COMMISSION OF THE EUROPEAN COMMUNITIES

STUDIES

The aeronautical and space industries of the Community compared with those of the United Kingdom and the United States

GENERAL REPORT **Volume 5**

COMPETITION INDUSTRY – 1971 – **4**

Survey carried out on behalf of the **Commission of the European Communities** (Directorate-General for Industry)

Project coordinator: Mr Felice Calissano, with the assistance of Messrs Federico Filippi and Gianni Jarre of Turin Polytechnical College and Mr Francesco Forte of the University of Turin

SORIS Working Group :

Mr Ruggero Cominotti
Mr Ezio Ferrarotti
Miss Donata Leonesi
Mr Andrea Mannu
Mr Jacopo Muzio
Mr Carlo Robustelli

Interviews with government agencies and private companies conducted by :

Mr Felice Calissano
Mr Romano Catolla Cavalcanti
Mr Federico Filippi
Mr Gianni Jarre
Mr Carlo Robustelli

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SORIS spa
Economic studies, market research
11, via Santa Teresa, Turin, Italy
Tel. 53 98 65/66

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STUDIES
Competition Industry No. 4
BRUSSELS 1971

THE AERONAUTICAL AND SPACE INDUSTRIES OF THE COMMUNITY COMPARED WITH THOSE OF THE UNITED KINGDOM AND THE UNITED STATES

VOLUME 1 The aeronautical and space research and development

VOLUME 2 The aeronautical and space industry

VOLUME 3 The space activities

VOLUME 4 The aeronautical market

VOLUME 5 Technology — Balance of payments
The role of the aerospace industry in the economy
Critical assessment of the results of the survey

CHAPTER 4

Technology — Balance of payments

CHAPTER 5

The role of the aerospace industry in the economy

CHAPTER 6

Critical assessment of the results of the survey

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CHAPTER 4

Technology — Balance of payments

1. INTER-COMPANY HOLDINGS

1.1 American Holdings in European Firms

As in all other branches of the economy, the United States are represented in the various European aerospace industries through holdings in the capital of a number of companies.

The table on the following page (Fig. 1) summarizes existing holdings and reveals the following main features:

(a) the number of such holdings is limited;

(b) they are certainly or probably linked with the sharing of technical knowledge.

Although few in number, these holdings are significant for two reasons:

(a) the role of the European companies involved;

(b) the transfer of technological knowhow enables the assignor to join the benefiting company, even if only as a minority shareholder.

This being so, it would appear reasonable to exclude any purely financial motive on the part of the investor.

Another case of participation, which does not appear in the table because it is very recent, is the formation (in December 1960) of the subsidiary Cobelda of SABCA (B), with SABCA itself and the American firm of Hughes Aircraft Co., each holding 50% of the shares. In 1969, when SABCA bought up all the Hughes shares, Cobelda became the electronics division of SABCA.

FIG. 1

Capital Holdings of American Aerospace Firms in EEC Aerospace Firms

EEC firms	Participating American firms	Capital holding	Transactions associated with capital holding
SNECMA (F)	Pratt & Whitney (now division of United Aircraft) since 1959	11.9%	Licence agreement for turbofan TF 30
REIMS AVIATION (F)	CESSNA, since 1960	49.0%	Licence agreement for the construction of aircraft designed by Cessna, for sale in Europe, Africa and Asia
AERMACCHI (I)	Lockheed, since 1959	20.0%	Licence agreement exclusively for the construction, outside the United States, of the Lockheed 60 (AL 60)
BÖLKOW (G)	Boeing, since 1965	25%, reduced in 1969 to 9.7% of the capital of the new company Messerschmitt-Bölkow-Blohm	Start of EWR/Boeing studies for the military aircraft VJ 101
VFW (G)	United Aircraft	26.37%	
FOKKER (NL)	Republic Aviation (now division of Fairchild Hiller) until. 1965	27-30%	
	Northrop since 1965	20.0%	

1.2 Holdings of European Firms in Other European Firms

The Community can also show examples of aerospace firms with holdings in their counterparts in other countries. Under the terms of cooperation agreements with Bölkow (West Germany), Nord-Aviation (F) obtained a 25% holding in Bölkow in 1965; a year later, in 1966, the two companies set up the UVP (Joint company for the sale of Bölkow-Nord Aviation products), which uses the sales networks of the constituent firms.

The formation (1969) of the new Messerschmitt-Bölkow-Blohm Company, subsequently reduced Nord-Aviation's holding to 9.7%.

In December 1966, Fokker (Netherlands) purchased 93% of the shares of SABCA (Belgium). Later (January 1969), under the terms of cooperation agreements between Fokker and Dassault (France), about 50% of the SABCA shares was taken over by Dassault, after SABCA's capital had been increased by 100%.

Apart from these share transactions and the regrouping of aerospace firms in progress in a number of countries (France and Germany), mention should also be made of the recent formation of the company known as the "Zentralgesellschaft VFW/Fokker GmbH, by Fokker and VFW (Germany).

These developments, and in particular the move made by Fokker and VFW, may be positive steps towards reestablishing the Community aerospace industry on a basis ensuring higher production and increased efficiency.

2. TECHNOCAL PAYMENTS

2.1 Introduction

The term "balance of payments" is taken to mean payments made or received by one country for the purchase or sale of patents, construction licences and technical assistance (knowhow).

The use of the expression "balance of payments" indicates that it does not include overall international movements and exchanges of scientific and technological knowledge. Such international exchanges have increased substantially since the Second World War, as trade in goods and service has grown, and it would be of the greatest value to have separate figures for such exchanges, partly as a means of calculating the approximate extent to which the various branches of industry in one country are technologically dependent on other countries and partly as a guide, however limited and rudimentary, to the productivity of industrial research[1].

Any such balance sheet of scientific and technological "trade" would therefore have to cover all transfers of the findings of all stages of scientific research, from basic research to development; in other words it would have to include:

- scientific theories, hypotheses and new experiments concerning "basic research";
- the "applied research" inventions still awaiting development;
- the detailed development of such inventions and studies leading to the industrial application of new products and processes, under the heading "development research".

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[1] Cf. here and for following pages, "La bilancia italiana dei pagamenti tecnologici del 1963" in Ricerca Scientifica e sviluppo economico", CNEN/CNR, Rome, 1968.

Apart from the difficulty of recording statistically the interchange of the findings of "basic research" and some of the results of "applied research", it must be borne in mind that some research findings, which by their nature could form the subject of commercial transactions, are handed over free of charge or are not transferred by direct sale, so that they are not accounted for in the overall balance of payments.

Here it should be noted that transfers of all kinds of research findings from country to country can be subdivided as follows:

- transfers free of charge, comprising:
  - (a) transfers of purely scientific discoveries which are not protected by law;
  - (b) transfers of technical processes, which are originally protected by law but later become public property;
  - (c) transfers of inventions which are protected on national territory but are offered to other countries as a gift (e.g., technical assistance to underdeveloped countries);
- transfers against payment, comprising:
  - (a) transfers not reported to government departments (e.g., exchanges of patents between associated companies in different countries; the direct exchange of technological knowledge between large industrial undertakings; exchanges between a parent company and its foreign subsidiaries);
  - (b) transfers of scientific and technological knowledge, linked with the investment of capital, the provision of services, or other financial transactions, from or to foreign countries;

(c) transfers through a direct commercial transaction.

In practice, therefore, only the results of applied research and development research which form the subject of a direct commercial transaction (transfers against payment, heading c) can be included in the balance sheet of payments for knowhow.

2.2 Technological Balance of Payments in the Aircraft Industry

It is only in recent years that government financial and statistical services in the various countries have compiled and published separate figures, by branches and countries, for payments relating to transfers of knowhow and have also tried to bring them into line with the recommendations of the OECD, which are aimed at the production of uniform and, therefore, comparable statistics.

Before giving the few figures available for the aircraft industry, it would be as well to refer again to what is said in Section 2.1 above regarding the limited extent to which transfers can be recorded, particularly because, in the branch under consideration, the figures available take no account of movements which are either not reflected, or not immediately reflected, in the financial returns. This applies in particular to:

- the delivery of licences in return for a capital holding. This form of payment is very frequent between companies of various sizes and is often combined with the payment of royalties;
- the delivery of "feed-back" licences and "cross-licensing", involving a return payment in kind (research or development carried out by the licensee) even though the transaction may involve a financial settlement;

- the provision of technical assistance (knowhow) to the purchasing firm by technicians and scientists from the supplying firm; such services are valued in the national currency of the purchasing firm and therefore involve no movement of funds which can be recorded by the authorities concerned.

France

France is the only country in Europe with even limited series of figures for the items making up the aircraft industry's technological balance of payments, broken down by country.

Figs. 2-7 show:

(a) that there was a surplus in 1964 and 1965 and a deficit in 1966;

(b) that technical assistance is the biggest item in both expenditure and income, and therefore in the composition of the balance sheet;

(c) that there was a constant, slight deficit with the United States, resulting from expenditure and income which were in the main lower than the figures for other countries (Germany, United Kingdom);

(d) that movements, and therefore balances, were biggest with Germany and easily ahead of the figures for the other EEC countries, at least during the three years under consideration;

(e) the appreciable weight of transfers in the aircraft branch on both the expenditure and income side of the overall technological balance of payments.

FIG. 2

FRANCE

Aircraft Industry's Technological Balance of Payments (1963-66) ($thousands)

Year	Expenditure			Income		
	Patents and licences[1]	Techn. assist-ance	Total	Patents and licences[1]	Techn. assist-ance	Total
1963	1,211	725	1,936	n.a.	n.a.	n.a.
1964	2,495	2,952	5,447	1,492	10,183	11,675
1965	711	9,715	10,426	1,575	13,520	15,095
1966	1,197	10,485	11,682	1,035	4,907	5,942

[1] According to the statistics of the Banque de France, the figures for licences only are 1,000 (1965) and 2,160 (1966) for expenditure and 1,400 (1965) and 880 (1966) for income.

Source: Economies et Sociétés, Politique de la Science et Ecart Technologique, No. 4, April 1969.

FIG. 3 Aircraft Industry's Technological Balance of Payments, Net Profit/Deficit by Items (1964-66) ($thousands)

Year	Patents and licences	Techn. assist-ance	Total
1964	-1,003	+7,231	+6,228
1965	+864	+3,805	+4,669
1966	-162	-5,578	-5,740

FIG. 4

FRANCE

Aircraft Payments as Percentage of Overall Technical Balance of Payments

Year	Expenditure			Income		
	Patents and licences	Techn. assist-ance	Total	Patents and licences	Techn. assist-ance	Total
1963	1,1	2,1	1,3	n.a.	n.a.	n.a.
1964	1,9	7,9	3,2	2,6	14,6	9,3
1965	0.5	18.9	5,6	2.6	15,6	10,2
1966	0.8	16.7	5,4	1,6	4,9	3,6

FIG. 5 FRANCE **Aircraft Industry's Technological Balance of Payments, by Countries** (1964-66)

Year	US	UK	GERMANY	NL	BELGIUM	ITALY	SWITZERLAND	Others	TOTAL
	Expenditure ($thousands)								
1963	859	603	327	-	-	8	39	100	1,936
1964	1,402	979	2,165	74	70	278	343	136	5,447
1965	1,628	1,284	6,132	376	41	416	516	33	10,426
1966	1,255	5,360	3,563	235	569	331	57	312	11,682
	Income ($thousands)								
1963	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.
1964	705	2,170	7,228	301	3	308	5	955	11,675
1965	771	1,342	10,516	25	140	423	6	1,872	15,095
1966	485	3,344	205	284	107	218	3	1,296	5,942

Source: Economies et Sociétés, Politique de la Science et Ecart Technologique, No. 4, April 1969.

FIG. 6

FRANCE **Aircraft Industry's Technological Balance of Payments, Net Profit/Deficit**, by Countries (1964-66) ($thousands)

Year	EEC					US	UK	SWITZERLAND	Others	TOTAL
	GERMANY	NL	BELGIUM	ITALY	TOTAL					
1964	+5,063	+227	-67	+30	+5,253	-697	+1,191	-338	+819	+6,228
1965	+4,384	-351	+99	+7	+4,139	-857	+58	-510	+1,839	+4,669
1966	-3,358	+49	-462	-113	-3,884	-770	-2,016	-54	+984	-5,740

FIG. 7

FRANCE

Studies and Technical Coöperation in the Aircraft Industry, Expenditure and Income (1964-66)[1]

Year	GERMANY	UK	Others	TOTAL	% of total expenditure or income for studies and technical cooperation
	Expenditure ($thousands)				
1964	1,580	-	1,580	3,160	5.6
1965	6,420	-	3,320	9,740	14.5
1966	3,560	5,820	2,000	11,380	14.3
	Income ($thousands)				
1964	7,160	1,840	1,400	10,400	13.0
1965	10,400	-	3,420	13,820	13.6
1966	-	3,880	1,040	4,920	4.5

1 Banque de France returns. The figures refer, under this new title, to the item "Technical Assistance" in the statistics previously compiled by the Ministère de l'Industrie. Because the methods of collecting and compilation are not the same, the figures may also show differences; according to the source quoted below, the consolidated figures from the Banque de France are considerably and systematically higher than the running totals for expenditure and income under "Royalties" and "Technical Assistance" in the Ministry's returns because of uncertainties concerning the allocation of data to branches.

Source: Economies et Sociétés, Politique de la Science et Ecart Technologique, No. 4, April 1969.

United Kingdom

On the basis of figures supplied by the Ministry of Technology, a very approximate reconstruction has attempted of payments received by the British aircraft industry, from 1961 to 1967, in respect of royalties and fees for licences and technical assistance (knowhow).

No figures are available for the granting of licences.

Royalties and Fees Paid to British Firms under Licence Agreements[1]

Branch	1961	1962	1963	1964	1965	1966	1967
Airframes	560	840	560	280	280	300	320
Engines	1,120	1,400	1,680	1,400	1,960	2,900	3,500
Equipment	560	700	840	800	790	800	840
TOTAL	2,240	2,940	3,080	2,480	3,030	4,000	4,660

1 "Redevances" received. Source: SORIS estimate.

In the case of airframes, India is the main source of such payments.

The principal countries for aeroengines are Sweden, Italy, India, US, France and Belgium.

It was found possible to estimate outgoing technical payments, but, since very few licences were acquired[2], it would appear likely that there was an almost continuous surplus on this account over the period.

2 For helicopters and a few engine projects (e.g., Continental and Gnome).

United States

For the United States no figures are available for the technological balance of payments in the aerospace field.
In the absence of such data, it is not possible to use transfers of scientific and technical knowhow to other countries to evaluate the effect of American investment in R&D and thus to demonstrate once again the technological gap between the United States and the countries of Europe.

Nevertheless, examination of all the licence and assistance agreements concluded between American and European firms[1] gives some idea of the amount of money moving in each direction and of the exchanges which such agreements generated in favour of the United States.

Taking only the F-104G programme, carried out under American construction licence by the aerospace industries of Germany, Italy, Belgium and Netherlands, royalty payments by the four collaborating countries can be estimated at a total of $20 million (5 million for airframes and 15 million for engines).

3. SHARE OF TECHNICAL AND FINANCIAL EXCHANGES IN THE OVERALL ACTIVITY OF THE EEC AEROSPACE INDUSTRIES

The abovementioned lack of complete data on the technological balance of payments in the aeronautical sector is not the only reason why this total cannot be used satisfactorily to assess the full significance of technological exchanges and the associated transfers of money.

This balance sheet, which uses uniform data, fails to reflect

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[1] See Figs. 9-18.

the varying importance of different agreements, particularly in the matter of licences.

Any judgment concerning licences should be based on the knowledge and experience which they bring to individual firms, in each separate case, and on the effect which work under licence may have, both on the overall activity of the licence company (work load ensured, standard of output) and in relation to the latter's sub-contractors, in order to assess the overall impact on the aerospace industry of the country in which the licensee is domiciled.

We hence decided to compile for each EEC country a table setting out, for all firms in the national aerospace industry, details of the products originally turned out and of their technical and financial links with foreign and other national firms.

A number of salient features may be noted for each country.

France

All three branches (airframes, engines, missiles) turn out a wide range of home-grown products; there is a substantial amount of sub-contracting for national programmes and international cooperation in the case of airframes.

There are only a few licence agreements with American companies, mainly in the airframes branch.

Germany

There is a considerable amount of sub-contracting and work under licence, in conjunction with foreign, mainly American, firms.

Italy

There are dominant links with American firms both for sub-contracted work and licence agreements.

Belgium

There is very little home-grown production; sub-contracting and construction under licence predominate, through links with European and American firms.

Netherlands

The leading aircraft company both manufactures its own products and sub-contracts work for foreign firms; it also has various technical cooperation links.

In the case of the United Kingdom, the table shows the large number of licences granted, mainly in the engine branch.

Flow Charts of Production and Finances of EEC Aerospace Companies

by Branches, (Figs. 9-18)

Key

————————> Own production

- · - · - · > Technical collaboration

- - - (L) - > Licence

- - - - - - > Sub-contracting

═══════⇒ Financial holding

(TP) = turboprop

(TF) = turbofan

(TJ) = turbojet

(TS) = turboshaft

(PE) = piston engine

(RE) = rocket engine

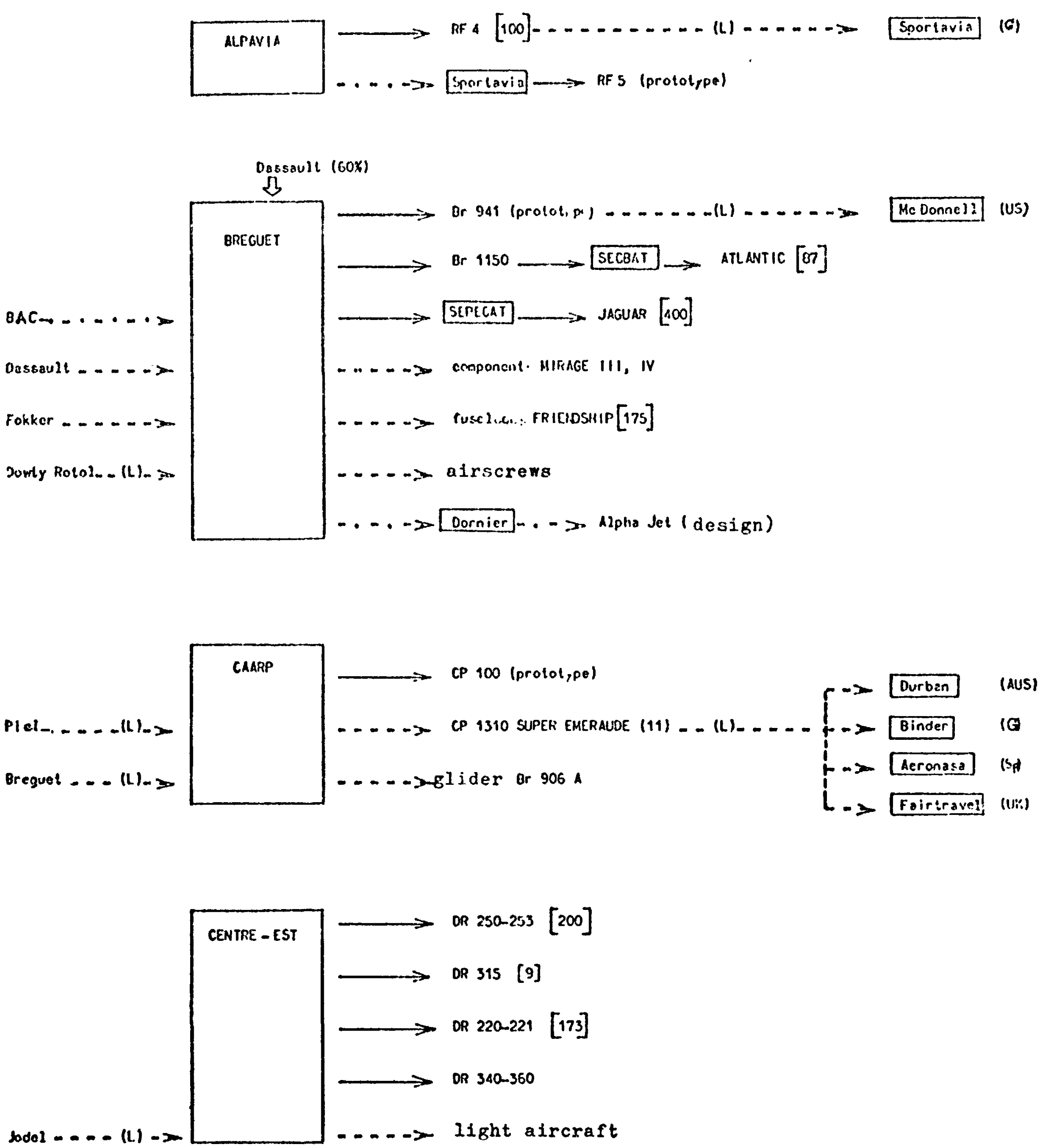
(RJ) = ramjet

[ ] = number ordered or produced

FRANCE

Airframes

FIG. 9



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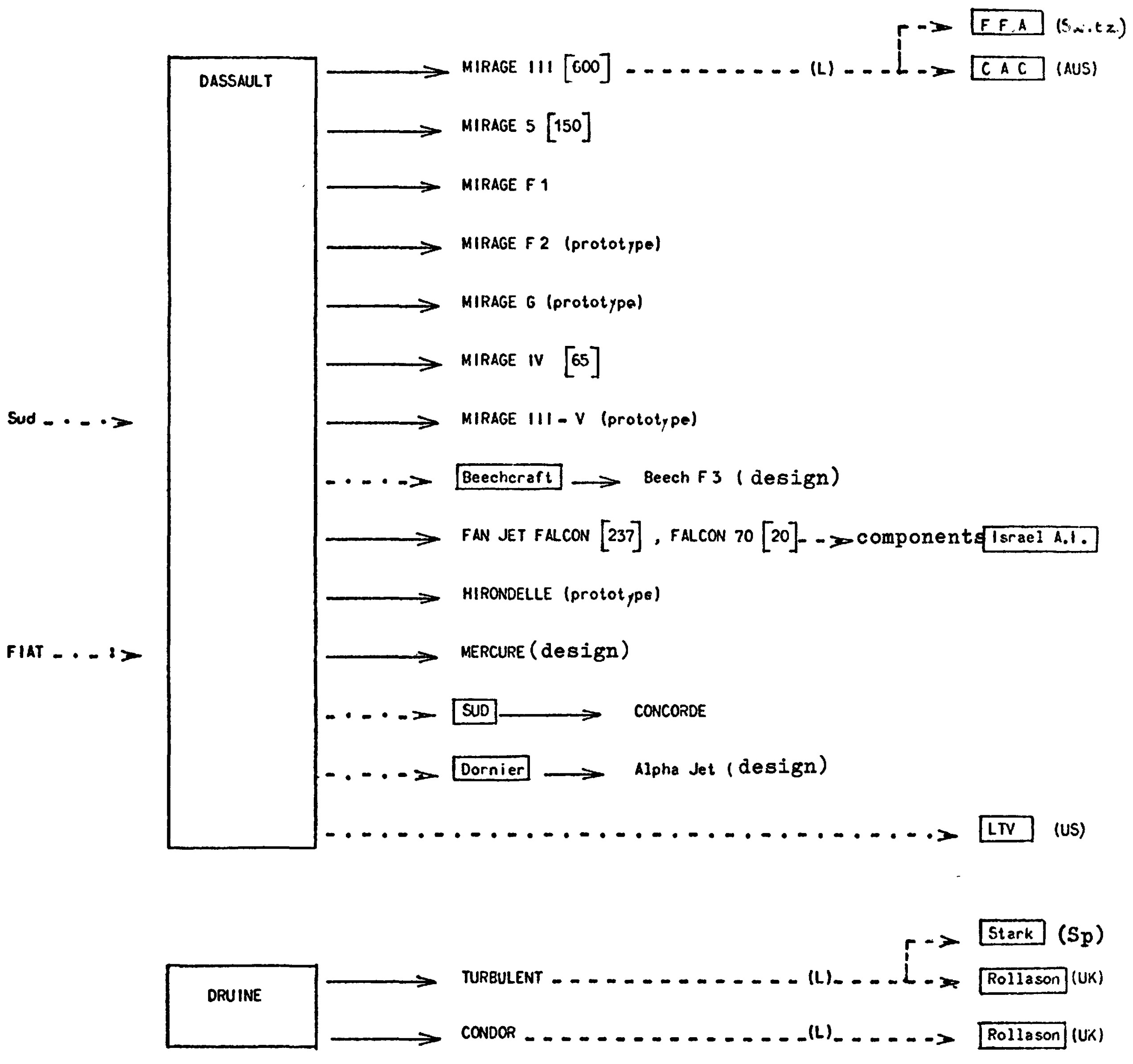

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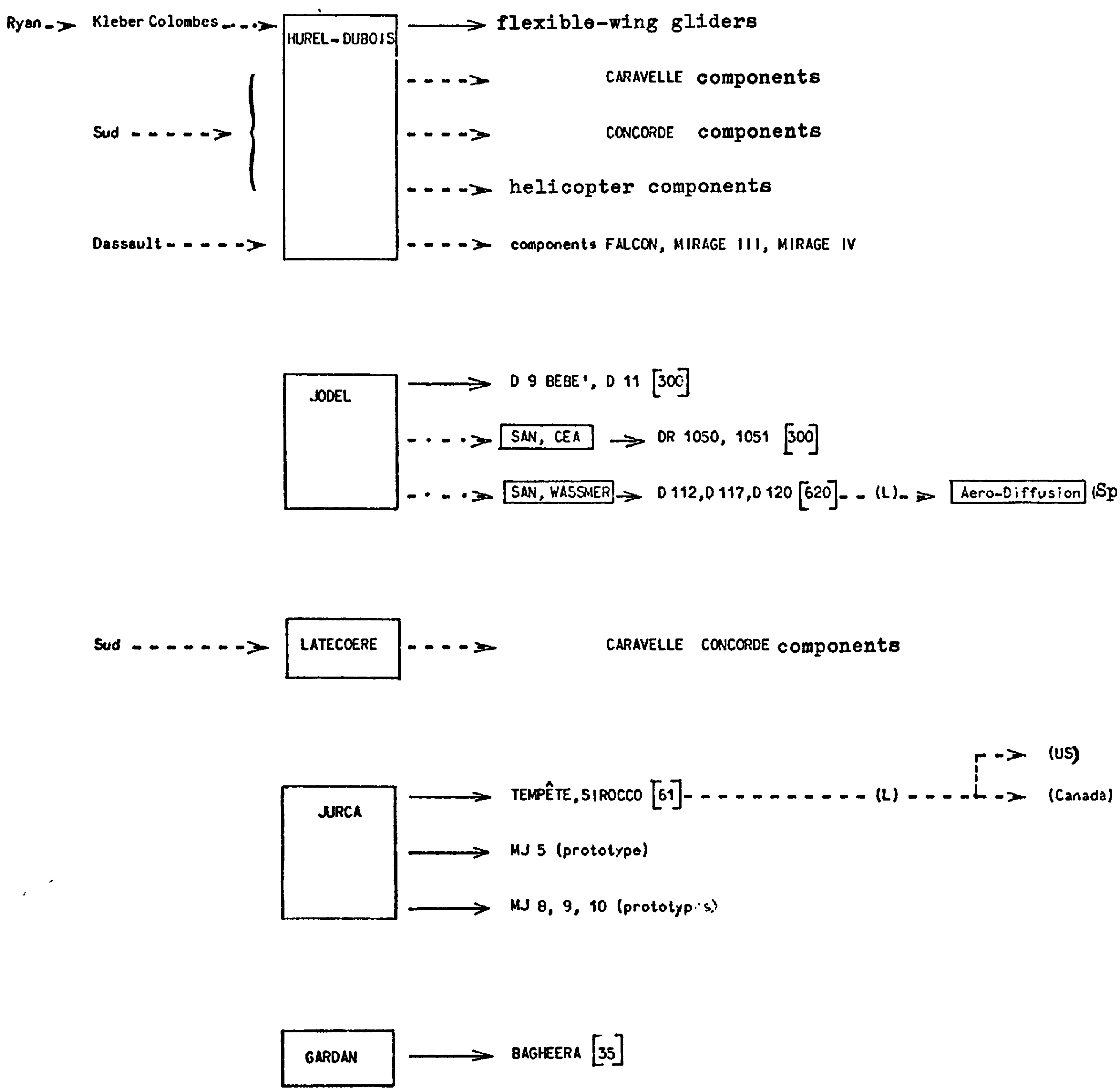

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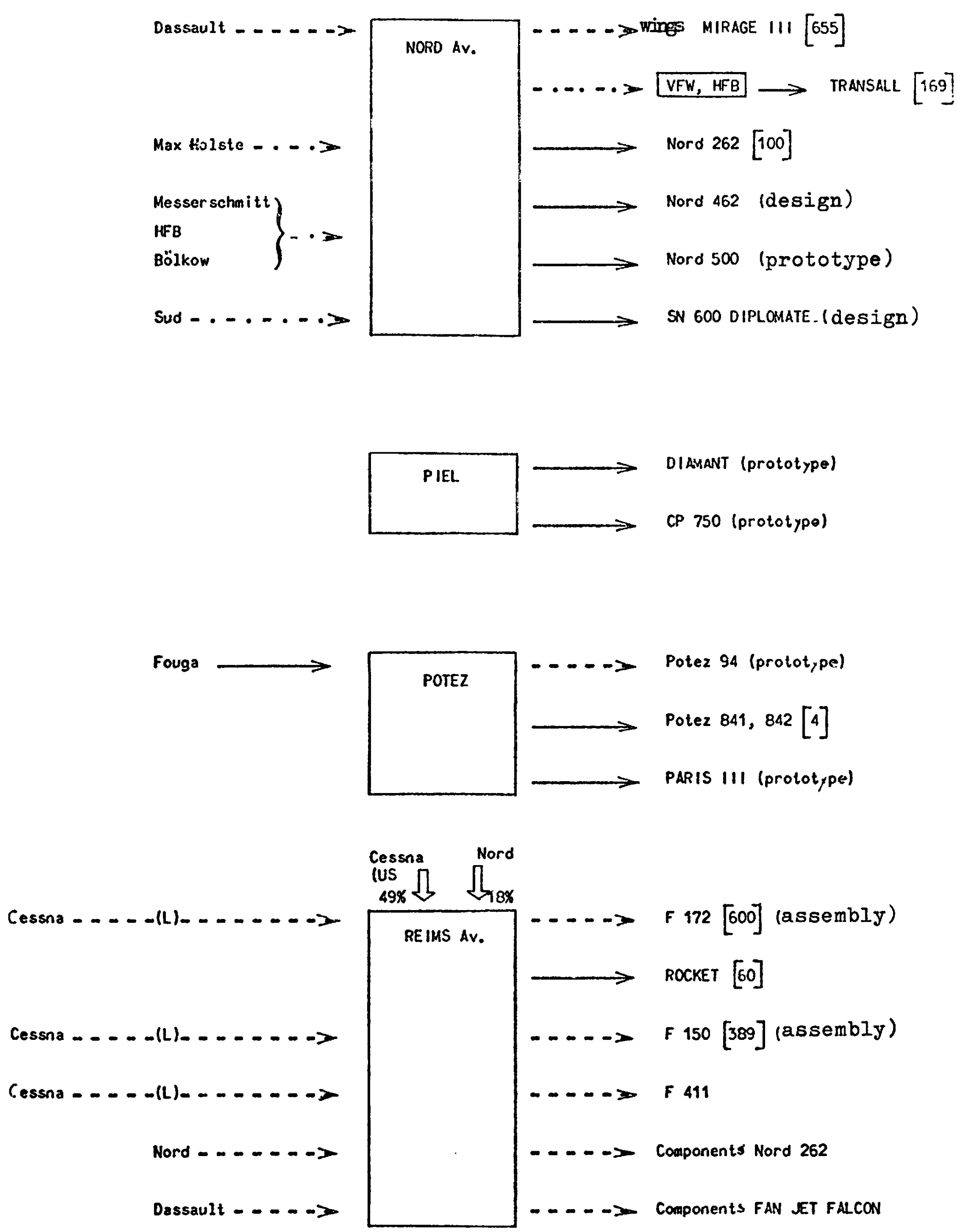

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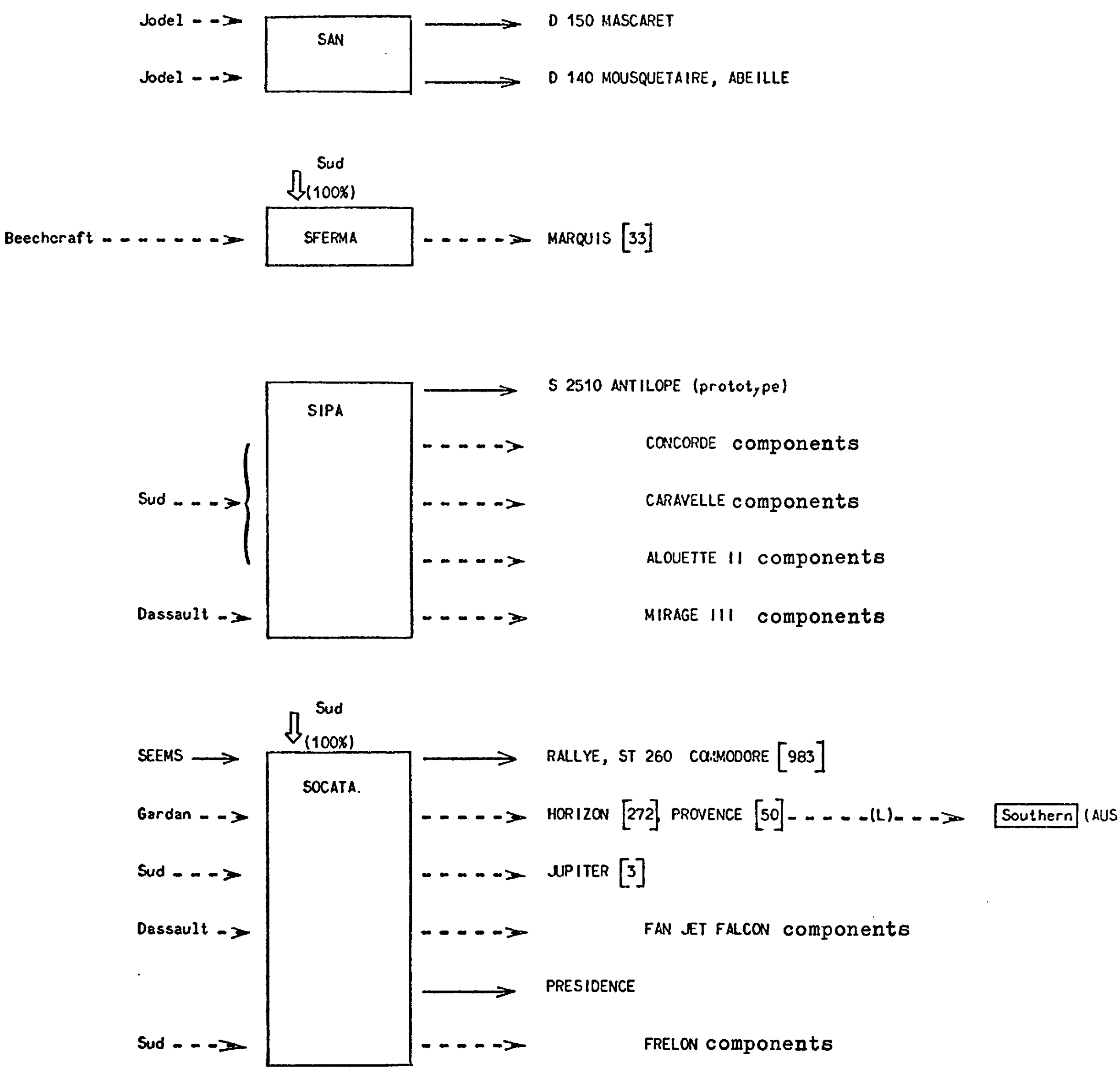

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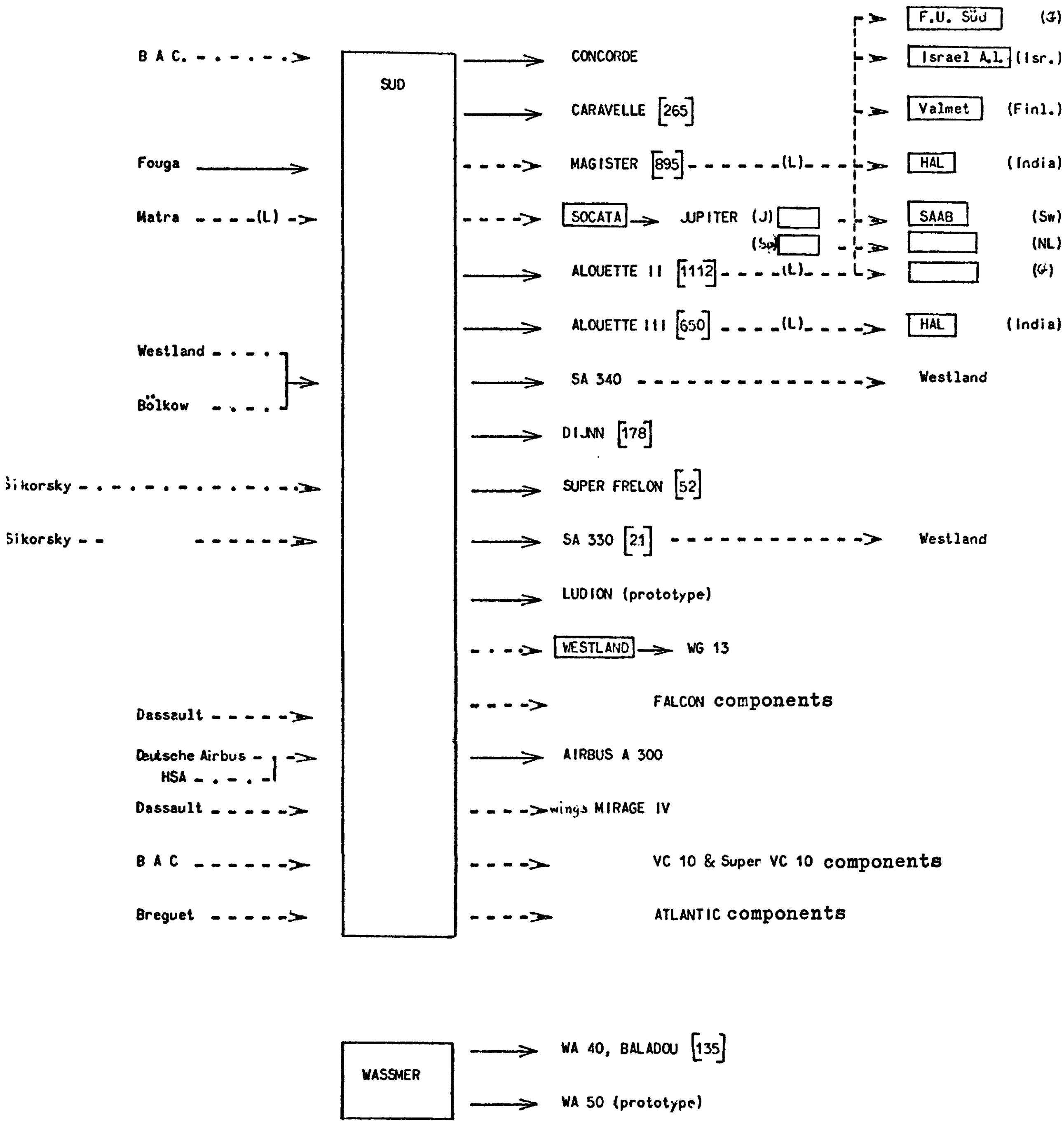
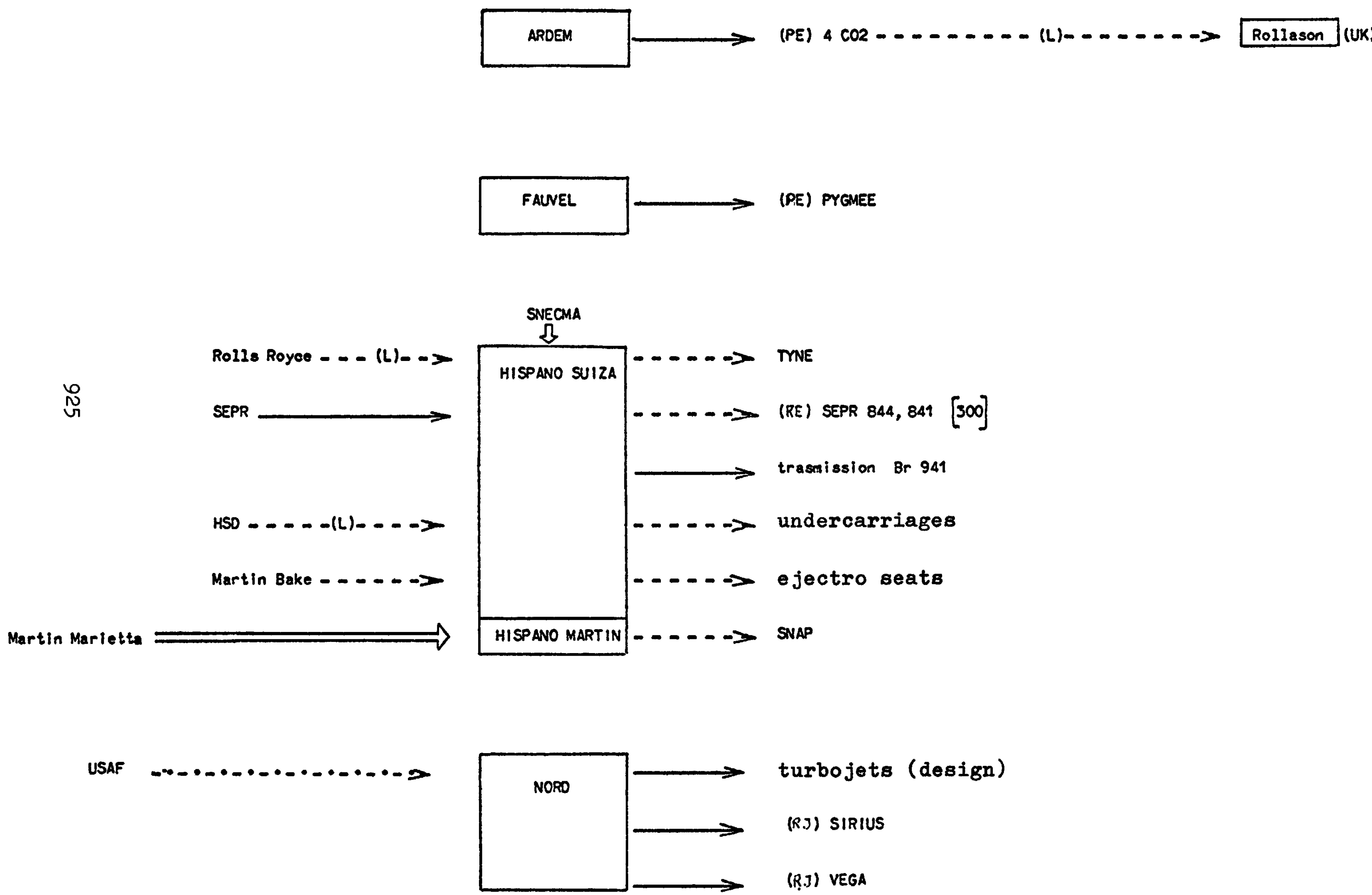


FRANCE

FIG. 10

Engines



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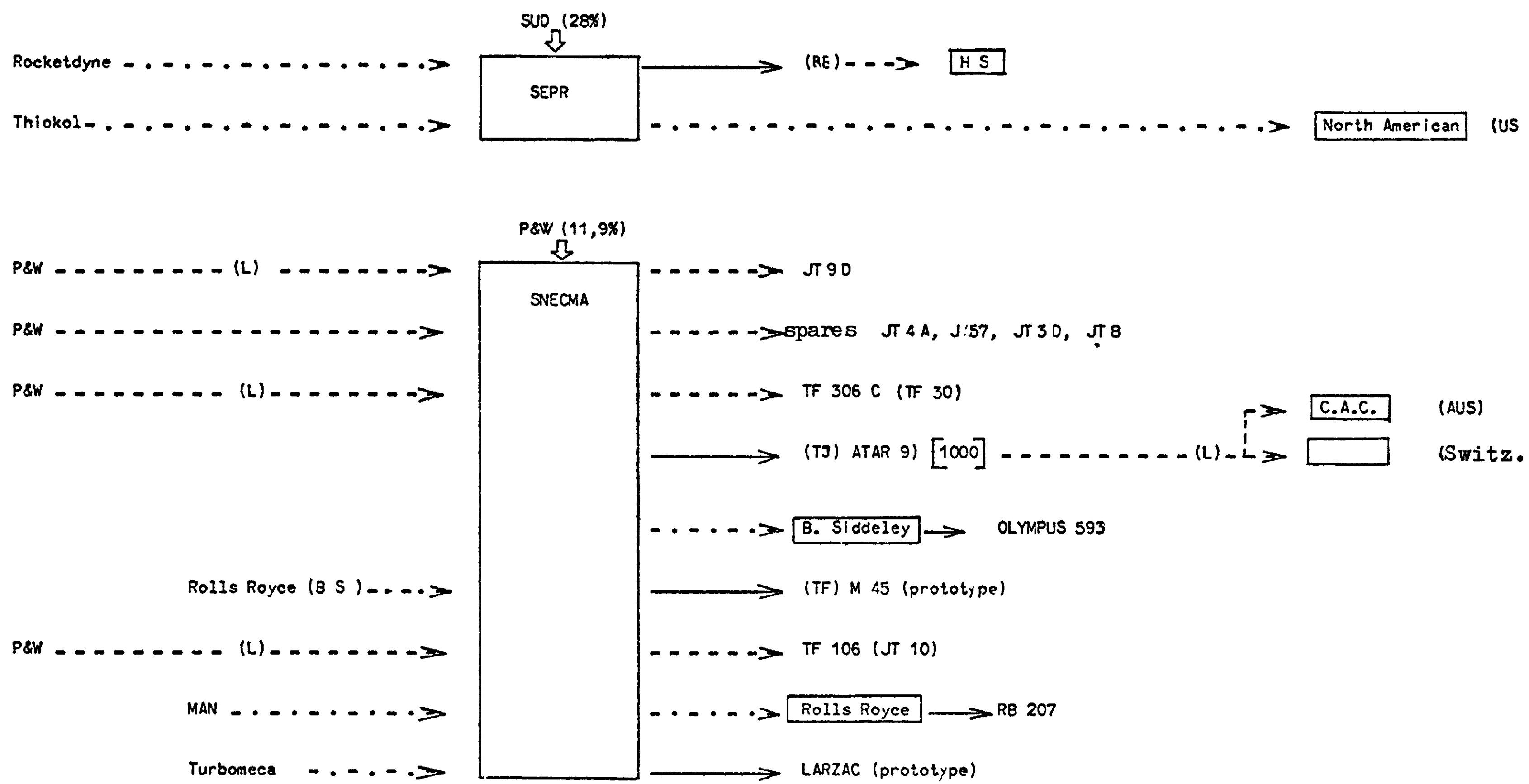

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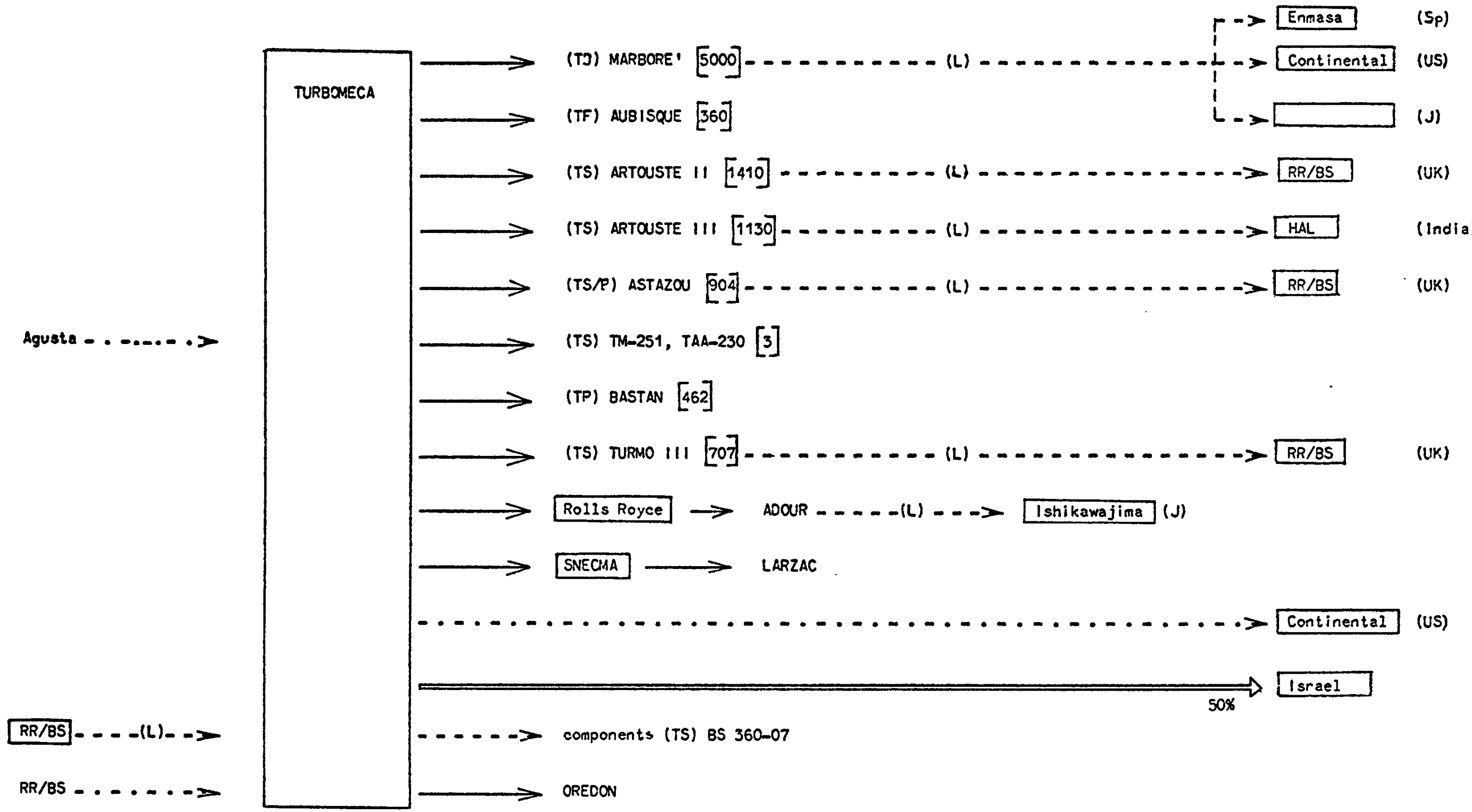
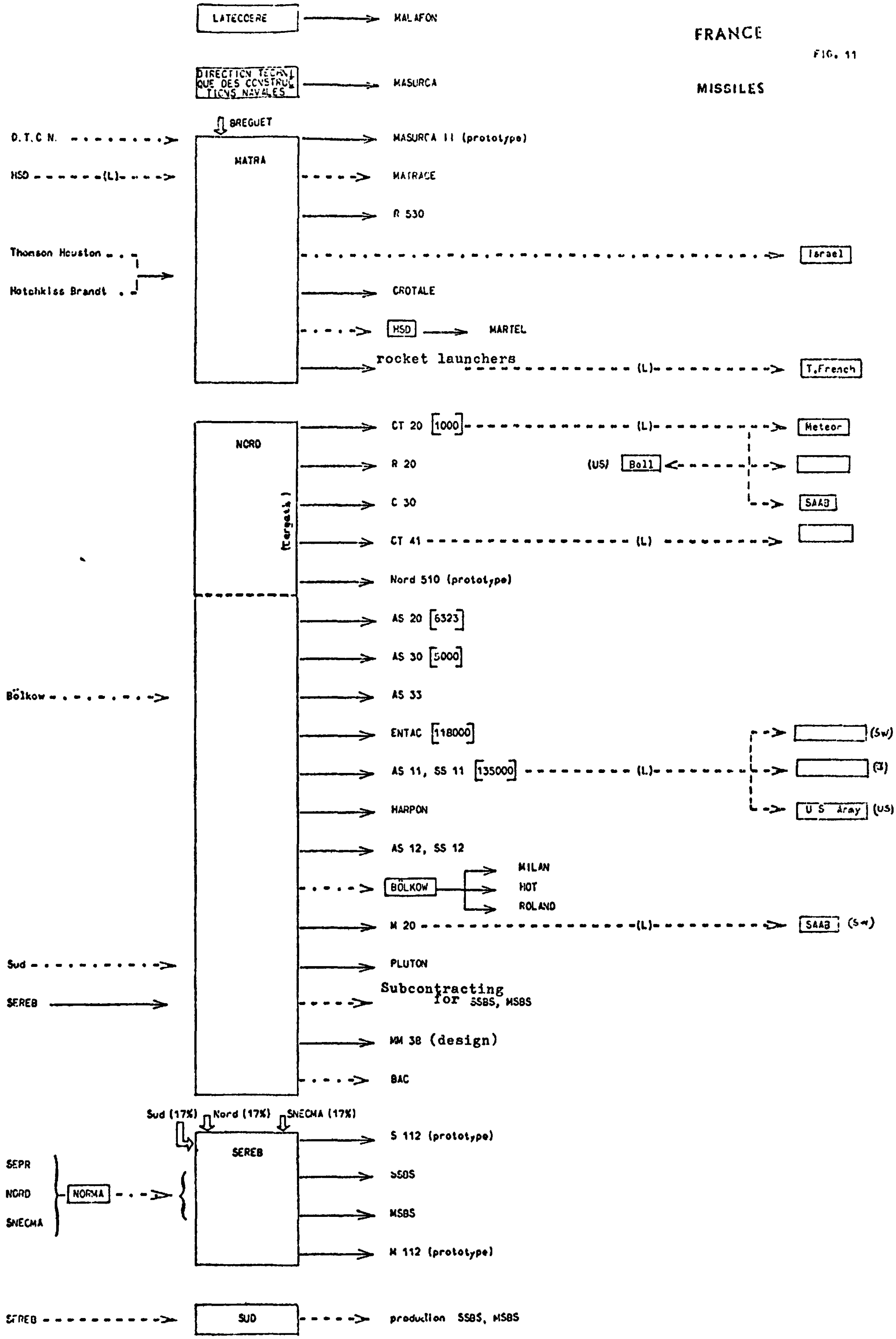
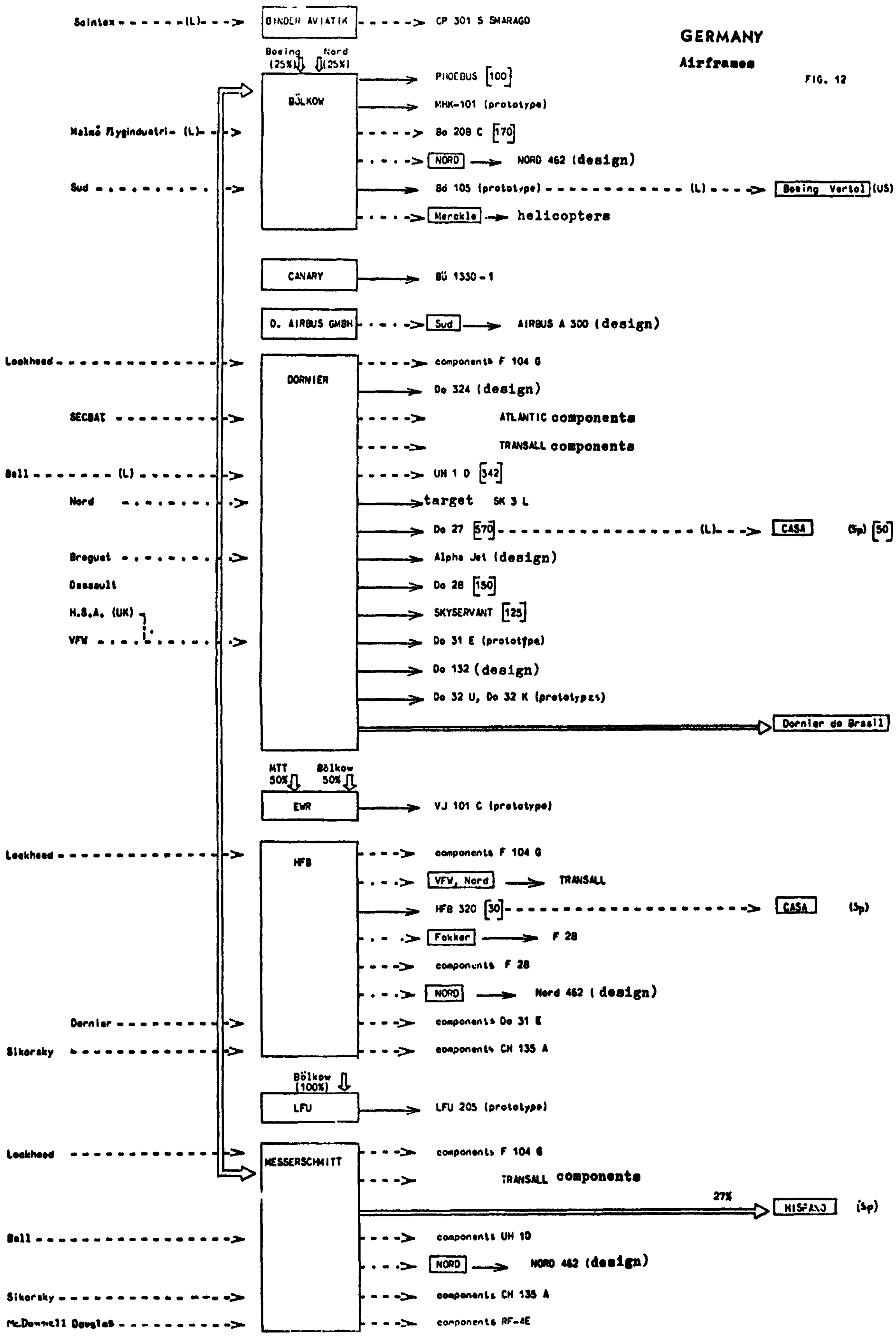


FRANCE

FIG. 11

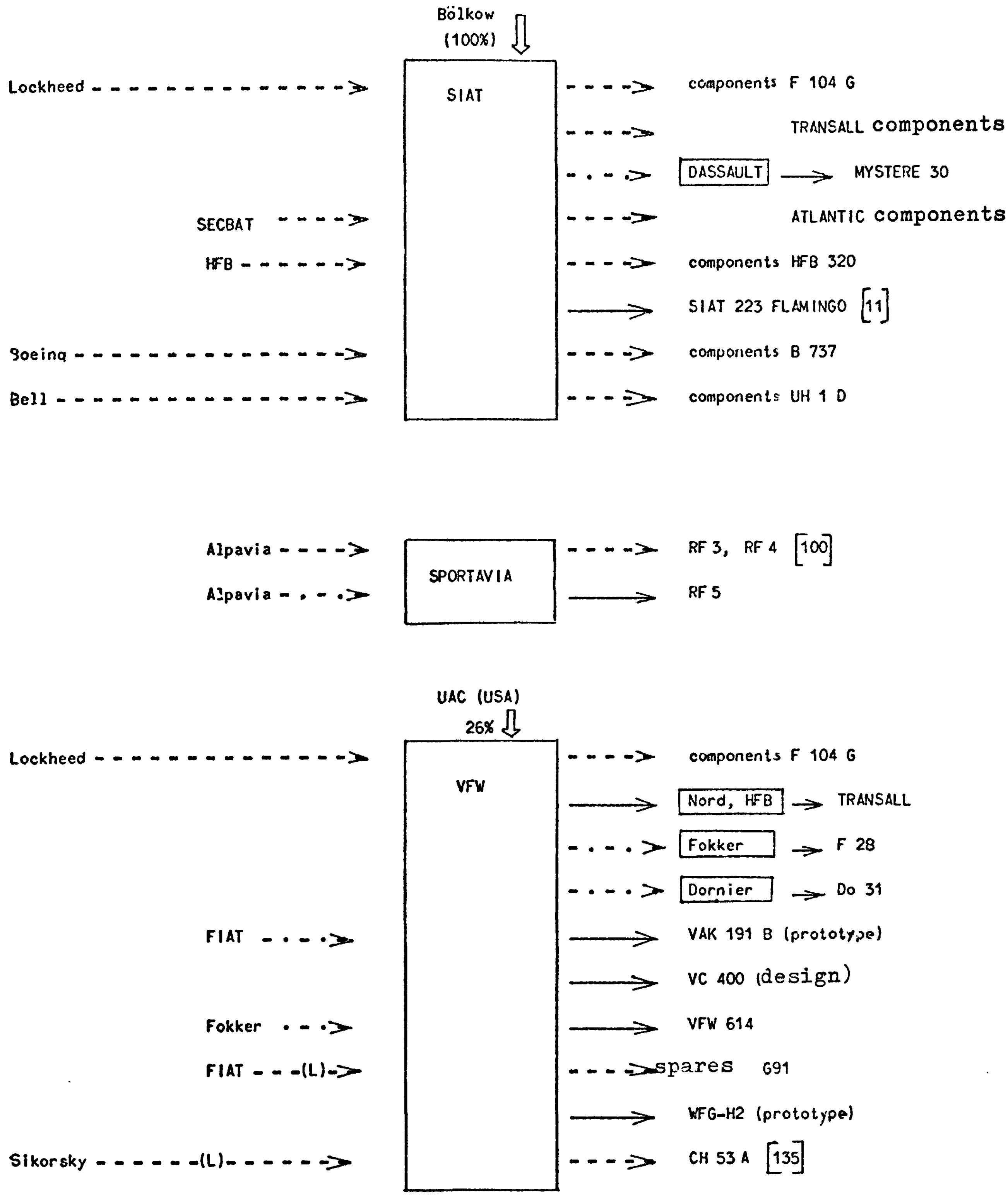
MISSILES





GERMANY
Airframes
FIG. 12
Sointex (L)
BINDER AVIATIK
CP 301 S SMARAGD
Boeing (25%)
Nord (25%)
BÖLKOW
PHOEBUS [100]
MHK-101 (prototype)
Malmö Flygindustri (L)
Bo 208 C [170]
NORD
NORD 462 (design)
Sud
Bö 105 (prototype) (L)
Boeing Vertol (US)
Merckle
helicopters
CANARY
BÜ 1330-1
D. AIRBUS GMBH
Sud
AIRBUS A 300 (design)
Lockheed
DORNIER
components F 104 G
Do 324 (design)
SECBAT
ATLANTIC components
TRANSALL components
Bell (L)
UH 1 D [342]
Nord
target SK 3 L
Do 27 [570] (L)
CASA
(Sp) [50]
Breguet
Alpha Jet (design)
Dassault
Do 28 [150]
H.S.A. (UK)
SKYSERVANT [125]
VFW
Do 31 E (prototype)
Do 132 (design)
Do 32 U, Do 32 K (prototypes)
Dornier do Brasil
MTT 50%
Bölkow 50%
EWR
VJ 101 C (prototype)
Lockheed
HFB
components F 104 G
VFW, Nord
TRANSALL
HFB 320 [30]
CASA
(Sp)
Fokker
F 28
components F 28
NORD
Nord 462 (design)
Dornier
components Do 31 E
Sikorsky
components CH 135 A
Bölkow (100%)
LFU
LFU 205 (prototype)
Lockheed
MESSERSCHMITT
components F 104 G
TRANSALL components
27%
HISPANO
(Sp)
Bell
components UH 1D
NORD
NORD 462 (design)
Sikorsky
components CH 135 A
McDonnell Douglas
components RF-4E

Fig. 12 continued



GERMANY

Engines

FIG. 13

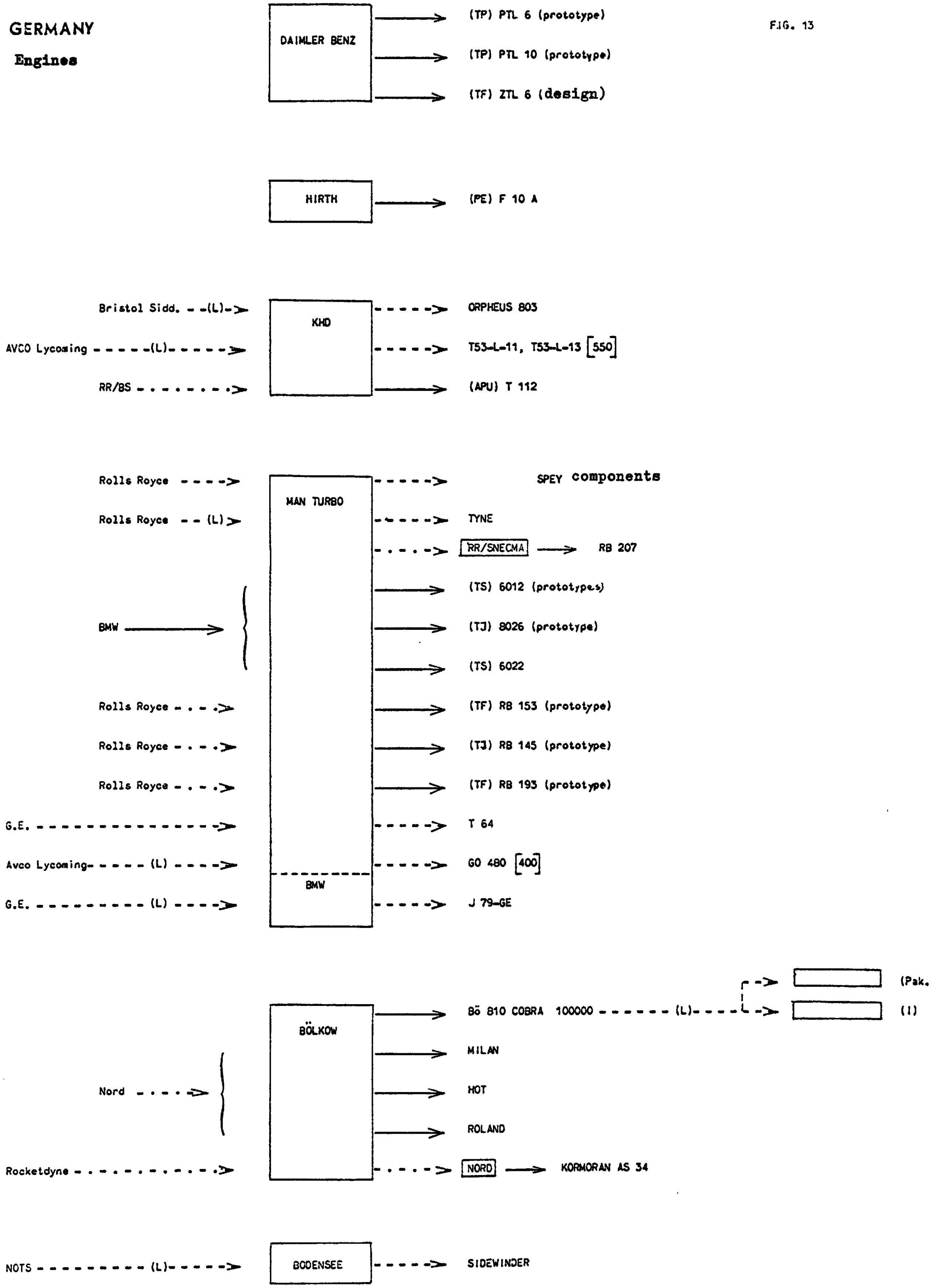


FIG. 14

ITALY

Airframes

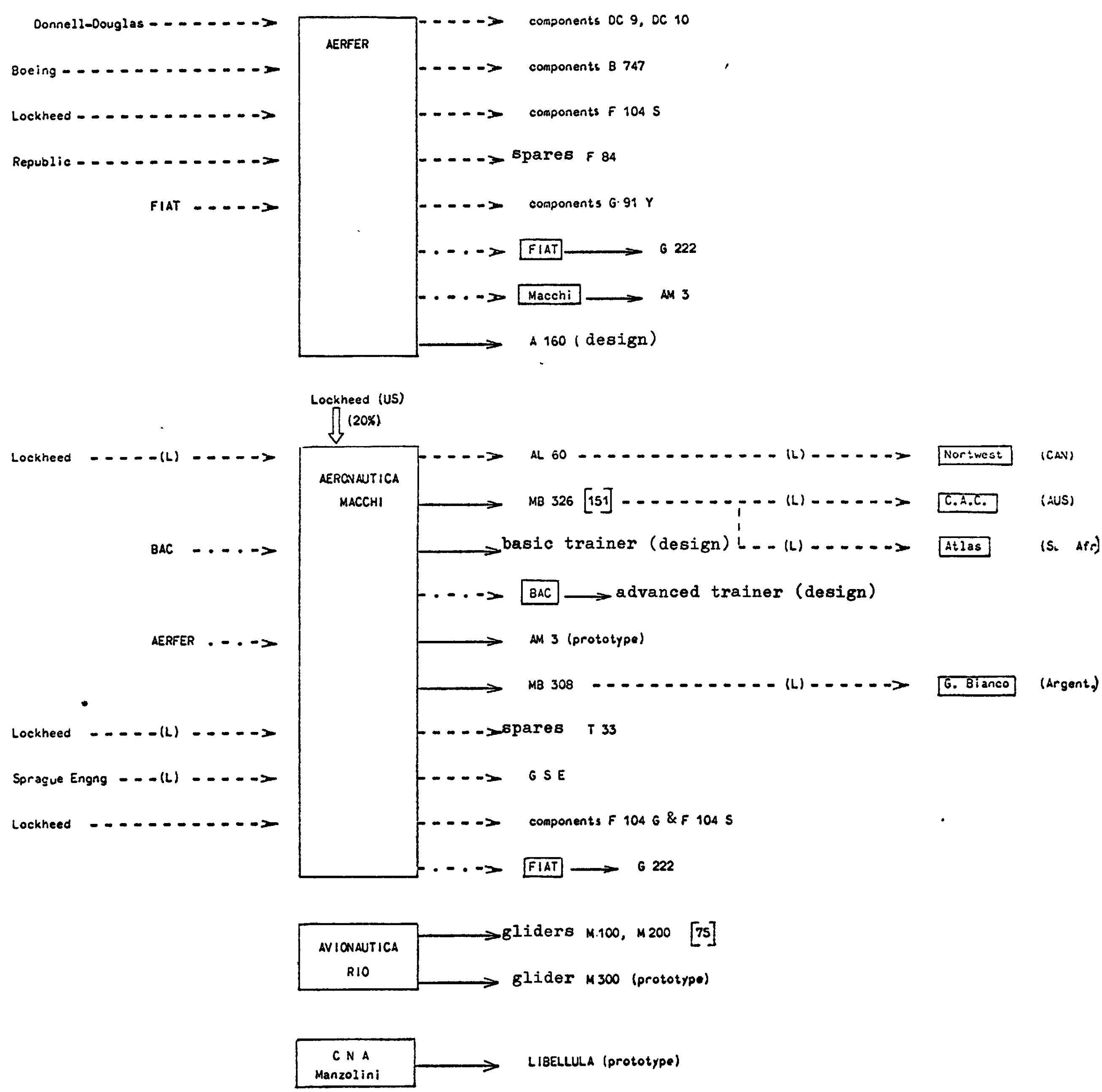


Fig. 14 continued

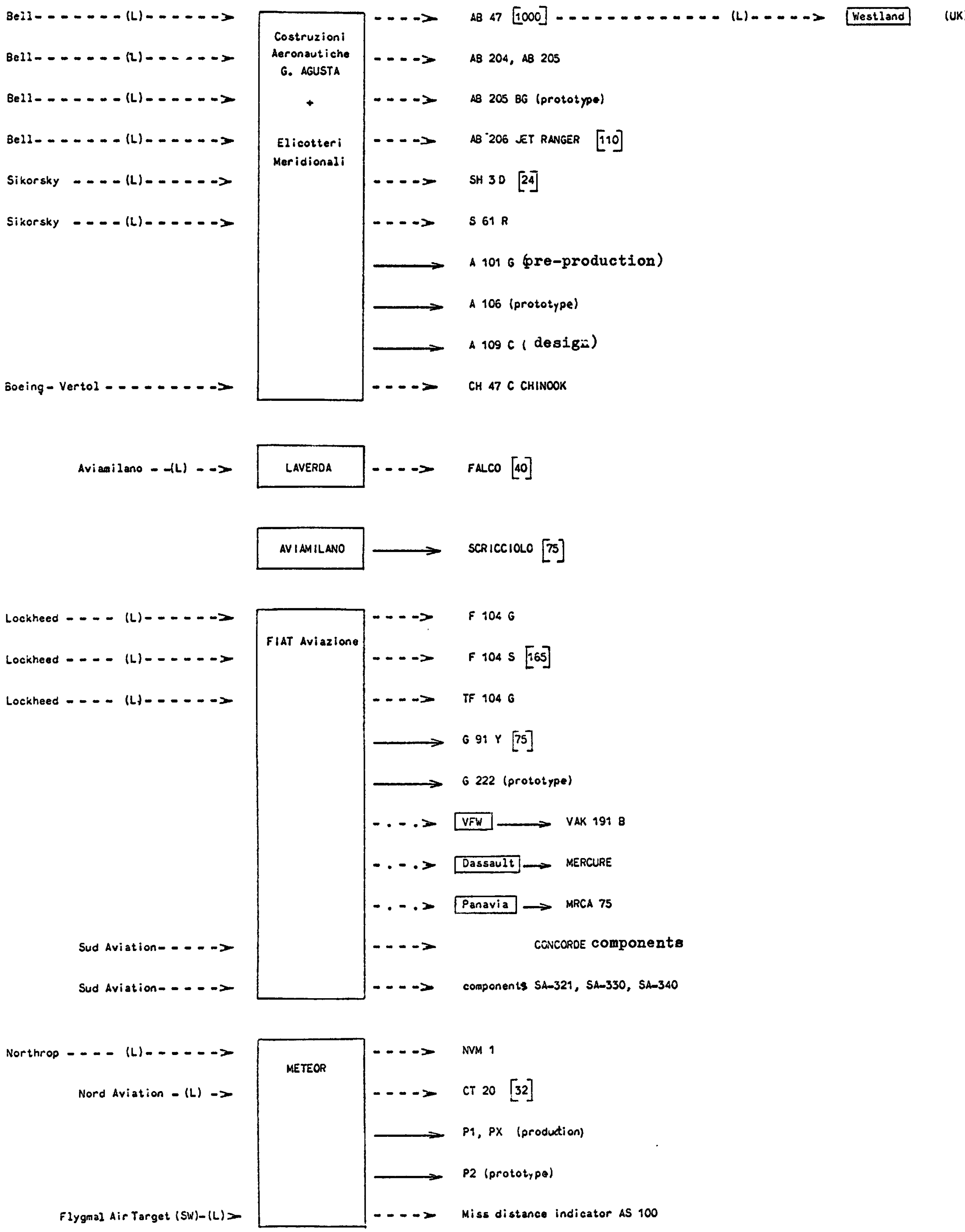
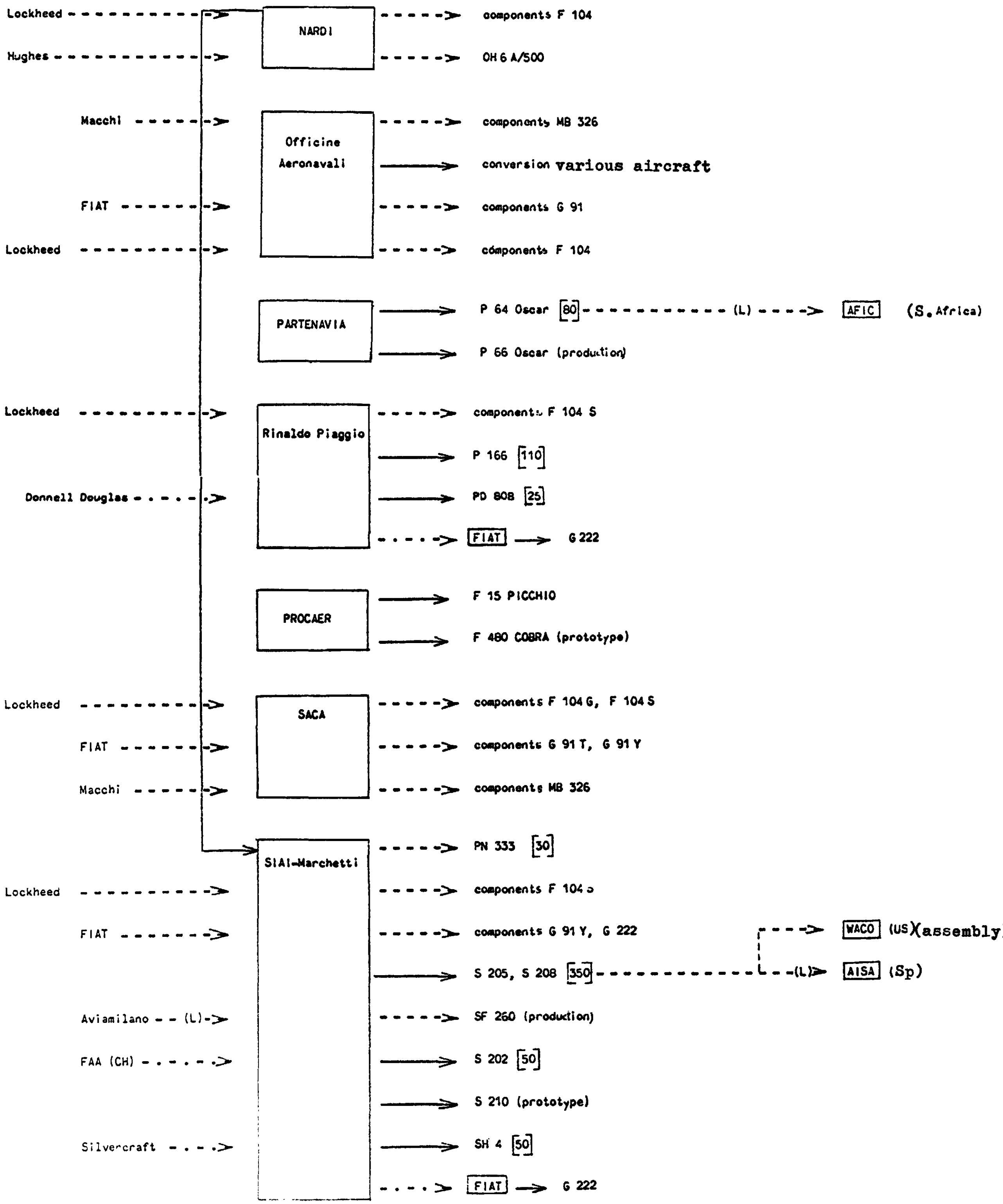


Fig. 14 continued



ITALY

Engines

FIG 15

General Electric	---->	ALFA ROMEO	---->	components J79-GE-11A & J79-GE-19
General Electric (L)	---->	ALFA ROMEO	---->	J85-GE-13
Rolls Royce (B.S.)	---->	ALFA ROMEO	---->	GNOME components
Rolls Royce (B.S.)	---->	ALFA ROMEO	---->	DART components
General Electric (L)	---->	ALFA ROMEO	---->	T58-GE-10

Turbomeca	-·-·->	AGUSTA	---->	TM-251
Turbomeca	-·-·->	AGUSTA	---->	TAA-230
		AGUSTA	——>	(PE) GA 40/A 140

General Electric (L)	---->	FIAT	---->	J79-GE-11A
General Electric (L)	---->	FIAT	---->	J79-GE-19
General Electric	---->	FIAT	---->	components J85-GE-13
Rolls Royce (B.S.) - (L)	>	FIAT	---->	ORPHEUS 803
Rolls Royce (B.S.)	---->	FIAT	---->	components
Curtiss Wright	---->	FIAT	---->	components J65
		FIAT	-·-·->	$\boxed{RR}$ ——> Viper 600

Rolls Royce (B.S.) - (L)	>	PIAGGIO	---->	VIPER 11
AVCO-Lycoming (L)	---->	PIAGGIO	---->	VO.435, GSO.480
AVCO-Lycoming (L)	---->	PIAGGIO	---->	T53-L-11 & T53-L-13
General Electric	---->	PIAGGIO	---->	components J85-GE-13

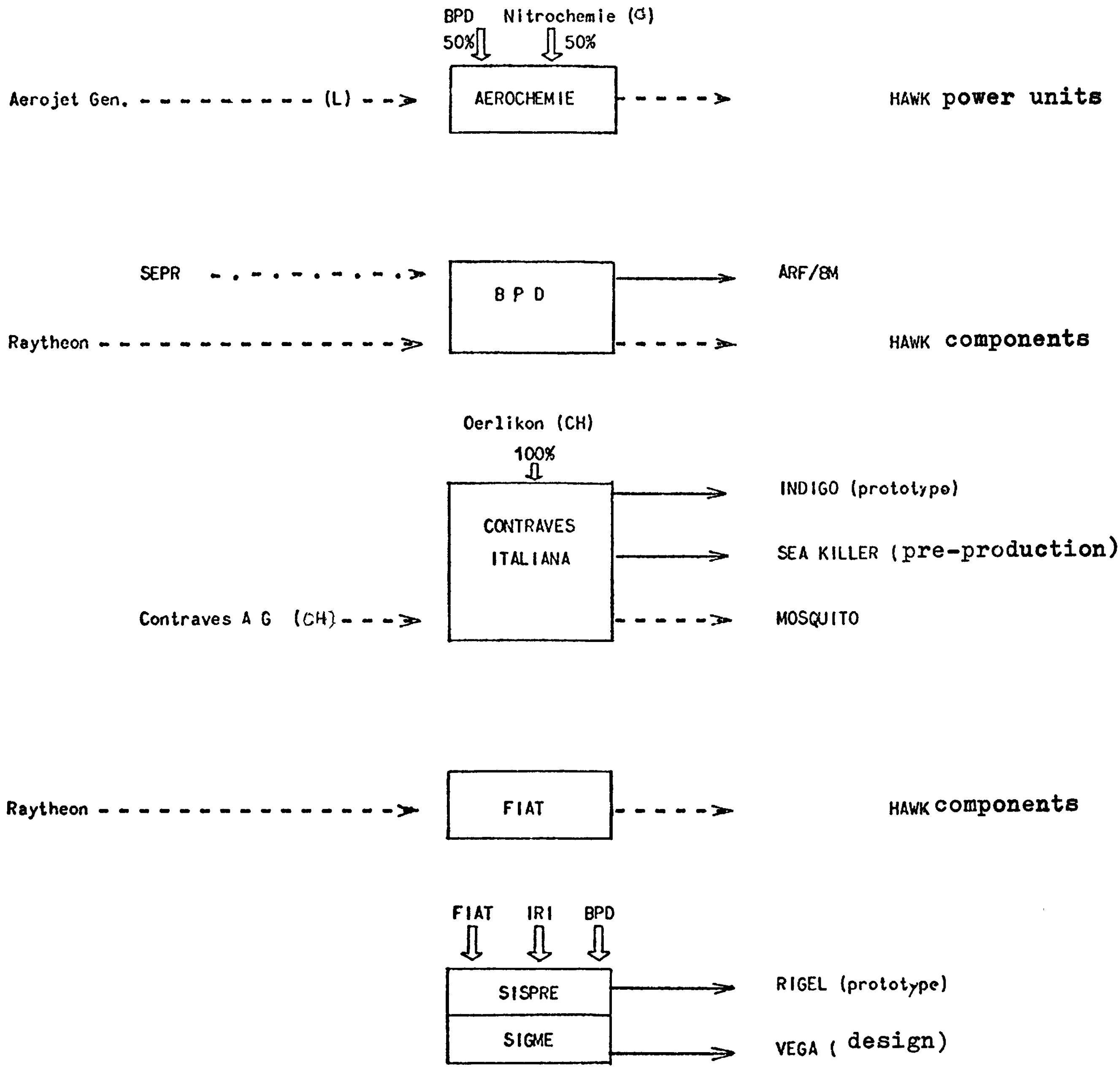
Turbomeca	---->	SACA	---->	components MARBORE , ARTOUSTE, PALOUSTE
General Electric	---->	SACA	---->	components J79-GE-19
General Electric	---->	SACA	---->	components J85-GE-13

		METEOR	——>	(PE) ALFA

ITALY

FIG 16

MISSILES



BELGIUM

FIG 17

Airframes

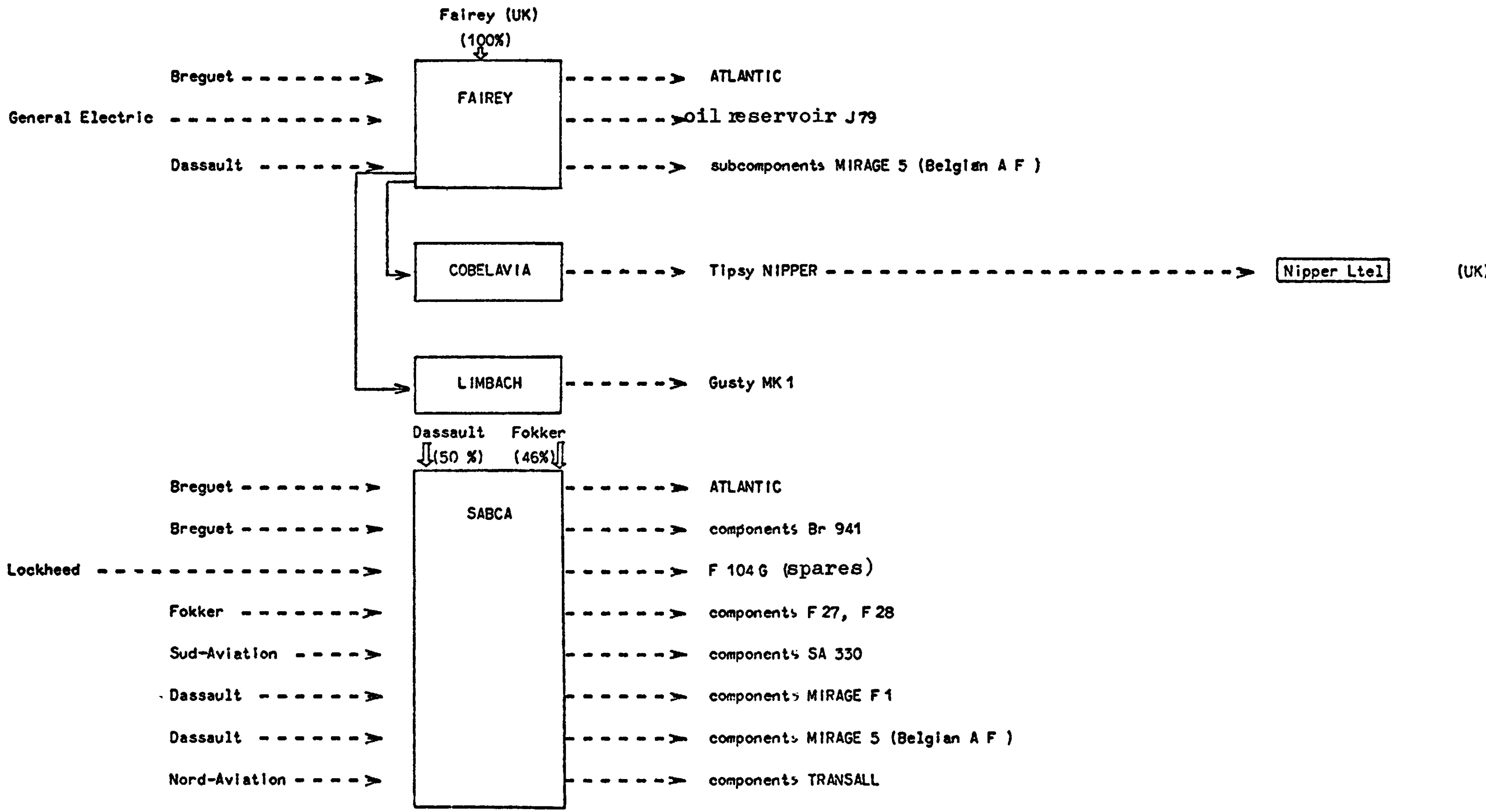
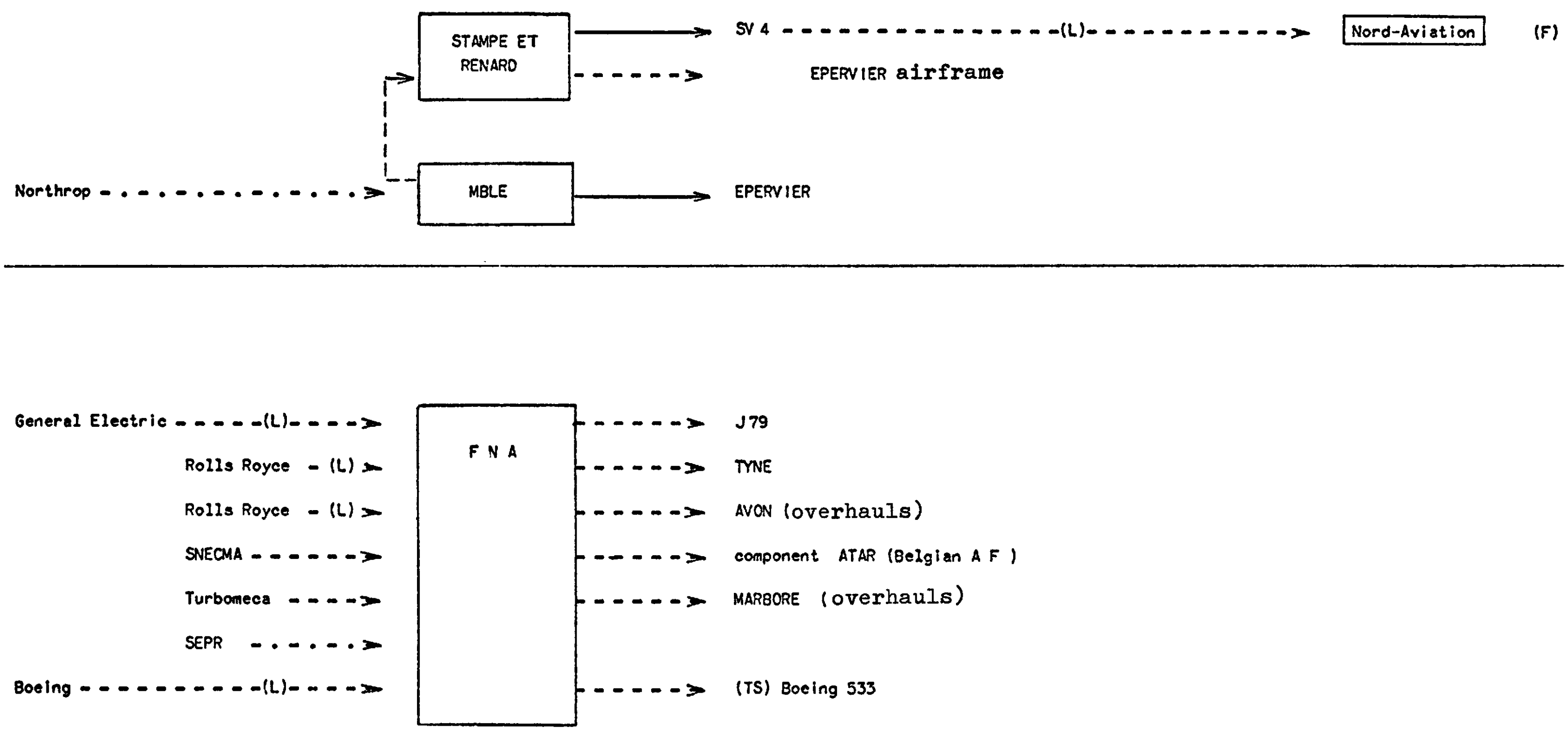
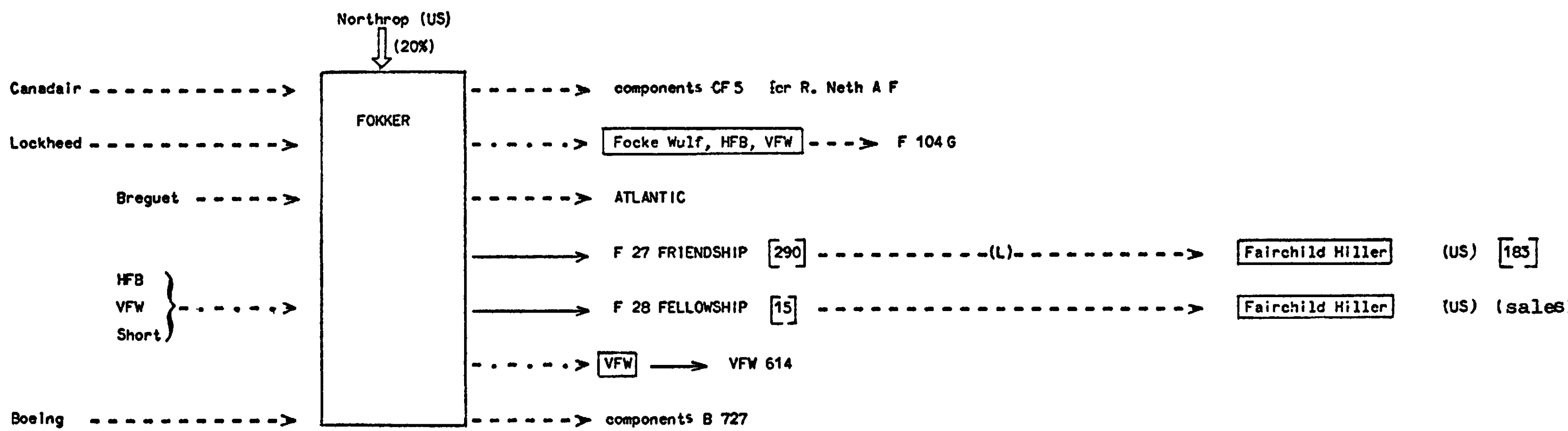


Fig. 17 continued



NETHERLANDS (before FOKKER-VFW merger) FIG 18

Airframes



United Kingdom - Main Licences Granted and Acquired

Licences granted		Licences acquired	
Project and branch	Country	Project and branch	Country
Airframes		**Helicopters**	
HS 748	INDIA	AB 47	ITALY
HUSKY	PORTUGAL	S 55	US
GNAT	INDIA	SH R D	US
		Stiff-hinged rotor	GERMANY
Engines			
AVON	SWEDEN	**Engines**	
	BELGIUM	ARTOUSTE	FRANCE
DART	INDIA	CONTINENTAL	US
HERCULES	FRANCE	GNOME	US
GNOME	ITALY	PALAS	FRANCE
ORPHEUS	GERMANY	PALOUSTE	FRANCE
	ITALY	TURMO	FRANCE
TYNE	BELGIUM		
	FRANCE		
	GERMANY	**Missiles**	
VIPER	ITALY	CT 20	FRANCE
	JUGOSLAVIA	CT 41	FRANCE
Missiles			
BULLPUP	NORWAY		
	TURKEY		

CHAPTER 5

The role of the aerospace industry in the economy

1. INTRODUCTION

In view of the very large amount of advanced technology involved in the aerospace industry and the extent to which it depends on other branches (engineering, metal-working, chemicals, electronics, etc.), any country or group of countries seeking to carry out major research and production programmes in the aerospace must at the same time consider the problem of raising standards to the highest possible level in all branches, and thus stimulating research and development over a large part of industry as a whole.

This process of stimulating a large number of branches (the aerospace sector is tied up with most branches of industry) takes place by direct or indirect transfer.

It is direct when scientific and technological work is provided or created for subsidiary branches and indirect when investment in aerospace research generates a very large number of new products and processes which will have a marked influence on markets and branches not necessarily linked with the aerospace industry.

In this chapter an attempt is made to carry out a qualitative assessment of the repercussions of aerospace activity. The only way to demonstrate the technical stimulus given to the various branches of industry is to use examples from American experience, just as reference must be made to the United States when considering the more general effects of aerospace activity on the economy and society as a whole.

Only in the United States has the effort been sufficient to produce measurable results; and it is only in certain branches and sectors of American development work that these results have produced qualitative changes entitling the direct and indirect effects of aerospace activity to be regarded as one of the decisive elements in the present gap between the United States and the rest of the world.

Furthermore, as the patterns of economic and social development in the United States and Europe are comparable, observations relating to the former may be used to arrive at valid conclusions for the latter.

The massive support given to research in the US, and the determination to pursue the most advanced technical objectives, are no casual choice, nor are they dictated solely by power strategies.

The problem first had to be faced many years ago, with reference to research for national defence; it was necessary to determine the probable effect of massive government support for studies and research and the extent to which the use of public funds was warranted. The positive outcome of this study long ago convinced the American authorities of the significance of government backing for studies, research and development with respect to the progress of the United States, and decided them to act accordingly.

The European governments have as yet no such clear conception of the importance of government support for major research and development.

Realization of the interdependence here discussed may perhaps convince them of the need for a continuous, purposful effort to narrow, if not completely close, the present gap between the United States and Europe.

2. TECHNOLOGICAL FALLOUT

Aerospace activity can produce six different types of effects, occurring jointly or separately:

1. Stimulation of basic or applied research.
2. Development of new processes and technologies.
3. Improvement of existing products (quality and reliability).
4. Increased availability of new materials, laboratories, experimental equipment, etc.
5. Development of new products.
6. Reduction of the costs of technology-intensive products (e.g., integrated circuits, etc.).

These effects may be regarded as constituting the general impact of aerospace activity on the whole of industrial activity.

In addition, they have a varying specific impact on individual products and problems, as is illustrated by Fig. 1.

This table shows the branches of industry and the fields of activity in which the effects produced by aerospace activity have been, or will be, the greatest.

They are:

(a) medicine and biology;

(b) electronics and electricity;

(c) mechanical engineering and materials;

(d) chemicals and propulsive systems;

(e) management techniques.

Spin-Off from Missile and Space Programmes

FIG. 1

Branch	Principal types of contribution identified						Apparent extent of contribution			Secondary contributions identified		
	Stimulus to basic or applied research	Development of new processes & technologies	Development of existing products	Increased availability of materials & equipment	Development of new products	Reduction in cost	Major	Moderate	Slight	Yes	Slight only	Only potential commercial importance
Instruments												
Electrical strain gauges	x		x	x	x			x		x		
Infrared instruments						x		x		x		
Pressure gauges	x			x	x			x				x
Temperature gauges			x		x			x		x		
Amplifiers for measuring instr.	x		x	x					x			x
Electronic components & various systems												
Semiconductors	x		x		x	x		x		x		
Microelectronics	x					x	x				x	
Thermoelectric coolers			x						x		x	
Connectors, cables, printed circuits			x					x		x		
Visualizers					x			x		x		
Control systems												
Inertial guidance	x						x			x		
Electronic data-processors	x		x		x			x		x		
Sources of energy												
Solar batteries	x					x		x		x		
Thermoelectric & thermionic converters	x						x			x	x	
Fuel cells	x							x				x
Magnetohydrodynamics	x						x					x
Propulsion												
Cryogenic systems	x			x		x		x		x		
Fluid transfer systems			x	x		x		x		x		

FIG. 1 continued

Spin-Off from Missile and Space Programmes

Branch	Principal types of contribution identified						Apparent extent of contribution			Secondary contributions identified		
	Stimulus to basic or applied research	Development of new processes & technologies	Development of existing products	Increased availability of materials & equipment	Development of new products	Reduction in cost	Major	Moderate	Slight	Yes	Slight only	Only potential commercial importance
Manufacturing methods												
Twisted fibres	x	x					x			x		
Chemical milling	x	x					x			x		
High-energy moulding	x	x					x				x	
Solid-state bonding materials	x	x					x				x	
Materials												
Refractory metals	x						x					x
Maraging steels	x								x			x
Physical metallurgy	x						NA			NA		
Superalloys	x								x			x
Epoxy resins					x				x	x		
Medical technology	x	x			x				x		x	
Re-entry simulation - Plasma jet	x				x		x			x		
Telemetering and Telecommunications	x		x					x		x		
Vibration tests	x	x	x					x			x	
Packaging and Despatching					x			x		x		
PERT		x					x				x	

Source: J.G. WELLES: THE COMMERCIAL APPLICATION OF MISSILE/SPACE TECHNOLOGY (DENVER, COLORADO, UNIVERSITY OF DENVER RESEARCH INSTITUTE, 1963).

2.1 Medicine and Biology

Astronauts on space flights are kept under continuous clinical observation and the data recorded are transmitted by remote control to ground stations.

When this system, i.e., the remote transmission of clinical data, has been introduced in hospitals, it will become possible to keep patients under observation from a single centre and to follow all critical changes in condition much more efficiently and quickly than hitherto.

Another, and equally important factor in this development process will be a reduction in hospital staffs, which will be of great significance in view of the ever-increasing difficulty of recruiting trained personnel.

New diagnostic possibilities are offered by miniaturized captive probes which can transmit information from inside the organs under observation.
The degree of miniaturization achieved with such apparatus is one result of space activities and opens up spectacular therapeutic prospects in all directions, but more especially in the field of cardiac stimulation, where the insertion of such devices into the thoracic cavity was virtually inconceivable without reliable and durable micro-batteries and miniature components.

The highly exacting demands of space flight have also involved the use of highly sophisticated personality tests. The same methods will find applications in many other sectors, more especially those where the safety and lives of other people may depend on optimum selection of operators.

2.2 Electronics and Electricity

Electronics and electricity have played a most important part in the growth of space activities. The guidance of space vehicles into the correct orbit, the on-board power supply and communications with ground stations would all have been impossible without all the amazing progress which has been made in these fields.

In return, however, space programmes have given, and are giving, an enormous impetus to fresh developments in electronics and the production of energy. Many such indirect effects can be mentioned the most important being:

(a) <u>Reliability</u>

Electronic equipment aboard space vehicles cannot be adjusted or serviced during a mission and must be capable of functioning perfectly and continuously for periods which can run into several years in the case of meteorological and communication satellites.

This requirement has enormously increased the reliability of components and manufacturers have had to undertake advanced research on production technique and processes, the improvement of materials, inspection methods, etc.

The high reliability thus achieved is finding, and will continue to find, many more important applications in other fields, such as computers, automation, remote control, etc.

(b) <u>Microelectronics</u>

The complexity of electronics systems continues to increase steadily:

- in 1945 there were 400 electronic valves in a complex ground aid set
- in 1958, it contained 4,000 transistors

- in 1965, this had expanded to 40,000 active components.

This growing complexity has been made possible by the development of microelectronics, with techniques offering a combination of greater reliability, smaller size, lower consumption and falling costs. Integrated circuits, which are of vital importance from the standpoint of both industrial applications (computers, etc.) and consumer durables, are basically attributable to the requirements of aerospace progress and will find increasingly advanced applications in more and more fields, with sensational improvements in the progress made in the electroncis industry.

The process of miniaturization is bound to continue and one authoritative American source (Standard and Poor's Compendium of American Industry) states, with reference to molecular circuits, which are today regarded as the last stage in this process: " ... the estimated possible packing density for such circuits is $5 \cdot 10^{12}$ parts per cubic foot as compared with $5 \cdot 10^{11}$ for the human brain .."

The degree of sensitivity now required of guidance and ground monitoring apparatus, which goes far beyond that of standard types, opens the way to the general adoption of a very wide range of electronic techniques in the immediate future.

The same applies to telemetry and data transmission and processing.

(c) Sources of electrical energy

Normal terrestrial sources of electricity cannot, of course, be used in space. As a result, advanced research has been devoted to the development of new sources. Examples include research and development work on the conversion of solar energy, new applications for atomic energy, and the production of electricity from chemical sources by using fuel cells.

Most existing space vehicles are powered by solar energy converted into electricity by means of photo-electric cells.

Research is being conducted with the aim of capturing and concentrating solar energy on thermodynamic or thermionic converters.

Radioisotopes can be used to obtain nuclear power, ranging from a few watts to several hundred. This new technology can be used to build small automatic generating stations for all types of ground installation in inaccessible areas.

Fuel cells, which are already used for space missions, are now suitable for mobile ground location stations, for telecommunications stations and for portable TV sets.

Finally, reference should be made to research (also stemming from aerospace work) into the properties of gases ionized at high temperatures, or plasmas, and into electric propulsion for interplanetary travel. These studies may well lead to the development of electric power stations equipped with magnetohydrodynamic generators for the direct, high-yield production of electricity by interaction between ionized gases and electromagnetic fields.

2.3 Engineering and Materials

In the field of mechanical engineering, aerospace activities require ultralight structures and materials capable of withstanding extremely severe ambient conditions.

Space flight involves the production and ultimate dispersal of extremely high kinetic energy.

This can only be achieved with new materials and fresh manufacturing processes, which both open up wide new possibilities in other branches of industry.

It has also been necessary to devise new methods of analyzing stresses to ensure the optimum use of materials.
So far, the effects of this new potential have been only sporadic (e.g., the use of the most advanced techniques to build pressure tanks for tanker ships, the use of new methods of stress analysis in designing bridges or pylons for high-tension lines), but in the near future we shall witness massive-scale extension of aerospace technology to shipbuilding to give a bigger payload than at present, weight for weight; the use of light, resilient structures capable of absorbing high kinetic energies will be extended to automobile construction to give better passenger protection, and to the railways to build faster trains, as such structures simplify problems of acceleration and braking.

The strength of steels has been raised to the highest level; steels with tensile strengths of up to 300 kg/mm^2 are now used in aeroplane undercarriages and are suitable for many other purposes.

New, very light, high-strength metals, such as titanium and beryllium, have also been introduced and brought into general use. Notable progress has been achieved with the lubrication of roller bearings used in vacuum conditions, and with paints by the development of materials which have a lifetime several times that of conventional types.

Full account must also be taken of the advance made as regards machining tolerances, servo-controls and new machining processes, all of which stem directly from aerospace activities (e.g., chemical milling, high-energy deep drawing, windings of epoxy fibres, diffusion bonding, etc.).

2.4 Chemicals and Propulsion

The need for high-energy fuels has led to a closer reexamination of the nature of chemical reactions and to an extension of the scope of pressure and temperature monitoring. This has substantially increased the potential of chemical technologies. The new methods of liquefying, storing and transporting gases developed for rocket propellants are of direct interest to all branches connected with the use of liquefied gases, such as the petrochemicals industry, iron and steel, transport, etc.

The introduction of improved techniques and materials in the manufacture of heat exchangers have led, and will continue to lead, to very substantial savings on the construction of both nuclear and chemical power stations. Modern heat exchange methods will also open up new prospects in the automobile industry.

Lastly, research into nuclear reactors for use in space and into plasma motors should bring about a further technical revolution in the not too distant future.

Work on nuclear reactors should result in the development of light, high-power reactors, while research on plasma motors should open the way to the direct generation of electricity from plasma without using turbine generators.

The full significance of plasma technology will become apparent when scientific knowledge has advanced far enough to permit the control of nuclear reactions.
Current space research into plasma technology is laying the theoretical and practical bases for future applications of this technology in the energy branch.

2.5 Management Techniques

One outstanding, and possibly the decisive factor in major aerospace programmes is the development of techniques for managing such vast undertakings as the Apollo project or the full-scale production of the Boeing 747. For the first time in industrial history, it is now possible to complete, on schedule, overall programmes which mobilize the labour and machinery of hundreds, if not thousands, of firms at one and the same time. This has been made possible by the development of entirely new management techniques and the use of systems engineering.

The best known of these management techniques is PERT (Programme Evaluation and Review Technique), which is based on a flow diagram of time sequences. The crucial points and events in the project are analyzed and shown on a graph with all their interdependent relationships. The time required to complete each operation between crucial points is estimated, with a margin of uncertainty, and fitted into an optimum flow for the completion of the project.

The programme thus arrived at is monitored continuously by means of computer systems, which display critical paths continuously, show the latest dates for carrying out activities in order to complete the whole project on time and calculate all uncertainty factors relating to the separate stages of the project.

Other techniques have also been developed. They include MCX (Minimum Cost Expediting), which is a linear parametric method used to determine the minimum cost of a project in relation to duration.

CPM (Critical Path Method), developed from MCX, is similar to PERT.

The basic difference between PERT and CPM is that, while the first is used to evaluate existing programmes, the second generates plans and programmes. PERT generates and shows all the limits of a programme; CPM generates a range of programmes correlated to the minimum cost hypotheses for each of them.

These new management control systems, which were originally introduced to monitor the progress and cost of work on government contacts, have now been extended to numerous other industrial and commercial applications, thus raising the general level of management.

According to a report by Boos-Allen and Hamilton, who were members of the team which devised the PERT system, 81% of the firms using PERT in 1959 applied it to government contracts only; by 1965, 50% of the same firms were using the system for purely commerical purposes, while a further 35% were using it for both government contracts and commercial work.

On this point, it is of interest to recall the problems which Boeing had to face when organizing the production of the 747. In all, 65% by weight of this aircraft is handled by subcontractors and 15,000 secondary and tertiary sub-contractors, scattered throughout the United States and in other countries.

The most important problems in such a complex organization are delivery on time and component reliability; such a complex programme calls for highly sophisticated and complex management systems and Boeing, assisted by TRW, worked out systems for the new Everett plant which would guarantee completion of the programme.

In an interview with our research workers, Boeing stressed system management as the most significant feature of aerospace fallout over the whole industry.

This fallout extends first from genuine space research and programmes to the aircraft industry and then tends to spread increasingly to other branches, including the federal state governments, as we shall explain at greater length in the second part of this chapter.

To sum up, technological fallout from the aerospace industry should not be regarded as a bare list of new materials or processes; attention should rather be focussed on the following points:

- there is a direct or indirect link between aerospace research and production and all technology-intensive branches of industry. Indeed, aerospace activity has stimulated their development and will continue to do so on an increasing scale, and all these technological advances (aerospace, nuclear, electronics, chemicals, metallurgy, etc.) will have their inevitable impact on all branches of the country's industry;
- the characteristic analytical planning which precedes aerospace programmes is raising American management to standards which cannot be matched by other countries and which, as they are extended to all other branches, will further widen the gap between American industry and that of every other country.

3. ECONOMIC FALLOUT

3.1 Transfer and Application of Aerospace Management Techniques to Social and Economic Problems

Probably the most significant aspect of the economic fallout of aerospace technology is the transfer of the latter, at management level, to the solution of the most important social and economic problems of contemporary society.

This transfer obviously takes place only if aerospace activity is on a genuinely large scale, as in the United States.

We shall try to identify briefly the characteristics of this transfer and to define the improved approach which it offers to the main social and economic problems.
As already noted, systems management was applied fully for the first time in the new form of aerospace management. NASA and DoD documents show that the development of a process system involves the following stages:

(a) definition of the problem and identification of the specific features of the system and its sub-systems, and special features;

(b) definition of the correlated actions and events for the formulation of sequences and plans for the management programme and the relevant work programmes;

(c) definition of the characteristics of sub-systems, their development and compatibility checking;

(d) production of sub-systems and control analyses;

(e) definition of the integration of sub-systems at system level, and final test of compatibility;

(f) checking of the feasibility of the system and of all correlated actions.

The outcome of this approach is fully integrated processes which can be completed quickly and efficiently. Analyses carried out in the United States showed that almost all current federal or state programmes for the solution of the community's most important problems had gone wrong because they were independently directed and finalized without rational correlation and a precise definition of objectives.

To counteract these shortcomings, stemming from the existence of overlapping levels of authority, and the fact that administrative divisions and the areas affected by particular problems do not coincide, there is now a move towards setting up regional systems which will be capable of solving the problems of the new community so formed, within a new legal and administrative pattern.

The second current line of action is the introduction of new systems derived from aerospace management techniques to solve the same problems efficiently, at the right time and with optimum use of financial resources.

This policy was adopted to remedy the following defects observed in existing management systems:

(a) <u>At federal level</u>

- No clear allocation of responsibility for decision-making or for establishing lines of communications between departments, including inability to define relationships, responsibilities and degrees of autonomy as between middle and top management.
- Inability to identify the best forms of organization for carrying out programmes.
- Lack of managerial coordination and of a national statistical system.

(b) <u>At state level</u>

- Little previous experience of long-term planning and programming.

(c) <u>At local level</u>

- Lack of communications between local and outside organizations.
- Inability to identify precise objectives and to maintain a regular check on programmes started.

- Inability to decentralize decision-taking.
- Lack of integration and coordination between programmes.
- Level of management too low to carry through complex, interrelated programmes.

In the light of these facts, and in order to avoid being overwhelmed by the weight of the social and economic problems created by the changed structure of urban communities (53% of American citizens are concentrated on 0.7% of the metropolitan territory), local and state authorities and the new regional organizations began to introduce computers and more sophisticated management systems derived directly from the aerospace industry, such as PERT and the new PPBS system (Planning Programming and Budgeting System).

New methods were adopted for compiling statistical returns, after which the next problem was how to make direct use of the programming and management experience accumulated by aerospace firms.

The first contracts were signed in California, where the Aerojet General Corporation was commissioned to work out a programme for waste disposal, the Space General Corporation a programme for preventing and checking delinquency and crime, the Lockheed Missiles and Space Company a statistical and survey programme at state level and North American Aviation a programme for an integrated transport system.

After these first experiments, the hardware of aerospace firms was used to deal with the following points:

1. Clear and unambiguous definition of the aims of each new programme.

2. Analysis of government organization in relation to the programme and determination of the reorganization measures required.

3. Close consideration of all interconnections and determination of aims for integration of the programme.

4. Determination of all interdependent relationships which will assist in achieving the objectives.

5. Optimization of the programme as regards times, costs and results.

6. Identification and analysis of all possible alternatives to any given programme.

These refinements were necessary in order to improve management relations between clients and experts at a subsequent stage, to define an approach more in line with the substance of the problems themselves and not involving the indiscriminate use of aerospace hardware alone and to introduce a terminology closer to normal administrative language, which is not always compatible with the special jargon of aerospace firms.

When these changes had been completed, the transfer had an enormous impact in the United States, both as regards the direct adoption of new aerospace management techniques by public administrations and as regards the conclusion of bigger and bigger research and management contracts with aerospace firms for public programmes.

The transfer was effected by imitation or analogy. A typical example of imitation is PPBS, the use of which was transferred to non-military institutions by a mere executive order from the DoD. The same applies to PERT and CPM.
More sophisticated problems have to be approached by analogy; for example, the concept of systems and sub-systems is applied

to the urban environment and its problems by analogy with the physiological system and computer programming.

Up to 1968 (according to the relevant specialist literature) no public body, other than NASA or the defence agencies, had introduced a completely integrated management system, but partial systems are being established at federal, state and local level with a view to improving management in the usual branches of administration and carrying out new programmes in less usual branches.

A series of bills have been tabled in the United States Congress with the aim of institutionalizing these systems throughout administration at all levels. A bill (S 430) was recently tabled in the Senate proposing the allocation of $125 million for the application of systems analysis and engineering to the study of local and national problems relating to education, unemployment, social security, crime, juvenil delinquency, atmospheric pollution, low-cost housing, transportation and waste disposal.

Another bill (S 467) before the Senate proposes the creation of a National Commission to promote new management systems at all levels of administration. In addition, the Governor of North Carolina has proposed the establishment of a Federal Institute.

Groups of experts and research workers have recently asked the federal authorities to promote:

(a) transfer of the new aerospace management techniques to all parts of the country, and between government bodies and industries;

(b) the general application of aerospace management systems to public bodies, in order to programme and plan the use and restructuring of national resources;

(c) identification of the regions least affected by aerospace activities, known as "aerospace technology depressed regions", with a view to making a special drive to transfer and apply the new techniques under an integrated programme designed to solve the following problems: education, transportation, employment, building, social security, waste, noise, social medicine, natural resources;

(d) generalization of an integrated regional information system in support of a federal information system;

(e) introduction of quality specifications for regional subsystems;

(f) creation of regional agencies to centralize all activities and responsibilities relating to technical and budgetary planning and programming.

As this process of mobilization continues at all levels, a study, completed in 1968 by the Aerospace Industries Association of America, lists 100 programmes selected from among those for which aerospace firms have been called in by public bodies; these are not aerospace programmes but relate to the following social and economic subjects: management of environmental resources, logistic information systems, use of new materials, health organization, oceanology, sources of energy, transportation, city planning.

It may be concluded, therefore, that the transfer of aerospace techniques is now almost complete and that it is providing, and will continue to provide, public authorities in the United States with parameters of efficiency which seriously suggest that it will become virtually impossible to bridge the gap which has been opened up with all other countries, including

Europe, in all matters relating to administrative action and the organization of everyday life.

3.2 Aerospace Activity and Economic Support Policies

Over the last few years the American economy has been running at an extremely high level.
Since government support and intervention has been mainly directed to the aerospace industry over the period, the reasons for this dynamic performance must be sought in the aerospace branch. Although Europe is not directly involved in aerospace competition, a survey, however brief, of the effects of aerospace investment is a vital guide to all the most modern economic support policies.

The amounts of money involved have already been clearly stated in previous chapters.
Here we shall be considering the most important qualitative aspect of the matter, namely, the characteristics of the cycle of investment in the aerospace industry.

Before the aerospace age, the economic cycle comprising investment, mobilization of technical resources and labour, purchase of materials and manufacture of the final product was counted in months.
The dominant economic pattern of any period is determined by the growth of industry at that time, or more accurately, by the cycle of investment in the various branches of industry.

In addition, the economic cycle tends to become identified with the specific growth cycle of industry at the given time.
The shortness of the economic cycle, and consequently short-term economic policies, were dictated by the short-term characteristics of the industrial cycle.

The change to a long cycle came with the growth of the aerospace industry and of branches associated with it (electronics, atomic energy, etc.) because of the time which elapses between the planning of a project and its completion. This cycle is now measured in years if not decades.

The effect of massive government support for such long-term programming has been a stabilization of the economic cycle and, inevitably, its gearing to a high rate of economic activity.

With the ever-growing importance of government spending policy in these technologically advanced branches and the pursuit of increasingly long-term objectives, this spending has lessened the significance of short-term fluctuations and fluctuations in specific branches of industry, which still have a short cycle. Industries making consumer goods which until a few years ago were greatly affected by short-term cyclical fluctuations can now absorb these trends more easily by aligning their investment programmes with those of the advanced technological branches pursuing long-term policies.

Today, the main effects of the aerospace industry on the overall business cycle in the United States are as follows:

(a) the aerospace industry has become the biggest customer for capital in the economy;

(b) the long-term planning which is a feature of investment in the aerospace industry has changed the traditional economic cycle, which it is progressively subordinating to its own requirements;

(c) these new requirements of the aerospace industry have revolutionized the traditional patterns of government spending. Because of these requirements, government and private spending policies now tend to coincide in both timing and quality.

Past experience indicated that it was correct economic policy for the government to cut spending during periods when private investment was expanding and vice versa. The opposite is now the case in the United States, where government spending rises when private investment is expanding, and both private and government investment in the advanced technological branches develop simultaneously and in agreement.

Since, moreover, the length of the economic cycle has historically been determined by investment factors, it must be expected that this new combination of government and private investment will tend to identify the economic cycle as a whole with that of the aerospace industry, which is of necessity long.

A long-term, programmed investment cycle, which has a major effect on all national economic activities, must inevitably stabilize the whole economic cycle at the levels produced by the volume of investment.
Moreover, the principle of programming such investments presupposes the simultaneous long-term programming of all resources - capital, technical, labour, etc.

The risk that, over the long period, the necessary skilled labour may not be available to carry out the integrated multiannual programmes which are typical of the aerospace industry involves long-term planning of labour resources at all levels (by the state as regards education and by firms as regards recruitment and training); the labour market has to be stabilized and all available resources have to be brought into use.

Lastly, competition from the aerospace industry on the market for capital and resources stimulates and promotes the growth of all branches of industry, which naturally have to offer alternative uses for capital and available resources which are just as attractive as those offered by the advanced technological industries and just as well protected from cyclical fluctuations; otherwise the branches concerned will inevitably decline or disappear.

Obviously this is bound to lead to long-term planning in all branches, including the oldest-established.

We must now consider whether Europe, at its own level, has been able to benefit from the new problems created by the aerospace age to work out a long-term policy for eliminating cyclical fluctuations, for planning long-term investments, for gearing spending policies, and their implementing measures, to the new problems raised by the advanced technological branches and for programming technological and labour resources.

The reply must be in the negative, not merely because of the sporadic nature of government spending in these branches, but also because there is no example of a forward-looking, long-term policy designed to stabilize the economic cycle at the highest possible level with a view to continuous, programmed growth.

Today there are two different worlds - the United States and Europe. It would appear that something completely new is developing in the United States economy, while Europe is still struggling and operating within a precarious economic structure which may well prove obsolete when the problems to be handled become too great for the means of action.

CHAPTER 6

Critical assessment of the results of the survey

1. INTRODUCTION

Because the aerospace industry makes intensive use of many kinds of technology and because it depends on other branches, its growth stimulates optimum skills in all branches and encourages research and the expansion of a wide area of industrial activity.
This process of stimulating other branches takes place through direct or indirect transfer.

The transfer is direct when scientific and technological activities are stimulated or induced in subsidiary branches; it is indirect when investment in aerospace research creates new processes and products which have a major effect on markets and branches not necessarily linked to the aerospace industry.

The technological impetus given to all branches of industry and, more generally, the effects of aerospace activity on the economy and society as a whole are clearly apparent in the United States because of the scale of the effort made.

Apart from the technological fallout from the aerospace industry, reference must be made to the latter's impact on the whole economy; basically, this impact derives not so much from the quantitative value of the branches concerned as from the qualitative characteristics of the business cycle of those branches.

In industrial companies, the dominant economic pattern at each stage of the system's development is closely correlated with the timing of investments in the various branches of industry; it therefore follows that the overall economic cycle tends to become identified with the specific growth cycle of industry at the given point in time.

Where there are certain quantitatively dominant branches (e.g., aerospace, electronics, etc.) characterized by a long-term economic process and by a high level of private and government investment, the characteristics of the economy of those branches tend to spread progressively to the economic cycle as a whole.

The fact that, for some years, short-term cyclical fluctuations have been practically insignificant in the United States can be attributed to the scope and long-term planning of investment in the technologically advanced branches and, in particular, in aerospace and the associated fields.

The result is that a basically stabilized economic cycle sets in, developing over long periods at high levels.

It would seem fair to conclude our survey by stating that Europe has so far proved incapable of taking advantage of the new problems created by the aerospace age either to bring about an irreversible process of growth and technological fallout, because of the sporadic and inadequate nature of government spending on aerospace R&D and production, or to work out long-term investment plans which are geared to the economic cycle of the technologically advanced branches and offer the opportunity of benefiting from the consequent economic fallout.

2. THE EEC AEROSPACE INDUSTRY'S OUTPUT AND MARKETS

Expressed in terms of final purchasers, the aerospace market in the EEC is made up as follows (in 1967): 63.2% government (military and civil, including flag carriers and their associates) and 2.3% private[1]. A total of 89% of R&D is financed (1967) by the government and 11% by private investment.

[1] The remaining 34.5% goes for export.

As regards ownership, at least 50% of the European aerospace industry is controlled directly by the government.
All the necessary conditions exist for the concerted programming of investments, production and marketing to achieve growth targets set for the industry by the government itself.

If, as is to be expected, the purpose of government intervention (at both national and Community level) is to raise the European aerospace industry to a level of efficiency comparable to that of the American industry, so that, after a period of special government assistance, the European industry could compete on the international market after passing the break-even point as regards structure and productivity, all programmes should then be directed to achieving that purpose.

Since this is only possible with an unbroken, optimum work load and large production runs, specific decisions concerning the types of aircraft needing R&D, production and marketing must be taken and implemented on the basis of the closest possible analysis of forecasts for the civil and military market over the decade 1970-80. These decisions cannot and must not be unrelated, but must be compatible with the capacities and structures of the EEC aerospace industry, and must be limited in number, in order to derive the fullest possible benefit from the resultant unification and the consequent hypothesis of optimum production runs.

Something is being done in this direction, as is demonstrated by the bilateral and multilateral cooperation programmes designed to satisfy the many requirements which are tending to concentrate on a few proposed types; against this must be set the cost of R&D and the limited market for each new type, which, if not specifically designed for a large number of customers, is liable to prove useless even before production starts. But much has to and can still be done in this direction by standardizing at Community level at least a few types for future use in the various countries.

Side by side with this policy of planned decisions, steps can also be taken, through the possibilities offered by contracting policy, to reorganize structures and increase productivity, both of which are also essential in order to attain full competitive power.

In our view, however, government action should be directed principally to the continuous correlation of supply capacity, programmed on the hypothesis of growing efficiency, to the potential demand created and formed according to a pattern covering the two convergent trends.

Modern programming methods and resources now provide all the reliability required for concerted programming. The structure of R&D is itself geared to this objective; it determines the best apportionment between research and development and between basic and applied research, so that the time required, on technical grounds, to complete any product is matched to the growth of demand. Moreover, expenditure on R&D itself acts as a regulator during the inevitable breaks in the productive process.

The following factors would appear to prove that differing elements can be correlated in a rational programme and that the capability exists for the coordinated and systematic capture of a fair share of the market for aircraft products:

1. Government funds are in fact spent on aircraft for military and civil requirements and are most unlikely to be cut off in the near future. The amount of such spending

increasingly tends to be a constant, if not increasing, proportion of the national product. It will therefore merely be necessary to direct this spending to the problems created by the expansion of the productive sector, and conversely to gear production to satisfying the demand created by such spending, in a new form of relationship which will leave narrow divisions behind and will open up wider prospects and lead to greater success.

2. The industry also has the necessary technological capability, as has been amply proved by the brilliant results of the most recent projects (Concorde, Jaguar, Mirage G, etc.).

3. The European aircraft industry can supply all the basic requirements of the European military market (trainers, tactical support and interceptor aircraft, light transports). Indeed, the planning and production of advanced aircraft of European origin (e.g., Mirage) and the production of very advanced types under licence (e.g., F-104) have given the industry a capability which should cover all requirements that can reasonably be foreseen over the next ten years and have freed it from the need to acquire foreign knowhow.
Moreover, the most recent project agreements, such as that for the MRCA 75, relate to an aircraft which will not only satisfy the needs of the European military market but will also be able to compete with types now planned to meet the same requirements in the United States.

4. The demand for civil aircraft is growing rapidly as air traffic steadily increases.
This growing passenger and freight traffic is becoming increasingly diversified to cover various requirements

previously met by other means of transport. On the other hand, the supply of transport, which is fairly rigid because the means available are not very flexible, is incapable of handling such a diversified demand economically. This is the root cause of the economic difficulties which face all airlines at the moment. The solution is therefore to diversify transport so that demand can be handled economically. This means that airline fleets must include a variety of types and models. Because of all that is involved in the design and construction of new aircraft, it seems unlikely that the American industry is capable of meeting all these requirements and supplying all the types needed for optimum airline operation. This offers the European industry an opportunity which, if taken up in the sectors in which it is best qualified and on the appropriate scale (short-haul transports, STOL, VTOL, etc.), may produce the market capability needed to fulfil the industry's growth hypotheses.

It would, of course, be incorrect to speak of any relation between supply and demand in the space sector, because demand is not autonomous but is the result of a political decision.

Here coordinated efforts must be continued along the lines fully discussed earlier in this report, in order to keep in touch with planning and production problems, which will have extremely important repercussions in the years to come.

3. STRUCTURAL PROBLEMS OF THE EEC AEROSPACE INDUSTRY

The EEC aerospace industry is today characterized by a heavy concentration of financial resources and a low to very low concentration of technical resources.

This situation is an obstacle to the reduction of costs through internal or external economics of scale, to the introduction of more up-to-date management methods and new programming and control systems and to the achievement of optimum production runs, of sufficeint length to benefit from the economic effects of numbers and high rates.

In our opinion, two of the basic elements in the concerted and purposeful programming mentioned earlier in our report are determination of an optimum technical size for the EEC aerspace industry, by correlating size hypotheses and R&D and production hypotheses, and promotion of the technical concentration, specialization and rationalization of plant at all levels.

The same policy is just as essential for the accessories industry, which is at present scattered over large numbers of competing firms in each country, most of them technically dependent on the United States.

In our view, cooperation between firms from different countries is a sound approach to the problem of achieving the capability to carry through major programmes and to optimize production runs.

However, with a view to improving the structure of the industry as a whole and achieving an equitable distribution of work and a fair return, rationalization will be necessary in the division of labour to avoid duplication of investments and production lines, so that the structure is geared to the product and not the product to the structure.

Any attempt to arrive at an optimum structure for the aerospace industry in the Community must allow for the fact that at the moment there is no aeroengine industry worthy of the name. It would therefore be extremely risky to embark on a programme of investment in research and development without at least some prospect of making the EEC independent in this branch.

The same argument applies to avionics. The policy of purchasing licences, which has been the general rule so far, cannot guarantee that the best type for the specific purpose will be available when it is needed.

Lastly, when we consider the policy of stimulating the industry in terms of efficiency, the principle of a fair distribution by nationality which has so far applied (e.g., ESRO and ELDO) in the allocation of orders and subsidies, has to be combined with that of competence, specialization and knowhow so that the measures adopted will produce their maximum effect and there will be no pointless back-pedalling.

4. SUGGESTED CHANGES IN ORGANIZATION

It emerges from our studies that some changes in organization, which moreover have widespread support, are needed at Community level to resolve a number of what in themselves are only subordinate problems, but have major implications for the design, production and marketing of aerospace products.

(a) The contracting policy of member countries should be made as uniform as possible and should aim at a Community policy based on existing examples in the United States.

(b) Certification regulations and technical standards for aerospace products should be aligned and should form the basis of Community standards, which should so far as possible be compatible with those in force on the biggest export market (US), in order to avoid creating a further drawback for the European industry.

(c) Customs legislation and, more important, customs regulations should be simplified and harmonized as between member countries because they are now unsuited for an industry like the aerospace industry, which depends on sub-contractors for components or semi-finished products from countries both within and outside the Community.

(d) Incentive policies concerning production for the home market in member countries and to aid exports should be standardized as between these countries and should lead on to a common policy for the whole Community.

5. RELATIONS BETWEEN THE EEC AND UNITED KINGDOM AEROSPACE INDUSTRIES

The main features of the British aerospace industry have been fully dealt with in our report. Here we shall simply stress our view that it is today in a more difficult position than the EEC industry.

In addition to the very low productivity of the British industry, it may be noted that from 1960 to 1967 the value of output in the United Kingdom rose by an average of only 1.7%, as compared with 11% in the Community.

Furthermore, taking the total output of the three areas (US, UK and EEC) as a single figure, we find that the British industry employs 16% of the total labour force but accounts for only 6.6% of total output.

At first sight, therefore, it would seem that the British industry has too big a labour force for its market potential and that its productivity is so low that radical restructuring may well be essential.

The British authorities were themselves aware of this need; a White Paper on the industry, published in 1947, asserted the government's intention to cut the number of employees to about 150,000 within six years[1]. Eighteen years later, Lord Plowden[2] concluded a searching analysis of the structure and problems of the British aircraft industry by stating the opinion that the industry should emerge smaller but stronger.

Consequently, any close association between the EEC and UK aerospace industries would appear to be out of the question until radical reorganization has been carried out in the United Kingdom; otherwise a large proportion of the suggested support for the aerospace industry would inevitably go towards covering higher aerospace costs in the UK.

The foregoing remarks apply to the airframes branch; very close cooperation with the British engines branch is still necessary because this is the main source from which the EEC aerospace industry can obtain the knowhow required to develop its own aeroengine industry.

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1 The cuts were not made, however, because of opposition and because chance factors (Korean war) brought about a temporary revival of the industry.

2 "Report of the Committee of Inquiry into the Aircraft Industry" appointed by the Minister of Aviation under the chairmanship of Lord Plowden, 1964-65.

APPENDIX

List of European aerospace bodies and organizations

List of European Aerospace Bodies and Organizations

National bodies and organizations		
R&D centres	Coordinating centres and authorities	Trade associations and organizations
BELGIUM	Bureau de Coordination des Commandes de Défense (B C C D), Ministry for Economic Affairs	Groupement Belge des Constructeurs de Matériel Aérospatial (GEBECOMA) Association Belge Interprofessionnelle des Activités Spatiales (BELGO SPACE)
FRANCE Centre d'Essais Aéronautique de Toulouse (C E A T) Centre d'Essais des Propulseurs (C E P) Centre d'Essais en Vol (C E V) Laboratoire de Recherches Balistiques et Aérodynamiques (L R B A) Centre d'Achèvement et d'Essais des Propulseurs d'Engins (C A E P E) Centre d'Essais des Landes (C E L) Office National d'Etudes et de Recherches Aérospatiales (O N E R A) Centre National d'Etudes des Télécommunications. (C N E T)	Direction des Recherches et des Moyens d'Essais (D R M E), Ministry of the Armed Forces Centre National d'Etudes Spatiales (C N E S)	Union Syndicale des Industries Aéronautiques et Spatiales (U S I A S)

continued

National bodies and organizations		
R&D centres	Coordinating centres and authorities	Trade associations and organizations
ITALY		
Direzione Laboratori Tecnici dell'Aeronautica Militare	Consiglio Tecnico Scientifico, Ministry of Defence	Associazione Industrie Aerospaziali (A I A)
Inter-arm experimental missile training range - Salto di Quirra	Centro Consultivo Studi e Ricerche, Ministry of Defence	
Divisione Studi della Direzione Generale delle Costruzioni e Approvvigionamenti Aeronautici	Consiglio Nazionale delle Ricerche (C N R)acting through: - Istituto per le Ricerche Spaziali - Commissione per le Ricerche Spaziali	
Ispettorato Telecomunicazioni ed Assistenza al volo (I T A V)		
Centro Studi e Ricerche di Medicina Aeronautica e Spaziale		
Centro Ricerche Aerospaziali (C R A)		
Centro Nazionale di Ricerca sulla Tecnologia della Propulsione e dei Materiali relativi (C N P M)		
Centro Studi Dinamica Fluidi (C S D F)		
Netherlands		
NationaalLucht - en Ruimtevaartlaboratorium (N L R)	Nederlands Institut Voor Vliegtingontwikkelnig (N I V)	
	Geophysics and Space Research Commission of the Royal Academy of Letters	

List of European Aerospace Bodies and Organizations

continued

National bodies and organizations		
R&D centres	**Coordinating centres and authorities**	**Trade associations and organizations**
West Germany		
Deutsche Forschung - und Versuchsanstalt für Luft - und Raum formerly DGF (AVA, DFL, DVL)	Deutsche Kommission für Weltraumforschung (DKfW)	Bundesverband der Deutschen Luft - und Raumfahrindustrie e V (BDLI)
Max Planck Institutes	Gesellschaft für Weltraumforschung (GfW)	
United Kingdom		
Aeroplane and Armament Experimental Establishment (A& AEE)	Ministry of Technology	Society of British Aerospace Companies (S B A C)
Rocket Propulsion Establishment (RPE)		
National Gas Turbine Establishment (NGTE)		
Royal Radar Establishment (RRE)		
Royal Aircraft Establishment (RAE)		
Signals Research and Development Establishment (SRDE)		
National Physical Laboratory (NPL)		
Explosive Research and Development Establishment (ERDE)		
Fire Research Station		

List of European Aerospace Bodies and Organizations

continued

International organizations		
R&D centres	Coordinating bodies	Trade associations and organizations
Institut Franco-Allemand de Recherches de Saint Louis (I S L) Von Karman Institute of Fluid Dynamics (VKI) European Launcher Development Organization (ELDO/CECLES) European Space Research Organisation (ESRO/CERS) International Telecommunications Satellite Consortium (INTELSAT)	European Conference on Satellite Communications (C E T S) NATO - Advisory Group for Aerospace Research and Development (AGARD) Committee on Space Research (COSPAR) International Astronautical Federation (IAF)	International Association of Aerospace Equipment Manufacturers (A I C M A) European Industrial Space Study Group (EUROSPACE) European Airlines Research Bureau (E A R B) International Civil Aviation Organization (ICAO) International Air Transport Association (I A T A) European Organization for the Safety of Air Navigation (EUROCONTROL) European Organisation for Civil Aviation Electronics (EUROCAE)

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