VANDERBILT UNIVERSITY

The BAC Concorde

System Overview

The BAC Concorde was engineered in the 1950s by Sir Arnold Hall of the Royal Aircraft Establishment in the UK. The Concorde was a pioneer of **high speed** and optimization of flight reaching speeds of **Mach 2.04 at over 60,000 feet** in the air as well as weight saving and enhanced performance. Only 14 of the 20 planes built were commercially used. The Concorde was retired in 2003 due to the decision to fly passengers sub-sonically, the lack of maintenance support, and concerns from 9/11. The Concorde was deemed a luxury for flying passengers from London to New York in three hours and many who remember it recall it to be “ahead of its time.”

System Overview

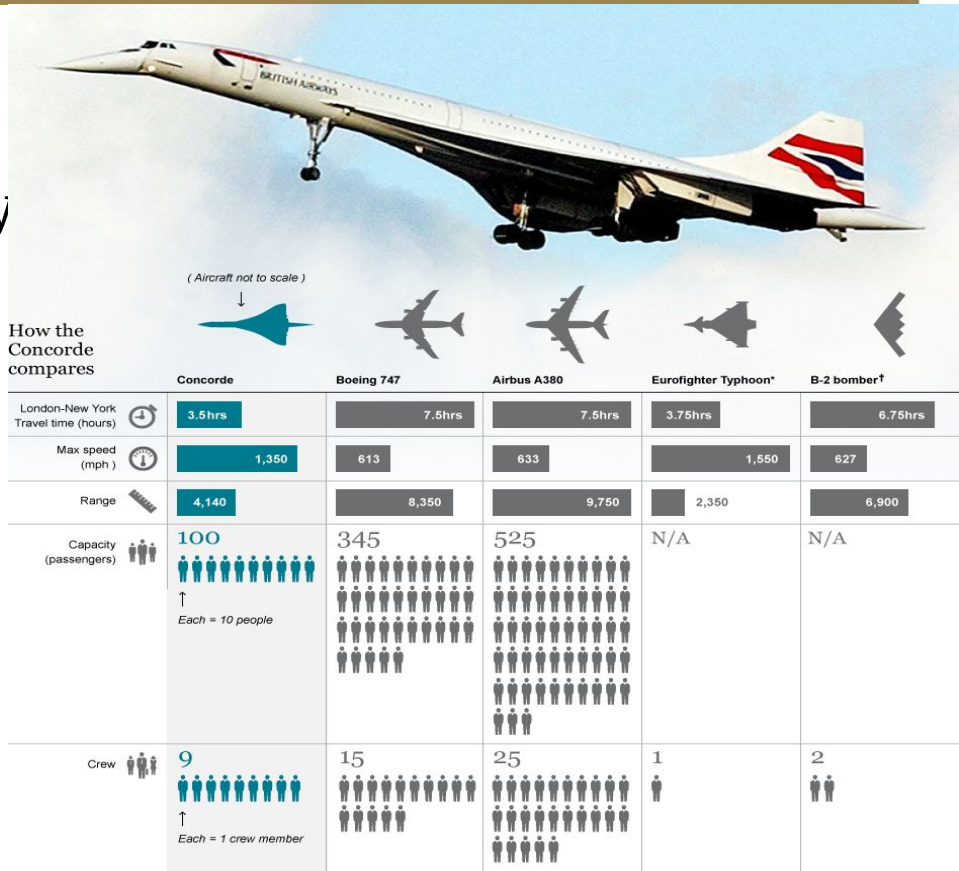
To **safely** and **affordably** transport **passengers** in flight at a minimum of **Mach 2**.

- Safety
- Customer experience
- Speed
- **Cost considerations**

System Challenges

Profitability

- Increase passenger capacity
- Increase fuel efficiency
- Decrease noise pollution
- Decrease crew



Originating Requirements

The Concorde shall achieve a minimum of Mach 2 speeds (R1.1)

The Concorde shall be able to hold at least **200 passengers** (R1.2)

The Concorde shall be able to travel a minimum of 3,500 miles (R1.3)

The Concorde shall reach a maximum altitude of 60,000 ft (R1.4)

The Concorde shall be able to fly 120 miles/ton fuel (R1.5)

The Concorde shall have a modern, interactive cabin experience (R1.6)

The Concorde shall not go above 100 dB (R1.7)

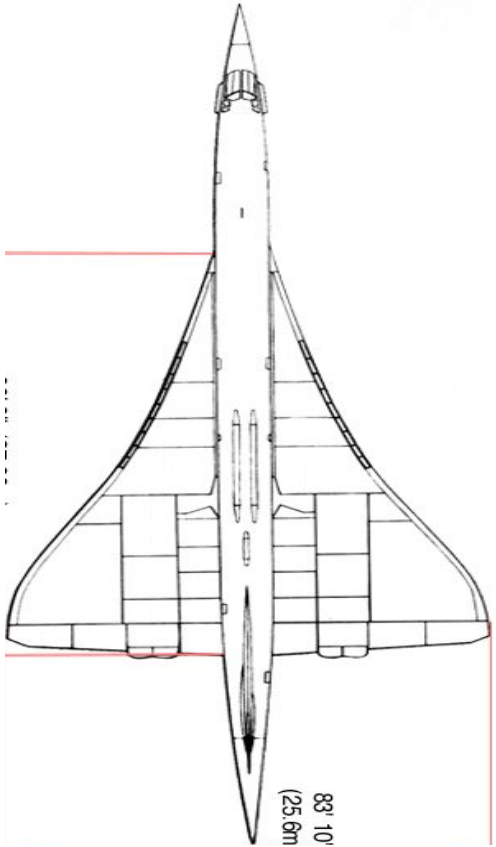
Stakeholders

- **Manufacturing Companies**: production, delivery, and maintenance of the Concorde; responsible for **meeting new mission requirements** — **British Aircraft Company and Aerospatiale**
- **Airlines**: The customers of the Concorde are airlines across the world who purchases from the manufacturing company and pays for future maintenance costs — **British Airways, Air France, and Singapore Airlines (profitability)**
- **Airports**: most time spent on ground so must be operable at large commercial airports —**Heathrow, Charles de Gaulle, JFK, Dulles, Singapore, other domestic airports (increase in passenger flow)**
- **Fuel Companies**: require large amounts of jet fuel in order to be operated by airlines, with price impacts—**Jet-A1 Providers (fuel efficiency may not be in best interest)**
- **Financial Institutions**: each unit cost is $25M-$30M to manufacture so financial institutions leased the planes to airlines—**Braniff International Airways and Caledonian (increase leasing power)**

Braniff International

Scenarios

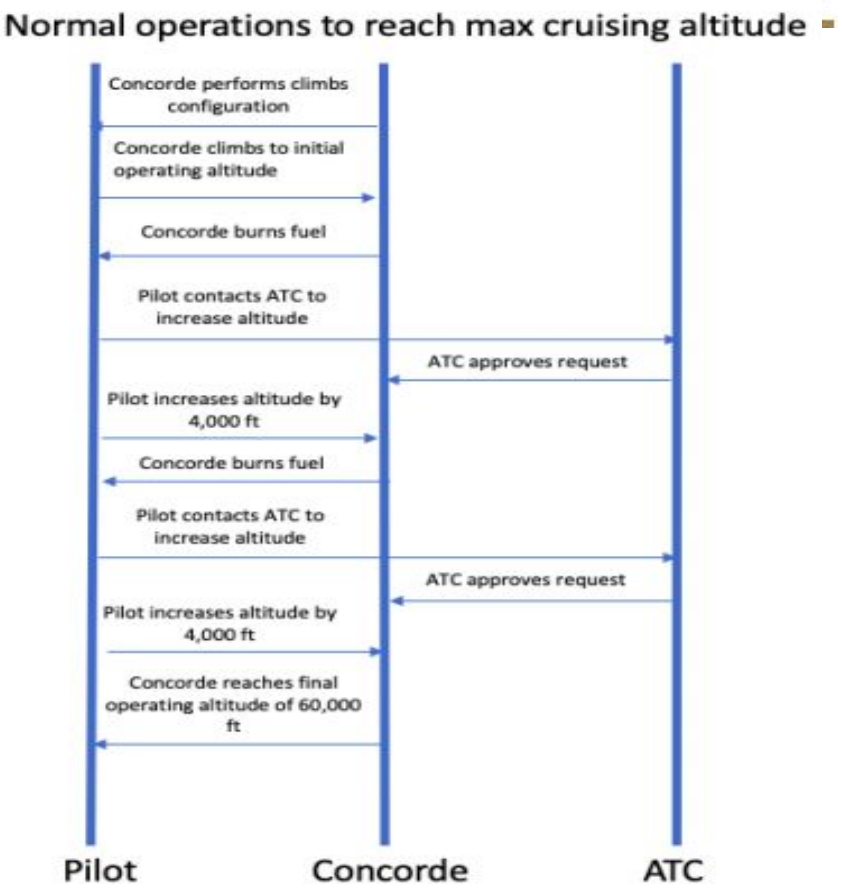
- **Ground Crew Refuels Concorde**
- Catering company loads plane with food
- Storm in path of plane's flight requiring a diversion
- Engine failure on climb configuration
- Heating cooling failure in cruise
- **Normal operations to reach max cruising altitude on hot day**
- Pilot makes preflight check
- Flight crew finds an issue during a walk around check
- **Workers load luggage**



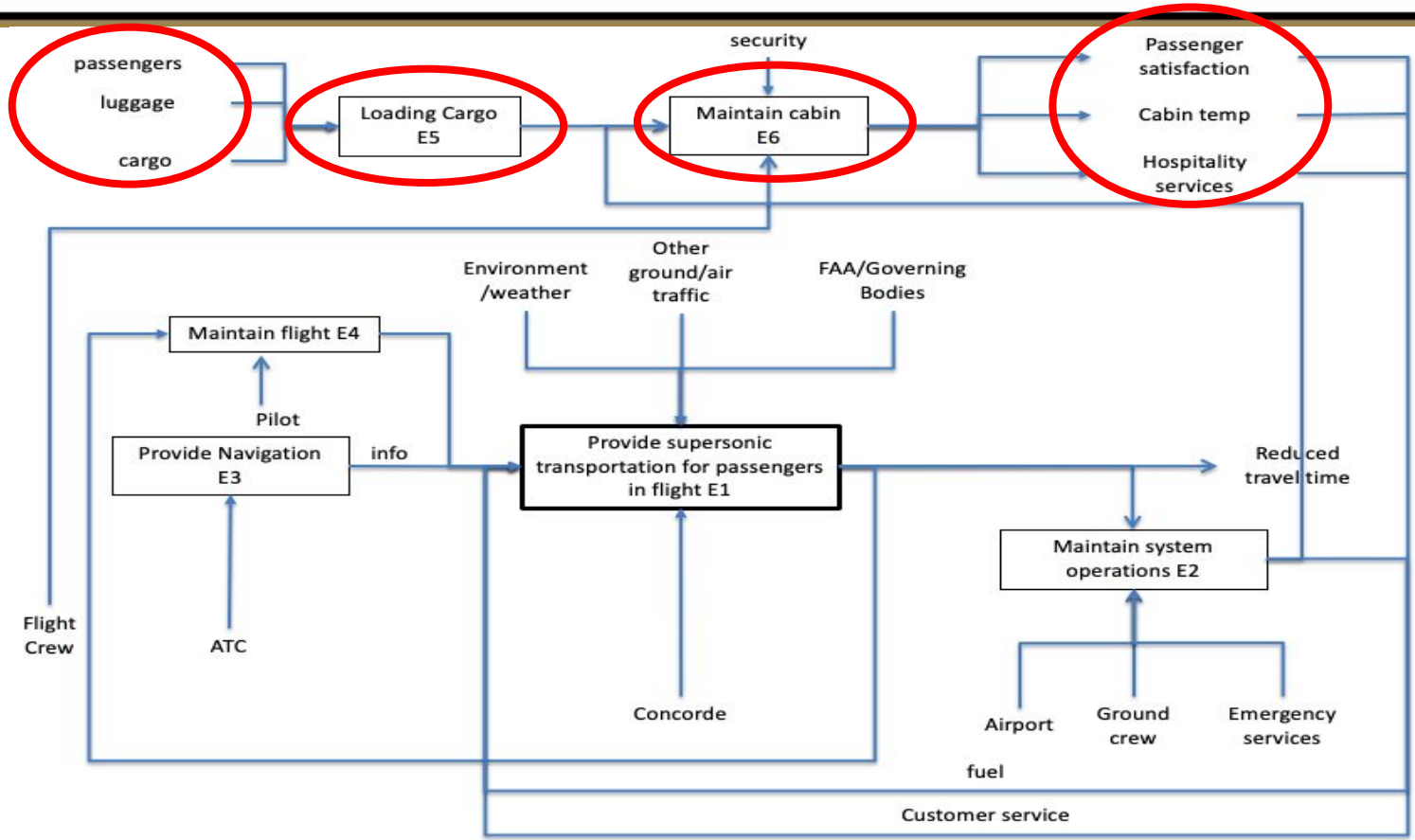
Input-Output Trace

Scenario: normal operations to reach max cruising altitude

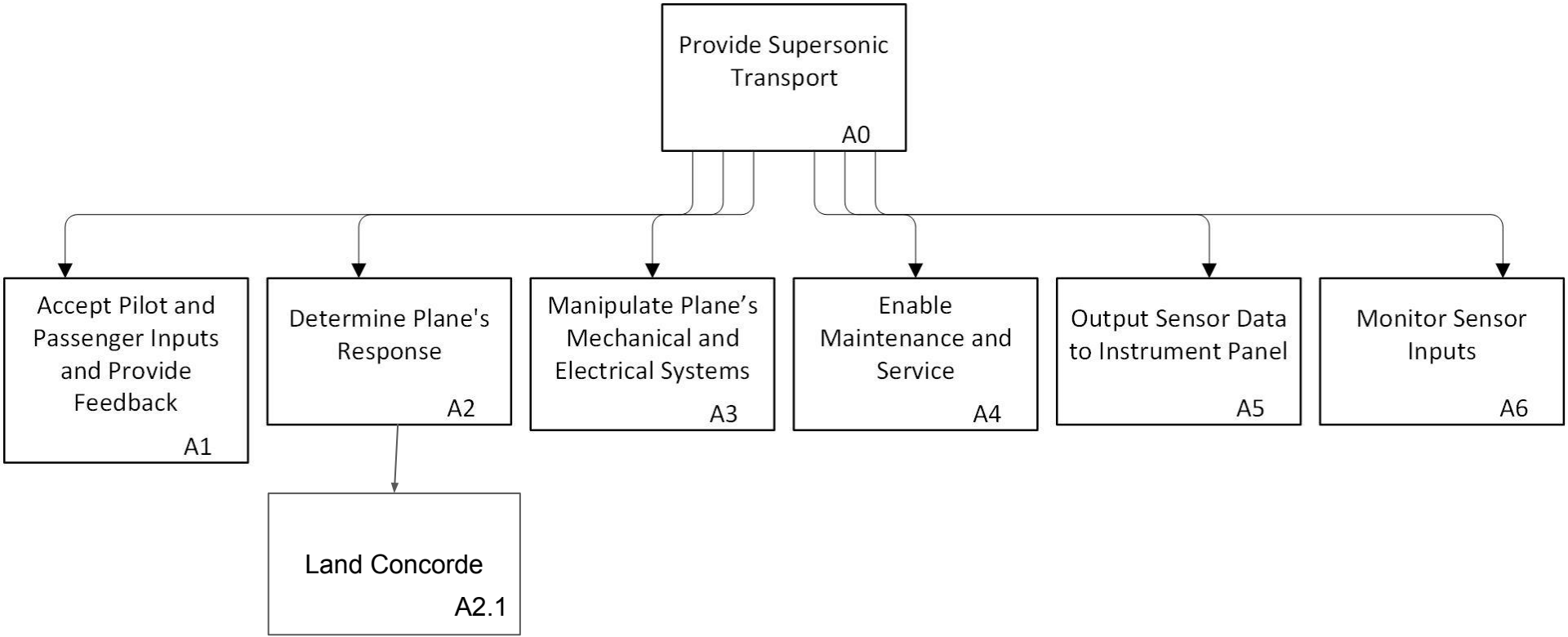
- Concorde performs climb configuration
- Concorde climbs to initial operating altitude
- Concorde burns fuel
- Pilot contacts ATC to increase altitude
- ATC approves request
- Pilot increases Concorde's altitude by 4,000 ft
- Concorde burns fuel
- Pilot contacts ATC to increase altitude
- ATC approves request
- Pilot increases Concorde's altitude by 4,000 ft
- Concorde cruises at final operating altitude of 60,000



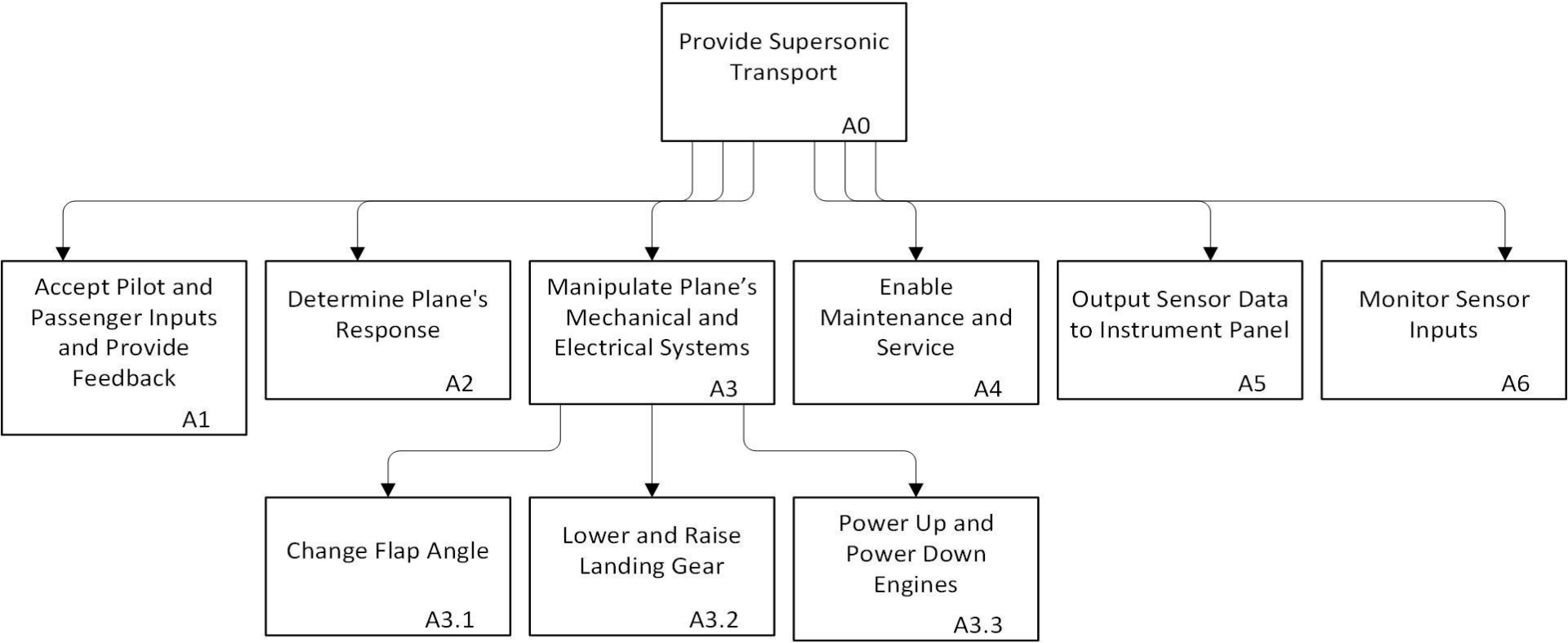
External Systems Diagram



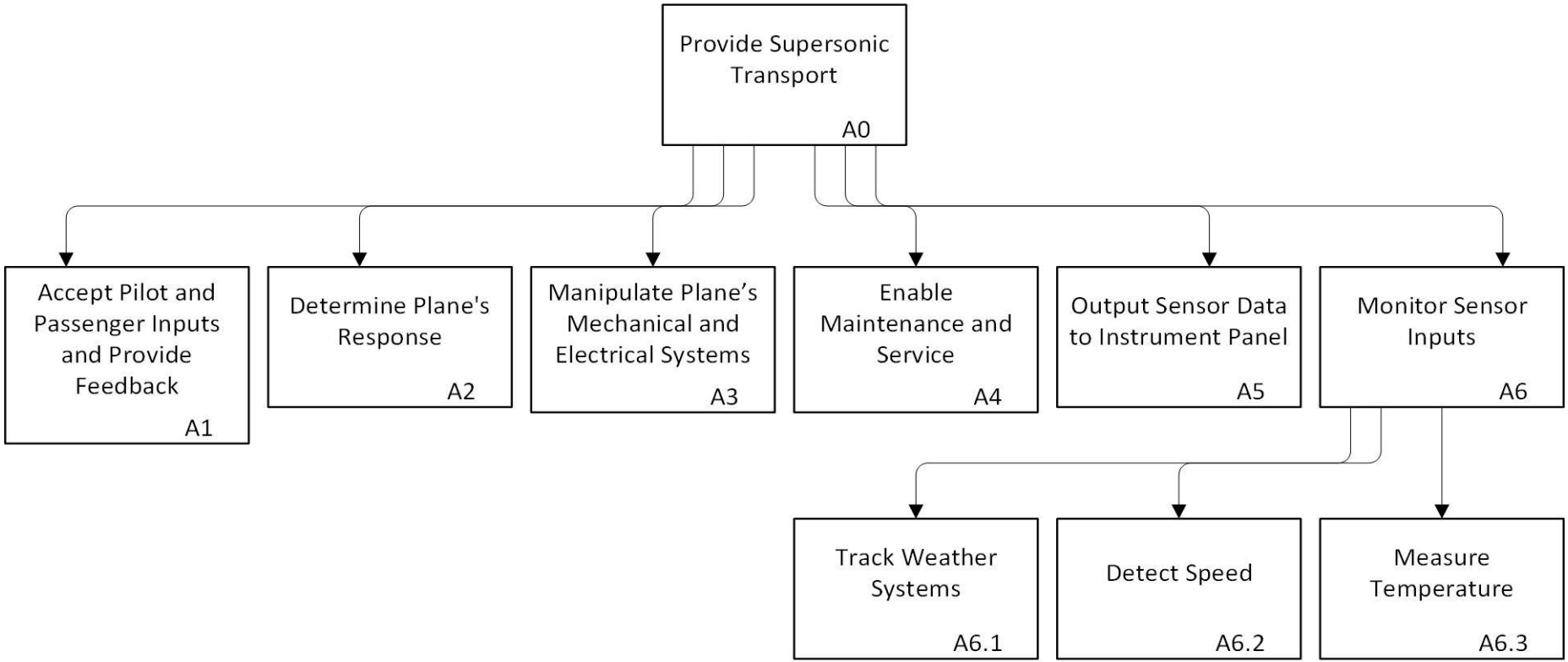
Functional Architecture



Functional Architecture: Process Model

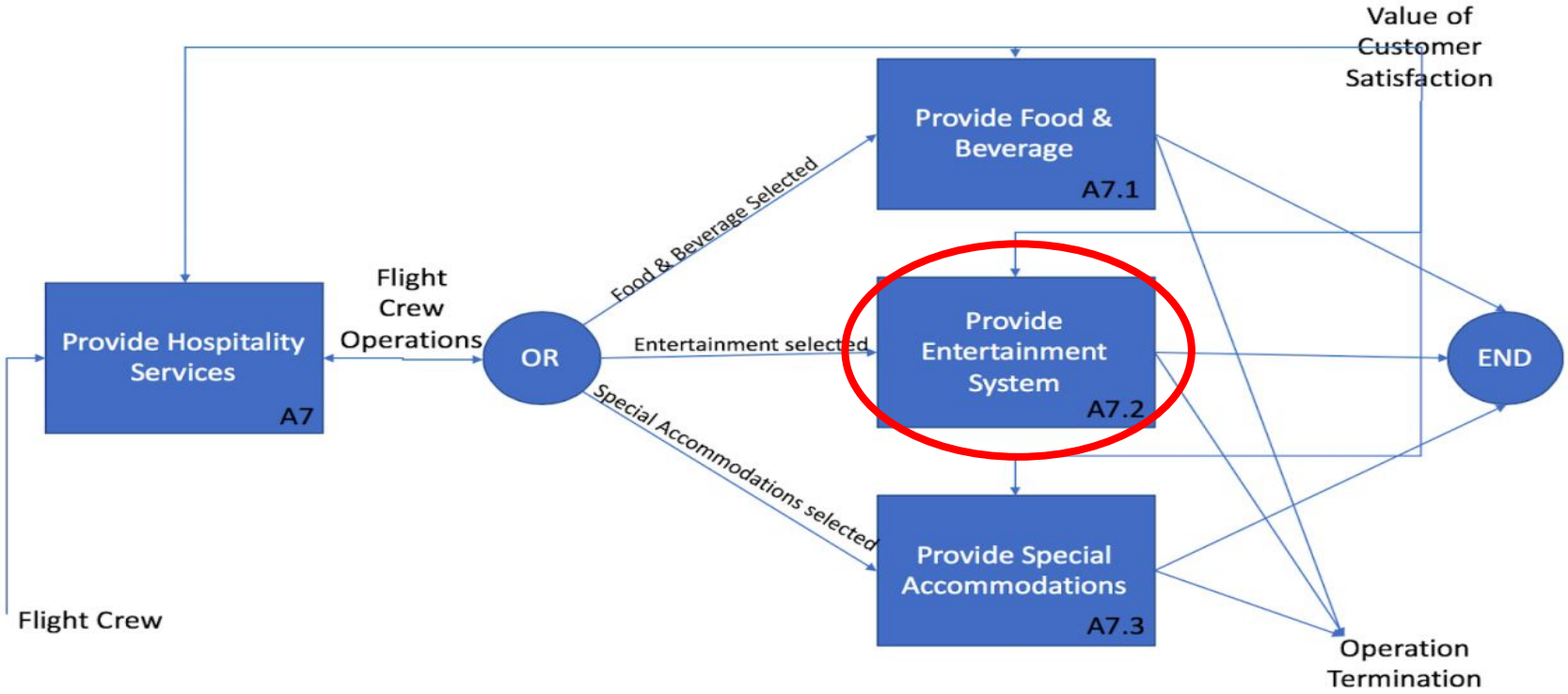


Functional Architecture: Input Processing

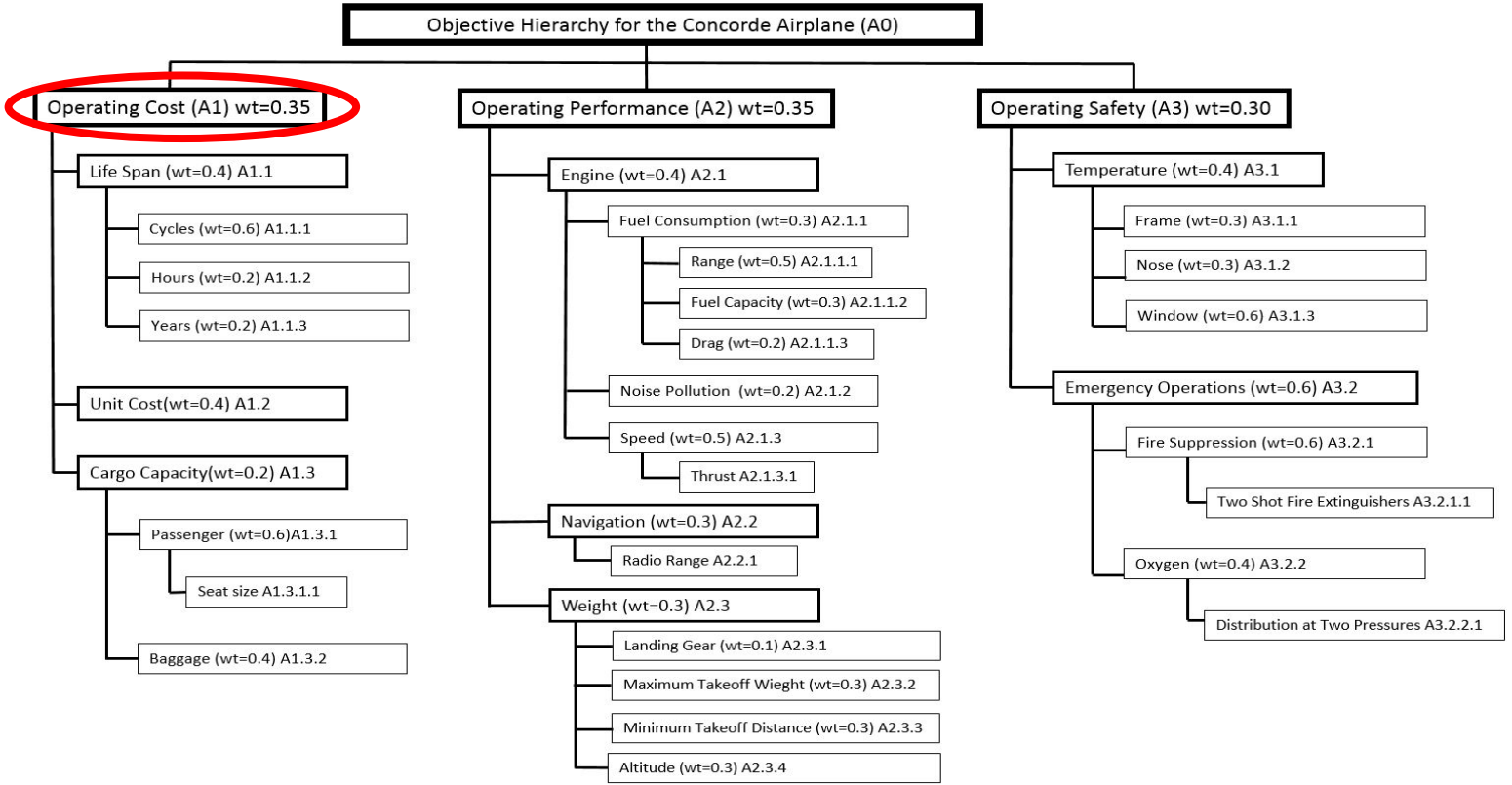


EEFBD (A7)

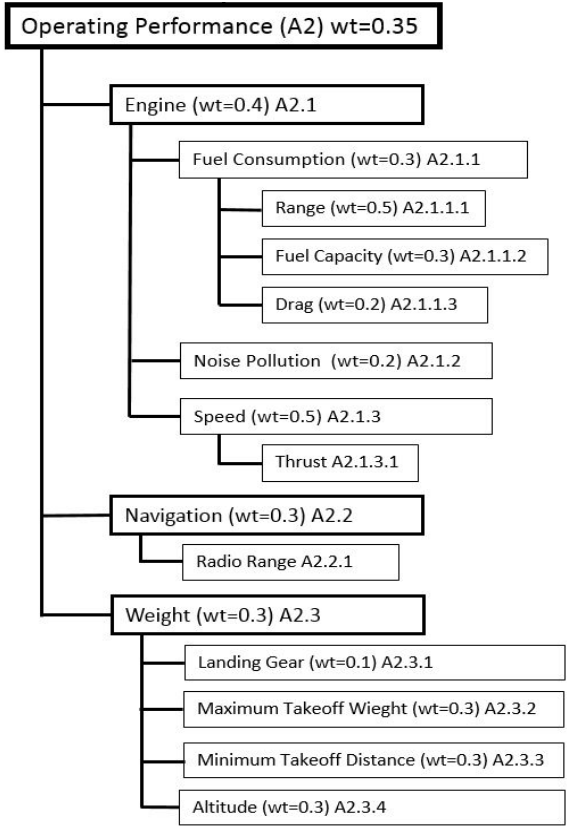
The Concorde shall have a modern, interactive cabin experience (R1.6)



Objective Hierarchy



Objective Hierarchy-Performance



Engine

- 4 Rolls-Royce/Snecma Olympus 593 engines with thrust of at least 30,000 lbf.

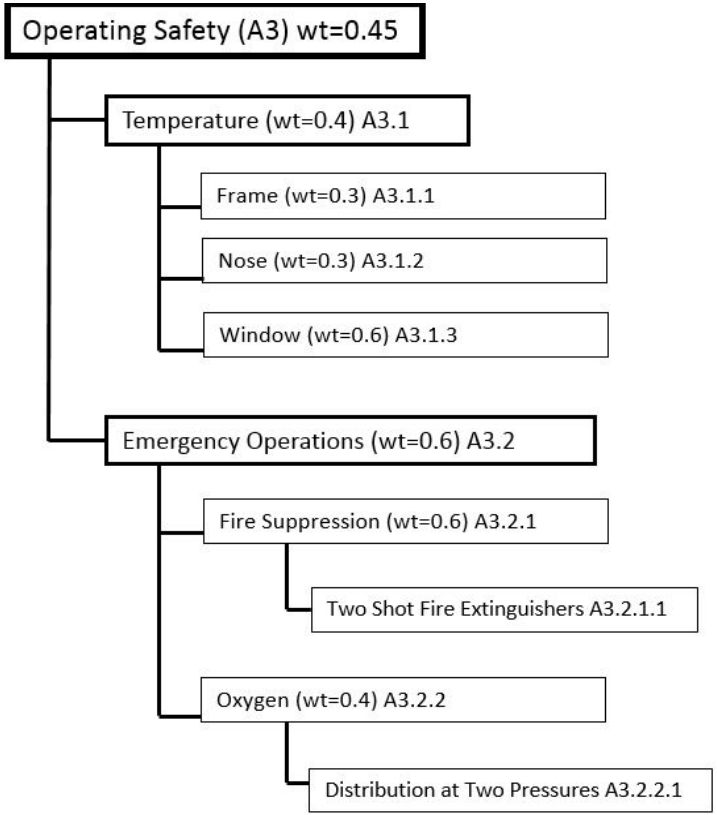
Navigation

- Communicate with ATC
- External light indicators visible approximately 2 miles away

Weight

- Weigh no more than 412,000 lbs (186,880 kg)

Objective Hierarchy-Safety



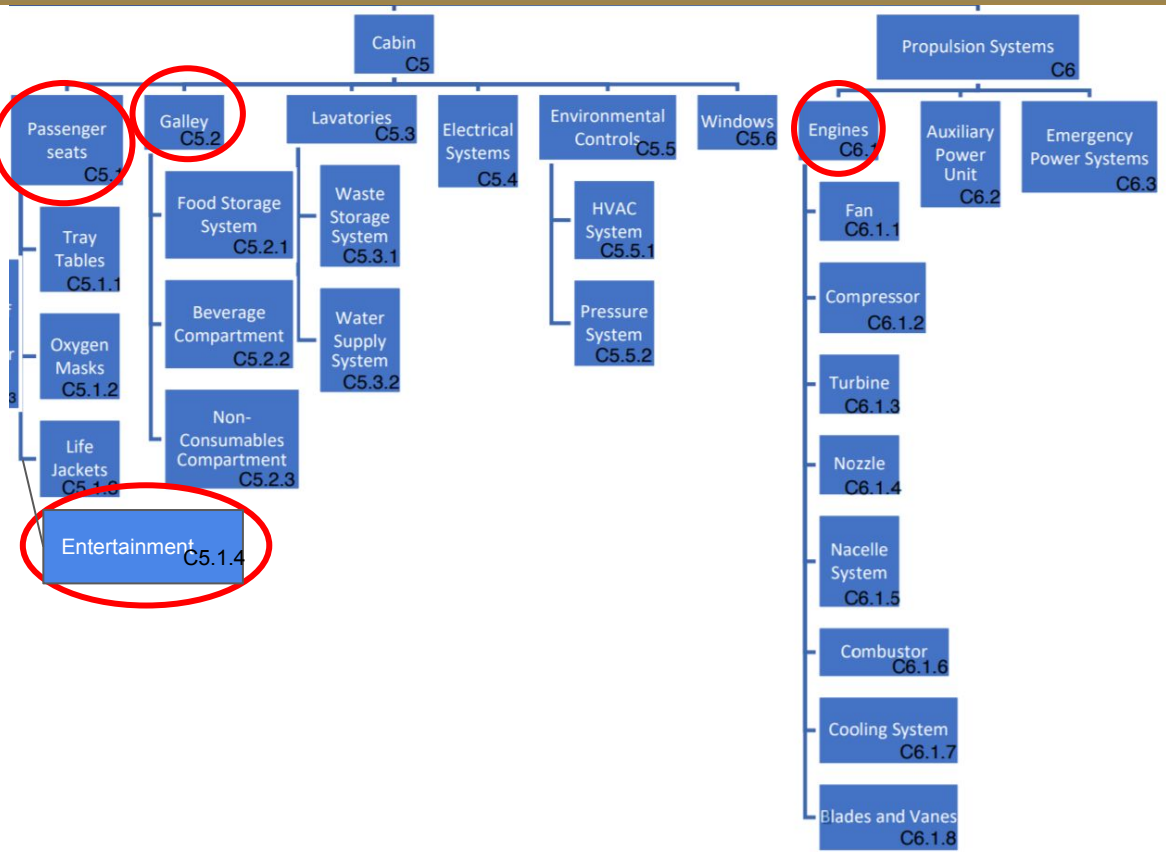
Temperature

- Frame shall not exceed 127° C
- External windows of Concorde should withstand a temperature variation from -50°C to 117°C

Emergency Operations

- Emergency oxygen systems below and above 14,000 feet in the air
- Two shot fire-suppression system

Physical Architecture—Enhancements



Operational Architecture

Prior ORD: The Concorde shall hold at least 120 passengers (R1.2)

REQUIREMENT	FUNCTION	PHYSICAL
R2 The Concorde shall be able to hold **200 passengers**	A1.1.1 Maintain Cabin Conditions; A7.3 Provide Special Accomodations; A1.1.1.2 Provide Seating Arrangement	C5 Cabin
R9.5.1 The lower baggage compartment shall have a capacity of 227cu feet and shall be located beneath the passenger seat between aircraft zone 131 and 132.	A7 Provide Hospitality Services	C3.2 Storage Compartment
R19 The Concorde will have an emergency oxygen system.	A1.1.1 Maintain Cabin Conditions	C5.1.2 Oxygen Masks; C5.5 Environmental Controls

Finite State Machine Applications

Validation and Verification

Increase passenger capacity to 200	**Inspection**—interior of the aircraft can be examined to determine if requirement is met
Increase fuel efficiency	**Simulation & demonstration**—simulation can be done to estimate the fuel efficiency/range by using preset variables; demonstration can be done to confirm what simulation claims
Decrease noise pollution	**Demonstration**—aircraft can fly over land and the sound it produces can be measured to determine if this requirement is met
Modernize cabin controls	**Inspection**—interior of cabin can be examined to see if cabin controls are modern and have a user interface consistent with aircrafts same generation

Risk Management

Risk	Likelihood	Consequence	Risk
Longer Evacuation Time	Almost Certain	Minor	High
Passenger Seat Failure	Unlikely	Moderate	Medium
Prolonged Grounding Time (Financial Risk)	Almost Certain	Moderate	High
New Engine Use	Rare	Severe	High

Questions?

Sources

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