A BRIEF HISTORY OF UAVs IN THE 1970s

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Abstract: *The technological development of the UAV domain has produced a conceptual revolution in the design, architecture and operation of these technical systems. The evolution of unmanned aerial systems has followed the same technological curve as manned aircraft and the continuous technological development of the UAV field has produced a conceptual revolution in the design, architecture and operation of these technical systems. After the 1970s, on the one hand, a series of modernizations of the launch-recovery systems of the air vectors took place and on the other hand, the development of miniaturized classes of UAVs.*

The article summarizes information about the most relevant historical landmarks regarding the experimental and operational technological achievements of the 1970s and 1980s.

Keywords: *UAV history, CL-227 Sentinel, Tadiran Mastiff, Ryan 147, performances aircraft*

Acronims

C2/C3	*Command, control / communication*	*HALE*	*High altitude long endurance*
HIMAT	*Highly Maneuverable Aircraft Technology*	*JATO*	*Jet-assisted take-off*
MAV	*Micro/miniature aerial vehicles*	*NAV*	*Nano aerial vehicles*
PAV	*Pico aerial vehicles*	*RPA/H*	*Remotely piloted aircraft/ helicopter*
RPV	*Remotely piloted vehicle*	*SD*	*Smart dusts (drone miniaturization)*
SIGINT	*Signal inteligence*	*UCAS*	*Unmanned combat aerial vehicles*
VTOL	*Vertical take-off*	*μUAV*	*Micro unmanned aerial vehicles*
C4ISR	*Command, Control, Communications, Computers (C4) Intelligence, Surveillance and Reconnaissance (ISR)*		
ISTAR	*intelligence, surveillance, target acquisition, and reconnaissance*		
MBLE	*Manufacture Belge De Lampes Et De Matériel Electronique*		

1. INTRODUCTION

1.1.Initial considerations

The bibliographic study carried out in this paper includes chronological and state-owned approaches, rather than temporal aspects of the major conflicts that began or took place during the 1970s, such as the Yom Kippur War or the Vietnam War. The analyzed period includes a series of projects on unmanned aircraft in different technological and operational stages (life cycle), the following paragraphs containing the most relevant constructive examples. The chronological approach for the period 1970-1980 regarding unmanned aircraft includes mainly state topics in alphabetical order. The exemplified producers being: Argentina, Belgium, Canada, Israel, USA, USSR and UAVs made in multinational productions.

1.2. Characterization of unmanned aircraft from 1970-1980

The standards used for unmanned aerial vehicle technologies have reached the level of maturity required for functional optimizations imposed by both end-user requirements and cost levels generated over the life cycle of UAVs as complex technical systems depending on the class, type and main uses of the UAV. them. In this context we can mention a number of advantages and disadvantages, recorded in the following paragraphs.

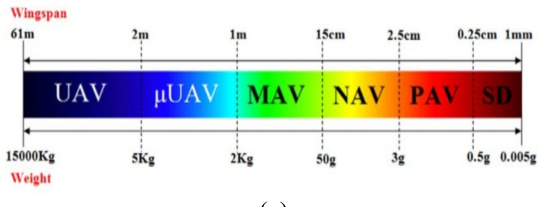
The most relevant advantages of the period studied on UAVs are: technical aspects of environmental protection, lower costs compared to piloted aircraft (for the same type of use), good quality of information taken from areas of interest (eg images), levels of superior accuracy due to GPS equipment, C3 and C4ISR technologies optimized according to the level of UAV equipment, high levels of reliability of integrated equipment, low risks both on the intrinsic operation of the UAV and from the perspective of missions (emergencies, crisis and conflicts), reduced implications on the health of the C2 crew of UAVs, perfectible capabilities sense and avoid, optimized levels of technical versatility of some classes of UAVs depending on the type of mission.

The disadvantages of using UAVs over the studied period can be summarized in: altered privacy levels with implications of individual freedom versus public security (commercial uses), legislative uncertainty (summary and non-aligned national regulations), insufficient security levels for hardware and software populated areas altered or C2 piracy situations, high levels of vulnerability to wildlife (airborne collisions) appropriate to the size and use of UAVs, possible criminal uses (espionage, drug trafficking), non-standard levels of vulnerability and encryption of C2 / C3 systems to piracy (especially for civil uses), dependence on atmospheric and climatic conditions of UAVs, insufficiently standardized levels of theoretical and practical training of operators for technical and operational skills. [1, 6, 22, 23, 38]

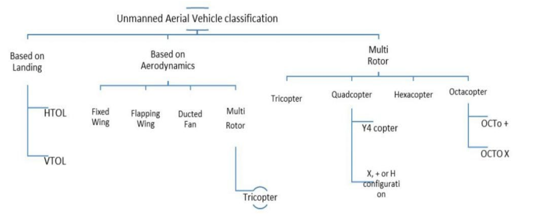
1.3.UAV classification

The continuous technological development of the UAV domain has produced a conceptual revolution regarding the design, architecture and operation of these technical systems. According to the specialized references [1, 2, 3] unmanned aerial systems have been identified with several names and acronyms throughout the historical evolution, the most used being: drones, RPV (remotely piloted vehicle), UAV (unmanned aerial vehicle) , UCAV (uninhabited combat aerial vehicle), UCAS (uninhabited combat aircraft system), RPA (remotely piloted aircraft), RPH (remotely piloted helicopter), MAV (micro aerial vehicle), the evolution of unmanned aerial systems followed the same technological curve as aircraft with human pilot on board.

Scientific studies [2, 3, 4, 5, 8, 9] provide a series of classifications of unmanned aerial vehicles from the civilian and military perspectives of UAVs. The most common classifications of UAVs are based on traditional criteria, such as: kinetic and mass performance criteria (weight, altitude and range); criteria regarding the constructive concept (type of load-bearing surface: fixed / rotating); criteria based on use / missions (civilian, military, mixed); propulsion type (propeller / reaction), see Fig. 1.1.



(a)



(b)

FIG. 1.1. UAV(S) classification
(a). The spectrum of the UAV classification [9], (b). classification of constructive concepts [10]

2. UAV HISTORICAL REFERENCES FOR THE PERIOD 1970-1980.

The period 1970-1980 is characterized by the adoption of constructive and aerodynamic concepts for optimizing flight performance, especially flight time and altitude. Information on significant unmanned aircraft projects can be accessed in classic online lists [17-21], some constructive benchmarks are set out in the following paragraphs, see Fig. 2.1.

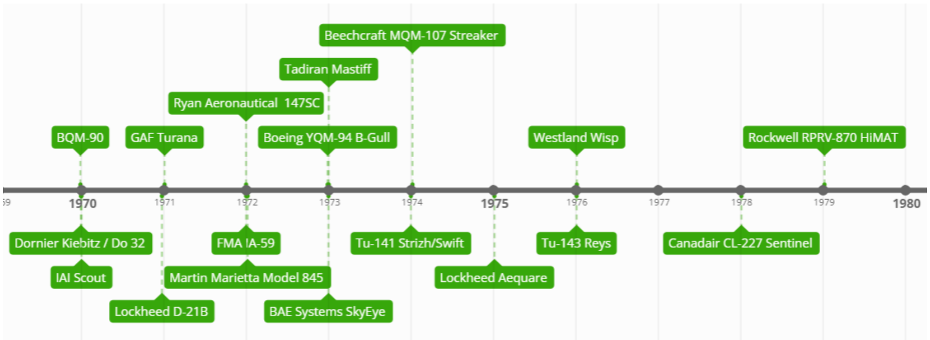


FIG. 2.1 UAV timeline for 1970-1980

Argentina produced in 1972 (until 1979) the FMA IA-59 prototype [39]. and Australia has been building 23 GAF Turana target drones since 1960 (with its first flight in 1971), which are powered by a solid rocket booster engine, see Table 2.1. [26].

FIG. 2.2. FMA IA-59, [39]

FIG. 2.3. GAF Turana, [26]

In the 1970s in Belgium, the MBLE Epervier drone was produced for the armed forces, which could fly for 25 minutes at a speed of 500 km / h at a total mass of 142 kg, [27], see Fig. 2.4.

Table 2.1 Turana and MBLE Epervier features

Performances	Turana	MBLE Epervier
Span (m)	1,6	2,38
Speed. max. (km/h)	650	500 (cruise)
Weight empty/max. (kg)	1470/1786	-/142
Ceiling (m)	6100	1830
Autonomy (h)	-	0.45
Propulsion	1 x Solid rocket booster 80kgf	1 x turbojet 0,5 kN

Canada produced in 1978 a prototype VTOL reconnaissance UAV with rotating wing type CL-227 Sentinel of Canadair / Bombardier, see figure 2.5, [28].

FIG. 2.4. MBLE Epervier [27].

FIG. 2.5. CL-227 Sentinel[28].

During the 1970s, Israel was the main producer of UAVs with two relevant examples of air carriers: IAI Scout and competitor Mastiff (1973), used both for real-time data acquisition in ISTAR monitoring and reconnaissance missions (mobility enemy units and surveillance of Syrian air bases) as well as in electronic warfare missions (location and radio interference), [1, 11, 12, 14], see Figures 2.6 and 2.7 and Table 2.2.

FIG. 2.6. IAI Scout, [13]

FIG. 2.7. Tadiran Electronic Systems Mastiff , [15]

Table 2.2 IAI Scout and Tadiran Mastiff features

Performances	IAI Scout	Tadiran Mastiff
Span (m)	4,96	4,25
Speed. max. (km/h)	176	185
Weight empty/max (kg)	96/159	72/138
Ceiling (m)	4600	4480
Autonomy (h)	7,5	7,5
Range (km)	-	50
Propulsion	1 x 22 CP	-

The British projects focused on rotary wing UAVs: Westland Wisp coaxial VTOL type (1976, 3 copies) in Figure 2.8, or on conversion to remote control target drones, for example Canberra U10 / D10 (18 copies) and U14 / D14 (6 copies) at English Electric), Fig. 2.9 [35, 36].

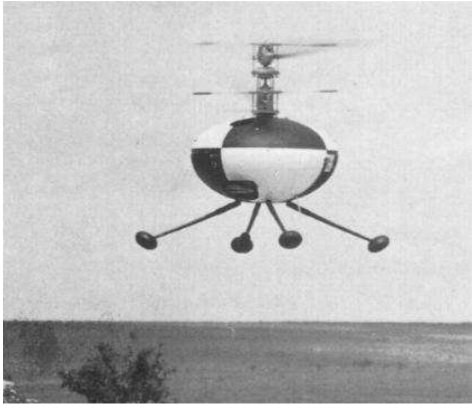


FIG. 2.8. Westland Wisp, [36]

FIG. 2.9. Canberra U10, [35]

In the US, according to [16], Ryan Aeronautical operated a series of modifications to the Model-147 Lightning Bug UAV, created the 147SC (AQM 34L) and 147N variants, and since 1972 it has been possible to transmit data online from onboard sensors, see figure 2.10 and table 2.3. Ryan 147 being produced in 28 variants and having missions in the period 1964-1974.

In the late 1960s and early 1970s, the COMPASS DWELL program developed the Martin Marietta 845 as a remotely piloted aircraft to be used as a communications relay in the Vietnam War (for 24 hours), see Table 2.3. [31]

Lockheed has been producing (since 1964) 38 D21s for supersonic reconnaissance missions (over Mach 3), the D21B flying in 1970, see Figure 2.11. [38]

FIG. 2.10. Ryan 147SC, [16]

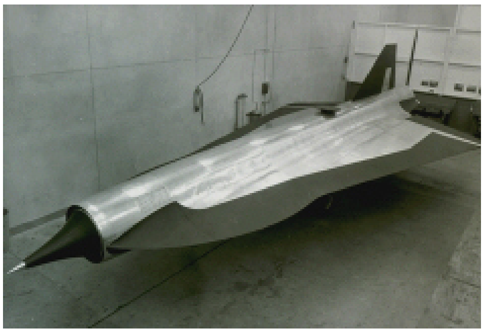


FIG. 2.11. D21B prototype, [29]

Table 2.3 Martin Marietta 845 and Ryan 147A features

Performances	Martin Marietta 845	Ryan 147A
Span (m)	18	4
Seed. max. (km/h)	240	-
Weight empty /max (kg)	- / 1050	-
Ceiling (m)	-	16800
Autonomy (h)	28	-
Range (km)	-	1930
Propulsion	1 x TIO360, 200 CP	1 x J69-T-41A

Between 1974 and 2003, Beechcraft produced the MQM-107 Streaker vector in over 2,200 units as a target towing drone, used primarily by the United States military and 11 other states. The US Air Force uses them in training shootings for their air-to-air missiles, such as the AIM-9 Sidewinder and AIM-120 AMRAAM, see Fig. 2.12 and Table 2.4.

FIG. 2.12. MQM-107 Streaker, [30]

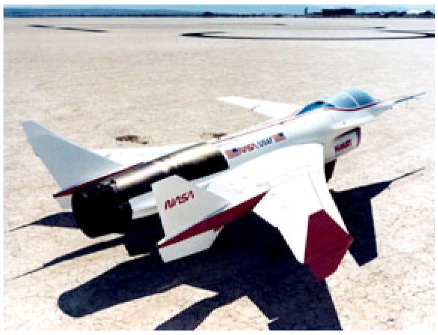


FIG. 2.13. HIMAT, [32]

Table 2.4 Lockheed D21 and MQM-107 Streaker features

Performances	Lockheed D21	MQM-107 Streaker
Span (m)	5,8	3
Speed. max. (km/h)	4062	925
Weight empty/max (kg)	- / 5000	- / 664
Ceiling (m)	29000	12000
Range (km)	5600	-
Propulsion	1 x ramjet RJ43	1 x Microturbo TRI 60

In the 1970s, a series of prototypes were made in the USA that tested various innovative technologies, the manufacturing units being Rockwell International / Boeing with HIMAT (NASA user) [32] or the US Navy with XBQM-108A as a VTOL vector. successfully the first tests the project being canceled, see figure 2.13 and table 2.4. The YQM-94 B-Gull prototypes (also called Compass Cope B) manufactured by Boeing (1973), see Figure 2.14 and Ryan YQM-98 R-Tern (also called Compass Cope R) manufactured by Ryan Aeronautical (1974) were designed for air reconnaissance missions, communications relay or atmospheric data sampling (Table 2.5), [40, 41, 42].

FIG. 2.14. YQM-94 B-Gull, [40]

FIG. 2.15. YQM-98 R-Tern, [42]

Table 2.5 YOM-94 B-Gull and Ryan YOM-98 R-Tern features

Performances	YQM-94 B-Gull	Ryan YQM-98 R-Tern
Span (m)	27,43	24,75
Speed. max. (km/h)	-	735
Weight empty/max (kg)	- /5897	2540/6490
Ceiling (m)	21340	-
Autonomy (h)	30	30
Propulsion	1 x General Electric J97-GE-100 , 23.4 kN	1 x Garrett YF104-GA-100 , 18 kN

In the period 1970-1980 Soviet UAV technology is materialized by Lavochkin La-17 (produced since the 1950s) maintained in service until the 1980s (used USSR / Russia, China and Syria) and the series Tu-123/141/143 for reconnaissance missions, see figures 2.16 and 2.17.

FIG. 2.16. Tu-123 Yastreb, [24]

FIG. 2.17. Tu-143 Reys, [33]

Designed in the 1960s and retired in 1979, the Tu-123 Yastreb / Hawk concept (52 units) was similar to the D-21 (USA) SIGINT on-board and / or data acquisition, with JATO launch and powered by a KR15 jet engine. / R-15 (see figure 2.12), strategic supersonic drone used for HALE missions. Tu-141 Strizh / Swift (introduced in 1974 / over 140 units) is a continuation of the Tu-123 project but with a medium range and Tu-143 Reys (introduced in 1976, produced in over 900 units) tactical reconnaissance (60-70 km), see Fig. 2.13 and Table 2.6. [24, 25]

Table 2.6 Tu-123 and Tu-143 features

Performances	Tu-123	Tu-143
Span (m)	8,41	2,24
Speed max. (km/h)	2700	950
Weight empty/max (kg)	11450/35610	-/1230
Ceiling (m)	22800	5000
Range (km)	3200	200
Propulsion	1 x Tumansky KR-15	1 x Klimov TR-117

The US-UK collaboration generated the BAE Systems SkyEye model as a reconnaissance UAV with a series of subvariants, flying the first prototype (RPA-12) in 1973, produced in over 40 units, with two 50hp engines (R4E-50) and 98HP (R4E-100), see figure 2.18 and table 2.7. [34, 37]

Table 2.7 BAE Systems SkyEye R4E features

Performances	Values	Performances	Values
Span (m)	7,32	Ceiling (m)	4880
Speed max. (km/h)	200	Autonomy (h)	8
Weight empty /max (kg)	-/ 570	Propulsion	1 x 52CP

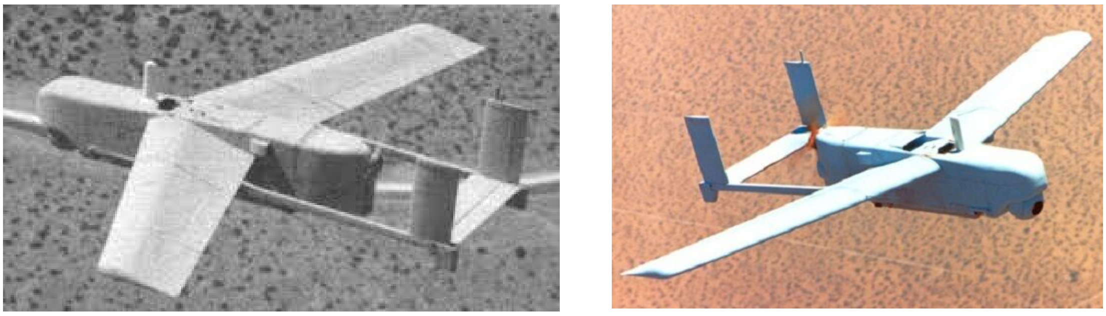
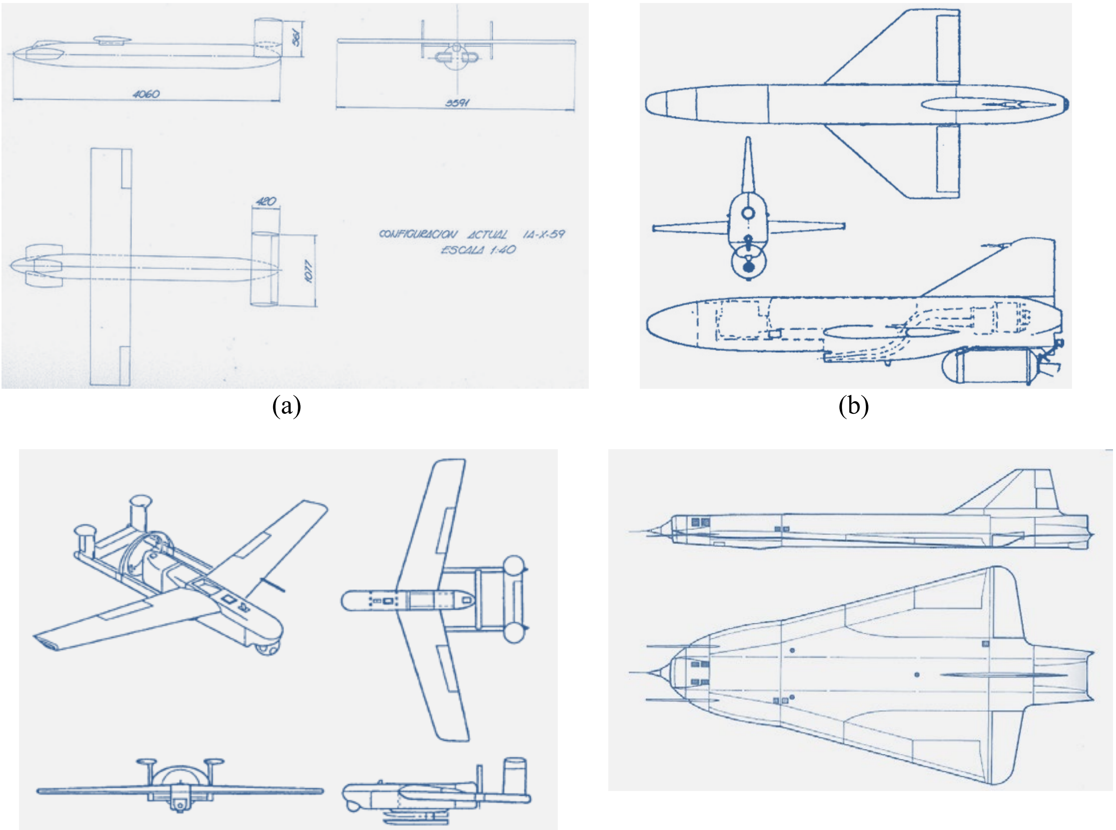


FIG. 2.18. R4E SkyEye, [34, 37]

3. ASPECTS OF UAV GEOMETRIES AND COMPARATIVE PERFORMANCE

3.1. Aspects of UAV geometries

A series of references provide some aspects of the aerodynamic concepts of unmanned aerial vehicles of the 1970s. The most relevant are set out in Fig. 3.1.

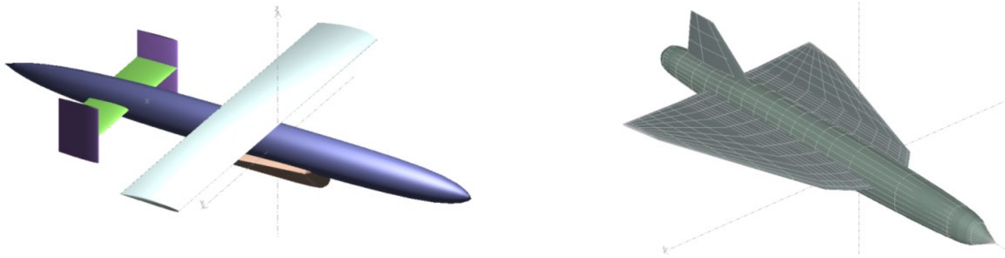


(a) (b)

(c) (d)

FIG. 3.1. UAV geometry, (a). FMA. I.A.X-59 [43], (b). GAF Turana [44], (c).R4E-50 Skyowl [37], (d). D-21 [45]

The relevant references provide a series of quantifiable aspects regarding the typology of air vectors used in the period 1970-1980, vectors at different stages of the life cycle (design, manufacture, operation / use). Figure 3.2 exemplifies a 3D geometry made with the XFLR5 freeware tool, [46].

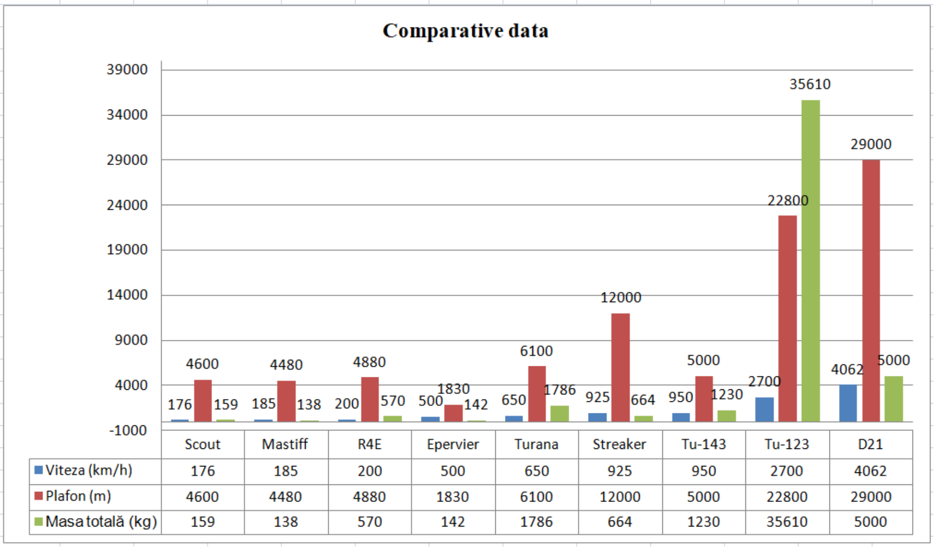


(a) (b)

FIG. 3.2. UAV 3D geometry, (a). FMA IA-59 , (b). Lockheed D21

3.2.Comparative performances

For a comparative highlight of the flight performance of unmanned aircraft during the 1970s, we present the graph in Fig. 3.3. Comparable performance is observed for unmanned reconnaissance aircraft (Tu-123 vs D21).



	Scout	Mastiff	R4E	Epervier	Turana	Streaker	Tu-143	Tu-123	D21
Viteza (km/h)	176	185	200	500	650	925	950	2700	4062
Plafon (m)	4600	4480	4880	1830	6100	12000	5000	22800	29000
Masa totală (kg)	159	138	570	142	1786	664	1230	35610	5000

FIG. 3.3. UAV comparative data for 1970-1980

CONCLUSIONS

The development of the UAV field after the 1970s produced a conceptual change in the architecture and operation of unmanned aerial systems on board which led to technological development directions that generated new capabilities (speed, autonomy, data processing speed, system reliability) and attributes of UAS (persistence, penetrability, integration, versatility), [6, 7]. After the end of the Vietnam War in 1975, digital technologies were used extensively due to cheap processors and software development.

Future bibliographic research efforts will focus on summarizing and essentializing information on relevant landmarks in the field of UAS for historical intervals after the 2000s.

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