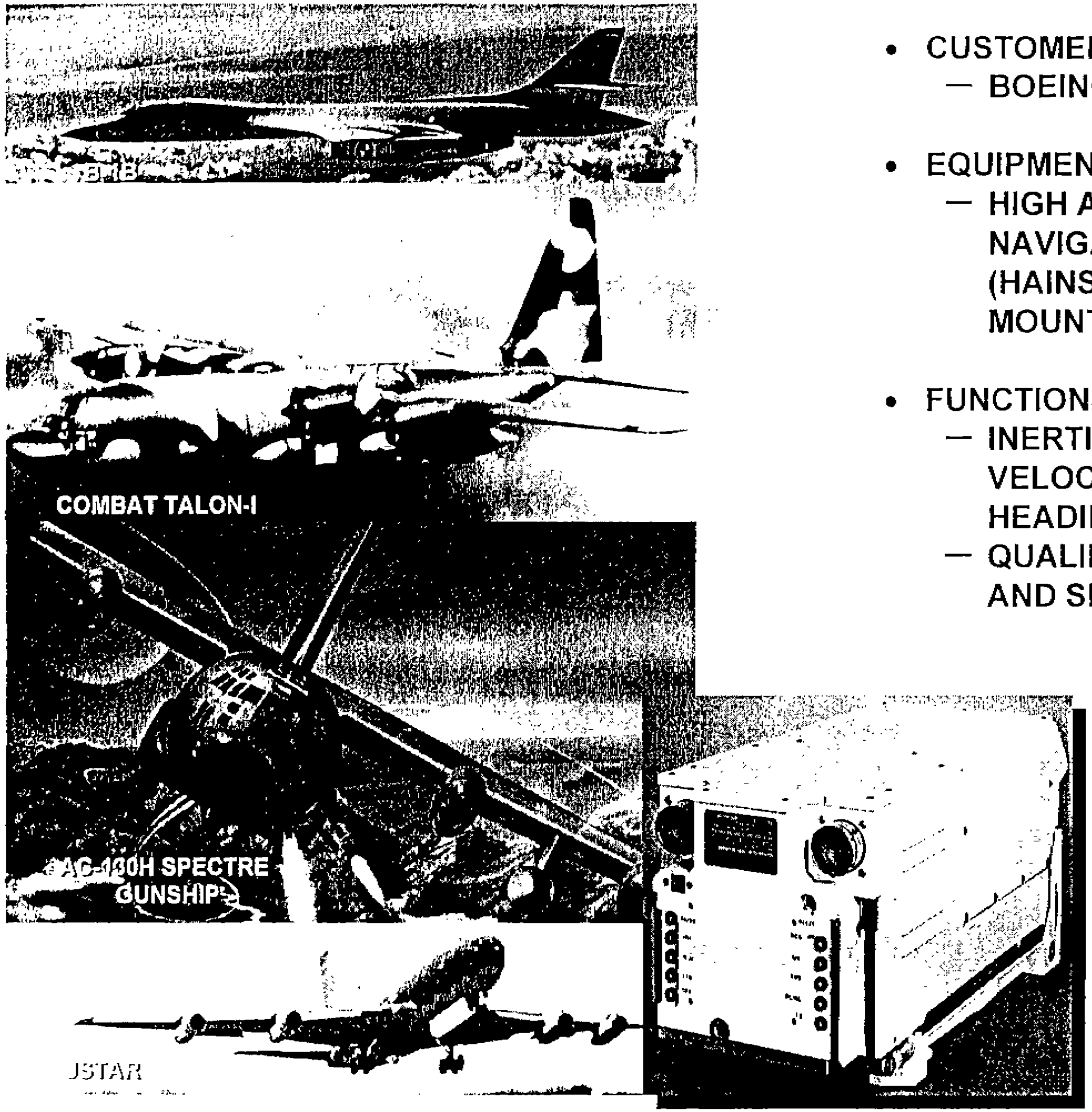
KEARFOTT BUILDS THE MOST ACCURATE INERTIAL NAVIGATION SYSTEM IN THE WORLD



- CUSTOMER/USER:
  - BOEING/USAF
- EQUIPMENT:
  - HIGH ACCURACY INERTIAL NAVIGATION SYSTEM (HAINS) (<0.2 nmi/h), MOUNTING RACK
- FUNCTIONS PROVIDED:
  - INERTIAL NAVIGATION VELOCITY, ATTITUDE AND HEADING INFORMATION
  - QUALIFIED TO ENAC 77-1 AND SNU 84-3 (SPA)

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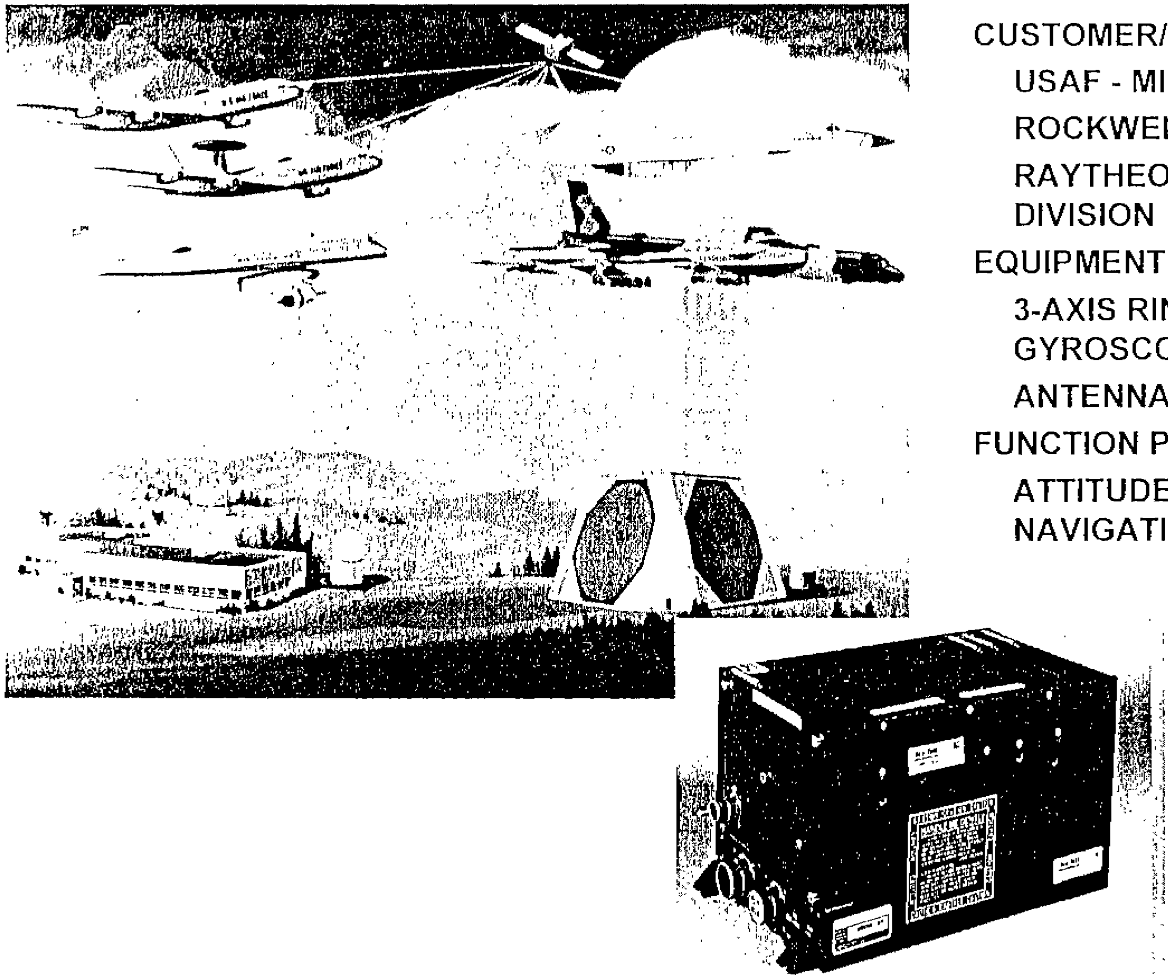
KEARFOTT DESIGNS AND BUILDS ANTENNA REFERENCE UNITS FOR U.S. STRATEGIC AND TACTICAL FORCES



CUSTOMER/USER:
- USAF - MILSTAR
- ROCKWELL INTERNATIONAL
- RAYTHEON EQUIPMENT DIVISION

EQUIPMENT:
- 3-AXIS RING LASER GYROSCOPE
- ANTENNA REFERENCE UNIT

FUNCTION PROVIDED:
- ATTITUDE AND BACKUP NAVIGATION

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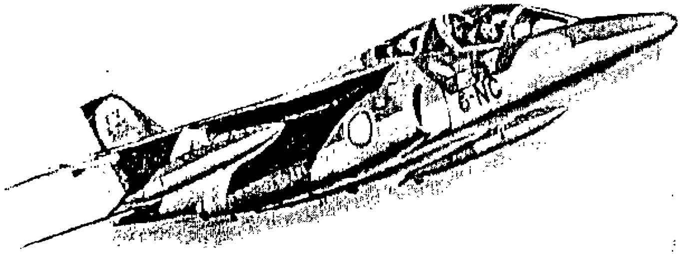
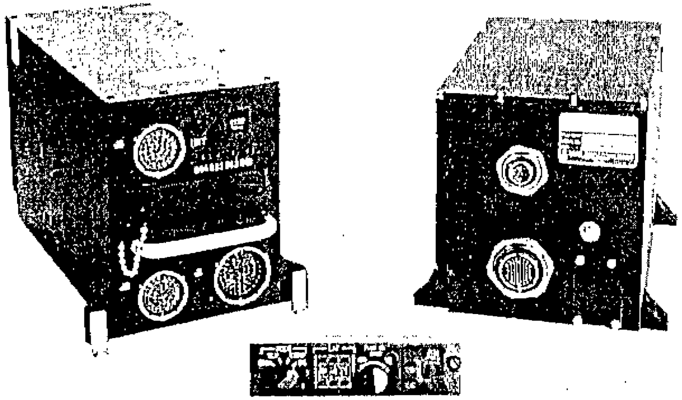
KN-4071 - LOW COST ATTITUDE HEADING REFERENCE SYSTEM (AHRS)





CUSTOMER/USER:

- INDUSTRIA AERONAUTICA DE PORTUGAL S.A./PORTUGESE A.F.

EQUIPMENT:

- 3 AXIS MONOLITHIC RING LASER GYRO (MRLG)
- SELF-CONTAINED GLOBAL POSITIONING SYSTEM
- OPTIONAL GROWTH WITH GPS/INS

FEATURES:

- 3 LINE-REPLACEABLE UNITS
  - » SYNCHRO CONVERTER UNIT
  - » MODE SELECT UNIT
  - » INERTIAL GPS UNIT

OUTPUTS:

- ANALOG HEADING, ROLL, PITCH
- OPTIONAL DIGITAL RS-422

POWER:

- 115 V, 400 Hz, 90 VA MA X

MODES:

— GYRO COMPASS	± 0.7°
— SLAVED	
HEADING	± 0.5°
ATTITUDE	± 0.25°
— GYRO	
HEADING	± 0.5°
ATTITUDE	± 0.25°
— *ENHANCED*	
HEADING	± *0.25°*
ATTITUDE	± *0.15°*

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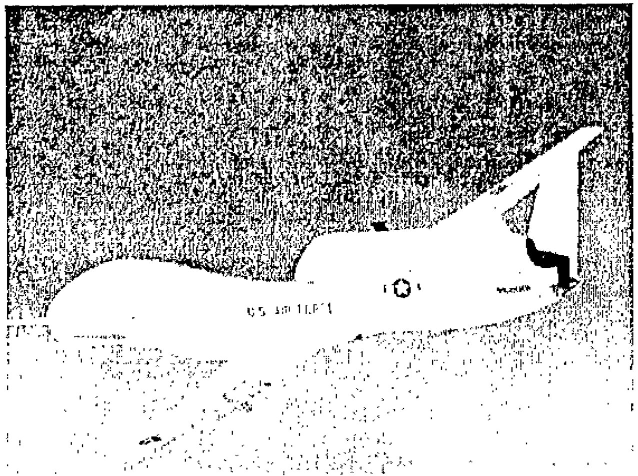
NAVIGATION & FLIGHT CONTROL



- CUSTOMER/USER:
  - NORTHRUP GRUMMAN
    - » GLOBAL HAWK UAV
- EQUIPMENT:
  - KN-4072
- FUNCTIONS PROVIDED:
  - POSITION, VELOCITY
  - ATTITUDE RATE
  - NAVIGATION BLENDED SOLUTION WITH GPS
  - FLIGHT CONTROL $\Delta\theta$ ΔV
- PRODUCTION QUANTITY:
  - ANTICIPATED 200 UNITS

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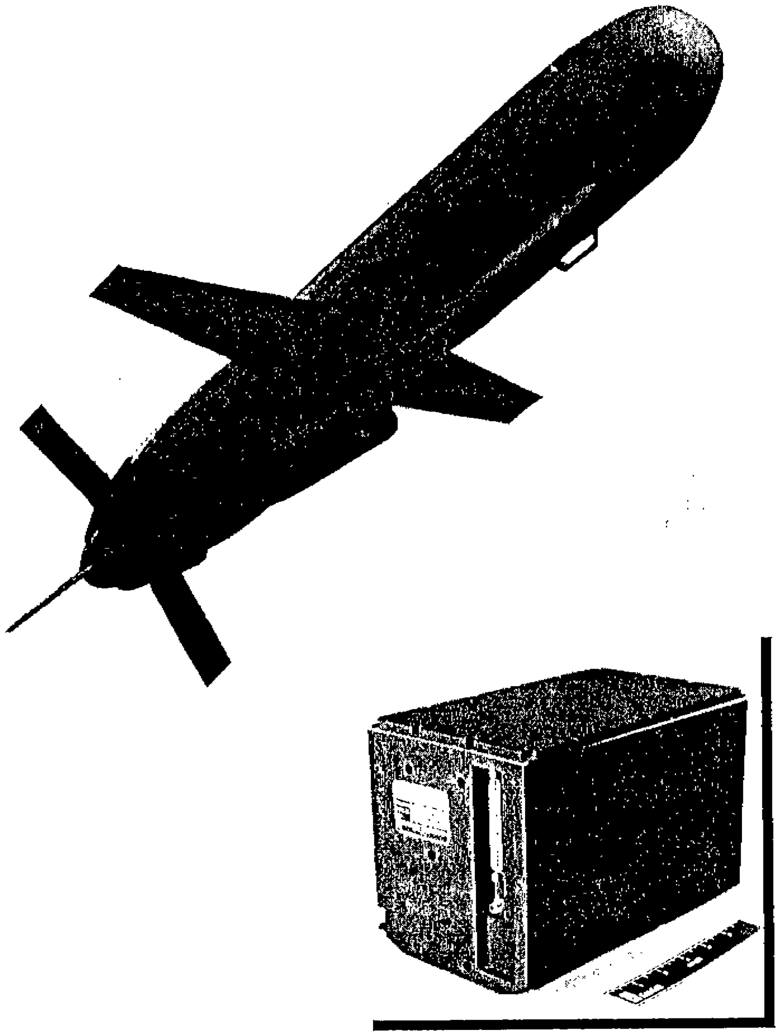
KN-4070 UNMANNED AIR VEHICLE (UAV)



- CUSTOMER/USER:
  - TAAS, ISRAEL/ISRAEL AIR FORCE
- EQUIPMENT:
  - 3-AXIS MONOLITHIC RING LASER GYRO (MRLG)
  - INERTIAL NAVIGATION SYSTEM
  - EMBEDDED GLOBAL POSITIONING SYSTEM (INS/GPS)
- FEATURES:
  - SIZE: (INCHES)
    9.1 (L) X 5.4 (W) X 6.0 (H)
  - WEIGHT:
    <5 (kg)
- OUTPUTS:
  - MIL-STD-1553B, RS-422, RS-232 (NAVIGATION AND GUIDANCE)
- POWER:
  - 28 V dc; 35 W, MIL-STD-704A
- MAINTENANCE:
  - TWO LEVEL/BUILT-IN TEST
  - NO SCHEDULED CALIBRATION REQUIRED
  - MTBF > 6000 H

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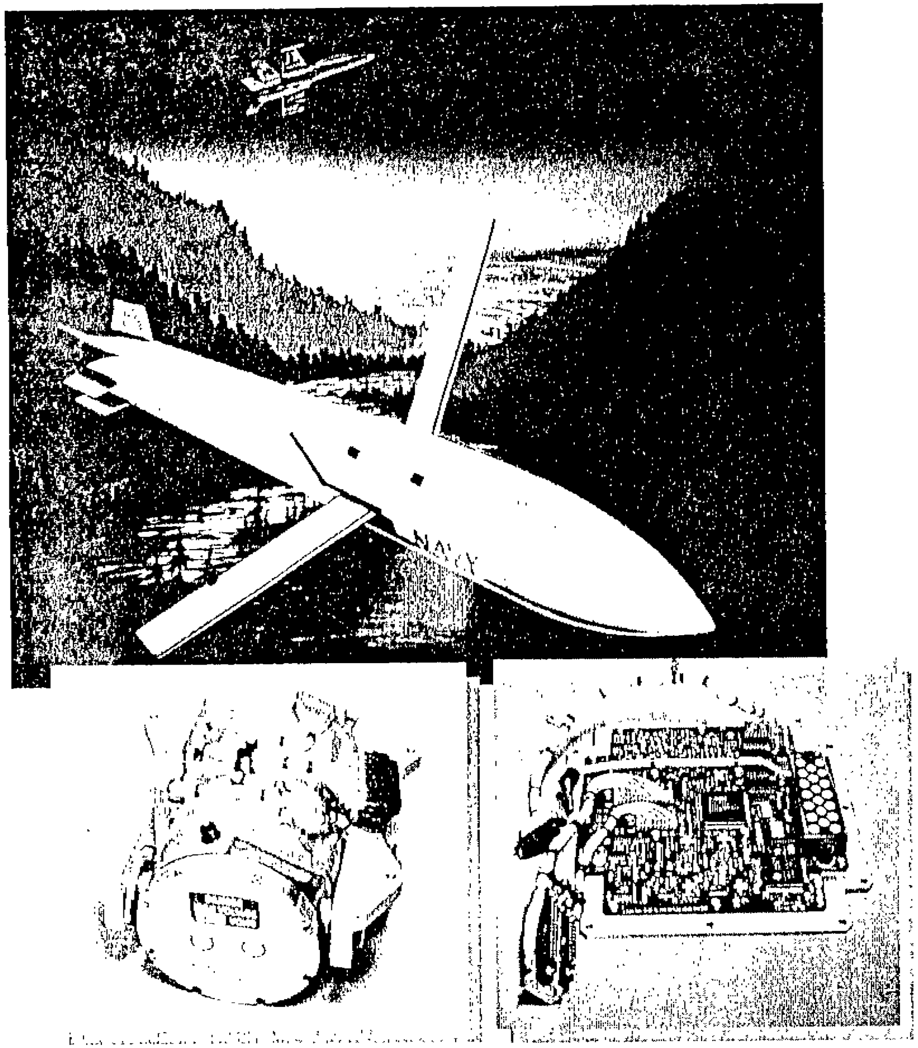
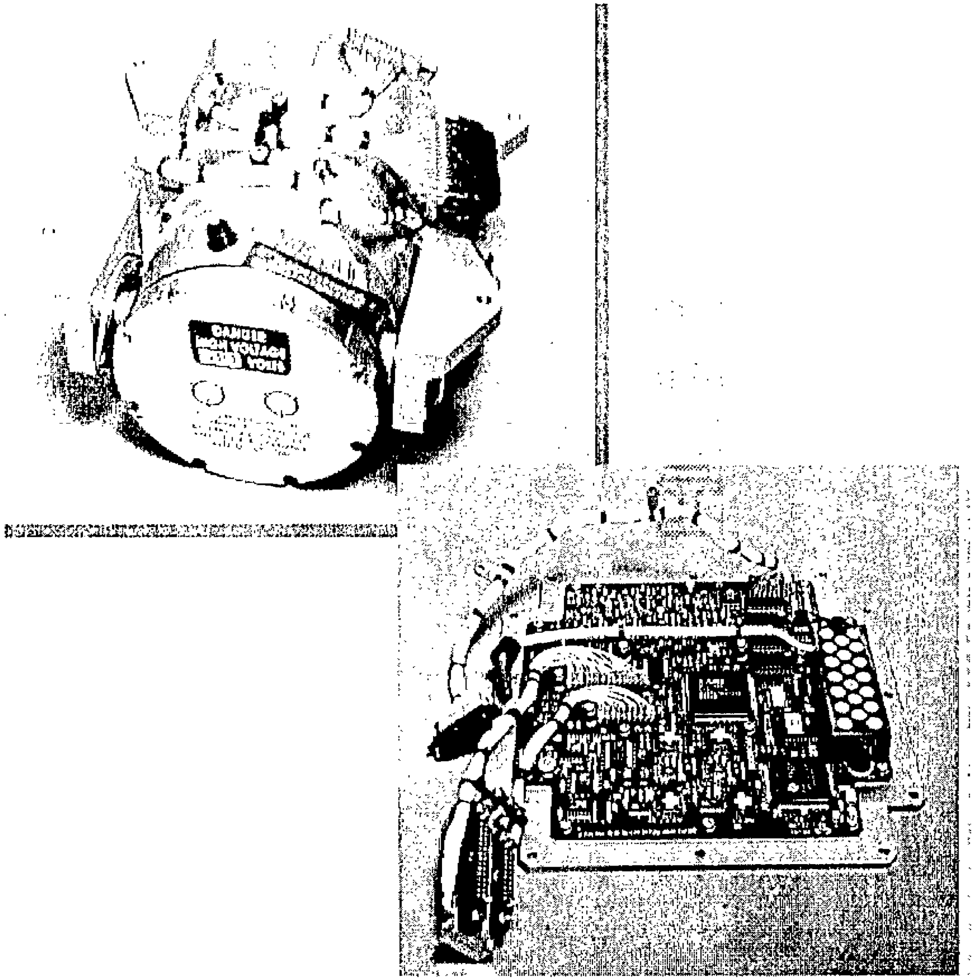
JOINT STAND OFF WEAPON (JSOW)



- CUSTOMER/USER:
  RAYTHEON, USAF, USN
- EQUIPMENT:
  3-AXIS RING LASER GYRO
  BASED INERTIAL
  MEASUREMENT UNIT
- FUNCTIONS PROVIDED:
  HIGH SPEED
  COMPENSATED ANGLE
  AND VELOCITY
  INCREMENT FOR FLIGHT
  CONTROL AND
  NAVIGATION
  COMPENSATED ANGLE
  INCREMENTS, $\Delta\theta$, FOR
  SEEKER STABILIZATION
- PLANNED PRODUCTION
  15,000 UNITS

LOW-COST TACTICAL IMU



- CUSTOMER
  - RAYTHEON
- EQUIPMENT
  - 3-AXIS RING LASER GYRO (RLG) INERTIAL MEASUREMENT UNIT
  - KEARFOTT MOD VIIA ACCELEROMETERS
- FUNCTIONS PROVIDED
  - $\Delta\theta, \Delta V$
  - FLIGHT CONTROL DATA RATES
  - NAVIGATION DATA RATES
- 20,000 UNITS ANTICIPATED

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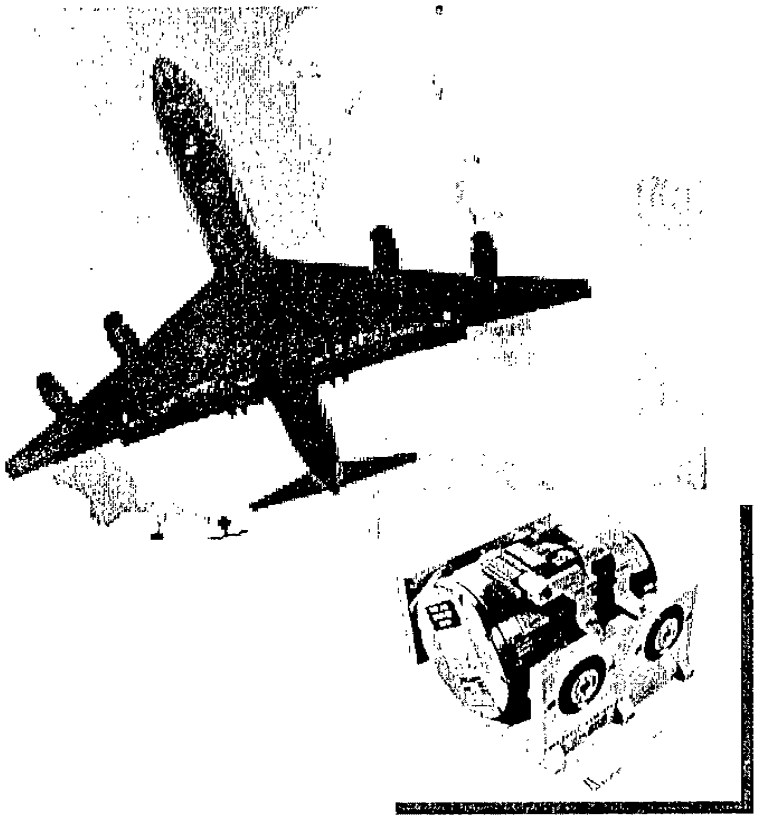
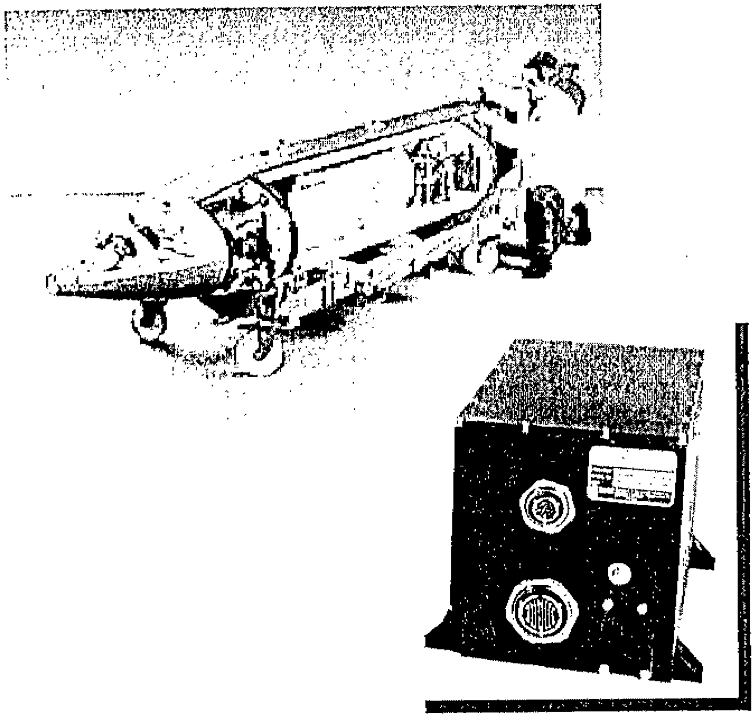
AIRBORNE TRACKING LASER



- CUSTOMER/USER:
  - LOCKHEED MARTIN
- EQUIPMENT:
  - KI-4901 - T24 IMU
- FUNCTIONS PROVIDED:
  - INCREMENTAL THREE-AXIS ANGULAR RATE $\Delta 0$
  - INCREMENTAL THREE-AXIS VELOCITY ΔV
- PRODUCTION:
  - 12 UNITS

SYNTHETIC APERTURE RADAR IMAGING



- CUSTOMER/USER:
  - ELTA ELECTRONICS INDUSTRIES
- EQUIPMENT:
  - KN-4072
- FUNCTIONS PROVIDED:
  - POSITION, VELOCITY, ATTITUDE INCREMENTAL ATTITUDE AND VELOCITY
  - BLENDED NAVIGATION WITH GPS
  - POSITION AND VELOCITY CORRECTIONS
- PRODUCTION:
  - 100 SYSTEMS

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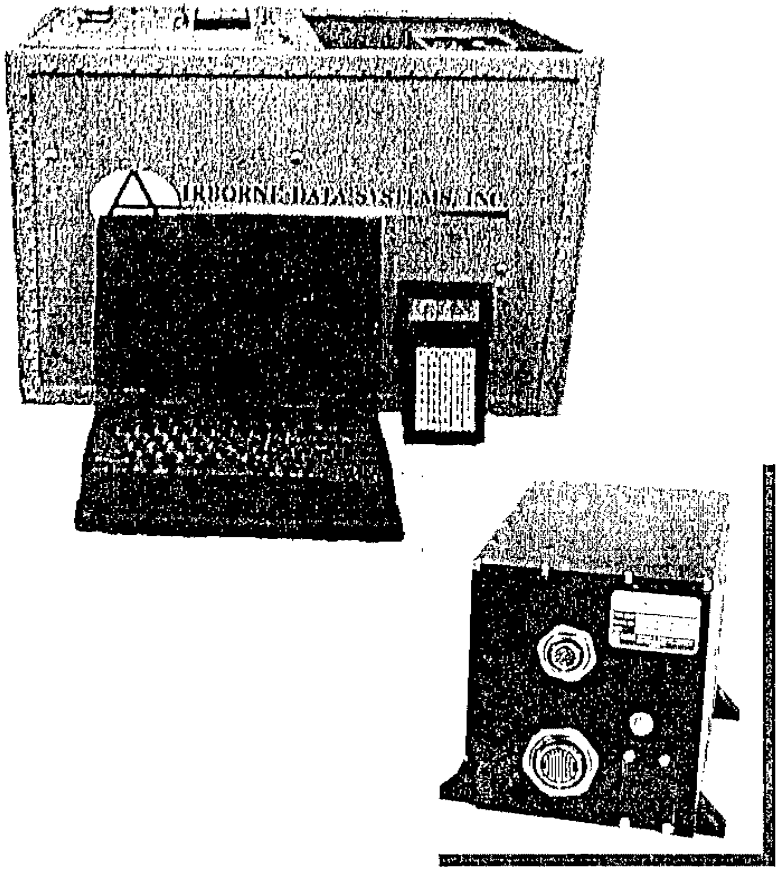
MULTISPECTRAL IMAGING SYSTEM



- CUSTOMER/USER:
  - AIRBORNE DATA SYSTEMS
- EQUIPMENT:
  - KN-4072
- FUNCTIONS PROVIDED:
  - POSITION, VELOCITY
  - ATTITUDE, ATTITUDE RATE
  - BLENDED NAVIGATION AND STABILIZATION DATA WITH GPS
- PRODUCTION QUANTITY:
  - 12 PER YEAR

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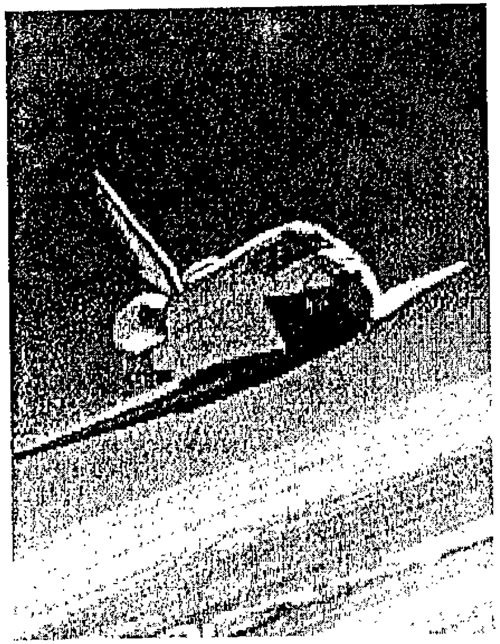
SPACE PRODUCTS



- PRECISION INERTIAL POINTING SYSTEM FOR SATELLITES
- DYNAMICALLY TUNED GYROSCOPE ATTITUDE REFERENCE SYSTEMS FOR SATELLITES AND INTERPLANETARY EXPLORATION VEHICLES
- HIGH ACCURACY INERTIAL NAVIGATION SYSTEMS (HAINS) FOR SPACE SHUTTLE GUIDANCE AND CONTROL
- THREE-AXIS ACCELEROMETER ASSEMBLIES FOR SATELLITES
- STAR TRACKERS FOR SATELLITES
- POSITION SENSORS, MOTORS AND ACTUATORS

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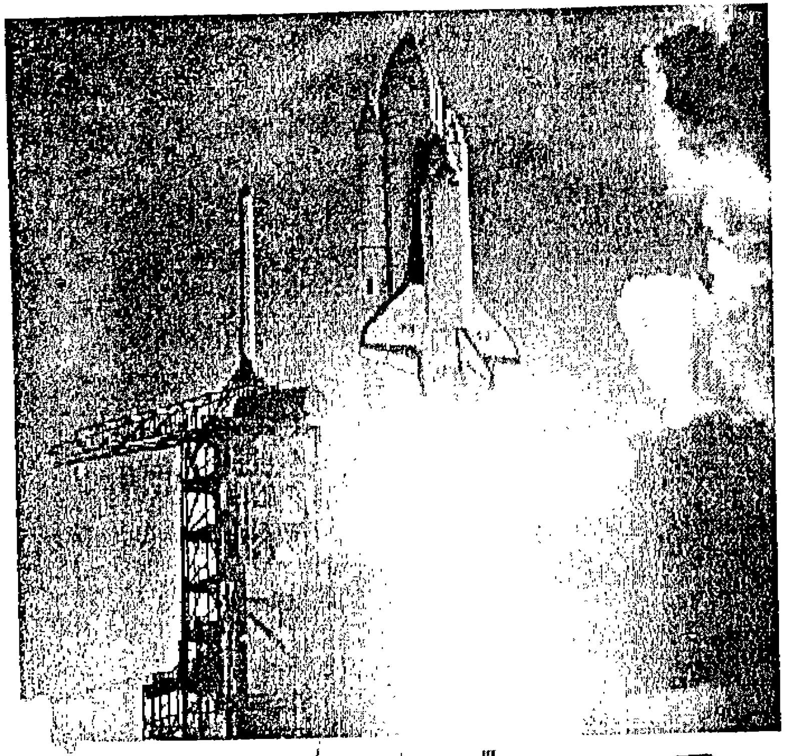
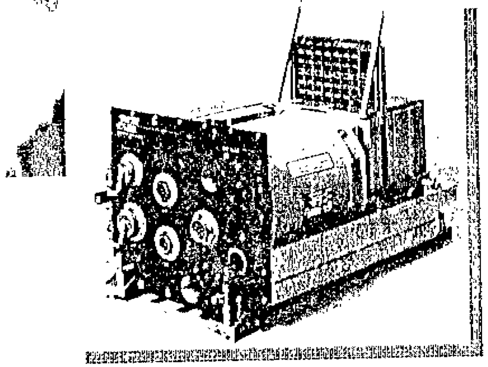
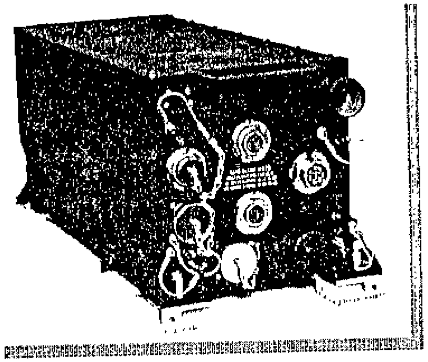
SPACE SHUTTLE PROGRAM

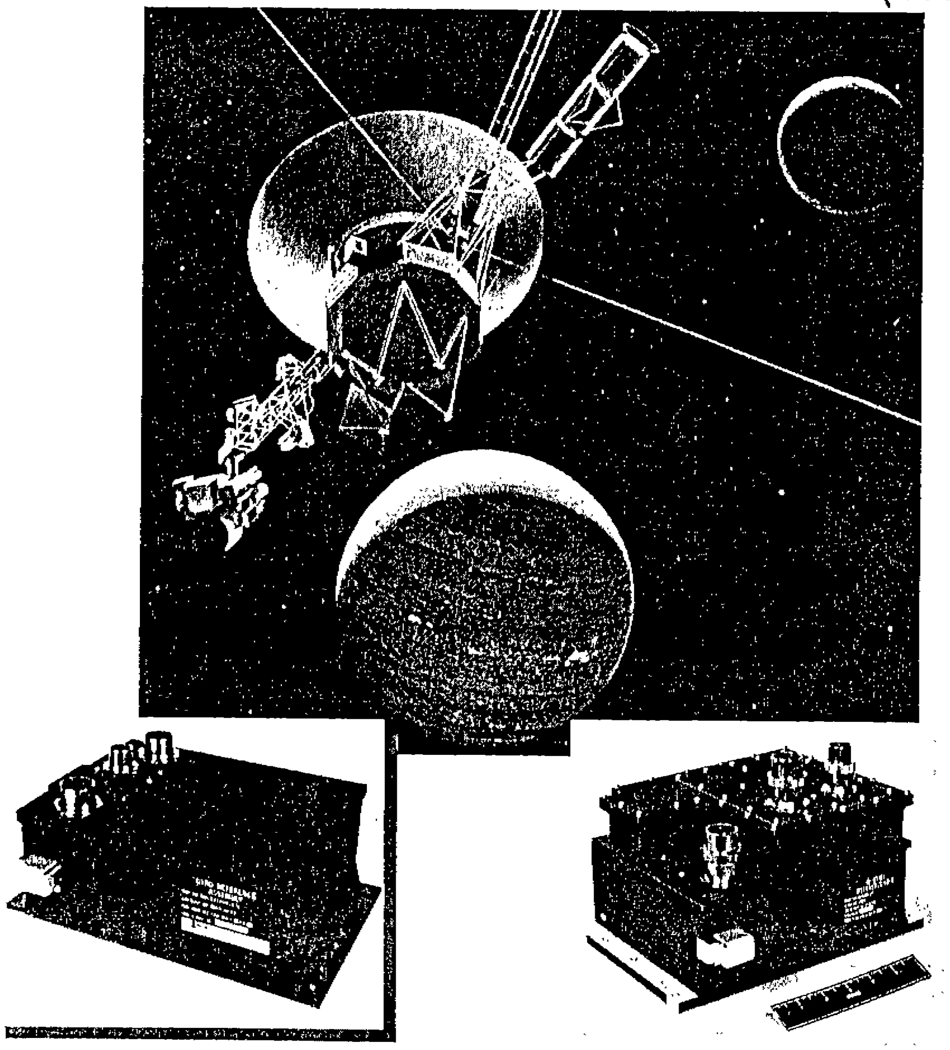


- CUSTOMER/USER:
  ROCKWELL INTERNATIONAL/NASA
- EQUIPMENT:
  KT-70 INERTIAL MEASUREMENT UNIT
  HIGH ACCURACY INERTIAL
  NAVIGATION SYSTEM
  (REPLACING KT-70)
- FUNCTION PROVIDED:
  ACCURATE VELOCITY AND ATTITUDE
  INFORMATION FOR USE IN THE
  ORBITER GUIDANCE, NAVIGATION AND
  CONTROL SYSTEM



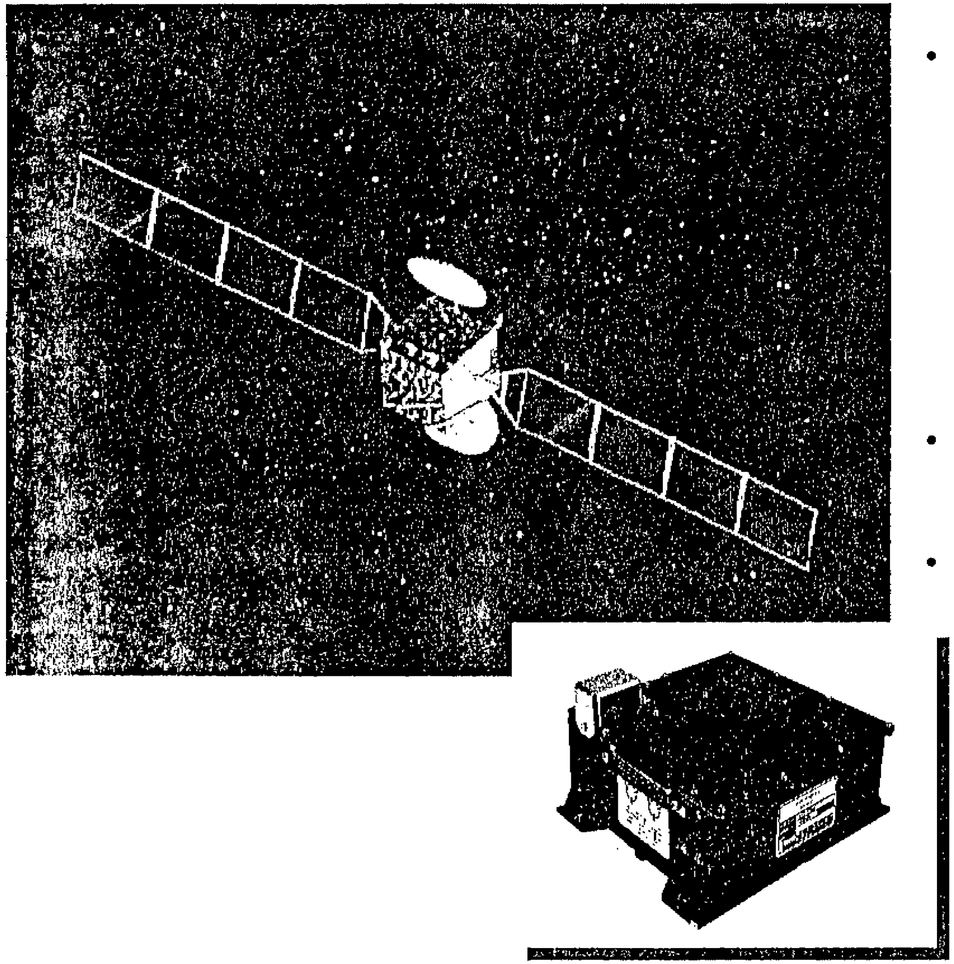


SPACE-QUALIFIED KEARFOTT INERTIAL REFERENCE UNIT (SKIRU)



- CUSTOMER/USER:
  NASA/GSFC, JPL, LM-D, LM-VF, LM-NJ, TRW
- APPLICATIONS:
  PRECISION POINTING AND NAVIGATION: VOYAGER 1 & 2, MAGELLAN, GALILEO, MILSTAR, DCSC III-IABS, MACS 4, MACS 5, GRAVITY PROBE B, SENSITIVE, TDRS7, TRMM, XTE, EOS AM-1, ZODIAQUE, AXAF-1
- FUNCTIONS PROVIDED:
  PRECISION RATE AND POSITION FOR ATTITUDE CONTROL SYSTEM
  TELEMETRY OF CRITICAL PARAMETERS

KEARFOTT LOW-COST SPACE-QUALIFIED SYSTEMS CHOSEN FOR COMMERCIAL SPACE APPLICATIONS



- CUSTOMER/USER:
  - NASA/GODDARD - MAP
  - TRW - NASA: TOMS-EP, SSTI/LEWIS
  - SPECTRUM/USAF: MSTI 2, MSTI 3
  - TRW - REPUBLIC OF CHINA - ROCSAT-1
  - HUGHES SPACE AND COMMUNICATIONS GROUP
  - TRW - GOVERNMENT OF KOREA - KOMPSAT
- EQUIPMENT:
  - DYNAMICALLY TUNED GYROSCOPE, TWO-AXIS RATE ASSEMBLY (TARA)
- FUNCTIONS PROVIDED:
  - RATE AND POSITION INPUTS TO THE ATTITUDE CONTROL SYSTEM

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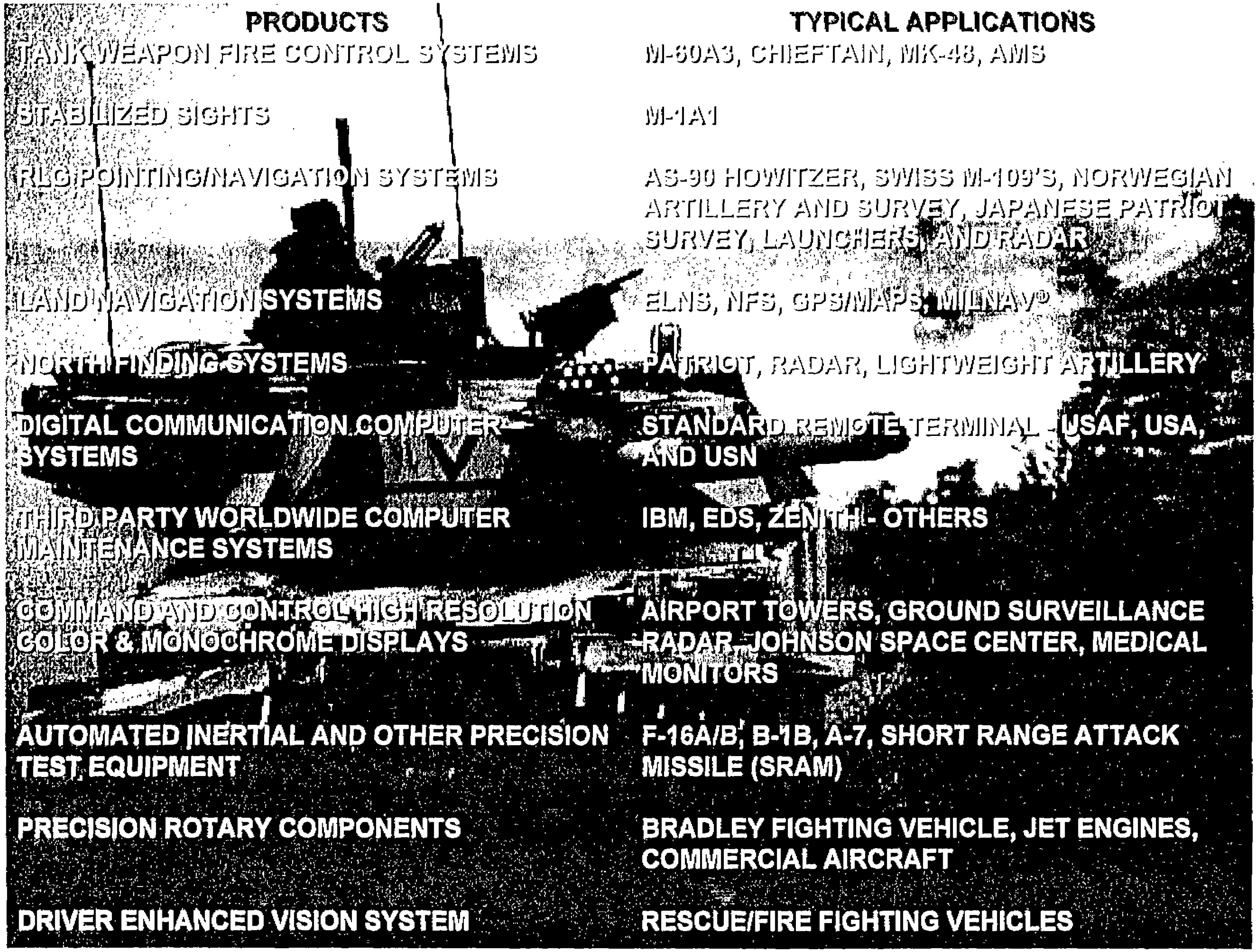
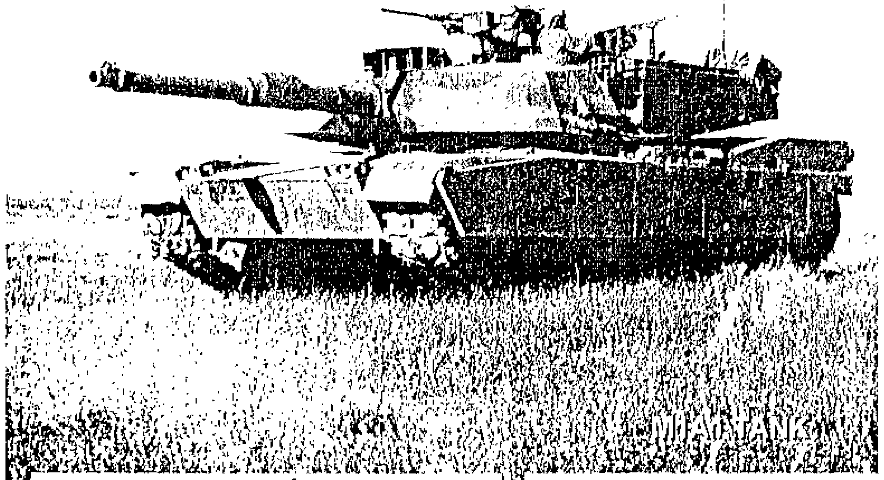
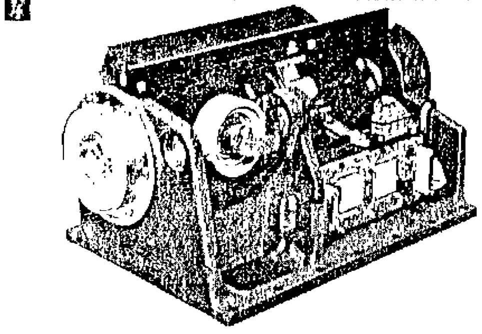
LAND PRODUCTS

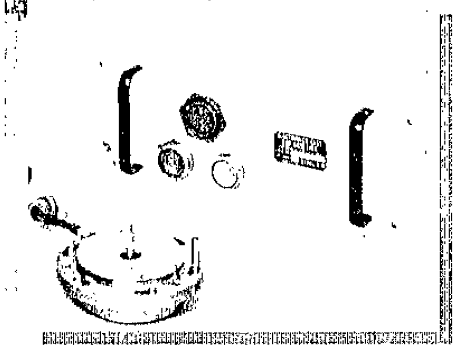


PRODUCTS	TYPICAL APPLICATIONS
TANK WEAPON FIRE CONTROL SYSTEMS	M-60A3, CHIEFTAIN, MK-48, AMS
STABILIZED SIGHTS	M-1A1
RLG POINTING/NAVIGATION SYSTEMS	AS-90 HOWITZER, SWISS M-109'S, NORWEGIAN ARTILLERY AND SURVEY, JAPANESE PATRIOT SURVEY, LAUNCHERS, AND RADAR
LAND NAVIGATION SYSTEMS	ELNS, NFS, GPS/MAPS, MILNAV®
NORTH FINDING SYSTEMS	PATRIOT, RADAR, LIGHTWEIGHT ARTILLERY
DIGITAL COMMUNICATION COMPUTER SYSTEMS	STANDARD REMOTE TERMINAL - USAF, USA, AND USN
THIRD PARTY WORLDWIDE COMPUTER MAINTENANCE SYSTEMS	IBM, EDS, ZENITH - OTHERS
COMMAND AND CONTROL HIGH RESOLUTION COLOR & MONOCHROME DISPLAYS	AIRPORT TOWERS, GROUND SURVEILLANCE RADAR, JOHNSON SPACE CENTER, MEDICAL MONITORS
AUTOMATED INERTIAL AND OTHER PRECISION TEST EQUIPMENT	F-16A/B, B-1B, A-7, SHORT RANGE ATTACK MISSILE (SRAM)
PRECISION ROTARY COMPONENTS	BRADLEY FIGHTING VEHICLE, JET ENGINES, COMMERCIAL AIRCRAFT
DRIVER ENHANCED VISION SYSTEM	RESCUE/FIRE FIGHTING VEHICLES

KEARFOTT PROVIDES EQUIPMENT FOR TANK FIRE CONTROL SYSTEMS

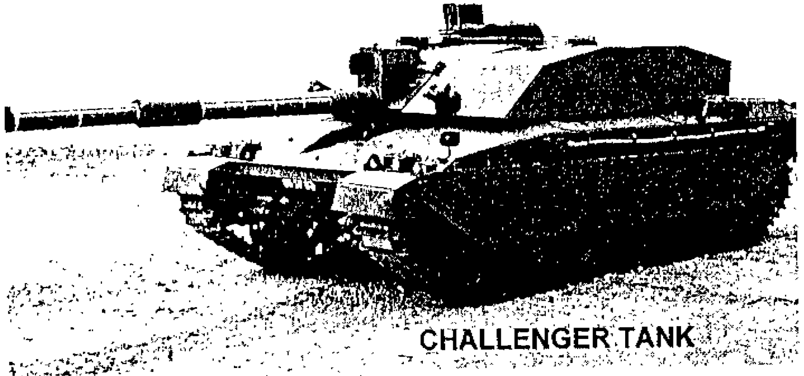




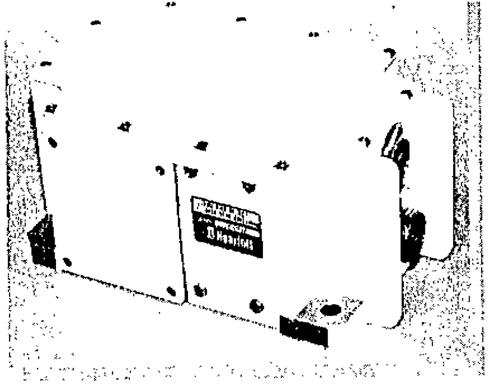


- CUSTOMER/USER:
  - GENERAL DYNAMICS/U.S. ARMY
  - GENERAL DYNAMICS/U.S. MARINE CORPS
- EQUIPMENT:
  - LINE-OF-SIGHT DATA SUBSYSTEMS
    - » SERVO TORQUE DRIVE ASSEMBLY - SINGLE AND DUAL AXIS
    - » ELECTRONIC ASSEMBLY - ANALOG/DIGITAL (VME BUS)
    - » GUN TRUNNION RESOLVER
- FUNCTION PROVIDED:
  - KEY ELEMENT IN FIRE CONTROL SYSTEM WHICH ENABLES THE TANK TO FIRE ON THE MOVE

CHALLENGER TANK PROGRAM



CHALLENGER TANK



- CUSTOMER/USER:
  - MARCONI RADAR AND CONTROL SYSTEMS, LTD.
- EQUIPMENT:
  - TWO-AXIS DYNAMICALLY TUNED CONEX MOD O GYRO PACKAGE WITH CAPTURE AND SIGNAL PROCESSING ELECTRONICS
- FUNCTION PROVIDED:
  - ANGULAR RATE DATA FOR TANK GUN CONTROL AND TURRET STABILIZATION

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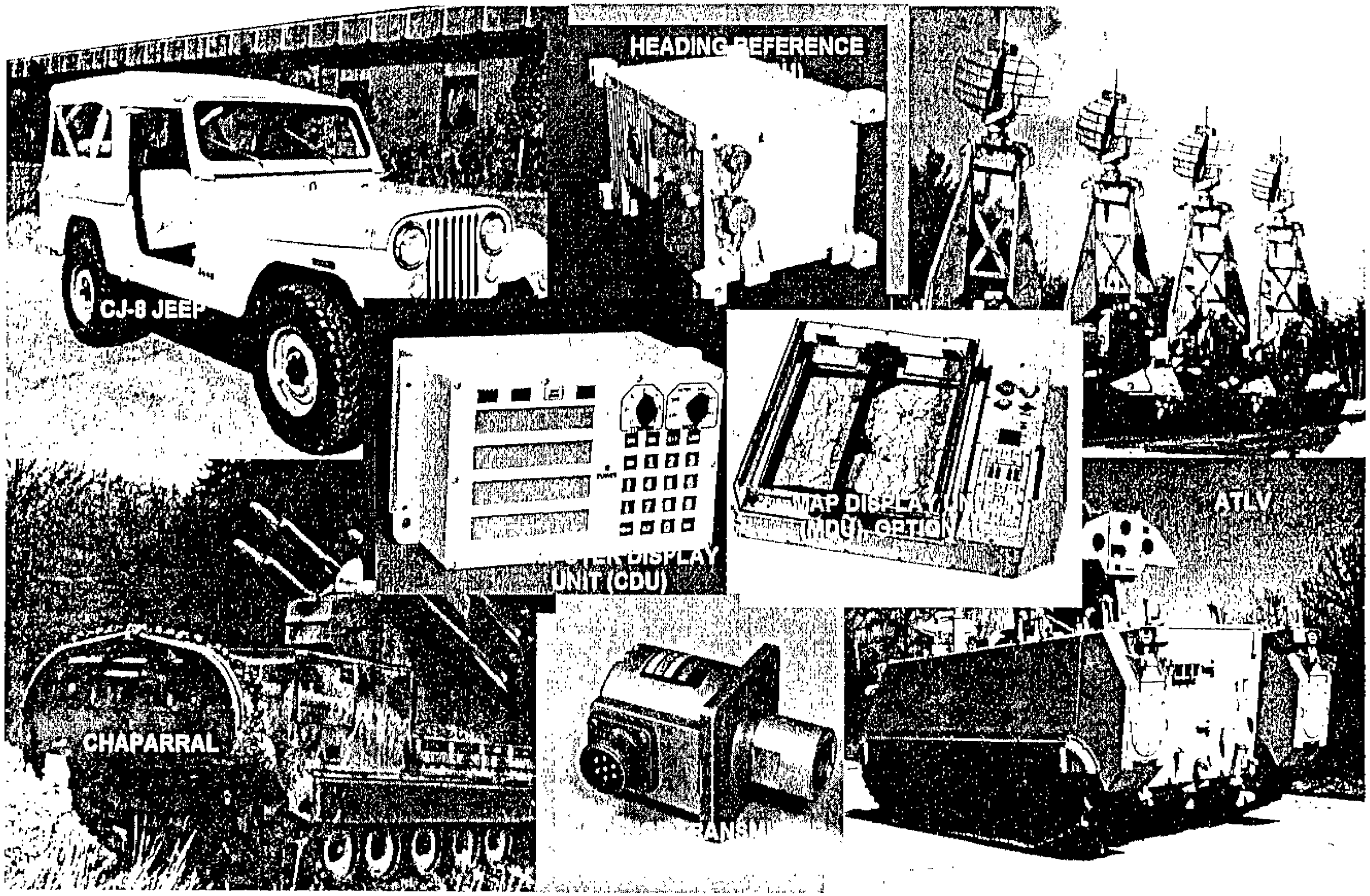
LAND NAVIGATION SYSTEM (LNS)
VEHICLE INSTALLATIONS



Kearfott

MODULAR AZIMUTH POSITION SYSTEM (MAPS)

- CUSTOMERS:
  - U.S. ARMY AMCCOM
  - VSEL/UK
  - SWITZERLAND
  - JAPAN
  - NORWAY
  - AUSTRIA
- EQUIPMENT:
  - RING LASER GYRO DYNAMIC REFERENCE UNIT (DRU)
  - CONTROL DISPLAY UNIT (CDU)
    - — COMMANDER
    - — GUNNER
    - — DRIVER
  - VEHICLE MOTION SENSOR (VMS)
- FUNCTIONS PROVIDED:
  - PRECISION GUN LAYING INFORMATION (HEADING/ALTITUDE)
  - VEHICLE POSITION DATA (VELOCITY, ALTITUDE, ATTITUDE RATES)
  - UPDATING VIA GPS, ODOMETER, OR ZERO VELOCITY UPDATES
  - MOVING BASE ALIGNMENT
  - SURVEY
  - ANTENNA POINTING

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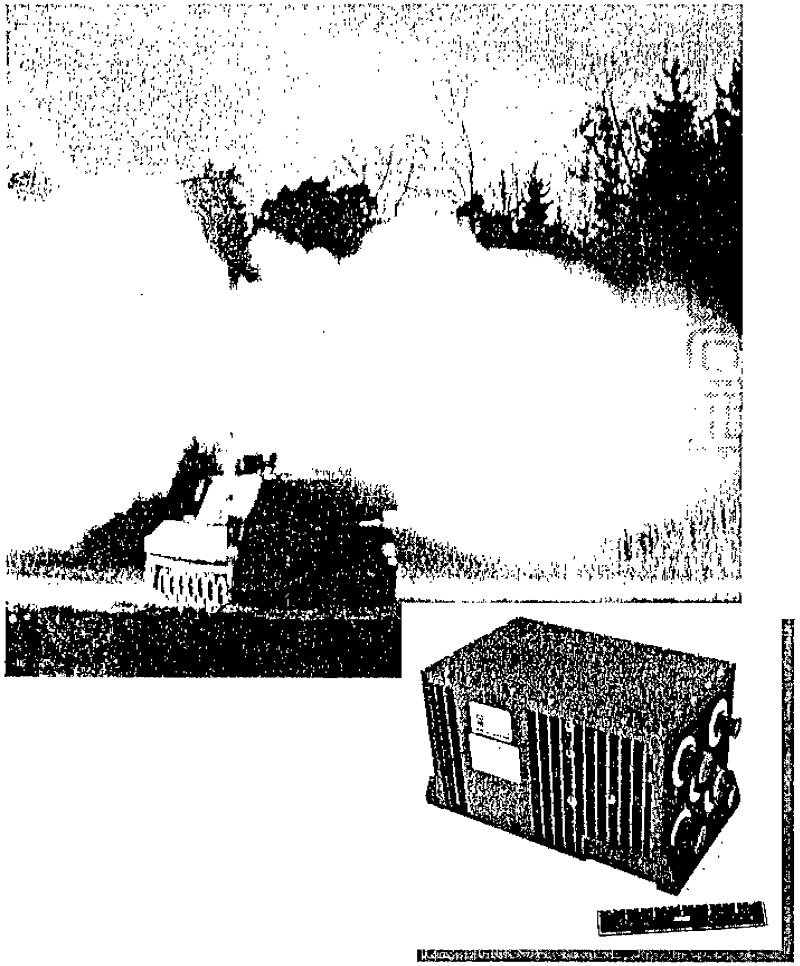
M109 UPGRADE



- CUSTOMER/USER:
  - SWITZERLAND ARMY
- EQUIPMENT:
  - KN-4053 MILNAV®
  - DISPLAY
    - COMMANDER
    - GUNNER
    - DRIVER
  - VELOCITY MOTION SENSOR
- FUNCTIONS PROVIDED:
  - POSITION, VELOCITY, HEADING ATTITUDE AND GUN POSITION
- PRODUCTION QUANTITY:
  - 200 TO 400 UNITS

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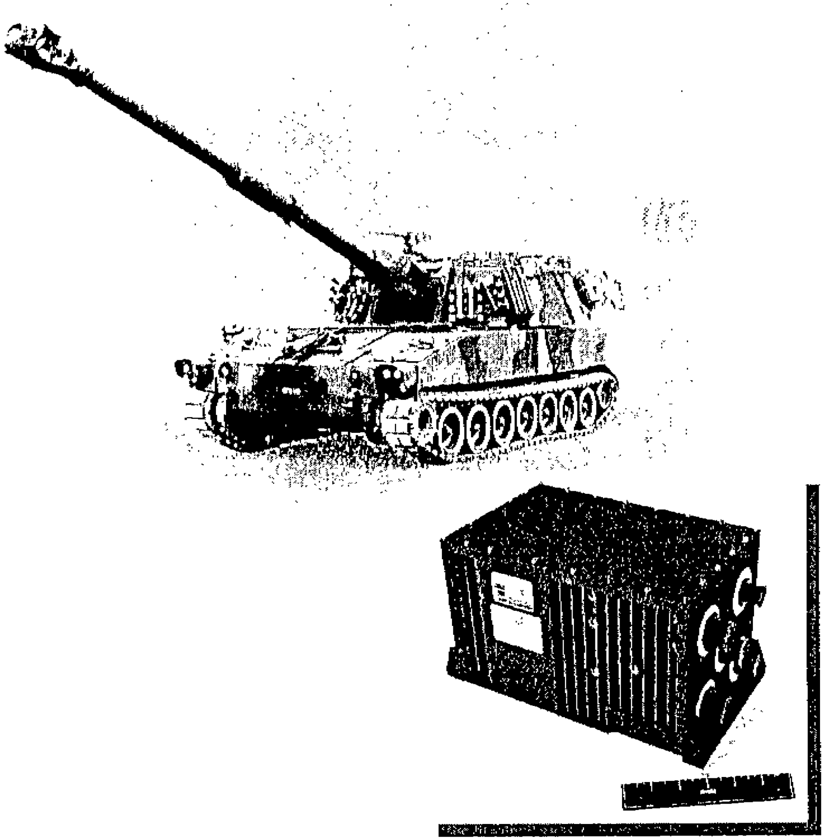
NEW HOWITZER



- CUSTOMER/USER:
  - SINGAPORE ARMY
- EQUIPMENT:
  - KN-4053 MILNAV®
  - VMS
- FUNCTIONS PROVIDED:
  - POSITION, VELOCITY, ATTITUDE, HEADING AND POINTING
- PRODUCTION QUANTITY:
  - 100 TO 150

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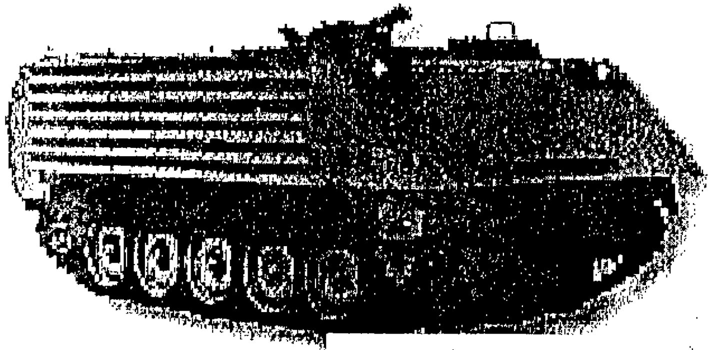
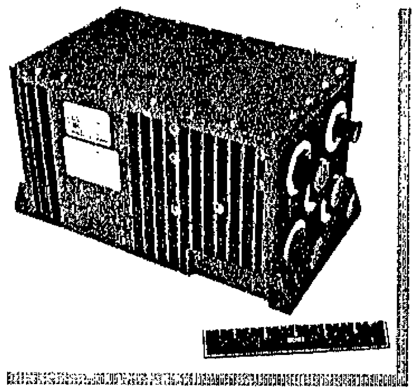
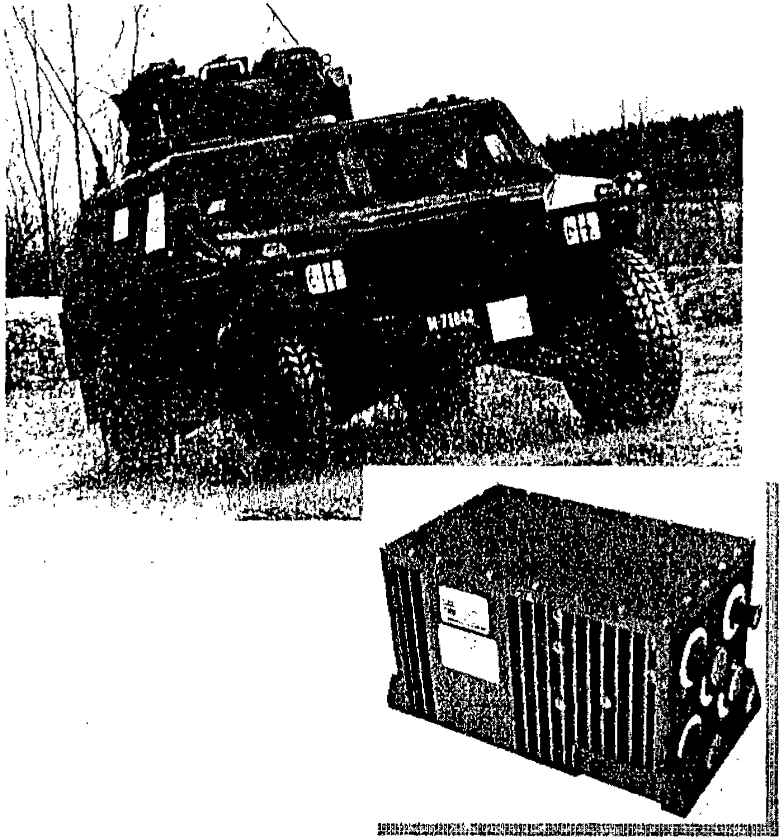
COMMAND AND CONTROL VEHICLE





- CUSTOMER/USER:
  - SINGAPORE ARMY
- EQUIPMENT:
  - KN-4051 MILNAV®
  - VMS
  - GPS
  - DRIVERS DISPLAYS
- FUNCTIONS PROVIDED:
  - POSITION, VELOCITY, HEADING
  - ATTITUDE
  - BLENDED GPS NAVIGATION
  - WAYPOINT NAVIGATION
- QUANTITY:
  - DEVELOPMENT 50
  - PRODUCTION 300

NAVIGATION TARGET ACQUISITION SYSTEM



- CUSTOMER/USER:
  - COMMERCIAL OFF-THE-SHELF (COTS) TRIALED INTERNATIONALLY
- EQUIPMENT:
  - KN-4053 MILNAV®
  - CONTROL DISPLAY UNIT
  - DRIVER DISPLAY
  - VMS
- FUNCTIONS PROVIDED:
  - ON BOARD TARGET LOCATION INTEGRATION WITH DAY NIGHT SIGHT/LRF
  - CONTINUOUS NAVIGATION OF FORWARD OBSERVER VEHICLE FOR RAPID DEPLOYMENT
- PRODUCTION
  - COTS

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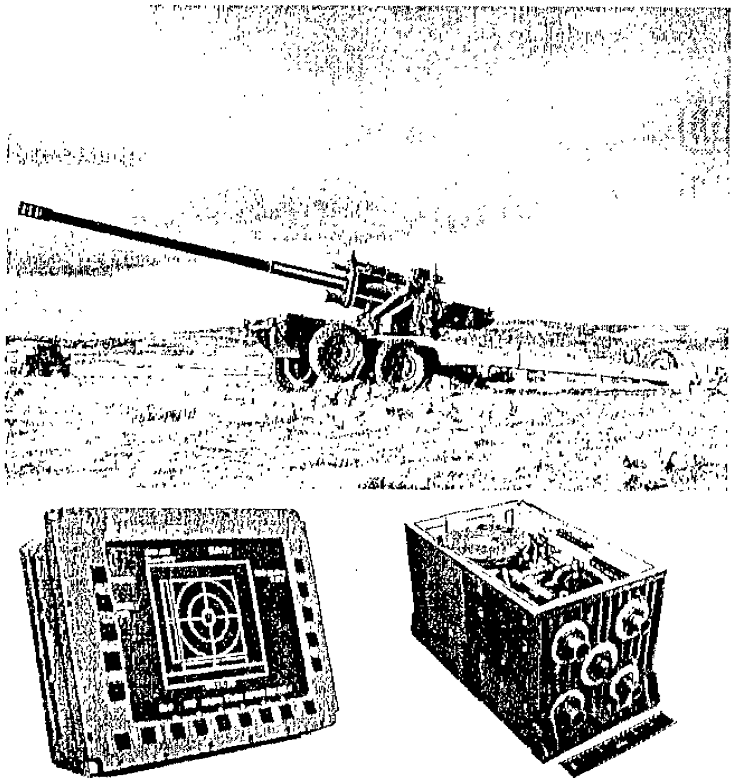
TECHNICAL FIRE CONTROL
MODULAR ARTILLERY FIRE CONTROL SYSTEM
(MAFCS)



CUSTOMER
- SANTA BARBARA

EQUIPMENT
- KN-4053 MILNAV®
- 6 x 8 COLOR DISPLAY
- VELOCITY MOTION SENSOR
- INSTALLATION DESIGN

FUNCTIONS PROVIDED
- ON WEAPON FIRE CONTROL
  - ♦ BALLISTIC SOLUTION
  - ♦ COMPENSATION FOR MUZZLE VELOCITY AND METEOROLOGICAL REFRESH
  - ♦ RADIO INTERFACE FOR FIRE DIRECTION AND SITUATION AWARENESS

PRODUCTION
- 100 - 200 UNITS

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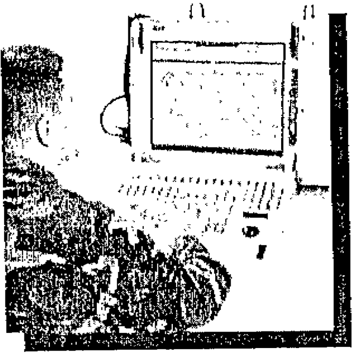
TACTICAL FIRE CONTROL
BATTLEFIELD COMMAND & CONTROL
BCC-2000



- CUSTOMER
  - IN DEVELOPMENT
- EQUIPMENT
  - COMMAND & CONTROL COMPUTERS
  - RADIO
- FUNCTIONS PROVIDED
  - TARGET SELECTION
  - FIRE DIRECTION
  - INTELLIGENCE DISPLAY
    - ♦ SITUATION AWARENESS
    - ♦ TARGET LOCATION
    - ♦ TARGET IDENTIFICATION

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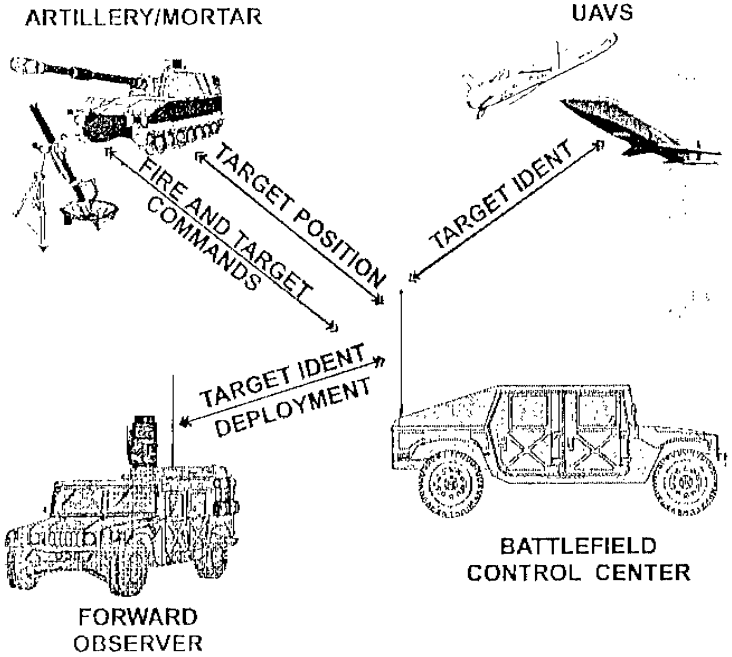
MODULAR BATTLEFIELD FIRE CONTROL SYSTEM
KCS-2000



CUSTOMER
- IN DEVELOPMENT

FUNCTION PROVIDED
- INTEGRATED BATTLEFIELD COMMAND & CONTROL
  - ♦ WEAPON SELECTION
  - ♦ TARGET SELECTION
  - ♦ "FRIENDLY" LOCATION
  - ♦ FIRE DIRECTION
    - ■ WEAPON
    - ■ MUNITIONS
    - ■ TARGET
  - ♦ DEPLOYMENT DIRECTION
    - ■ FORWARD OBSERVER
    - ■ WEAPON

SB212-1
12/09/99

Kearfott

WE HAVE THE UNIVERSE COVERED!

SEA

- STRATEGIC MISSILE GUIDANCE SYSTEM FOR THE USN TRIDENT MISSILE
- INERTIAL REFERENCE SYSTEMS FOR USN MK-48 ADVANCED CAPABILITIES TORPEDO (ADCAP)
- NAVIGATION SYSTEMS FOR 209 CLASS SUBMARINES
- NAVIGATION SYSTEMS FOR 1200 TON CLASS CORVETTES
- POSITION SENSORS, MOTORS, GEARHEADS FOR SHIPS
- ACCURATE MARINE GYROCOMPASS SYSTEM
- POWERFUL MODULAR OPERATOR COMMAND AND CONTROL CONSOLES FOR SHIPS AND SUBMARINES
- STATE-OF-THE-ART, LIGHT WEIGHT, LOW COST, RING LASER GYRO SEANAV FOR PATROL BOATS AND UNMANNED VEHICLES
- ELECTRONIC CHART DISPLAY SYSTEMS
- SEABORNE NAVIGATION SYSTEM (SEANAV)

LAND

- MOBILE HOWITZER POINTING AND NAVIGATION SYSTEMS (MAPS, MILNAV®)
- PRECISION GUN LAYING SYSTEM
- TARGET ACQUISITION SYSTEMS
- LAND NAVIGATION SYSTEMS
- NORTH FINDING SYSTEMS
- TANK RATE GYRO UNITS
- TANK GUNNER STABILIZED SIGHTS
- COLOR LIQUID CRYSTAL TANK DRIVER DISPLAYS
- TANK VIDEO DISPLAY UNITS
- INTEGRATED FIRE CONTROL SYSTEMS FOR TANKS AND ARTILLERY
- INERTIAL SENSORS AND NAVIGATION SYSTEMS FOR SURFACE-TO-SURFACE MISSILES
- POSITION SENSORS, MOTORS, ACTUATORS FOR LAND VEHICLES
- POSITION SENSORS, MOTORS, ELECTRONICS FOR THE MACHINE TOOL INDUSTRY
- INTEGRATED LAND NAVIGATION AND FIRE CONTROL SYSTEMS
- MINIATURE LAND NAVIGATION SYSTEM (MILNAV®)

AIR

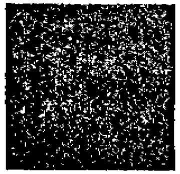
- USAF STANDARD HIGH ACCURACY PRECISION INERTIAL NAVIGATION SYSTEM (SPA)
- IMPROVED USN STANDARD ATTITUDE HEADING REFERENCE SYSTEM ISAHRS WITH GPS CAPABILITY
- DYNAMICALLY TUNED GYROSCOPE INERTIAL NAVIGATION SYSTEM FOR AIRCRAFT
- RING LASER GYROSCOPE STRAPDOWN INERTIAL NAVIGATION SYSTEM FOR AIRCRAFT, ANTENNA POINTING, AND TACTICAL MISSILES
- INTEGRATED INS/GPS SYSTEMS
- AUTOMATIC DEPOT INERTIAL NAVIGATION TEST SYSTEM (ADINTS)
- INERTIAL INSTRUMENTS AND ACTUATORS FOR AIRCRAFT, MISSILES AND REMOTELY PILOTED VEHICLES
- FLIGHT CONTROL ACTUATORS FOR HARPOON ANTISHIP MISSILE
- PRECISION ROTATING COMPONENTS
- LINEAR VARIABLE DIFFERENTIAL TRANSDUCERS FOR COMMERCIAL AIRCRAFT
- FLIGHT DIRECTOR AND AUTOPILOT SYSTEMS
- CARGO LOADING SYSTEM FOR COMMERCIAL AIRCRAFT
- FLIGHT AND NAVIGATION INSTRUMENTS
- CENTRAL DIGITAL AIR DATA COMPUTERS
- COLOR AND MONOCHROME CRT AND LCD AIRCRAFT DISPLAYS
- DISPLAY PROCESSORS

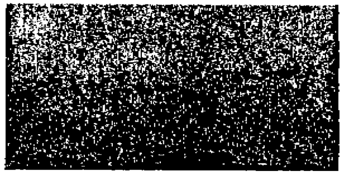
SPACE

- PRECISION INERTIAL POINTING SYSTEM FOR SATELLITES
- DYNAMICALLY TUNED GYROSCOPE ATTITUDE REFERENCE SYSTEMS FOR SATELLITES AND INTERPLANETARY EXPLORATION VEHICLES
- HIGH ACCURACY INERTIAL NAVIGATION SYSTEMS (HAINS) FOR SPACE SHUTTLE GUIDANCE AND CONTROL
- THREE-AXIS ACCELEROMETER ASSEMBLIES FOR SATELLITES
- STAR TRACKERS FOR SATELLITES
- POSITION SENSORS, MOTORS AND ACTUATORS
- TWO-AXIS RATE GYRO PACKAGES FOR COMMERCIAL SATELLITES
- RING LASER GYRO INERTIAL REFERENCE SYSTEMS

BP-150/40.76
5/6/99

Kearfott Guidance & Navigation Corporation
A Subsidiary of Astronautics Corporation of America





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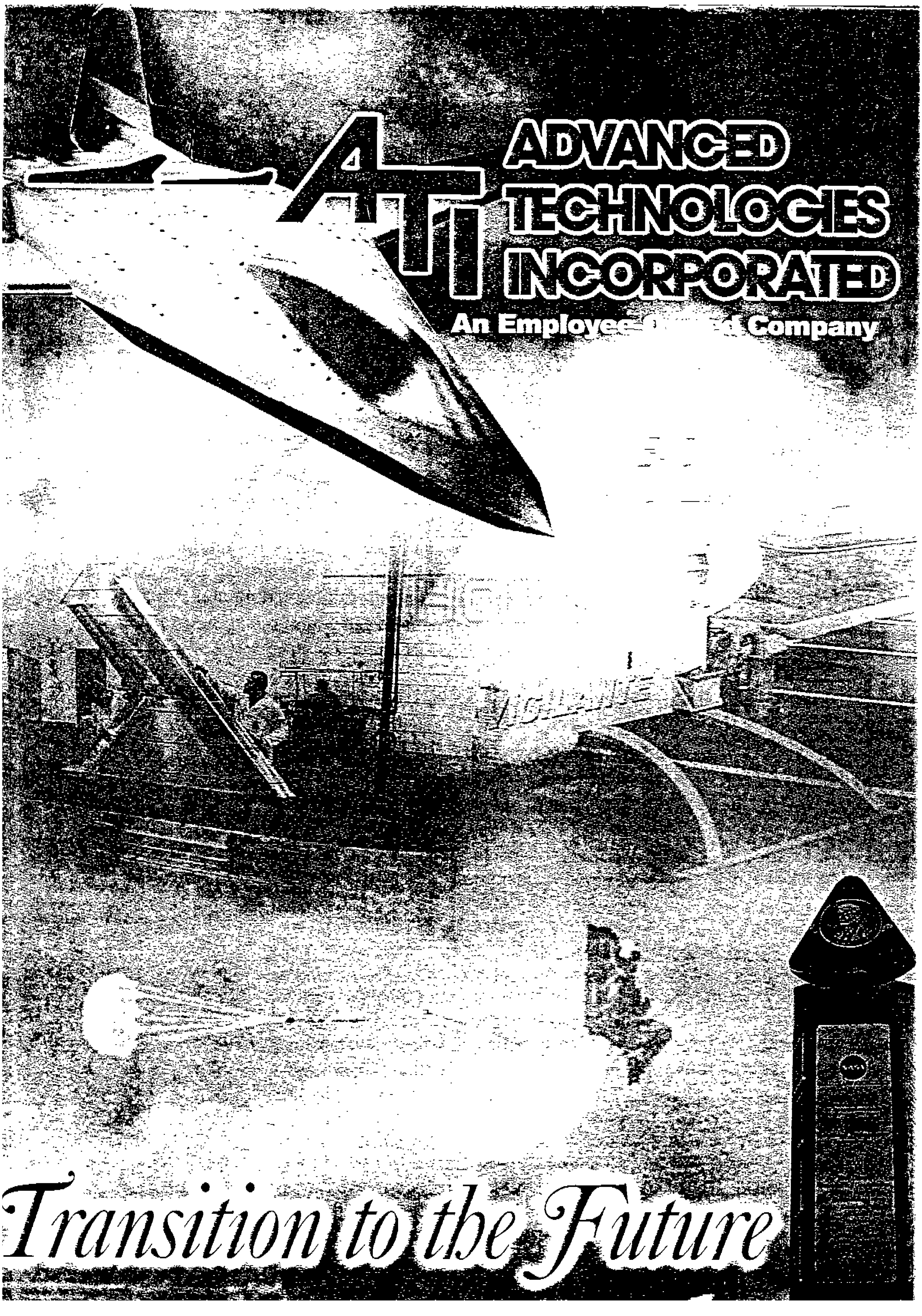

ADVANCED TECHNOLOGIES INCORPORATED

An Employee-Owned Company

Transition to the Future

ADVANCED TECHNOLOGIES INCORPORATED

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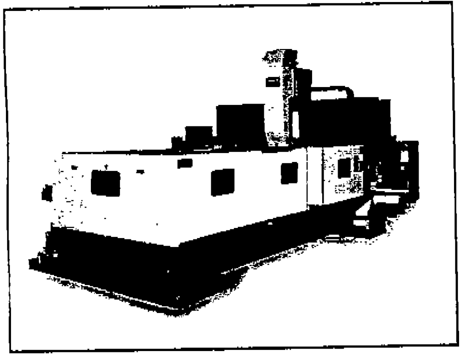
Company Profile

Advanced Technologies Incorporated (ATI), an employee-owned company, began business operations in 1988, establishing itself as a reliable supplier of research and development products, primarily in the United States and international aerospace domain.

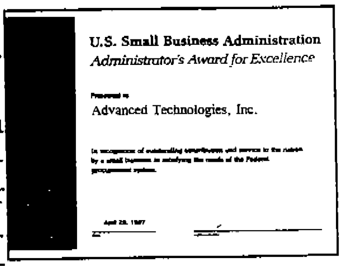
3-D Cad Scree

ATI has the resources needed to analyze, design, manufacture and test your development hardware. Our engineers and technicians as employee-owners are committed to customer satisfaction and product quality. State-of-the-art 3D CAD/CAM software and multi-axis CNC machine centers complement our custom-built 52,000 square foot facility. The facility houses a full precision machine shop, wood and sheet metal shop, high-bay hanger and a composite laminating clean room with low temperature material storage and software controlled curing equipment. Cleared strong rooms with secured computers and communications protect our customer's classified/proprietary data.



Double Column C.N.C.
Vertical Machining Center

Our expertise and quality is recognized



U.S. Small Business Administration
Administrator's Award for Excellence

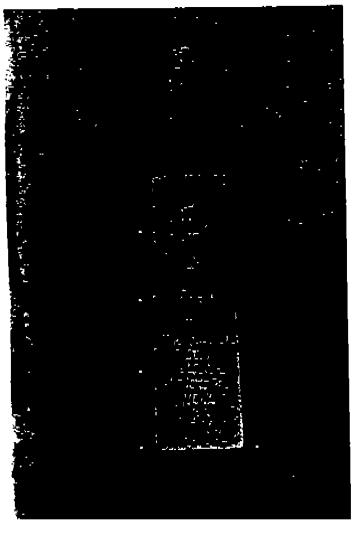
Advanced Technologies, Inc.

U.S. Small Business Administration
"Outstanding Contribution to the Nation"

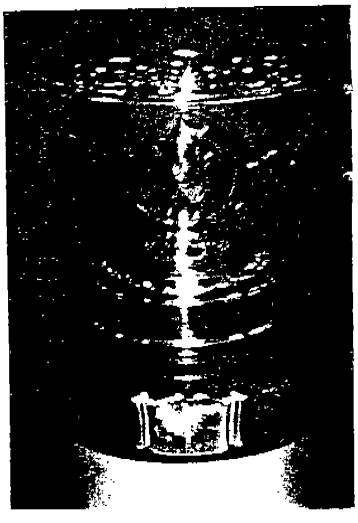
ATI's Quality Program is ISO 9001 compliant, ensuring a total quality management approach to our products and services. Our customer base encompasses all of the principal airframe manufactures and government research centers world-wide. ATI has received several "outstanding supplier" and "awards for excellence" from our customers, and was honored to received NASA's highest award for quality and excellence, the George M Low 2000. This was in recognition for ATI's contribution to the advancement of excellence to the NASA space program.

For more information on Advanced Technologies, Incorporated (ATI), or visit our website.

George M. Low Award
"Contribution to the Advancement of Excellence to the NASA Space Program"



Howard Hughes Awar
"Outstanding improvement i
fundamental helicopter technology



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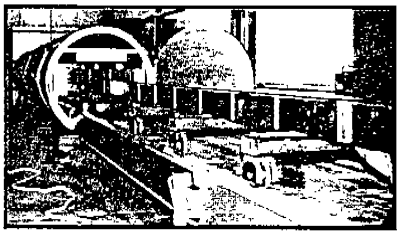
COMPOSITES



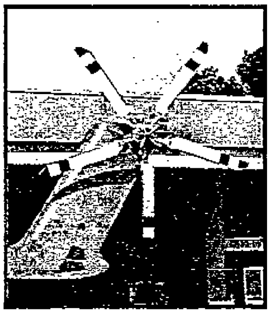
ATI has an extensive background in aerospace composite structures. We have in-house software to analyze structures of hybrid composite materials, both in static and rotating environments. ATI has produced tooling for autoclave, pressure bag and closed die part curing. Components ranging in size from a few square inches and weighing only 150 grams to 60 square feet weighing 1,000 pounds, have been designed, tooled, and fabricated by ATI. Computer controlled presses and ovens and large material freezer storage complement our 10,000 square foot clean room facility, fully conforming to FAA requirements.

• *WIND TUNNEL COMPOSITE COMPRESSOR BLADES*

ATI developed the manufacturing plan, designed and fabricated all tooling, and produced 210 production composite compressor blades for the NASA Ames Research Center's Unitary Wind Tunnel. The all-composite blades replaced existing aluminum blades to provide infinite life and reduce operating maintenance. 18 proof test blades were also fabricated, static and endurance tested.

• *NASA 40 x 80 WIND TUNNEL (NFAC)*

ATI is currently under contract to replace the existing fan drive blades in the NASA Ames 40 x 80 x 120 National Full Scale Aerodynamic Center (NFAC) wind tunnel. The 90 existing wooden blades will be replaced with all-composite blades offering longer life under higher operating conditions. ATI has designed and analyzed the composite/foam blade structure and is currently building the tooling string and 5 test articles which will undergo quality, structural and fatigue testing prior to product manufacture. Each blade assembly will consume over 600 pounds of composite material to produce the 50 square foot surface.



• *S-61 COMPOSITE ROTOR BLADES*

Full-scale main rotor and tail rotor blades were designed, analyzed, fabricated, and tested to meet FAA certification requirements. The all-composite rotor blades incorporate advanced airfoil technology, twist and swept tips for improved lift performance and infinite life cycle. ATI designed and fabricated the tooling string, developed the manufacturing plan, and quality control plan for FAA conformance.

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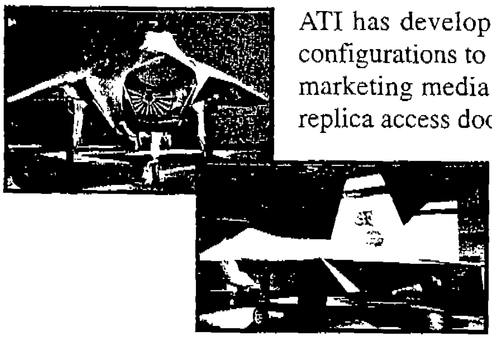
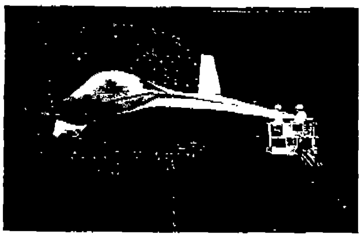
FULL SCALE MODELS

• *MOCKUPS AND TRAINING SYSTEMS*

ATI has developed several full-scale mockups of advanced aircraft and helicopter configurations to validate engineering and supportability analysis, and to support major marketing media presentations. Engineering and supportability mockups can include replica access doors and internal equipment such as drive/propulsion systems, weapons bays and cockpit layout and equipment. Marketing mockups produced by ATI have included complete passenger configurations with all support services to static display models. Cockpit simulators and escape system sled test equipment along with repair and maintenance training stations have been produced. ATI has produced the following full scale vehicles: the F-22, Comanche RAH-66 Helicopter, Sikorsky S-92 and S-92M Helicopters, the JSF One-Team Display Model, Korean Air Multipurpose Helicopter, and several F/A-18E/F training stations.

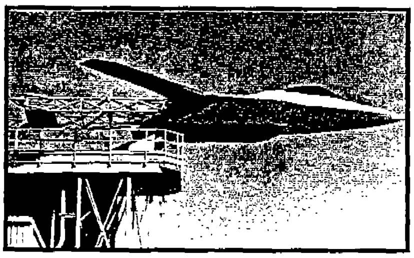


• *RADAR CROSS SECTION & ANTENNA MODELS*



ATI produces full-scale model test articles with replicated external surfaces for radar cross section and antenna placement testing. State-of-the-art composite materials and core are formed and cured in soft tooling to produce the skin sections. These are mounted onto light aluminum truss frames to produce the final external configuration. Laser placement and inspections ensure that the final product meets the customer's specifications of both quality and dimensional accuracy. For aluminum skinned aircraft, the truss frame contains accurate stationed bulkheads and longerons similar to the production airframe. Sheet aluminum is roll formed, trimmed, and attached to produce the external configuration.

ATI has produced the following test articles: the Joint Strike Fighter (JSF), the Comanche helicopter airframe and rotor components, and several generic test shapes for radar cross section models, the F-22 and F/A-18EF.



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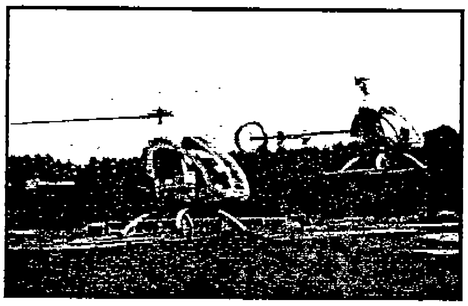
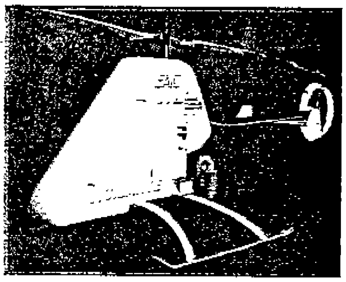
RAPID PROTOTYPING

ATI routinely executes extremely aggressive build schedules for various prototypes of aerospace products. These are used as first test articles, tooling and process proof of part and/or proof of totally new concept. ATI supports the customer's products from conceptual design through tooling and manufacture to testing and data analysis. We have always met our customer's schedule and technical requirements within the funding allowed. ATI is sensitive to the customer's requirements and proprietary data and will always deliver a quality product on schedule.

• *FLIGHT VEHICLES*

ATI developed from concept to production, a one- and two-man rated lightweight experimental helicopter including the developmnt of the power train, rotor hub and controls, fuselage structure, and composite rotor blades and tooling. ATI provided the preliminary design and wind tunnel testing, the dynamic and steady analysis, proof loading, crash-worthy structural integrity analysis and all flight testing of the prototype vehicles. Direct liaison with FAA staff insured compliant and safe flight oprations. To date, over 100 rotorcraft are flying with several thousand flight hours accumulated. In recognition of this program, the American Helicopter Society awarded ATI the "Howard Hughes Award."

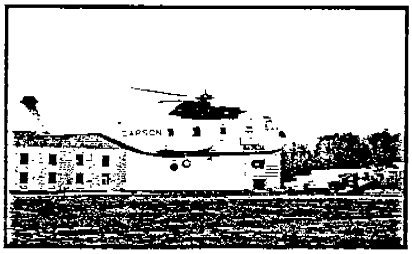




ATI has developed the Vigilante unmanned helicopter based on a version of our lightweight helicopter. The Vigilante can carry a 300-pound payload for 3 hours, takeoff and land with the push of a button, navigate by pointing and clicking on a digital map, fly by vector commands from a joystick, and auto-rotate to the ground with a 4:1 glide ratio. Customized fuselages accommodate payloads ranging from gimbaled FLIR turrets, to radars, to communications relay antennas. A turbo-charged 4-stroke engine provides consistent power under hot and high conditions. Customers include NASA, the US Navy, and the US Air Force.

• *Rotor BLADES*

ATI has provided design, analysis, tooling, fabrication, and FAA STC certification of composite main and tail rotor blades for the Sikorsky S-61 helicopter. The blades incorporate advanced cambered airfoils and swept tip geometry. All structural (steady and dynamic) fatigue testing and manufacturing processes have been conducted by ATI's staff. Flight test results show an 11% increase in hover performance with lower vibratory loading than the originally supplied rotor system.



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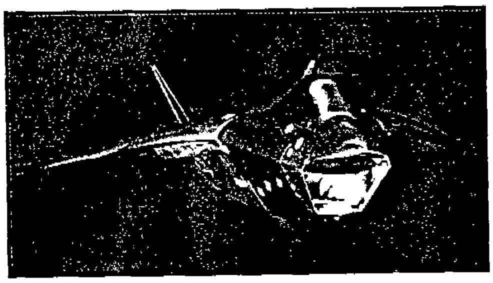
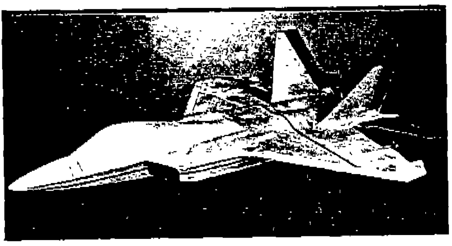
WIND TUNNEL MODELS

• PRECISION FORCE & MOMENT MODELS



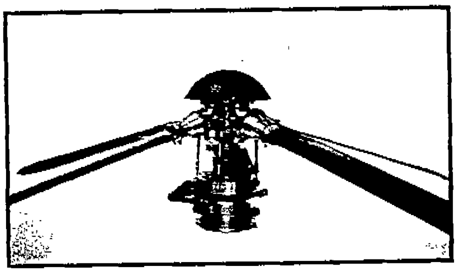
Our projects have included simple, straight-forward low speed lift and drag models, and close tolerance, precision metal high-speed performance models. Models are instrumented with static and dynamic pressure taps, thermocouples, and strain-gaged hinge moment balances. Jet effects propulsion models, hot and cold flow propulsion exhaust models, precision 2-D airfoil models, hypersonic models and models for cryogenic testing conditions have been designed, analyzed and fabricated.

• DYNAMIC SCALED MODELS



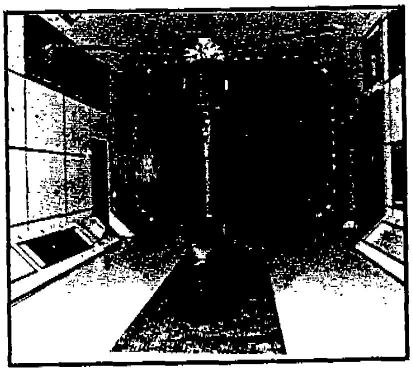
Most all mass / inertia scaled models have similar construction techniques. An extremely durable but light composite wing and fuselage skins are formed and cured in female tooling, these are assembled over composite bulkheads and stringers to form a monocoque structure. Remote control actuators and linkage to activate control surfaces are installed, and the required target mass, roll, pitch and yaw inertias matched by adding discreet weights internal to the structure. Low and high speed dynamic models (mass and stiffness scaled) have similar construction methods, the exception being the skins are tailored in thickness to meet the required stiffness (EI, GJ) and frequency. ATI has designed and built the following dynamic models: F-22 Spin Model, P7-low Speed Flutter Model, F-22 Drop Model, JSF High Speed Tail Flutter Model, JSF Spin Model, S-92 Helicopter Ditching Model and a NASA Free Flight Model.

• ROTOR BLADES

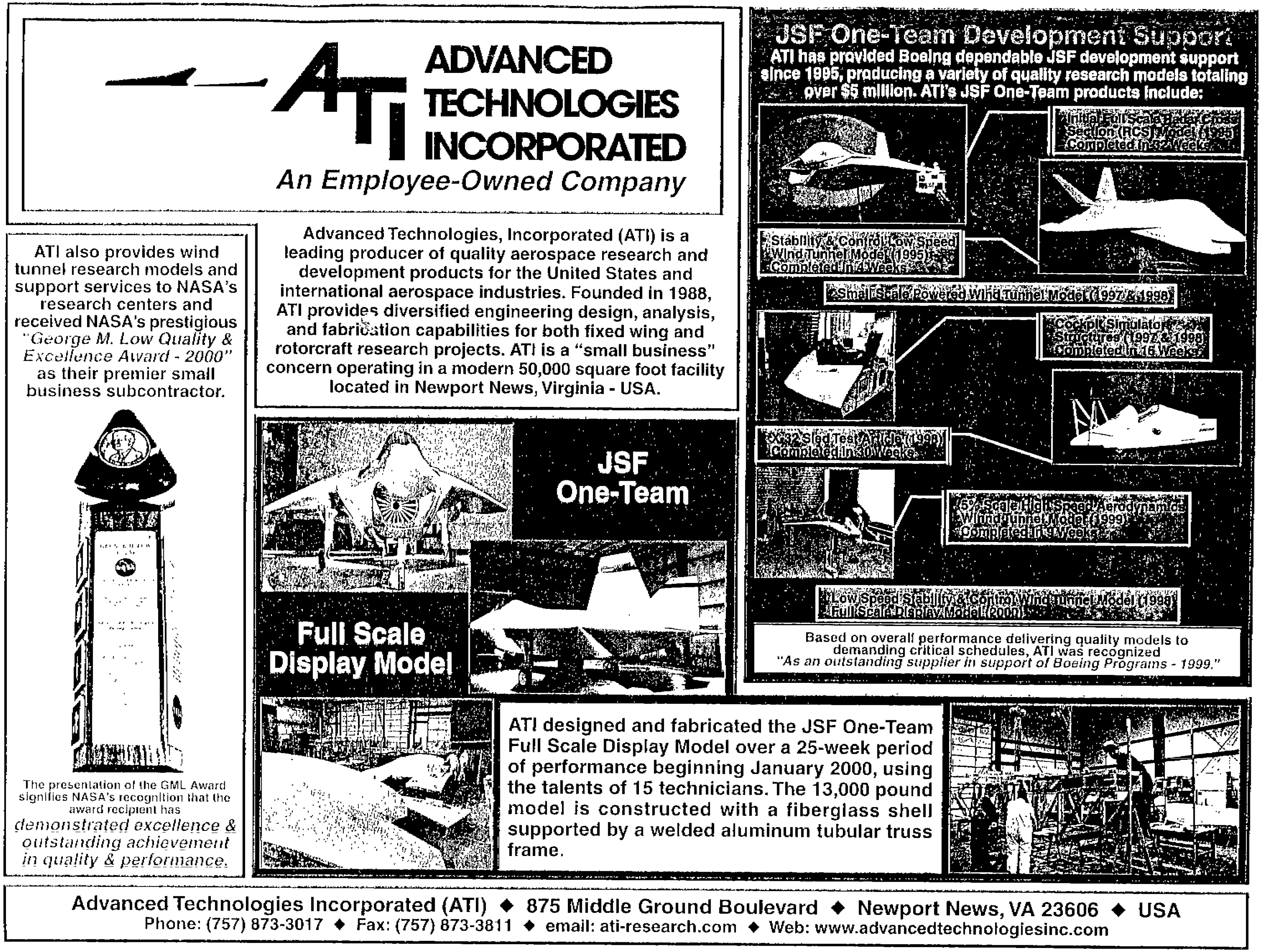


ATI is a leader in producing all-composite rotor blades for sub-scale performance or dynamic wind tunnel testing. ATI uses in-house developed software to predict rotating frequency placement of the blades and retention hardware and performs internal installation of strain gage and pressure instrumentation. ATI is currently working on low noice planform and smart material blade structures.

• FACILITY & TESTING EQUIPMENT



Rotor test stands, force and moment measuring balances, actuated control systems, remotely actuated instrumentation probes, model support stings and struts, and balance adapters have been designed and fabricated to support wind tunnel model testing. ATI's rotor test stands have been powered by electric, hydraulic, or pneumatic motors up to 500kw with strain-gaged rotor balances to measure six components of steady and dynamic loading. Servo actuated rotor controls integrated into data and operator control consoles have been produced by ATI. Turnkey programs from design, fabrication, EMI/EMC testing and facility installation and acceptance testing can be provided by our experienced staff.



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Advanced Technologies, Incorporated (ATI) is a leading producer of quality aerospace research and development products for the United States and international aerospace industries. Founded in 1988, ATI provides diversified engineering design, analysis, and fabrication capabilities for both fixed wing and rotorcraft research projects. ATI is a "small business" concern operating in a modern 50,000 square foot facility located in Newport News, Virginia - USA.

ATI also provides wind tunnel research models and support services to NASA's research centers and received NASA's prestigious *"George M. Low Quality & Excellence Award - 2000"* as their premier small business subcontractor.

The presentation of the GML Award signifies NASA's recognition that the award recipient has *demonstrated excellence & outstanding achievement in quality & performance.*

JSF One-Team Development Support

ATI has provided Boeing dependable JSF development support since 1995, producing a variety of quality research models totaling over $5 million. ATI's JSF One-Team products include:

Initial Full Scale Radar Cross Section (RCS) Model (1995)
Completed in 32 Weeks

Stability & Control Low Speed Wind Tunnel Model (1995)
Completed in 4 Weeks

Small Scale Powered Wind Tunnel Model (1997 & 1998)

Cockpit Simulator Structures (1997 & 1998)
Completed in 16 Weeks

X-32 Sled Test Article (1998)
Completed in 30 Weeks

5% Scale High Speed Aerodynamics Wind Tunnel Model (1999)
Completed in 9 Weeks

Low Speed Stability & Control Wind Tunnel Model (1999)
Full Scale Display Model (2000)

Based on overall performance delivering quality models to demanding critical schedules, ATI was recognized *"As an outstanding supplier in support of Boeing Programs - 1999."*

JSF One-Team

Full Scale Display Model

ATI designed and fabricated the JSF One-Team Full Scale Display Model over a 25-week period of performance beginning January 2000, using the talents of 15 technicians. The 13,000 pound model is constructed with a fiberglass shell supported by a welded aluminum tubular truss frame.

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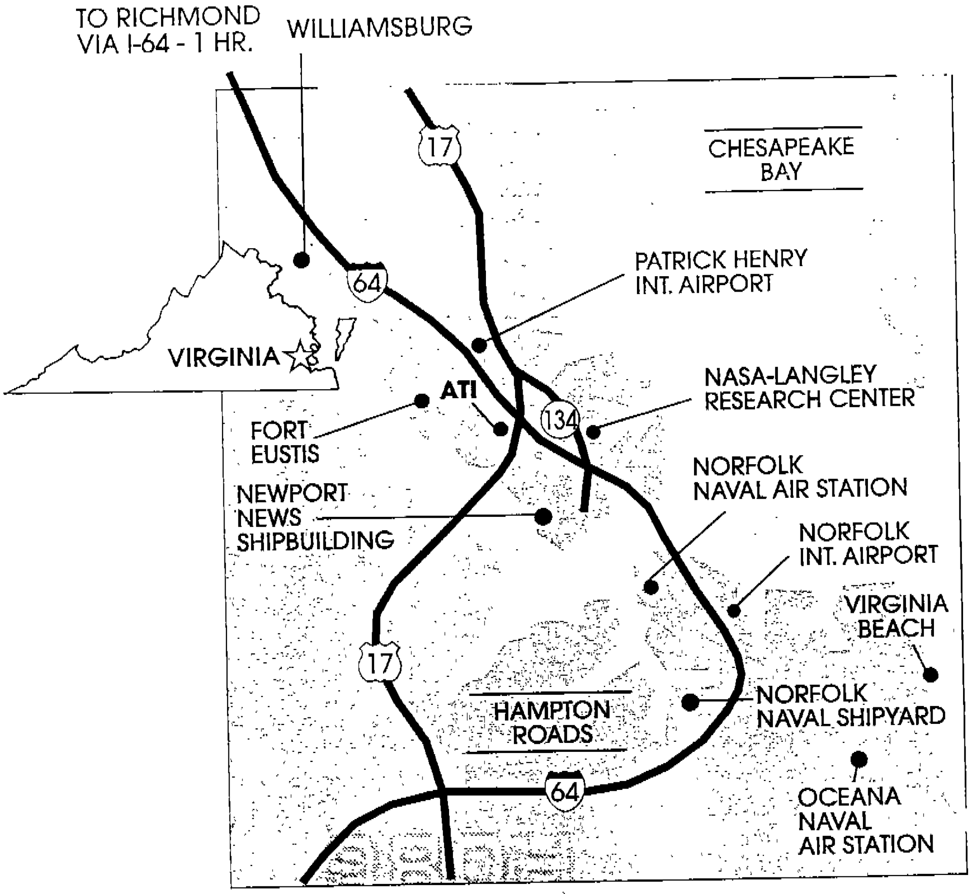

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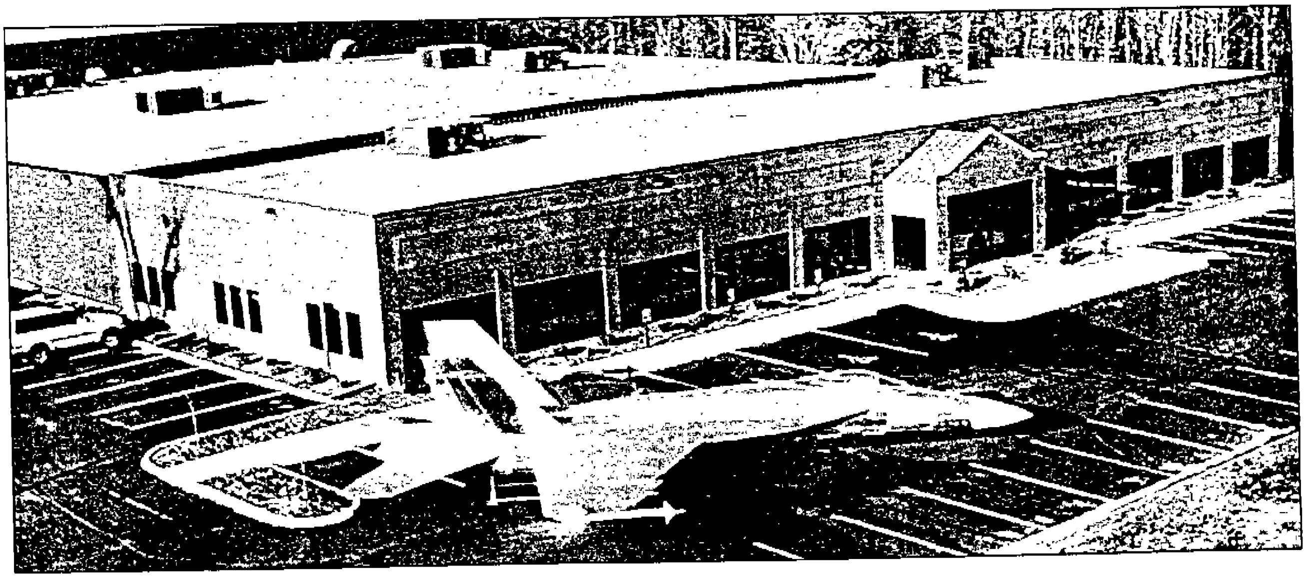

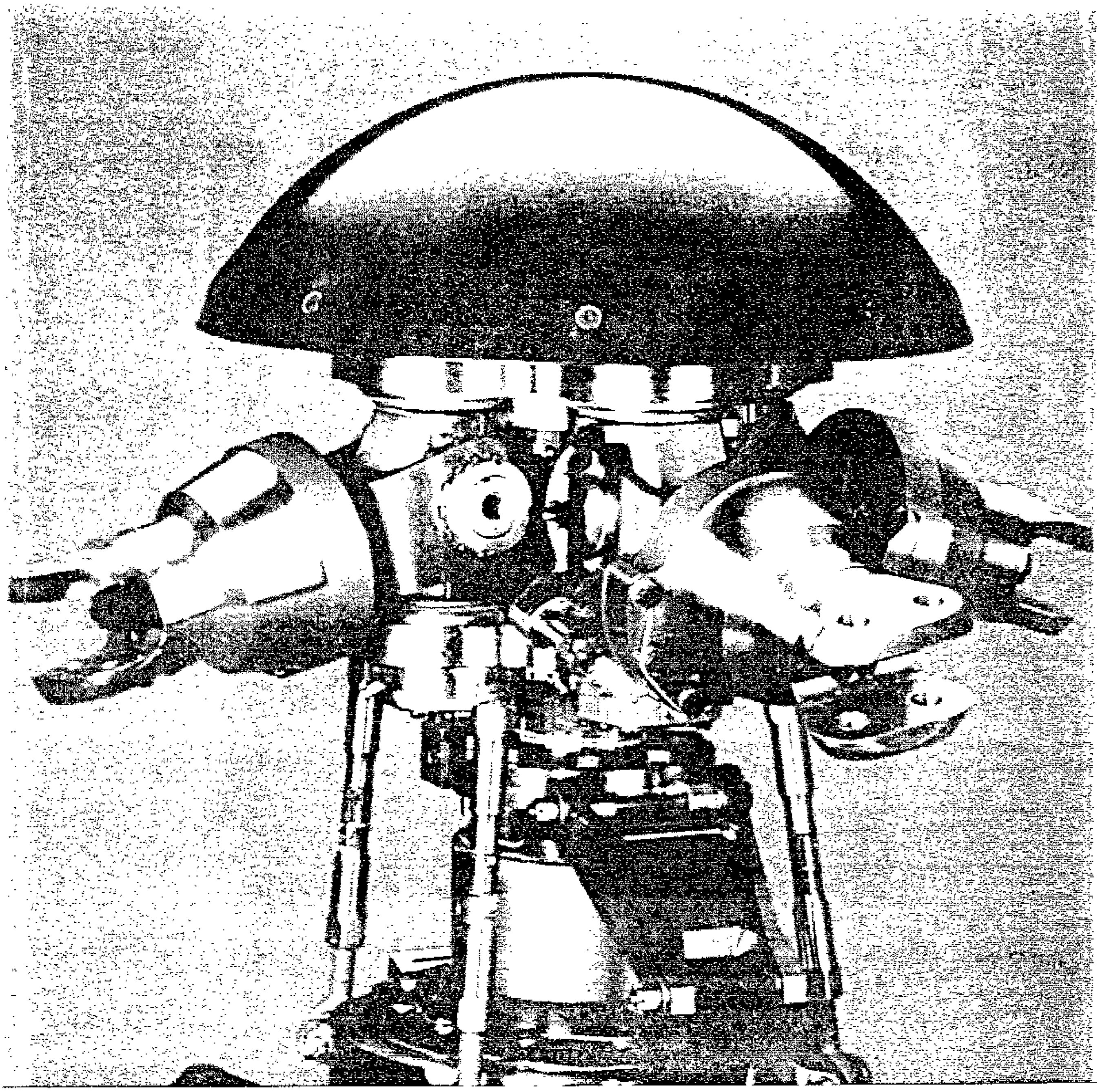

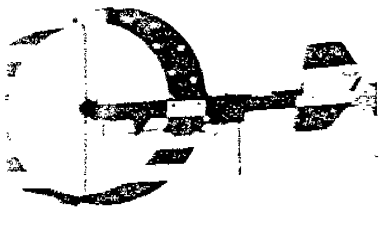

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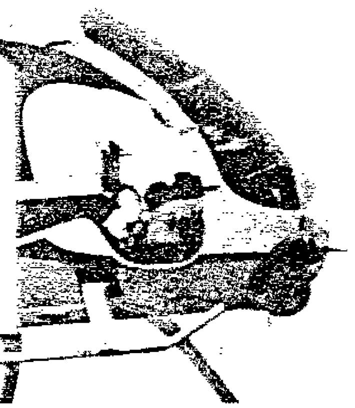

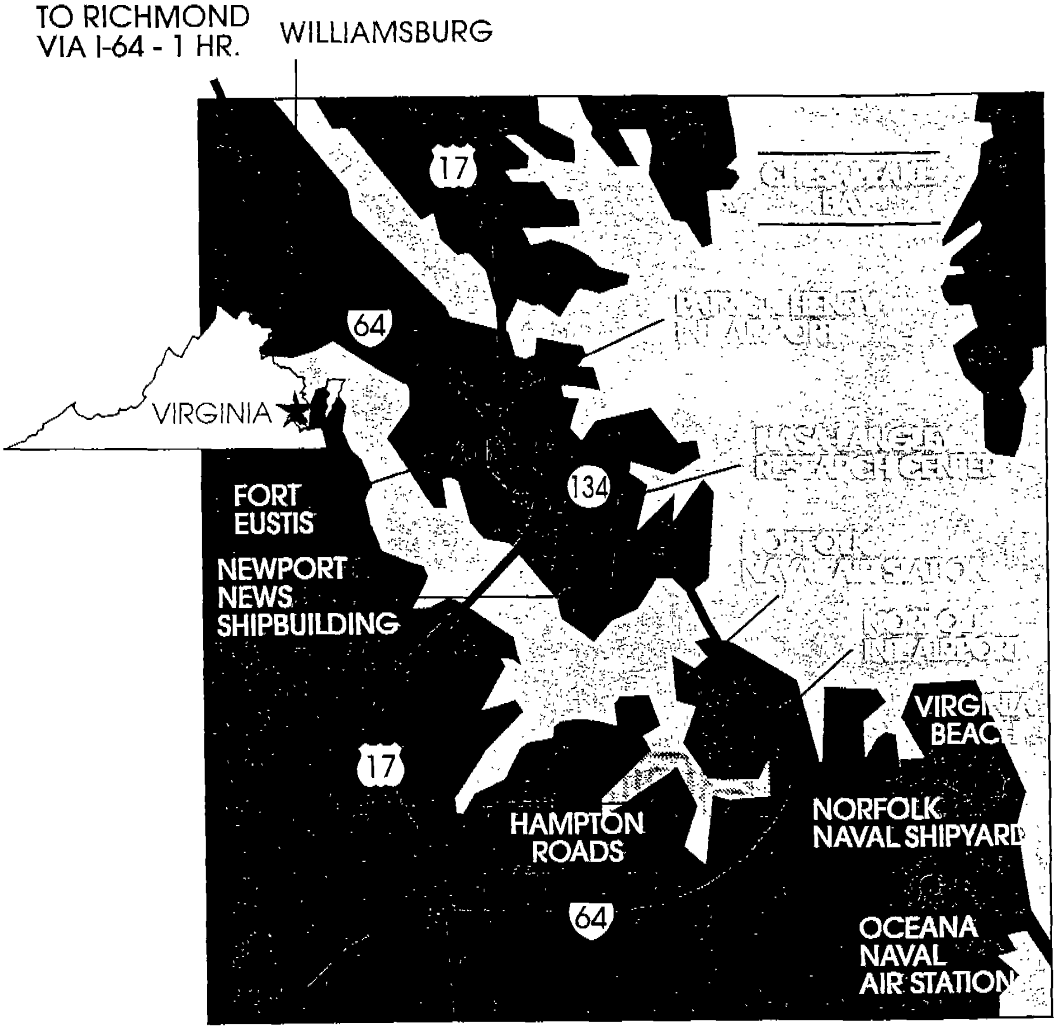

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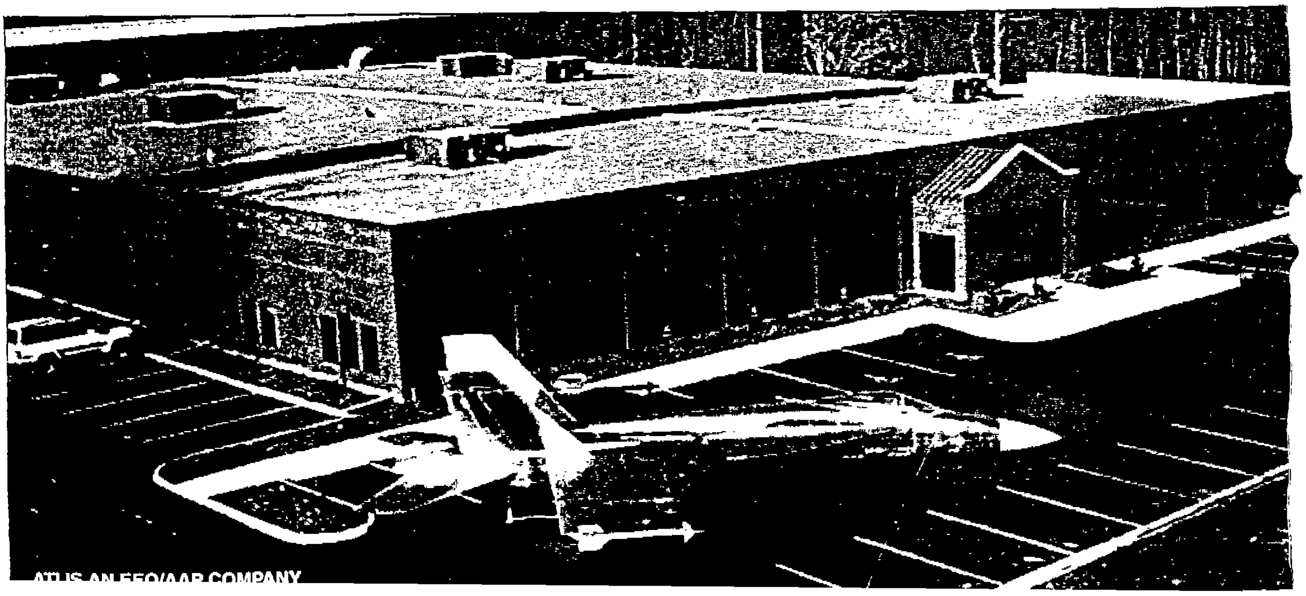
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