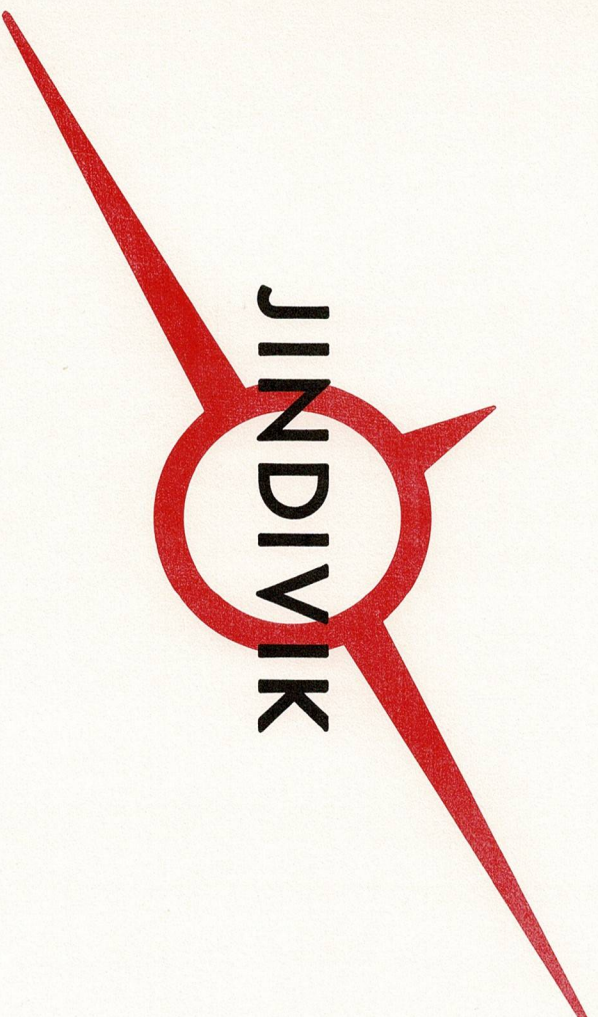


A MODERN CONTROL SYSTEM DERIVED FROM TURANA



FOR TARGET AND RPV APPLICATIONS

**PREPARED BY
GAF CONTROL SYSTEMS GROUP
OCTOBER 1972**

PROPOSAL

TO REPLACE THE JINDIVIK CONTROL SYSTEM WITH A MODERN TURANA-
DERIVED CONTROL SYSTEM INCORPORATING TURANA-COMPATIBLE GROUND
CONTROL EQUIPMENT.

PURPOSE OF THE PROPOSAL

● TO IMPROVE RELIABILITY

- By incorporating Missile proven-(Ikara/Turana) engineering techniques and solid state components.'
- By Reducing overall complexity of the system. (e.g. fewer units and interconnections).
- By an improved operating system requiring reduced operator effort both in flight and on the ground.

● TO IMPROVE OPERATIONAL FLEXIBILITY

- By an improved Control System design offering flexible manoeuvre capabilities either pilot controlled or computed on the ground or in the drone.
- By a Turana/Jindivik compatible Ground Control Equipment offering a choice of Target Drone to achieve the most suitable target presentation.

● TO INCREASE PAYLOAD CAPACITY

- Resulting from reduced equipment size and weight and offering improved potential for RPV applications. (Volume of proposed equipments is less than 2 cub. ft.)

● COST REDUCTION

- Per Drone cost reduction.
- Reduction of Post Design costs resulting from the commonality with Turana.
- Replacement of all outmoded autopilot components and equipments instead of the expensive "piece-meal" approach of replacement as they become obsolescent.

● DESIGN COMMONALITY

- Commonality of design with modern autopilots (Turana) reduces the required support expertise.
- G.A.F. is Design Authority for both Turana and Jindivik Control Systems.

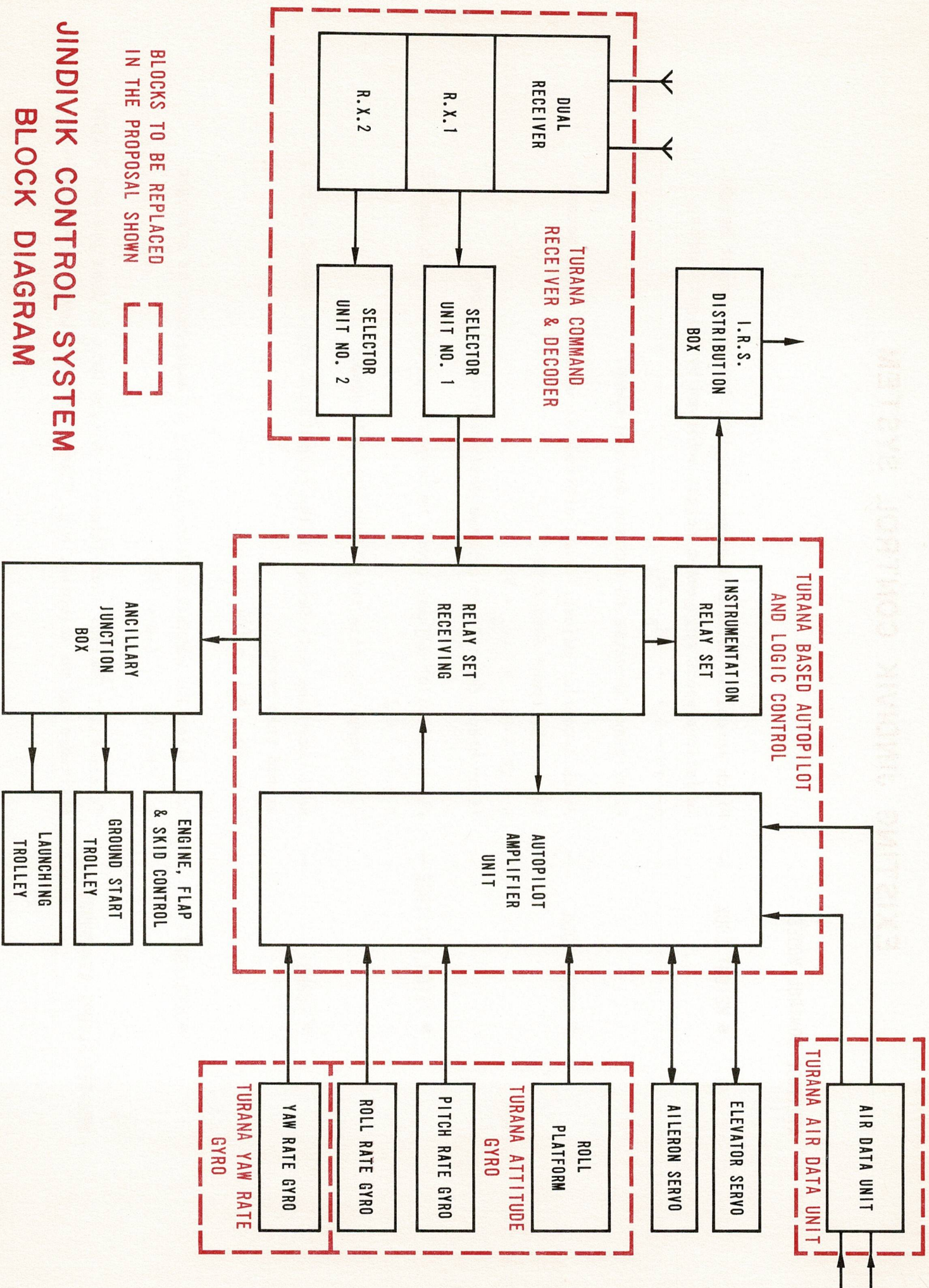
IMPLEMENTATION

● DRONE IMPLEMENTATION

- Turana Command Receiver and Decoder replaces Radio Receivers and Selectors.
- Turana-based Autopilot and Logic Control replaces existing Amplifier Unit, Relay Set Receiving and Instrumentation Relay Set.
- Turana Air Data Unit replaces the Jindivik Unit.

● GROUND CONTROL EQUIPMENT

- Turana Control Unit and Transmitter replaces existing Control Console and Radio Transmitter.
- Batsman's Control Unit provides azimuth control in both turns and Heading Mode. (Heading Mode provides continuous crossing velocity control).
- Pilot's Control Unit provides take-off and landing controls as well as attitude and throttle controls.



BLOCKS TO BE REPLACED
IN THE PROPOSAL SHOWN



JINDIVIK CONTROL SYSTEM BLOCK DIAGRAM

EXISTING JINDIVIK CONTROL SYSTEM

ATTITUDE CONTROL MODES

- **HEIGHT LOCK** — Pitch Autopilot Maintains drone at height lock engagement height. Variations about engagement height achieved by height beeping.
$$\eta = (\theta - \theta_D) + (H_B - H_E)$$

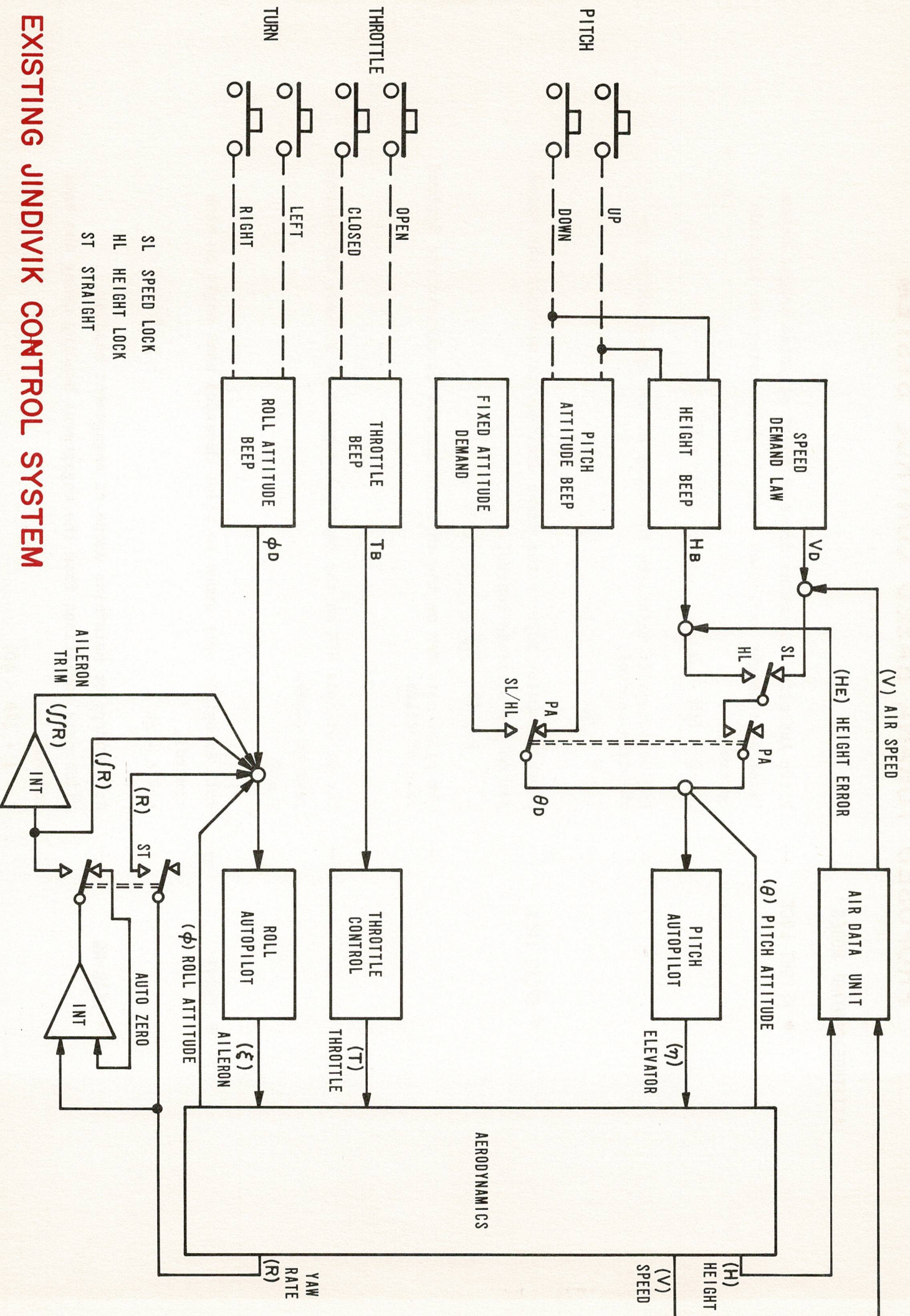
Pilot Beeps throttle to achieve desired speed.
- **SPEED LOCK** — Pitch Autopilot adjusts drone attitude to maintain speed according to the speed demand law.
$$\eta = (\theta - \theta_D) + (V_D - V)$$

Pilot beeps throttle to achieve desired rate of climb.
- **PITCH ATTITUDE** — Pitch Autopilot adjusts drone to beeped or fixed attitude demand
$$\eta = (\theta - \theta_D)$$

Pilot beeps throttle to achieve desired speed.
- **TURNS** — Roll Autopilot Sets Drone to the beeped bank angle demand (with a stored trim term).
$$\xi = (\phi - \phi_D) - \int \int R$$
- **STRAIGHT** — Roll Autopilot maintains drone heading at engagement of straight.
$$\xi = (\phi - 0) - (\int R + \int \int R)$$

PRE-SET FLIGHT ATTITUDES

To aid Pilot Control when Telemetry Return Data is lost pre-set Flight Attitudes may be selected, e.g. Climb, Descend, Level & Approach.

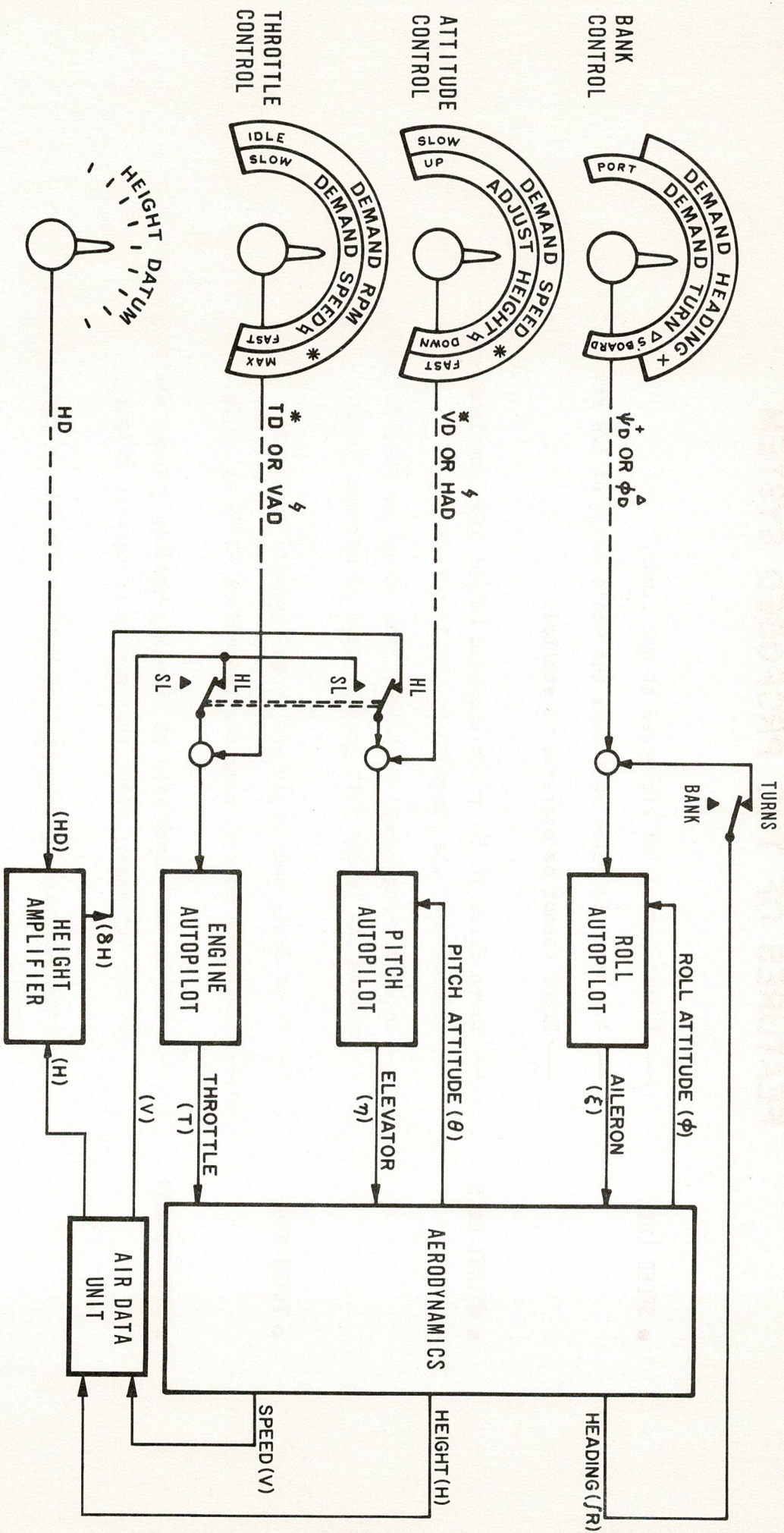


EXISTING JINDIVIK CONTROL SYSTEM

PROPOSED TURANA BASED CONTROL SYSTEM

ATTITUDE CONTROL MODES

- HEIGHT LOCK
 - Pitch Autopilot maintains drone at pilot selected height datum.
Pilot sets height variation from the datum using the attitude control.
$$\eta = \theta + (\delta H - H_{AD})$$
$$\delta H = H - H_D$$
 - Engine Autopilot maintains the drone at the speed set on the throttle control.
$$T = V - V_D$$
- SPEED LOCK
 - Pitch Autopilot adjusts the drone attitude to maintain the speed set on the attitude control.
$$\eta = \theta + (V - V_D)$$
 - The pilot sets RPM on the throttle control to achieve the desired rate of climb.
$$T = T_D$$
 - The pilot sets RPM on the throttle control to achieve the desired rate of climb.
- TURNS
 - Roll Autopilot sets drone to pilot demanded bank angle on bank control.
$$\xi = \phi - \phi_D$$
- HEADING
 - Roll Autopilot maintains drone at engagement heading.
Pilot sets variations from the engagement heading using the bank control
$$\xi = \phi + (J_R - \psi_D)$$



ψ HEIGHT LOCK (HL)
 $*$ SPEED LOCK (SL)
 $+$ HEADING
 Δ TURNS

PROPOSED TURANA BASED CONTROL SYSTEM

FEATURES OF THE PROPOSED SYSTEM

● SPEED LOCK

- Direct control of air speed at all times.
- Air speed is selectable over the whole range of 120 kt. to 500 kt.
- Drone cannot be oversped or stalled.

● HEIGHT LOCK

- Drone flies at the pilot-demanded height with continuous fine control over the range 30 ft. to 70,000 ft.
- Automatic engagement of height lock occurs at 1500 ft. thus preventing impact with ground (even at maximum speed).

● TURNS MODE

- Pilot dials bank angle and drone responds precisely.
- Continuous control over the range from +2.5g to -2.5g.

● HEADING MODE

- Provides the capability of changing heading (track) while flying in the 'straight' mode, thus making navigation simple.
- Provides crossing velocity control for Batsman at take-off and landing.

● RETURN DATA

- Closed loop sensing and control ensure drone response and assure satisfactory operation on loss of telemetry return data.

● L - BAND OPERATION

- This development would be coincident with the requirement to change operations into the L-Band frequencies (the currently used 400-420MHz Band will be taken over by the Post Office).

DRONE IMPLEMENTATION COSTS (1972)

JINDIVIK EQUIPMENTS TO BE REPLACED

	CUSTOMER		Proposed Turana Based Replacements [() Indicates Actual Turana Price]
	AUST.	U.K.	
Radio Receivers (2) } Selector Units (2) }	5000*	5000*	6000
Relay Set Receiving	3400	3400	
Instrumentation Relay Set	4900	4900	
Autopilot Amplifier Unit	10000	3400	2500
Bendix Setting to Work	3000	3000*	5000
Air Data Unit	3600	3260	880
	<u>29900</u>	<u>22960</u>	910
			2370
			<u>17660</u>
Rate Gyro (3)	2450	2450	1210
Roll Platform	4050	4050	1510
Inverter Equipment	1230	1230	<u>2720</u>
	<u>7730</u>	<u>7730</u>	
Total	\$ 37630	\$ 30690	Total \$ 20380

*Indicative Estimate Only

COST COMPARISON (1972)

● DEVELOPMENT COST

X \$ 1,000

From Project commencement to completion of post trial analysis including hardware and trials costs.

490

● COST COMPARISON

Jindivik Equipments to be replaced

* U.K. Customer 30.7

* AUST. Customer 37.6

* Does not include amortization of development costs

Proposed Turana-based Control System

20.4

Development cost amortized over 50 sets

9.8

30.2

NOTE : This proposal uses only one Receiver/Decoder. If a Duplex System is required an additional \$6000 should be added.

● INDIRECT COST SAVING

- Increased Drone life due to improved reliability
- Reduction in cost of Post Development Technical Support for Jindivik
- No requirement to develop replacements for outmoded equipments and components.

● GROUND EQUIPMENT

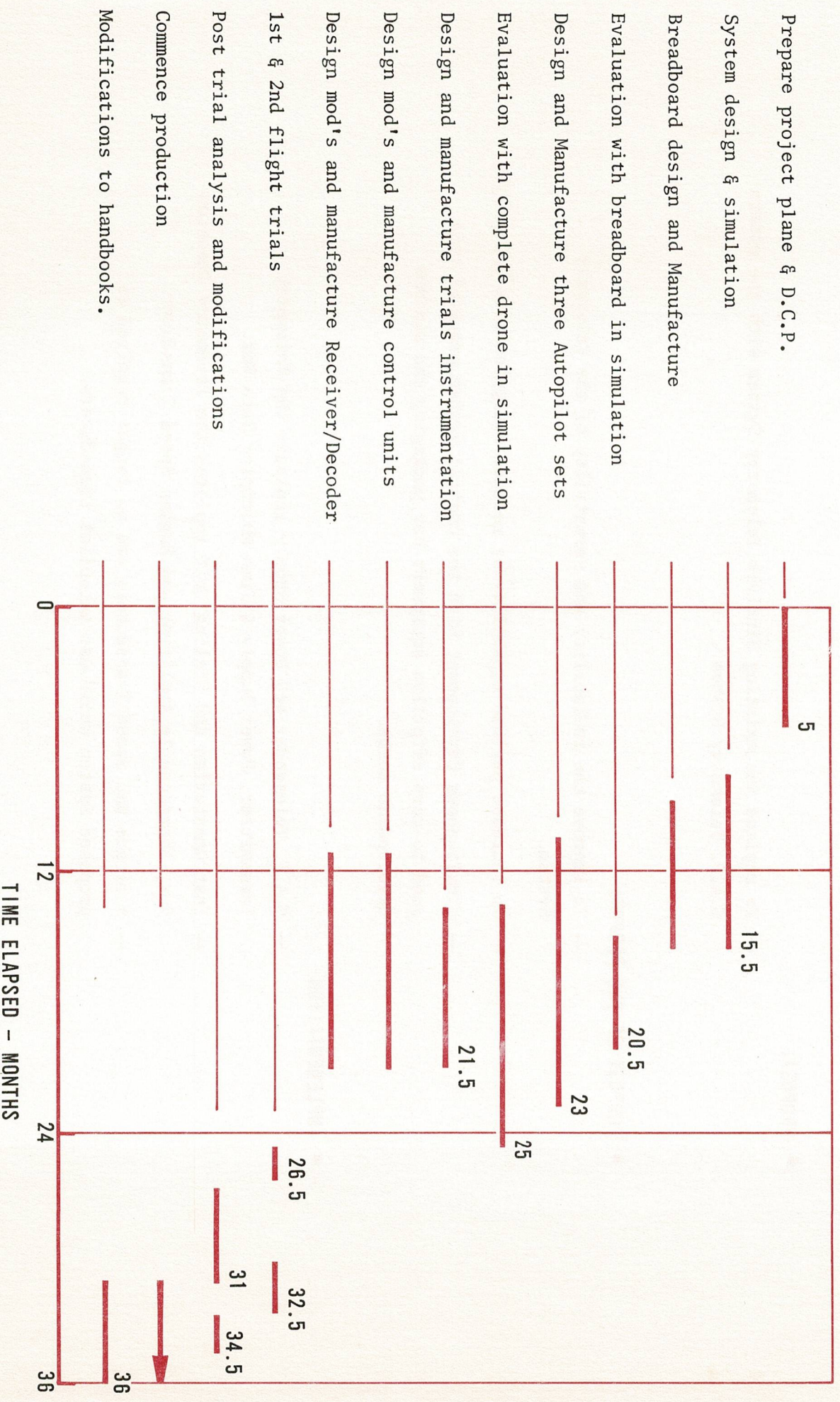
Target Control Unit (Inc. Bats & Pilots Position)

17.5

Ground Command Transmitter

45.0

TIME - BASED PROGRAM



TELEMETRY PROPOSAL

● PROPOSAL

- To replace the existing Jindivik Telemetry System with the modern G.A.F. Telemetry System..

● PURPOSE OF THE PROPOSAL

- To improve the reliability and versatility of the Telemetry System.
- To increase payload capability by reduced equipment size and weight.
- Simultaneous development with the control system proposal will lead to more effective equipment bay packaging and minimum development costs.

● IMPLEMENTATION

- G.A.F. Telesender and Power Supply replaces the Telemetry Transmitter, Power Supply & Time Multiplex Data Box.
- Instrumentation and Scaling Unit replaces the Telemetry Junction Box, Thermocouple Amplifier and Engine Speed Transducer.
- Altitude and Speed Transducers are no longer required as proposed System would use autopilot transducers.

● FEATURES OF THE PROPOSED SYSTEM

- 4000 Hz sample rate with up to 48 primary channels
- 24-channel sub-commutation available on primary channels
- High accuracy digitization available for primary channels
- Coincident development with the requirement to operate in the L-Band frequencies
- A Turana-compatible and transportable system suitable for operation on alternative ranges
- Volume of proposed equipments less than $\frac{1}{2}$ cubic foot

● COMPARATIVE COSTS

JINDIVIK EQUIPMENTS TO BE REPLACED	PROPOSED GAF TELEMETRY SYSTEM
Tele Transmitter	1690
Tele Power Supply	860
Tele Junction Box	990
Time Multiplex Box	1090
High Alt. Transducer	390
Low Alt. Transducer	390
Vert. Speed Transducer	420
Air Speed Transducer	270
Thermocouple Amplifier	710
Eng. Speed Transducer	490
	\$ 7300
	\$ 6500

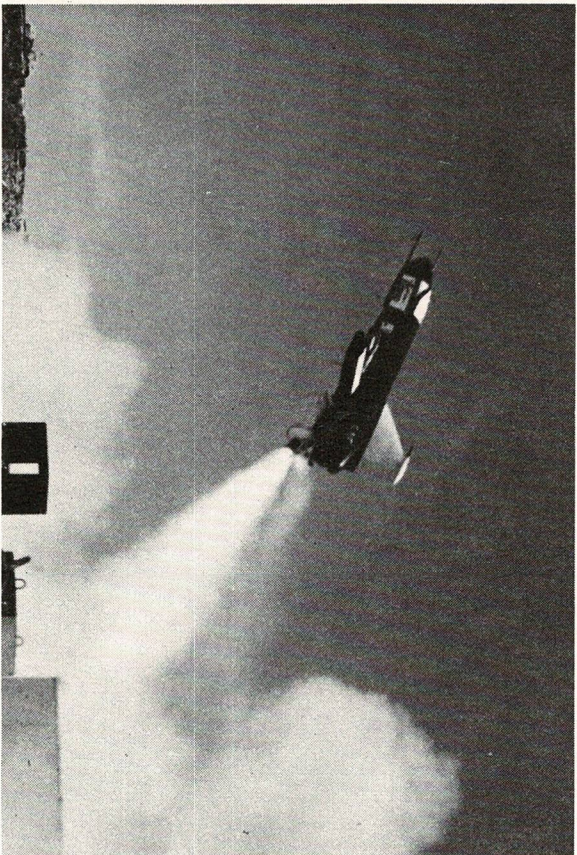
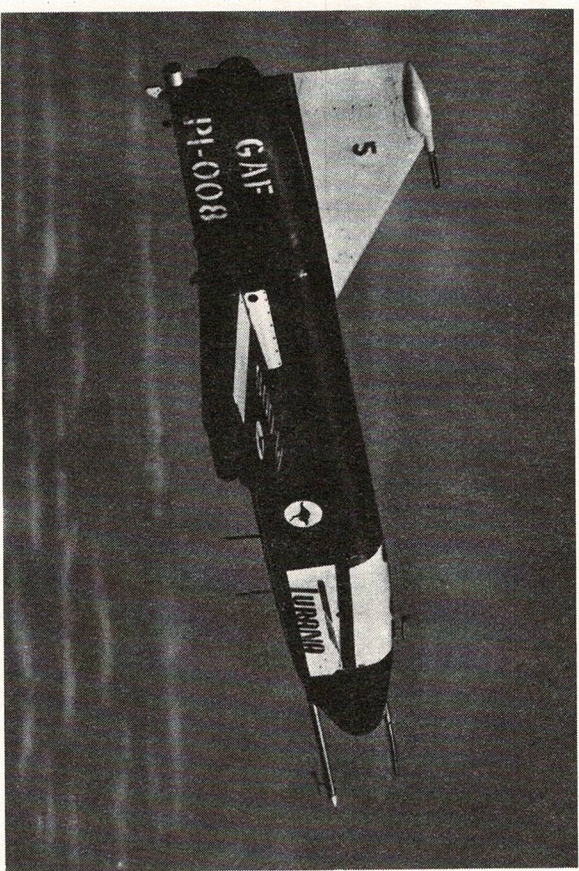
● GROUND EQUIPMENT

A Portable Ground Equipment System (excluding Antennae)

\$ 60,000

PROVEN GAF DESIGN COMPETENCE

G.A.F. was responsible for the development of the Turana Target Drone System. This project was approved for commencement in Sept. 1969 and successful system proving trials were completed at Woomera in July 1971. Without modification of the Control System successful Gunnery and Sea Recovery trials were held at Jervis Bay in November 1971 and August 1972.



The success and short development period for the Control System resulted from the extensive use of the G.A.F. Digital and Hybrid Computational facilities for the Autopilot and Control System Design. These simulation facilities were also used for pre and post trial simulation, as well as Target Controller Training and familiarization.