HERMES PROBABILISTIC RISK ASSESSMENT

PILOT STUDY

* François PARISOT ESA/CNES

* Juan MUÑOZ IBERESPACIO

Figura 1.

INTRODUCTION
CONTEXT OF THE STUDY (1)

- 1989: FIRST CONTRACT WITH IBERESPACIO
- STUDY OF THE CONTRIBUTION OF PROBABILISTIC ANALYSIS FOR THE OPTIMAL CONSTRUCTION OF SYSTEM SAFETY. STATUS IN AERONAUTICAL AND NUCLEAR EUROPEAN INDUSTRIES.
- MAIN CONCLUSION: GROWING TREND TOWARD THE INCORPORATION OF QUANTITATIVE SAFETY ASSESSMENT.
- AGREED RECOMMENDATION: UNDERTAKING OF A PROTOTYPE PROOF STUDY ON HERMES.

Figura 3.

CONTEXT OF THE STUDY (2)

- SELECTED SUBSYSTEM:HERMES/MTFF DOCKING ASSEMBLY
- WHY?:
  - REASONABLY COMPLEX.
  - INTERFACE BETWEEN HERMES AND MTFF.
- KICK-OFF: JANUARY 91.
- MAIN STEPS OF STUDY:
  - ANALYSIS OF DOCUMENTATION.
  - DESCRIPTION OF SUBSYSTEMS AND ITS FUNCTIONNING.
  - INTERIM REPORT.
  - MODELIZATION.
  - QUANTIFICATION.
  - RESULTS.

Figura 4.

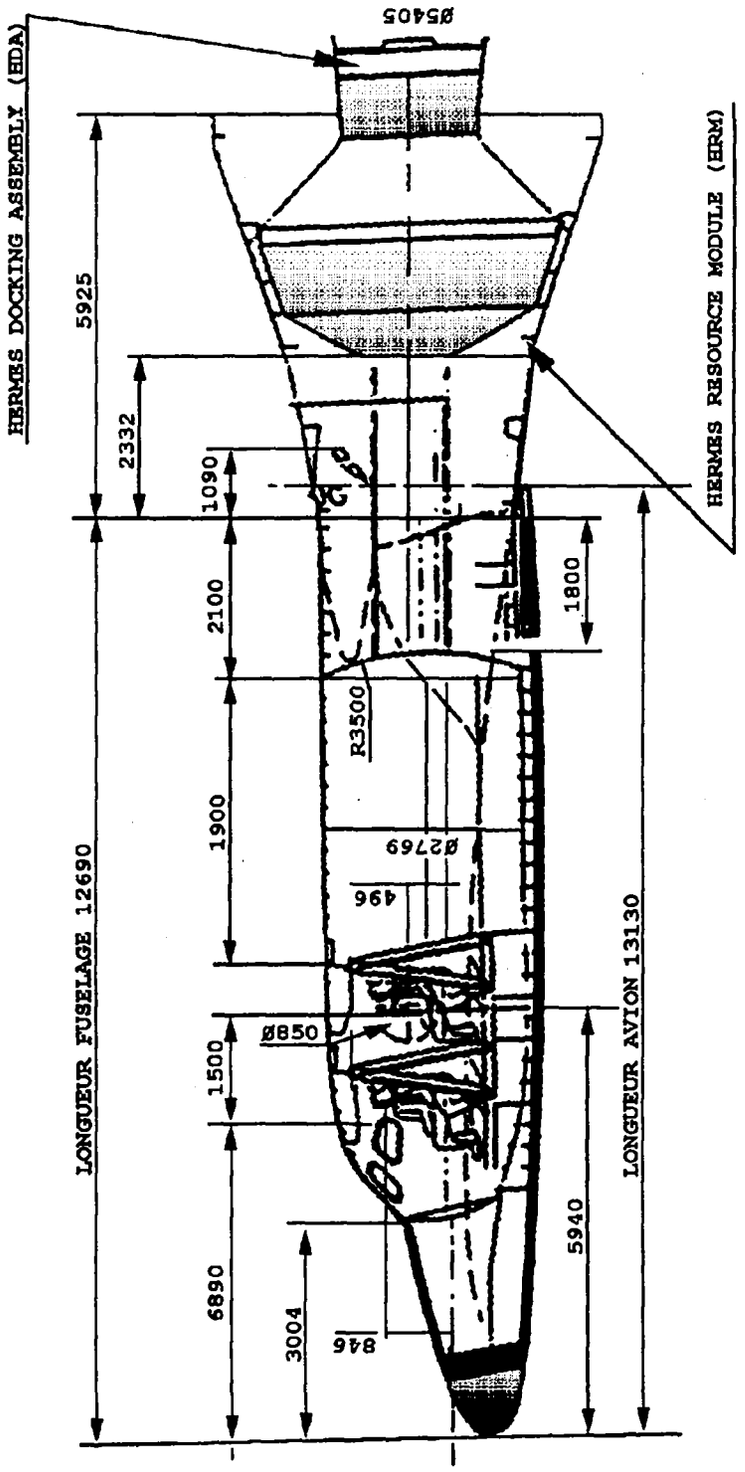
HERMES DOCKING ASSEMBLY (HDA)
HERMES RESOURCE MODULE (HRM)
Ø5405
5925
2332
1090
2100
1800
R3500
1900
Ø2769
496
Ø850
1500
6890
3004
846
5940
LONGUEUR FUSELAGE 12690
LONGUEUR AVION 13130

Figura 5.

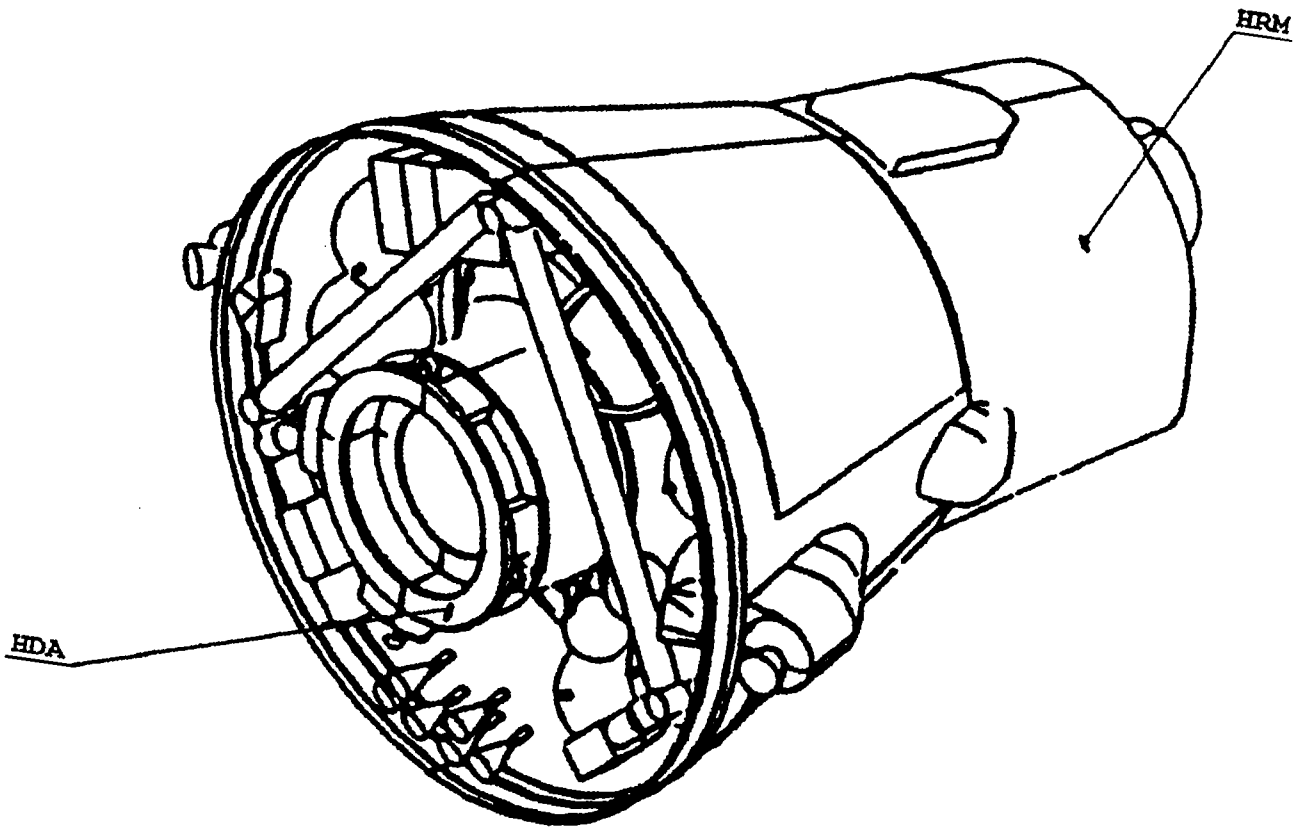

Figura 6.

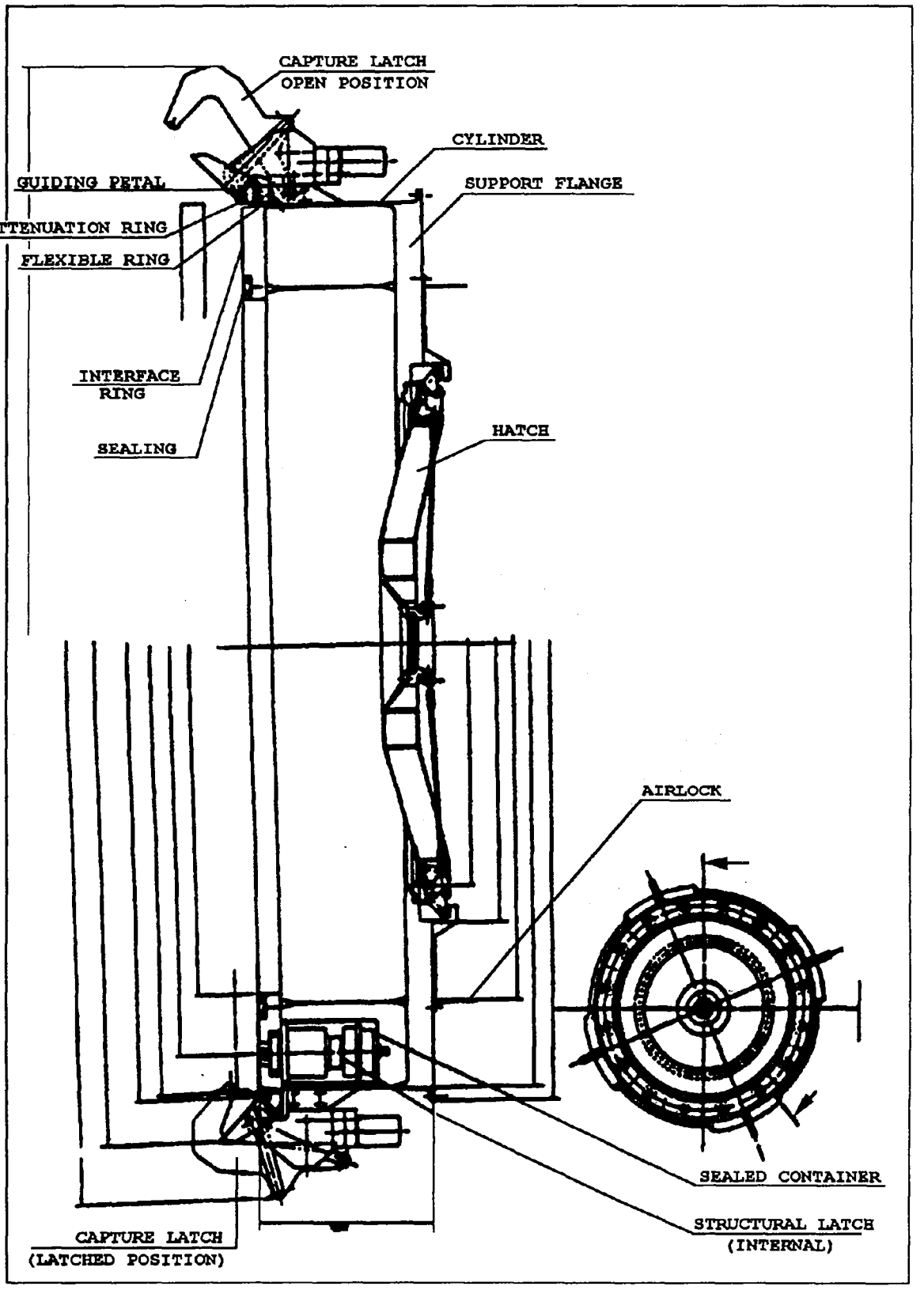
CAPTURE LATCH
OPEN POSITION
CYLINDER
GUIDING PETAL
SUPPORT FLANGE
ATTENUATION RING
FLEXIBLE RING
INTERFACE RING
SEALING
HATCH
AIRLOCK
SEALED CONTAINER
STRUCTURAL LATCH
(INTERNAL)
CAPTURE LATCH
(LATCHED POSITION)

Figura 7.

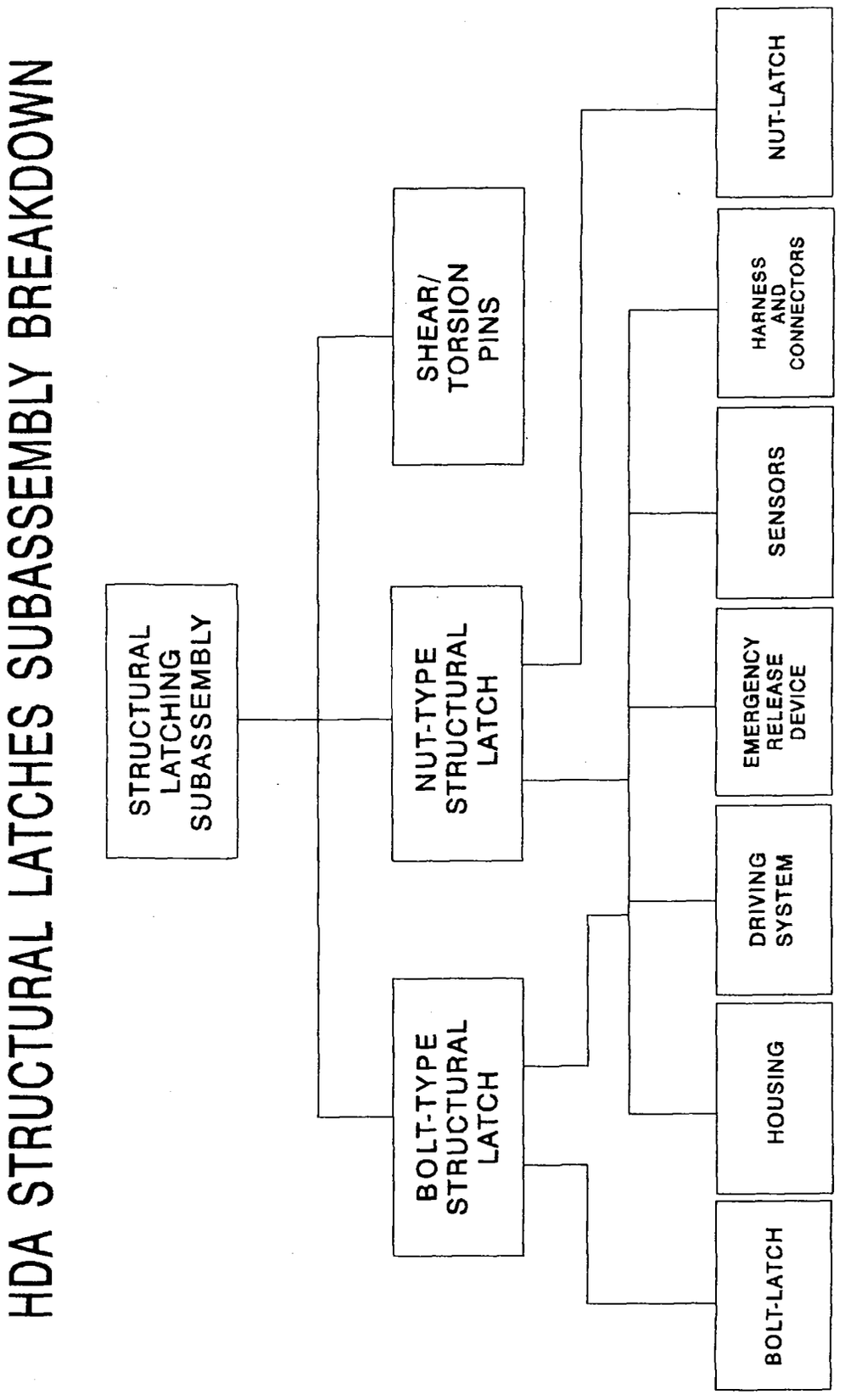
HDA STRUCTURAL LATCHES SUBASSEMBLY BREAKDOWN
STRUCTURAL LATCHING SUBASSEMBLY
NUT-TYPE STRUCTURAL LATCH
SHEAR/ TORSION PINS
BOLT-TYPE STRUCTURAL LATCH
NUT-LATCH
HARNESS AND CONNECTORS
SENSORS
EMERGENCY RELEASE DEVICE
DRIVING SYSTEM
HOUSING
BOLT-LATCH

Figura 8.

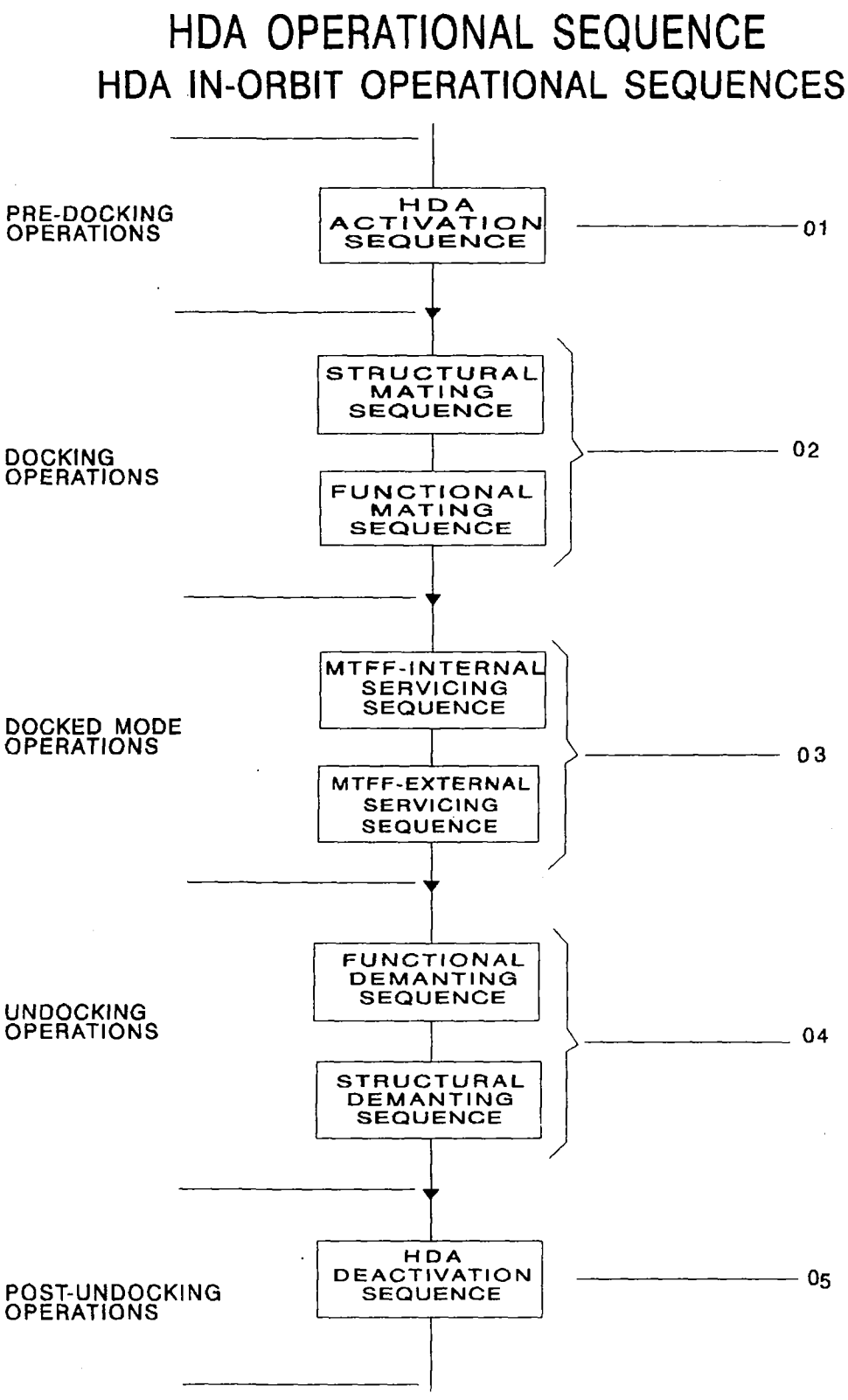
HDA OPERATIONAL SEQUENCE
HDA IN-ORBIT OPERATIONAL SEQUENCES
PRE-DOCKING OPERATIONS
HDA ACTIVATION SEQUENCE
01
DOCKING OPERATIONS
STRUCTURAL MATING SEQUENCE
FUNCTIONAL MATING SEQUENCE
02
DOCKED MODE OPERATIONS
MTFF-INTERNAL SERVICING SEQUENCE
MTFF-EXTERNAL SERVICING SEQUENCE
03
UNDOCKING OPERATIONS
FUNCTIONAL DEMANTING SEQUENCE
STRUCTURAL DEMANTING SEQUENCE
04
POST-UNDOCKING OPERATIONS
HDA DEACTIVATION SEQUENCE
05
END OF HDA IN-ORBIT OPERATIONS

Figura 9.

HDA FUNCTIONS FOR THE STUDY

ACCORDING TO: HERMES DOCKING ASSEMBLY TECHNICAL SPECIFICACION AND HERMES ASSEMBLY OPERATIONAL FLOW ANALYSIS.

F1: STRUCTURAL FUNCTION.
F2: ENVIRONMENTAL PROTECTION FUNCTION
F3: HDA CONFIGURATION MANAGEMENT FUNCTION.
F4: MECHANICAL DOCKING/UNDOCKING FUNCTION.

- F4a: TO PROVIDE THE CAPTURE OF MTFF DOCKING PORT.
- F4b: TO PROVIDE THE CENTERING AND CLOSURE OF BOTH VEHICLES.
- F4c: TO PROVIDE CANCELLING OF RELATIVE VELOCITY VETWEEN VEHICLES AND ABSORPTION OF RESIDUAL ENERGY.
- F4d: TO PROVIDE THE LOCKING OF THE HMS/MTFF STRUCTURAL INTERFACE.
- F4e: TO PROVIDE THE LATCHING OF THE HMS/MTFF STRUCTURAL INTERFACE.
- F4f: TO PROVIDE THE UNLATCHING OF THE HMS/MTFF STRUCTURAL INTERFACE.
- F4g: TO PROVIDE THE RELEASE OF THE MTFF.

F5: FUNCTIONAL CONNECTION/DISCONNECTION.
F6: MTFF SERVICING SUPPORT FUNCTION.

Figura 10

FUNCTION VERSUS OPERATIONAL MODES

	OPERATIONAL MODES				
FUNCTION	01	02	03	04	05
F4a	x	x			
F4b		x			
F4c		x			
F4d		x			
F4e		x			
F4f				x	
F4g				x	

OPERATIONAL MODE 01

FUNCTIONS VERSUS SUBASSEMBLIES

FUNCTION	STRUCTURE	GUIDING/ ATTENUATION	CAPTURE LATCHING	STRUCTURAL LATCHING	HATCH	INTERFACE SEALING
F1a	x				x	
F1e	x					
F3a			x	x	x	
F4a			x			

Figura 11.

D-BM MODELLING
GENERAL ASSUMPTIONS

MISSION TIME 240 HOURS

- $0_1 + 0_2$: 48 HOURS
- 0_3 : 168 HOURS
- $0_5 + 0_6$: 24 HOURS

MTFF HALF 6 MONTHS BETWEEN VISITS.AFTER EVERY VISIT AS GOOD AS NEW.

HERMES DOCKING ASSEMBLY (Mechanism) CONTROL ELECTRONICS (HDMCE).

- TWO TRAINS M, R
- EACH LATCH 4 SENSORS PER LOOP (FOUR POSITION)
- DOUBLED CIRCUIT UP TO MIB'S
- HATCH SENSORS 1 DIFFERENT SENSOR PER LOOP
- POWER BUSES AND MIB'S CONSIDERED EXTERNAL

ENVIRONMENTAL CONTROL AND LIFE SUPPORT SYSTEM
(ECLSS) WAS CONSIDERED EXTERNAL

Figura 12.

SUCCESS CRITERIA AND MODELLING HYPOTHESIS

- FOR DOCKING 3 CAPTURE LATCH ASSEMBLIES ARE NECESSARY
- FAILURE ON BOTH TRAINS, MAIN AND REDUNDANT ARE NECESSARY TO LOSE THE FUNCTION
- 14 OF 16, NOT BEING TWO ADJACENT, ESTRUCTURAL LATCHES ASSEMBLIES ARE NECESSARY FOR DOCKING
- ALL CAPTURE/STRUCTURAL LATCHES FOR DEDOCKING
- SMALL LEAKS ECLSS SYSTEM COMPENSATED
- FAILURE OF TWO FLEXIBLE RING NECESSARY
- FAILURE OF BOTH SEAL RINGS NECESSARY
- STRUCTURAL LATCH PASSIVE FAILURE IN MTFF HALF ARE INCLUDED
- β FACTOR

Figura 13.

SPECIFIC MODELS

- BASIC HERMES DOCKING ASSEMBLY MODEL (HDA)

  NON COMPLIANCE WITH SUCCESS OF THE FUNCTIONS
  LOGIC STRUCTURE BASED ON THE FAUL FREE METHODOLOGY WITH A COMPUTER PACKAGE

- LOSS OF CREW, HERMES OR MTFF MODEL (HC1)

  ONLY THE PARTS AFFECTING CRITICAL OR CATASTROPHIC FAILURE WERE SELECTED

  EXPOSITION TIMES PROBABILITY TO TAKE INTO ACCOUNT THE RELATIVE FAILURE DURING GLOBAL MISSION

- RECOVERY ACTIONS MODEL (HC1R)

  TAKE INTO ACCOUNT RECOVERY ACTIONS BY CREW (IVA/EVA)

Figura 14.

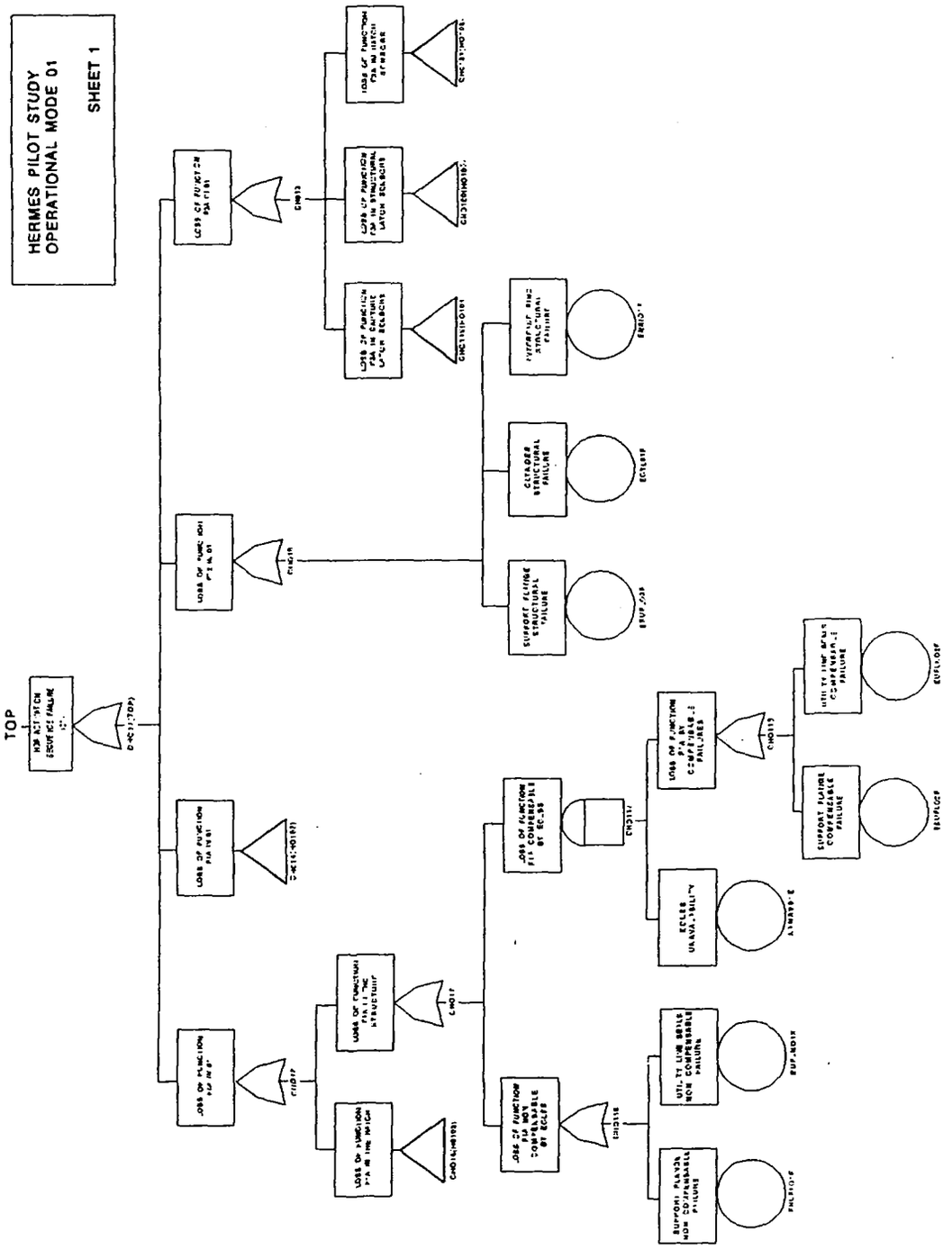

Figura 15.

HERMES PILOT STUDY

DATABASES FOR QUANTIFICATION

- AVCO
- WASH-1400
- DATA TRANSMITTED BY ESA/CNES TEAM
- NUREG/CR-1278

DATABASE INCLUDES

- BASIC EVENT DESIGNATOR
- SOURCE OF DATA
- MEAN VALUE (1/h) OR (/d)
- RANGE
- REMARKS

SPECIAL BASIC EVENTS (GREATHER THAN 1)
HAVE BEEN INCLUDED

EXPOSITION PROBABILITY BASIC EVENTS

Figura 16.

HERMES PILOT STUDY

MAIN STUDY RESULTS

1. LOSS OF MISSION FAILURES OF THE SYSTEM

   All failures associated with HDA or MTFF components will be included in this category,if they imply only not ensuring the correct performance of functions by the system without risk to human lives or space vehicles.

2. CRITICAL FAILURES OF THE SYSTEM

   Failures of HDA or MTFF components that could result in risk to space vehicles.

3. DIRECT CATASTROPHIC FAILURES OF THE SYSTEM

   Failures of HDA or MTFF components for which catastrophic consequences (risk to human lives) are direct.

4. CATASTROPHIC FAILURES OF THE SYSTEM INDUCED BY CRITICAL

   Critical failures of HDA or MTFF for which recovery actions taken by the crew have not been successfull.

Figura 17.

HERMES PILOT STUDY SENSITIVITY ANALYSIS

- THE SENSITIVITY ANALYSIS CONSISTED GENERALLY IN CHANGING THE VALUES ASSIGNED ONE ORDER OF MAGNITUDE GREATER AND ONE ORDER OF MAGNITUDE SMALLER.
- SOME SENSITIVITY ANALYSIS INVOLVED CHANGING THE INITIAL ASSUMPTIONS.

■ STRUCTURAL LATCH MECHANICAL FAILURES

	GREATER (%)	SMALLER (I%I)
R1	378	7.11
R2	---	----
R3D	800	91.2
R3I	---	----

■ SECOND PORT ON MTFF

	(I%I)
R1	91.9
R2	----
R3D	----
R3I	----

Figura 18.

SPECIFIC CONCLUSIONS

LOSS OF MISSION RESULTS (R1)

- GOVERNED BY
  - STRUCTURAL FAILURES
  - MTFF HATCH EXPOSITION TIME
- THE SECOND HATCH MTFF IMPLEMENTATION REDUCE 12 TIMES THE RESULTS
- DOUBLE TIME BETWEEN VISITS IMPLY A INCREASE OF 94% ON RESULTS

CRITICAL FAILURE RESULTS (R2)

- GOVERNED BY
  - FAILURE OF STRUCTURAL/CAPTURE LATCHES MOTORS AND MECHANISMS
  - FAILURE OF SENSORS
  - HATCHES AND HUMAN ACTIONS

CATASTROPHIC FAILURES RESULTS(RED+R31)

- GOVERNED BY
  - MECHANICAL FAILURES OF STRUCTURAL LATCHES (89.26%)
  - EMERGENCY SPECIAL RELEASE DEVICE IMPLY A REDUCTION OF 91% ON RESULTS

Figura 19.

CONCLUSIONS AND RECOMMENDATIONS

GENERAL CONCLUSIONS

- THE SUITABILITY OF THESE TYPE OF QUANTITATIVE STUDIES HAS BEEN DEMONSTRATED.

  - IDENTIFICATION OR RELEVANT PRIORITIES
  - DIFERENTS ASPECTS TOGETHER (HUMAN, MECHANICAL...)

- APPLICATION IN FIRST STAGES ALLOWS SOLUTIONS TO BE IMPLEMENTED WITHOUT SIGNIFICANT IMPACT.

- UNCERTAINTIES HAVE COME UP ON DATA AND HUMAN ESTIMATIONS

- DEPENDENCIES BY COMMON CAUSE FAILURE HAS BEEN TAKEN INTO ACCOUNT THROUGH β FACTOR.

Figura 20.

RECOMMENDATIONS

- USE OF QUANTITATIVE METHODS DURING THE PROJECT DESIGN

- IMPLEMENTATION OF A SECOND PORT IN MTFF

- NEED OF EMERGENCY SPECIAL RELEASE DEVICE FOR REDUCTION OF CATASTROPHIC FAILURES

- HUMAN FAILURES REDUCTION THROUGH ERGONOMIC AND HUMAN RELIABILITY ANALYSIS

- NEED OF SPECIFIC DATABASE MORE SUITABLE TO OBJECTIVES

Figura 21.

AMBIENTALIA

Reus, España
19 Noviembre/November 92