SEVENTH FRAMEWORK PROGRAMME (FP7)

CARGOMAP

AIR **CARGO** TECHNOLOGY ROAD **MAP**

Project number: 284551

Air Cargo R&TD Road Map

Document reference					
Work Package	*Classification*	*Nature*	*Partner*	*Date*	*Issue*
WP3	PU	R	CIRA	16/10/2013	V1.0

Document control			
Responsible	*Organisation*	*Name*	*Date*
Author	CIRA	Marcello Amato	01/04/2013
Partners involved	ADC	Adriaan de Graaff	01/05/2013
	DLR	Peter Meincke Stephan Horn	01/08/2013
	Gruppo Class	Giuseppe Siciliano	01/08/2013
	ILOT	Bartosz Dziugiel	01/08/2013
	SLOT	Noemi Král	01/08/2013
	TUoD	Paul Roling	01/08/2013
Reviewer	CIRA	Marcello Amato	15/10/2013
Approver	SLOT	Roland Gurály	16/10/2013

Document change log			
Issue	Date	Author	Comments
0	April 2013	M. Amato	Preliminary Outline
0.1	May 2013	A. de Graaff	Second Draft
0.3	August 2013	M. Amato	Third Draft
0.4	September 2013	A. de Graaff	Fourth draft
0.5	October 2013	A. de Graaff	Fifth draft
1.0	October 2013	Noémi Král	Final draft
2.0	November 2013	A. De Graaff	Final report

Table of Contents

1 EXECUTIVE SUMMARY 9
2 CARGOMAP PROJECT – SUMMARY 10
3 ACRONYMS 12
4 INTRODUCTION 14
5 AIR TRANSPORT IN EUROPE 15
6 FLIGHT PATH 2050: A VISION FOR THE ATS OF THE FUTURE 24
7 THE CARGOMAP APPROACH TO DEVELOP THE RTD ROADMAP 27
8 CARGO INDUSTRY OVERVIEW 31
9 CARGO TRANSPORT MODES 35
9.1 Road transport 35
9.2 Rail transport 47
9.3 Maritime transport 59
9.4 Air Cargo 65
10 SWOT ANALYSIS FOR THE COMPETITIVENESS OF FREIGHT TRANSPORT 89
10.1 Road Freight Transport 89
10.2 Rail and Intermodal Freight Transport 91
10.3 Maritime Freight Transport (containers) 93
10.4 Air Cargo Transport 94
11 OUTCOME OF THE QUESTIONNAIRES TO THE AIR CARGO STAKEHOLDERS 95
11.1 Long haul (> 6000 km) 95
11.2 Medium haul (1000-6000 km) 97
11.3 Short haul (< 1000 km) 98
11.4 Very short haul (<200 km) 99
11.5 Research needs 99
12 AIR CARGO DEMAND AND FUTURE TRENDS 100
12.1 Air Cargo Demand 100
12.2 New transport concepts 106
12.3 Possible substitution issues 107
12.4 Future competition with new air cargo entrants 109
12.5 The Airbus global forecast 2011-2030 113
12.6 The Boeing global forecast 2012 115
12.7 Bauhaus, TU Munchen and Airbus forecast 2011- 2030 117
12.8 TUD forecast 119
12.9 The CargoMap forecast for Europe 120
12.10 Adaptation to City-pair Level for global forecasts 123
12.11 Selection of Airports 124
12.12 Focus on Peaks in Demand Forecast 126
12.13 Influence on Air Cargo of future factors 127
13 AIR CARGO IN THE FUTURE ATS – VISION AND REQUIREMENTS 132
13.1 Vision for Short Term (2020) 132

13.2 VISION FOR MEDIUM TERM (2035) 135
13.3 LONG TERM 2050 141
13.4 ADDITIONAL REQUIREMENTS FOR FUTURE DEVELOPMENTS OF AIR CARGO 142

14 OVERVIEW OF CURRENT RESEARCH AND POLICY INITIATIVES 145

14.1 EU SCENARIO 145
14.2 INTERNATIONAL SCENARIO 147

15 AIR CARGO ROADMAP 151

15.1 INNOVATIVE AIR VEHICLES TO SERVE THE FUTURE AIR CARGO MARKET 151
15.2 RANKING OF ALTERNATIVE AIRCRAFT 179
15.3 UNMANNED AIRCRAFT 180
15.4 THE ISSUE OF A NEW AIR CARGO CONTAINER 180
15.5 THE INTERMODAL TRANSPORT CHAIN 182
15.6 THE RESEARCH ROADMAP 183

16 RECOMMENDATIONS FOR THE EUROPEAN COMMISSION 193

17 REFERENCES 196

List a figures:

Figure 1: Main airports in Europe ... 15
Figure 2: Infrastructure bottlenecks at the world's 30 largest freight airports in 2007 ... 16
Figure 3: Boeing Market Outlook - new pilots and technicians ... 19
Figure 4: Night-flight restrictions at the world's 30 largest airports in 2007 ... 21
Figure 5: ACARE achievements ... 24
Figure 6: Approach to develop SRIA ... 25
Figure 7: CargoMAP approach ... 27
Figure 8: Concepts and their relationship ... 28
Figure 9: Recent load factors ... 29
Figure 10: Cost distribution ... 29
Figure 11: Jet fuel and crude oil price ... 30
Figure 12: RTD Roadmap development methodology ... 30
Figure 13: Direct relationship of Air Cargo Growth with GDP development ... 31
Figure 14: Air FTKs with respect to world trade volumes ... 32
Figure 15: Air FTKs from and to China on 2011 ... 32
Figure 16: Share of cargo between Sea and Air ... 33
Figure 17: Rail map of China ... 34
Figure 18: Evolution of tonnes by road (EU27 excl. UK) ... 35
Figure 19: Road freight TKM by country and its evolution, 2007-2010 ... 36
Figure 20: Road freight transport by EU hauliers by macro-area ... 37
Figure 21: Extra-EU road freight transport by partner countries ... 37
Figure 22: road freight transport in Europe ... 38
Figure 23: Average costs od road freight ... 40
Figure 24:Age distribution of heavy good vehicles ... 42
Figure 25: Evolution of the length transport infrastructures in Europe ... 43
Figure 26:Evolution of freight transport by mode (EU27, billion tkm) ... 47
Figure 27: Growth of freight transport by mode (EU27, tkm) ... 47
Figure 28: Growth of freight transport by mode, 2005-2009 (EU27, tkm) ... 48
Figure 29:Main rail freight corridors in Europe ... 49
Figure 30: Rail freight in Europe by Country, 2010, billion tkm ... 49
Figure 31: Rail freight in Europe by Country, change between 2010 and 2009, million tkm ... 50
Figure 32: General business model ... 50
Figure 33: Traditional operational model for cross border traffic ... 52
Figure 34: New operational model for cross border traffic ... 53
Figure 35: impact of the potential high speed rail connections ... 54
Figure 36: potential effect of high speed rail cargo in the Baltic area ... 55
Figure 37: Rail transport (Passenger and freight) ... 58
Figure 38: Evolution world economy, trade and seaborne flows, 1075-2011 ... 59
Figure 39: Evolution of world overall trade, 1075-2011 ... 60
Figure 40: Global container trade, 1990-2011 (TEU and annual % change) ... 60
Figure 41: Estimated container flows on major East-West routes, 1995-2009 (TEU) ... 61
Figure 42: General typology of door-to-door transport chain ... 61
Figure 43: Evolution of the maximum capacity of a container ship (thousand TEU) ... 63
Figure 44: Key Players in the Air Cargo Market ... 65
Figure 45: Top 25 Cargo Airlines 20 ... 69
Figure 46: Business model - Integrator ... 70
Figure 47: Top cargo Airports 2011 ... 71

FIGURE 48: AIR CARGO PRODUCT CHARACTERISTIC 72
FIGURE 49: COMMODITY DENSITY........ 73
FIGURE 50: VALUE DENSITY 73
FIGURE 51: DEVELOPMPENT IN AIR CRAGO GOODS IN THE FUTURE 75
FIGURE 52: TYPE OF GOOD AND MARKET SHARE 76
FIGURE 53: AIR FTKS AND WORLD TRADE VOLUMES........ 76
FIGURE 54: IMPORT AND EXPORT WITHIN CONTINENTS........ 77
FIGURE 55: AIRCRAFT TYPES 78
FIGURE 56: AIR FREIGHT DIVISION........ 78
FIGURE 57: FLEET DEVELOPMENT - CONVERTED FREIGHTERS........ 81
FIGURE 58: LARGEST FLEETS WIDE-BODY PASSENGERS JETS 81
FIGURE 59: AVERAGE DISTANCES ON AIR CARGO 82
FIGURE 60: COMPARISION OF SHIPPING COSTS .... **ERROR! BOOKMARK NOT DEFINED.**
FIGURE 61: OVERVIEW OF STUDIES ON PRICE ELASTICITY IN DEMAND FOR AIR FREIGHT TRANSPORT 83
FIGURE 62: COST OF DIFFERENT TRANSPORT MOEDS........ 84
FIGURE 63: COST PER KG FOR DIFFERENT TYPES OF GOODS........ 84
FIGURE 64: PERFORMANCE VS. COSTS 86
FIGURE 65: FREIGHTER AIRCRAFT FLEET COMPOSTION IN 2030 VS. 2011 86
FIGURE 66: AIRCRAFT DIVISION NEEDED FOR REPLACEMENT AND GROWTH MARKET........ 87
FIGURE 67: AIRCRAFT DIVISION NEEDED FOR REPLACEMENT AND GROWTH MARKET........ 87
FIGURE 68: 20 YEARS FLEET GROWTH AND DEMAND........ 88
FIGURE 69: TRAFFIC GROWTH 88
FIGURE 70: EA-17 TRADE IN GOODS BY TYPE OF GOODS, 2011, EURO BILLIONS 101
FIGURE 71: EXTERNAL EU-27 TRANSPORT OF GOODS BY MODE, 2010, BILLION EURO 101
FIGURE 72: INTRA-EU27 TRANSPORT OF GOODS BY MODE, 2010, BILLION TKM........ 102
FIGURE 73: DIVISION OF EXPRESS, MAIL AND SCHEDULED FREIGHTERS 102
FIGURE 74: EXPRESS PARCEL SERVICES WITHIN EUROPE........ 103
FIGURE 75: FREIGHTER DEMAND FORECAST PROCESS........ 103
FIGURE 76: FORCES AND CONSTRAINTS FOR AIR CARGO GROWTH........ 104
FIGURE 77: INFLUENCING FACTORS 105
FIGURE 78: OVERVIEW OF AIR FREIGHT FORECASTS 105
FIGURE 79: TRANS-EURASIA EXPRESS 107
FIGURE 80: TRUCK FLIGHTS IN EUROPE 108
FIGURE 81: COMPETITIVE RELATIONSHIPS BETWEEN AIR FREIGHT TRANSPORT AND OTHER TRANSPORT MODES........ 109
FIGURE 82: AIRPORT EXPANSION PLANS IN THE MIDDLE EAST........ 110
FIGURE 83: FUTURE WIDE-BODY FLEET DEVELOPMENTS........ 111
FIGURE 84: FLEET EXPANSION PLANS OF MIDDLE EAST AIRLINES .... **ERROR! BOOKMARK NOT DEFINED.**
FIGURE 85: FORECAST 2011-2030 BASED ON 3 SCENARIOS........ 117
FIGURE 86SHIFT OF AIR CRAGO GOODS TILL 2030........ 117
FIGURE 87: SHIFT OF AIR CRAGO GOODS TILL 2030........ 118
FIGURE 88: SHIFT OF AIR CRAGO GOOD TILL 2030 118
FIGURE 89: TUD FORECST........ 119
FIGURE 90: TONNAGE PER ROUTE FOR THE TOP 40 TONNAGE 119
FIGURE 91: TONNAGE OPPORTUNITY COMPARISION 120
FIGURE 92: EU27 FREIGHT TRANSPORT BY MODE, 1995-2010, THOUSANDS MIO TKM 121
FIGURE 93: EU27 FREIGHT TRANSPORT, HISTORICAL TREND PROJECTION TO 2050, THOUSANDS MIO TKM AND AAGR 121
FIGURE 94: EUROPE'S GLOBAL TRADE LONG TERM GROWTH RATES........ 122
FIGURE 95: BASELINE SCENARIO OF FREIGHT TRANSPORT FOR EUROPE, 2010-2050, THOUSANDS MIO TKM 122
FIGURE 96: LONG-TERM FORECAST IN 2000 AND 2010 123

FIGURE 97: REPRESENTATION OF THE CALCULATION STEPS TO ARRIVE AT A CITY-PAIR DETAIL LEVEL 123
FIGURE 98: MARKET SHARE OF AIR CARGO BY ECONOMIC REGION IN 2012 (AIRBUS, 2012) 124
FIGURE 99: TOP 20 AIR CARGO GROWTH PREDICTIONS 124
FIGURE 100: THE AVERAGE CARGO DENSITY IN THE TOP 10 ECONOMIC MARKETS OF 2035 126
FIGURE 101: W EIGHTED AVERAGE MASS DENSITY FOR TOP 20 CARGO FLOWS 126
FIGURE 102: MARKET DEMAND VERSUS DISTANCE 127
FIGURE 103: INFLUENCE OF SOCIAL MEDIA 127
FIGURE 104: INFLUENCE OF 3D PRINTING 128
FIGURE 105: IATA E-FREIGHT 129
FIGURE 106: SMART GATE CONCEPT AT SCHIPOL AIRPORT 130
FIGURE 107: CONCEPTUAL STUDIES BY BOEING AND AIRBUS 134
FIGURE 108: INTERCONTINENTAL CARGO FLOWS FOR 2011 AND FOR 2030 136
FIGURE 109: MARKET OUTLOOK FOR2035 137
FIGURE 110:DEVELOPMENTS I AIRCRAFT DESIGN IN 2009 138
FIGURE 111: APPROACHING LIMITS ACCORDING TO ROLLS ROYCE 139
FIGURE 112: AIRBUS AND BOEING AIRCRAFT FAMILIY 139
FIGURE 113: NEW AIRCRAFT TYPES 140
FIGURE 114: NEW AIRCRAFT TYPES 140
FIGURE 115: NEW GENERATION OF MEDIUM- AND SHORT-HAUL AIRCRAFTS 141
FIGURE 116: OVERVIEW OF EU SCENARION IN REGARD PROJECTS 146
FIGURE 117: OVERVIEW OF EU SCENARION IN REGARD PROJECTS 147
FIGURE 118: PELICAN AIRCRAFT (BOEING) 154
FIGURE 119: WIGE AIRCRAFT CONCEPTS 154
FIGURE 120: VERY LARGE SUBSONIC AIRCRAFT CONCEPTS 156
FIGURE 121: VERY EFFICIENT SUBSONIC AIRCRAFT 157
FIGURE 122: VERY EFFICIENT SUBSONIC AIRCRAFT CONCEPTS 157
FIGURE 123: VERY EFFICIENT SUBSONIC AIRCRAFT CONCEPTS 158
FIGURE 124: SLOW FLYING SUBSONIC AIRCRAFT CONCEPTS 160
FIGURE 125: SUPERSONIC CARGO AIRCRAFT CONCEPTS 161
FIGURE 126: HIPERSONIC CARGO AIRCRAFT 162
FIGURE 127: MORPHING AIRCRAFT SUITABLE FOR FORMATION FLIGHT 163
FIGURE 128: JOINED SMALL AIRCRAFT CONCEPTS 164
FIGURE 129: SMALL LONG HAUL AIRCRAFT CONCEPTS 166
FIGURE 130: LARGE MEDIUM HAUL AIRCRAFT CONCEPTS 167
FIGURE 131: QUANTITATIVE ASSESSMENT - LARGE MEDIUM HAUL AIRCRAFT 167
FIGURE 132: LARGE AIRSHIP 168
FIGURE 133: NEW REGIONAL AIRCRAFT WITH A PAYLOAD OF 50 TONS 169
FIGURE 134: NEW REGIONAL AIRCRAFT WITH A PAYLOAD OF 50 TONS 170
FIGURE 135: TILT ROTOR AIRCRAFT WITH A CAPACITY OF 20 TONS 171
FIGURE 136: ADVANCED FAST ROTORCRAFT 173
FIGURE 137: FUTURE AUTOGYRO PLANES 173
FIGURE 138: ADVANCED SMALL AIRCRAFT USING THE FAN-WING CONCEPT 174
FIGURE 139: ADVANCED SMALL AIRCRAFT 176
FIGURE 140: CESSNA CARAVAN 177
FIGURE 141: UAS SYSTEMS 178
FIGURE 142: NOVEL AIR CONTAINERS 181
FIGURE 143: EC 194

List of tables:

TABLE 1: TOP 10 LAND OPERATORS IN EUROPE (ROAD + RAIL) IN 2009 39
TABLE 2:OPERATING COSTS OF ROAD FREIGHT TRANSPORT: % OF TOTAL, BY COUNTRY 39
TABLE 3: MAIN CONTAINER SHIPPING COMPANIES (2011) 62
TABLE 4: TIME SENSITIVY OF GOODS 85
TABLE 5: PRICE SENSITIVY OF GOODS 85
TABLE 6: SUMMARY OF CONCLUSIONS RELATED TO NOVEL SLOW FLYING AIRCRAFT LONG HAUL AIRCRAFT 96
TABLE 7: SUMMARY OF CONCLUSIONS RELATED TO THE PROPOSED NOVEL AIR CONTAINERS 96
TABLE 8: SUMMARY OF CONCLUSIONS RELATED TO THE LOCATION OF AIRPORTS: FOCUS ON HUB'S 97
TABLE 9: EU-27 TRADE IN GOODS BY PARTNER, 2011, EURO MILLIONS 100
TABLE 10: OVERVIEW OF MAIN AIRPORTS PER REGION 125

1 Executive summary

Main goals of the CARGO Map (CSA-SA) project are:

- Analysis of current situation in air cargo and the demand with the involvement of the stakeholders in Europe.
- Expected future bottlenecks/challenges in air freight transport and the identification of the corresponding requirements. The requirements will identify the technology needs and regulatory issues to be addressed.
- Synopsis and evaluation of possible improvements related to future business models and business cases.
- Definition of a technology roadmap to fill the technology/regulatory/operative gaps in order to fulfil the requirements considering the current capabilities.

The project aims to investigate what new challenges and opportunities exist for new air cargo aircraft in the future, responding to societal challenges and the concept of seamless multi modal transport chains.

Based on business cases, the possible need for novel dedicated air cargo planes has been derived and the technologies that will be needed to create these novel airplanes have been identified in the roadmap.

Whilst identifying novel technologies, only those specific to air cargo vehicles and operations are shown in the roadmap, assuming that the generation of generic new technologies in aviation will take place.

Current and planned research activities have been identified together with the missing elements to enable a new generation of air cargo aircraft to be developed between 2030 and 2050. Such a roadmap on a European scale does not exist for dedicated cargo planes.

Each activity is developed in a specific task and WPs and the results are presented in specific deliverables.

The Roadmap document is collecting all the results in a single self-standing report, referring to the specific deliverables for detailed analysis. This document is thus providing a summary of main achievements and the technology roadmap developed in the project.

The roadmap will be proposed to the European Commission, the private industry, Member States and networking organizations like ACARE to select research and technology topics for future cargo aircraft RTD projects and prioritize funding.

2 CargoMAP Project – Summary

The Air Cargo technology Roadmap (CargoMap) project focuses on the future role of air freight and the definition of a technology roadmap for future cargo aircraft responding to end user requirements and environmental needs.

The goals of the project are:

a. Analysis of current situation and the demand with the involvement of the stakeholders in Europe among all actors.
b. Identification of the expected future bottlenecks/challenges in air freight transport and the corresponding requirements. The requirements will identify the technology needs and regulatory issues to be addressed.
c. Synopsis and evaluation of possible improvements related to future business models and cases.
d. Definition of a technology roadmap to fill the technology/regulatory/operative gaps in order to fulfil the requirements considering the current capabilities.
e. Dissemination of the results.

Consortium

The effectiveness of the consortium is built on the diversity and the complementarity of the project partners. The consortium members were selected with the aim of studying the European air cargo transportation community from different perspectives and bring in the experience of other projects dedicated to strategic road mapping. The competences of the partners complete one another in a way that forms a strong and reliable team.

The following table summarizes the participants of the project:

Partner name	Country	Activity	Role in the project
Slot Consulting Ltd.	Hungary	Coordinator	Management of the consortium Contribution to the technical analysis Managing the dissemination activities
Deutsches Zentrum Für Luft - und Raumfahrt Ev – DLR	Germany	WP Leader	Leader WP1 and Contributor in WP2;
Gruppo Clas Srl	Italy	WP Leader	WP2 technical leader Contributor to technical activities
Ad Cuenta BV.	Netherlands	Contributor	Technical activities, user group, Roadmap drafting and dissemination activities
Technische Universiteit Delft	Netherlands	Contributor	Technical and dissemination activities
Centro Italiano	Italy	WP	WP3 leader

Partner name	Country	Activity	Role in the project
Ricerche Aerospaziali Scpa		Leader	Contribution to technical activities
Instytut Lotnictwa	Poland	Contributor	Technical expertise in air cargo especially in small aircraft segment

Expected Achievements

Novel concepts in aviation need a long time to mature. So it is appropriate to develop a technology roadmap aimed at future technologies specifically related to novel air cargo aircraft.

The main aim of the project therefore is to prepare a RoadMap that will show which specific enabling technologies and operational issues will be needed and at what time. In this technology roadmap the focus will be on technologies specifically aimed at air cargo operations and the dedicated air cargo aircraft. Reference is made to generic technologies in aviation but the roadmap will focus on air cargo related issues.

CargoMap will also examine novel trends in air freight that may be the result of economic growth in Asia and the connections between Europe and Asia. CargoMap will also analyse the potential use of additional air cargo operations in Europe and its consequences. Time focus will be 2035 as in the SRIA, including a perspective towards 2050.

Strategic expected impact:

- Support improvements of air freight in European transport by adoption of a new business cases and advanced technology in order to responding to new end user requirements and environmental needs.
- Map the RTD programmes and projects in Europe
- Set up recommendations for future EU Framework Programmes related to Air Cargo Aircraft

3 Acronyms

AEA	European Airlines
ATO	Air Transport and Operations
ATM	Air Traffic Management
BL	Base Line
BWB	Blended Wing Body
DOC	Direct Operating Cost
EU	European Union
FF	Formation Flyer
FTK	Freight Tonne Kilometre
GDP	Gross Domestic Product
HTA	heavier-than-air
HULA	Hybrid Ultra Large Airship
IOC	Indirect Operating Cost
ISECOM	Institute for Security and Open Methodologies
ILA	International Berlin Air Show
JIT	Just In Time
LAAS	Local Area Augmentation System (LAAS).
LP	Lean Principles
LTA	lighter-than-air
LCC	Low-cost carrier
MTOW	Maximum Take Off Weight
MZFW	Maximum Zero Fuel Weight
nm	Nautical Miles
OEM	Original Equipment Manufacturer
OPAM	Operational Performance Assessment Methodology
PRC	People's Republic of China
RCF	Relative Cost Factor
RTD&I	Research Technology Development and Innovation
SCI	step-change-innovations
STOL	Short Take-Off & Landing

SR	Max Maximum Specific Range
SWIM	System Wide Information Management
TAT	Turn-around time
TVF	Time Value Factor
VL	Value Liner
VTOL	Vertical Take-Off & Landing
UAV	Unmanned Aerial Vehicle
WAAS	Wide Area Augmentation System
WIGE	Wing In Ground Effect

4 Introduction

The Roadmap document is collecting the results of the CargoMap Project in a single self-standing report, referring to the specific deliverables for detailed analysis.

The Roadmap is thus providing a preliminary summary of main achievements of the CARGOMAP Project and the technology roadmap derived with a new approach:

- investigate challenges and opportunities for air cargo operations in the future, responding to societal challenges and the concept of seamless multi modal transport chains;
- study the current business models and provide alternative business cases for new types of air cargo operations;
- define new requirements for novel air cargo planes;
- identify the technologies that will be needed to create these novel airplanes.

The report is structured following the approach to develop the roadmap.

- Overview of the Air Cargo Industry in terms of transported goods' types and existing stakeholder categories (integrators, airlines, manufactures, etc.), current business models and possible new approaches.
- Forecasted air cargo demand and future trends for short/medium/long haul and domestic service for different commodities.
- Highlights from Flightpath 2050 with a special focus on the goals and enablers for the Air Cargo.
- Description on the approach to develop the R&TD roadmap.
- Vision for the air cargo in the future ATS for 2020, 2035 and 2050.
- European and international scenario for air cargo industry and R&TD activities.
- Air Cargo Roadmap for the medium term (2035) and for the long term (2050) looking to:
  - Products and Technologies;
  - Business Models and Operations;
  - Enabling Conditions.

5 Air transport in Europe

Europe is one of the densely populated continents on Earth that occupies an area of 4,324,782 square km with 497.198.740 inhabitants (forecast for the year of 2011). Geographically, it is almost 4.200 km height and 5.600 km wide. These dimensions define the framework of the market related to the European transportation.

Air transportation is considered to be the most efficient transportation means and therefore has a dominating position for long distance transportation. It is also significant at short or medium distances, but upon various factors influencing the passenger‘s mode selection criteria, it competes with rail and car transport. The European air traffic network contains about 170.000 links between 450 civil commercial airports.

European Airports

A characteristic feature of the European air transport service market is the co-existence of several large centres performing trans-continental links and a dense net of local links between the majority of small cities and tourist resorts. According to the EPATS research report published in 2006, Europe has 1270 airports and 1300 landing fields.

Regarding the airports, the top 100 hundred busiest – ranked by the total passengers per year in 2010 – is shown in the Figure below. Accordingly, there is a geographical concentration at the region London-Amsterdam-Munich-Milan. In addition, just the top 25 IFR airports generate 44% of all flights.

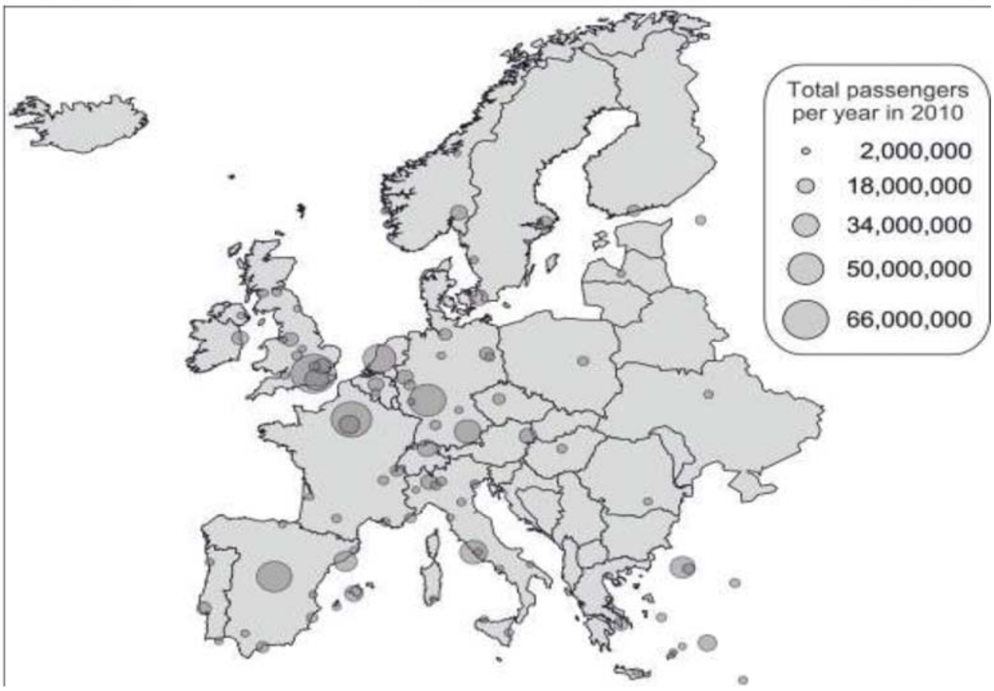
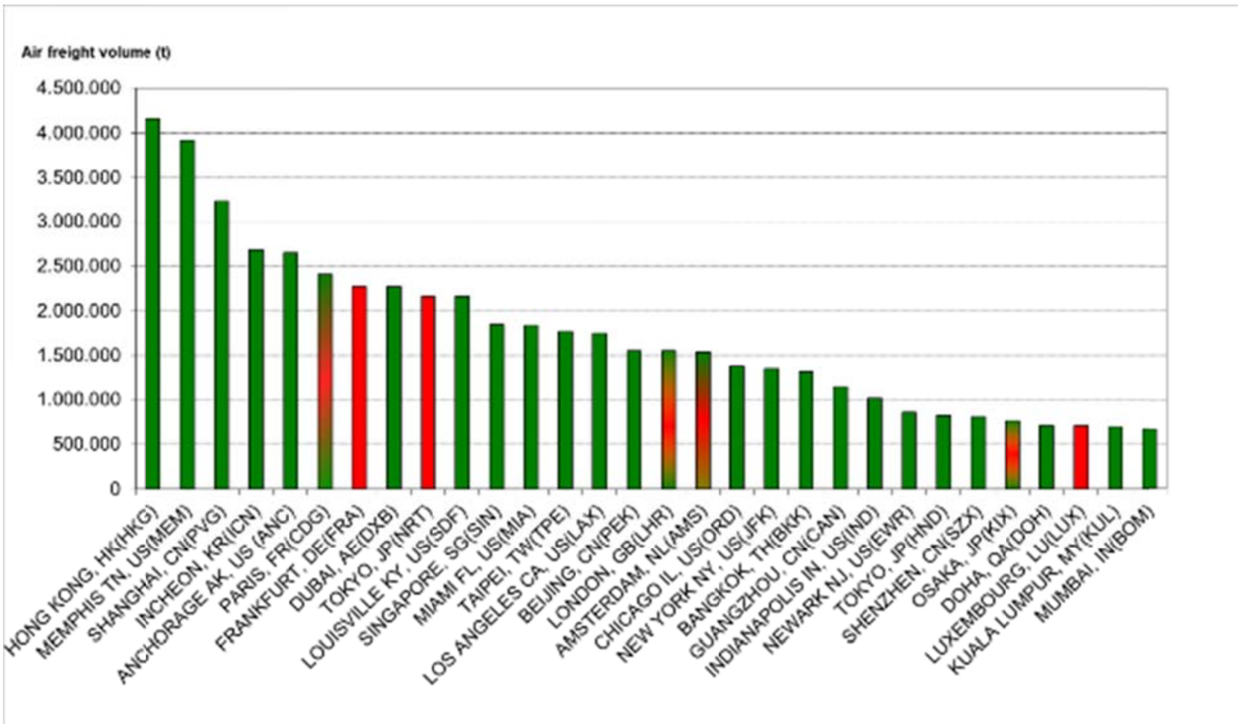


Figure 1: Main airports in Europe

Source EPATS project

The figure below shows the infrastructural capacity situation at the selected airports. Infrastructure bottlenecks are primarily related to capacity utilisation on take-off and landing runways and have less to do with the availability of terminal capacities. The utilization of airport infrastructure capacity is reflected in the availability of slots (time windows for take-offs and landings). Collecting infrastructure data is generally rather difficult and the information for some airports is therefore only based on estimates.



No capacity limit   Limited capacity   Night flying

Figure 2: Infrastructure bottlenecks at the world's 30 largest freight airports in 2007

Source: Original Graph, Data Basis:

ACI (Ed.) (2008), Boeing (Ed.) (2008b), IATA/ACI/ATAG (Ed.) (2003), FAA (Ed.) (2004), EUROCONTROL (Ed.) (2008)

The graph shows that airports which are also very important in passenger air transport (Frankfurt am Main, the New York airports John F. Kennedy and Newark, Chicago O' Hare and London Heathrow etc.) are confronted with significant infrastructure bottlenecks. Passenger airlines often have a higher priority than freight flights at these airports, for example in terms of slot allocations and terminal capacities. Due to these restrictions, freight airlines sometimes choose secondary airports for their air freight service operations.

Expansion work has been or is being carried out to improve the capacity of runway capacity at certain airports. It must be taken into account that these investments in the airport infrastructure will take a long time to implement. The time period required for planning, obtaining permits, building through to usage can be over ten years. Looking at the forecasted growth figures for air transport, even medium to long-term capacity bottlenecks at airports, especially in Europe, Japan and the USA, must therefore be expected and these could have a regional effect on the development of air freight.

A medium-term flight forecast published by EUROCONTROL in February 2011, describes the annual numbers of instrument flight rules (IFR) movements until 2017:**11.5 million IFR movements in Europe for 2017**, which is 21% more relative to the 2010 levels.

The strong growth of 4.5% in 2011 reflects the compensations for adverse events in 2010, with little over half of that. This is basically due to that fact that 2010 is marked by economic and related traffic growth slow-down. On the other hand, significant geographical variance is observed in the forecast, in which traditionally more mature markets in the west will typically see slower growth over the next 7 years.

The **future navigation concept** and applications shall be based on performance based navigation standards rather than just on technologies and equipage requirements. Performance based navigation concepts include Area Navigation (RNAV) and Required Navigation Performance (RNP). RNAV enables aircraft operation on any desired flight path allowing user preferred routings and trajectories.

RNP is a statement of the aircraft navigation performance necessary for operation in an area or necessary for a specific procedure, such as complex arrival and departure procedures and includes the attribute of on-board performance monitoring and alerting. RNAV and the application of RNP is the platform for a seamless, harmonised and cost effective navigational service from departure to final approach. This will provide significant benefits in safety, efficiency and capacity.

The **current navigational infrastructure is a fragmented** and ever expanding collection of different technologies, systems, concepts and services. This situation causes increase of operating and service costs for airlines. The future navigational infrastructure should provide a global coverage with unrestricted access to navigational position information at minimum cost.

A future global navigational infrastructure based on GNSS (**Global Navigation Satellite System)** enabled RNAV (Area Navigation) and RNP (Required Navigation Performance) will deliver many benefits in safety, efficiency, capacity and economy. Some of the most important are the followings:

- Transition to RNAV with performance enabling the expeditious navigation of aircraft using one globally accessible capability will provide efficiency benefits even within high density airspace (dynamic routings, standard approach and departure procedures),
- Increased capacity with maintaining or enhancing safety through more autonomous operation of aircraft in dense airspace (reduction of controller workload),

- Safety improvement, route mileage reduction (fuel savings), flight time reduction (crew cost), reduction of airborne equipage requirements and infrastructure investment as well as overall maintenance costs will improve economy.

According to EUROCONTROL, 90% of en-route ATFM (Air Traffic Flow Management) delays were concentrated in a small number of ACCs (Area Control Centres) (17 out of 67), but these delays affected negatively the entire European network. The European airspace is very complex and fragmented. It is used by approximately 25-35.000 commercial flights per day, operated by some 5.000 aircraft, flying between 100 major (and many more secondary) airports, using typically 600 airspace sectors.

Almost 500 routes have developed around the twists and turns of national borders and many air routes have to deviate areas set aside for military flights. These flights account for low flight route efficiency, and therefore consume more fuel than the necessary quantity. Due to these military areas, the amount of restricted airspaces and the geographical location of the most popular routes, it is estimated that **approximately 70% of flights are concentrated into 14% of the available airspace.**

The Single European Sky (SES) program has advocated the use Flexible Use of Airspace and has taken a major step in encouraging national air navigation service providers to develop joint operations with their neighbours by mandating the development of common functional airspace blocs throughout Europe. Due to the envisioned efforts, it is expected that the capacity of the European airspace will be increased by using the available resources in a fully flexible manner.

Another problem is the current **approach to airspace design**.

European airspace is managed in a fragmented manner. Due to these circumstances, aircraft cannot fly their most efficient trajectories, which finally leads to unnecessary additional workload for air traffic control, increased fuel consumption and augmented operational costs.

There is a growing concern over the possible **shortage of new pilots and technicians**. If aviation is to grow as predicted by Airbus and Boeing, a substantial number of new staff needs to be educated and trained.

Boeing has made predictions on the number of staff needed in the next years in its Market outlook 2012:

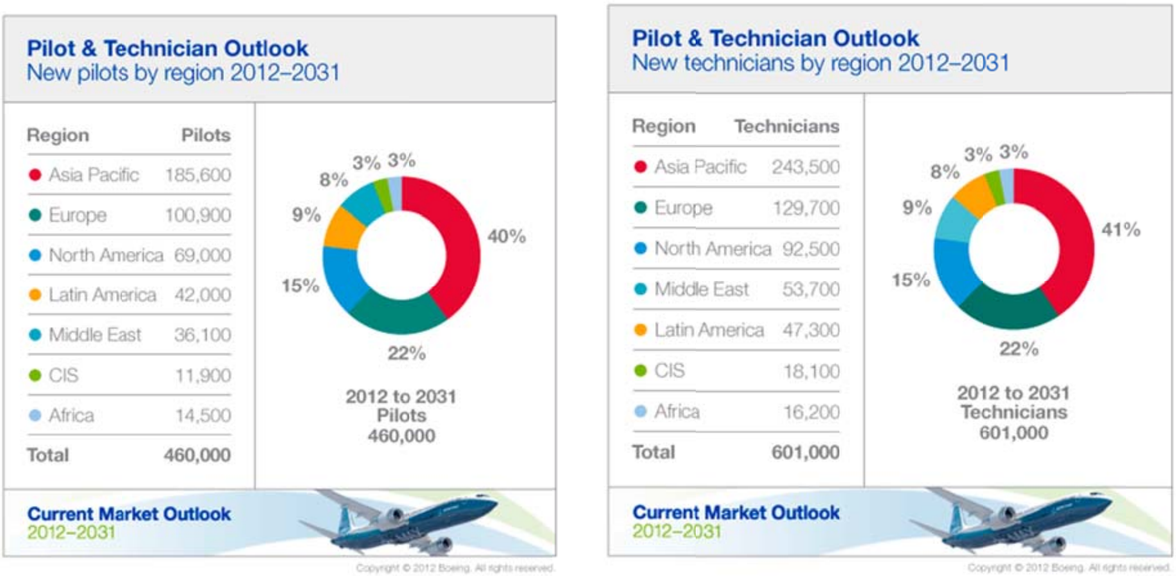


Figure 3: Boeing Market Outlook - new pilots and technicians

(Source Boeing market forecat 2012)

The continuously **increase of fuel prices**, and the fuel consumption itself gets more and more attention. The engineering developments, the technology enhancements, and the advanced operations all have an aspiration to **reduce aviation fuel consumption** and the associated CO2 and non-CO2 emissions. Fuel efficiency of civil **aero-engines** has steadily improved over the last 40 years.

This was achieved for example by

(i) increasing the overall pressure ratio,
(ii) using more advanced materials,
(iii) applying more efficient turbo-machinery, and
(iv) high bypass ratio architecture.

As a result of the features above, the generated noise and GHG (Greenhouse gas) emissions (CO, UHC) were reduced dramatically. Because of the higher temperature and increasing overall pressure ratio, the nitrogen oxides emissions remained relatively steady.

Drag reduction is another essential factor, and problem to cope with once aiming **to decrease fuel consumption**. By exploiting the available CFD (**Computational fluid dynamics**) technology, the optimization of the 3 dimensional form of the aircraft elements is significantly facilitated, but still not an exact process.

Another powerful method to further decrease the fuel consumption is to target novel materials or aircraft design / operating methods being able to substitute or replace some of the “traditional” aircraft elements with innovative solutions that **decrease the aircraft total weight**.

The prospects for the use of sustainable fuels on a commercial scale are now being measured in years, not decades. The stakeholders from around the world are working together to bring new, sustainable fuels to the market, which are eligible to the required aviation requirements.

In the current operational framework, **pilots have limited situational awareness** of the surrounding airborne traffic   Therefore, it would be crucial to support these users with advanced cockpit instruments or tools being able to augment their situational awareness.

The **current communication** method is also a constraint. The problem with communication is that the increasing air traffic volume require more and more data links. In addition, due to the nature of air transportation, the transmitted messages should be acknowledged by the recipient, while poor reception conditions also require messages to be repeated. Furthermore, as en-route controllers cannot manage an infinite number of aircraft in the same time, sectors are designed with at least one radio channel for eachof them. While sectors being separated enough could use the same channel, the present operational circumstances still require a huge amount of frequencies. The problem is however, that these are limited to a certain amount. While the ICAO has introduced an 8.33 kHz channel spacing in the VHF band to increase the available number of channels, further channel splitting would be technologically not feasible. Therefore, under the present operational and technological circumstances, experts believe that a communication jam could potentially happen in the coming years. Actions to cope with the problem are already on the way, and for example the voice service for 2020 will be complemented by SATCOM for the oceanic and remote areas. However, further investigations are needed, especially once considering that coming communication methods should be strengthen to meet new security requirements.

A major problem on the ground is the **limited information exchange** between the airlines, the airport operators and the actors of the air traffic management. While the information exists within the stakeholders, it is not exchanged and fully exploited. This problem leads to delays, wasted fuel burn during aircraft queue-up for take-off, or waiting for terminal gates. To exploit the system capabilities, and permit aircraft operators to plan flight schedules more closely the available airspace capacity, the coordination and the communication between the actors should be further developed.

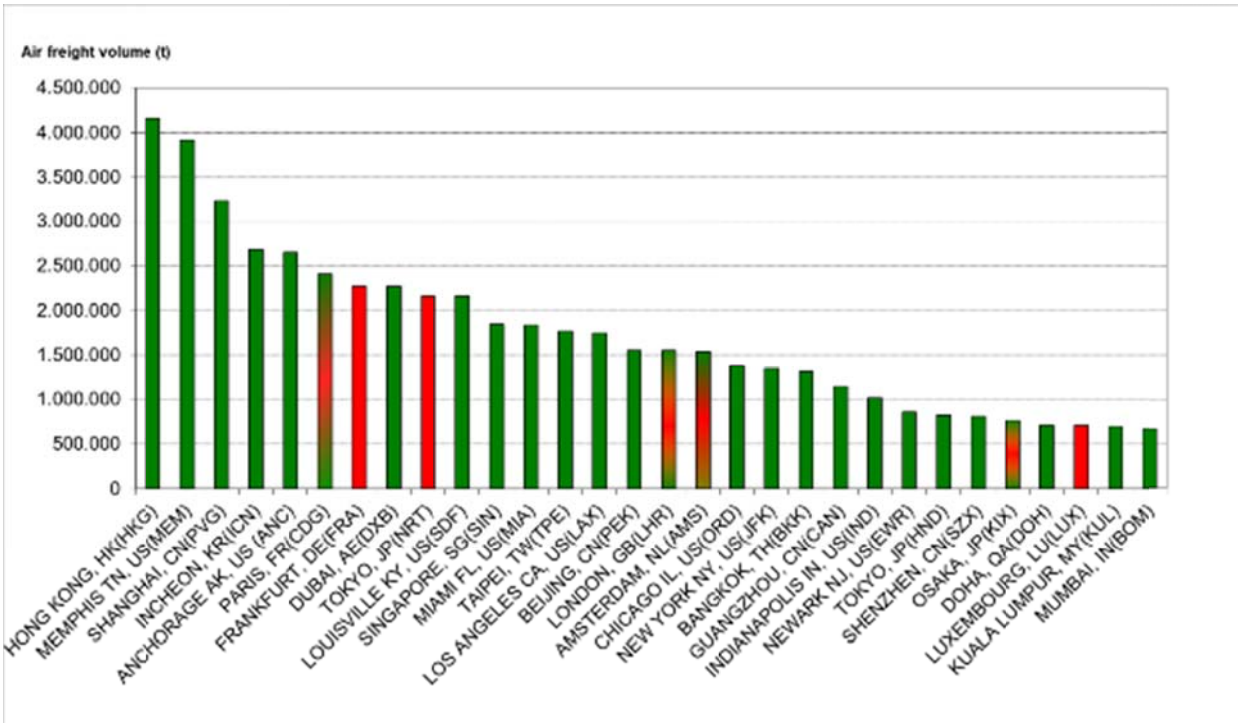
A potential solution for this problem is the Airport Collaborative Decision Making (A-CDM), which directly links airports into the air traffic management network and gives the users the opportunity to reach a wide range of operational data.

The A-CDM process could be supported by the System Wide Information Management System (SWIM).

Aviation is **heavily regulated** to increase safety and security. Aviation is probably the most regulated transport mode compared to the other modes.

Lack of airport capacity is partly due to severe restrictions on night flying. The existing night-flight restrictions and present infrastructure bottlenecks at the 30 largest freight airports in the world according to volume are shown below. It can be seen that only the Tokyo Narita and Luxembourg airports have an absolute night-flight ban which prohibits flight operations during the night hours. At the Paris Charles de Gaulle, Frankfurt am Main, Amsterdam, London Heathrow and Brussels airports, there are limited night-flight operations. Aircraft which exceed a specific level of noise emissions or are of an older design are not granted take-off or landing permission. At all the other listed airports, night-flight operations with aircraft which meet the ICAO requirements listed in Chapter 3 are generally possible. Some other airports, such as New York (JFK) and Bangkok, set a maximum noise level or impose noise surcharges (at Tokyo Haneda, for example).

The air freight industry is, in contrast to passenger transport, much more reliant on night-flight operations in order to fulfil commercial time and reliability requirements. Being able to fly at night is an essential factor for integrators in particular when they choose airports for their air freight services and decide where to make long-term investments. They need this to be able to deliver next-day express consignments. Around 50% of the flight movements in the express sector take place at night. A threat of night-flight restrictions contributed significantly to DHL deciding to move its air freight hub from Brussels airport in Belgium to Leipzig/Halle in 2004.



No capacity limit Limited night flying Night flying

Figure 4: Night-flight restrictions at the world's 30 largest airports in 2007

Source: Original Graph, Data Basis: ACI (Ed.) (2008), Boeing (Ed.) (2008b), Avigation Networks (Ed.) (2008)

The analyses clearly show that the number of the largest airports at which there are restrictive environmental policies on night-flights and noise is limited. It can also be seen that these airports are mainly concentrated in European countries and to some extent in Japan. The airports in Asia's emerging economies, such as those in Shanghai or Beijing, or even those in Dubai in the Middle East, are not subject to such regimentation.

(Note: At the Cargomap workshop held on October 30th 2013 in Brussels, the airport representative urged the research community to develop quiet aircraft to avoid night flying restrictions. Also it was noted that airport cost in the USA are substantially lower than in Europe as ATM services are 50% cheaper and security costs are borne by the government not by the airports. This calls for a level playing field in Europe).

A considerable proportion of the global anthropogenic emissions of greenhouse gases is accounted for by the emissions from transportation modes such as road vehicles, ships and aircraft. These transportation means are together responsible for an estimated 18% of the CO_2 emissions, 37% of the NO_2 emissions and 11% of the air pollution due to SO_2.

Air traffic causes a relatively small total proportion of around 2.2% of the global CO_2 emissions of this, between 0.3% and 0.6% arise from air freight transport in passenger and cargo aircraft. The share of the emissions from purely freight flights is just over 0.3%

Air traffic also affects the climate by creating vapour trails and changing cloud formations. Air traffic contributed 0.02 to 0.03°C to the total global warming on the Earth's surface of around 0.7°C according to climate modelling calculations.

The air traffic emissions relevant to climate are expected to rise, as the global demand for passenger and freight air transport services will increase. The anticipated annual improvements in fuel efficiency will only be in a range of 1 to 1.5%.

The battle against climate change and its consequences has become a central issue in European environmental policy in recent years. In the Kyoto Treaty, which came into force on 2005, the European Union and its Member States committed themselves to reducing the emission of greenhouse gases between 2008 and 2012 by 8% compared to the base year 1990. A great many measures have been implemented in the European Union since 1998 in order to achieve this ambitious reduction commitment. The introduction of the EU-wide CO_2 emissions certificate trading for the energy industry and energy-intensive factories is only one climate-protection measure, although it stands very much in focus.

The air transportation industry has so far been largely exempt from the greenhouse gas reduction measures because the counties which signed the Kyoto Protocol have not been able to agree on the form in which the emissions from international air transport should be allocated to the countries involved. Appropriate solution proposals and measures for Emission Trading in global air transport are soon to be developed within the ICAO however.

On the basis of model calculations by the DLR Institute of Air Transport and Airport Research for selected flight routes, the value of the necessary emission rights per kg of freight would be:

- 0.02 EUR/kg on short-haul flights (e.g. Frankfurt am Main – London Heathrow with an Airbus A 321-100 and belly freight of 1,000kg)
- 0.14 EUR/kg on long-haul flights (e.g. Frankfurt am Main – Singapore with an Airbus A 340-300 and 10,000kg belly freight).

These values do not, however, allow a conclusion to be drawn on the extent to which air freight transport will actually become more expensive for its clients because the possibility of passing on the additional costs arising for the airlines depends on factors such as the intensity of competition and the price elasticity of different air freight market segments, e.g. standard freight, express freight. A study carried out by the consultancy Ernst & Young states that freight airlines will probably be able to pass on around 30% of the cost of purchasing emission certificates to their clients. The EU, in contrast, assumes that the majority will be transferrable. Based on the assumptions regarding the price of the necessary certificates and the airlines' ability to pass these costs on to clients, the introduction of emissions trading can be expected to cause a slight to moderate price increase for air freight transport on routes within and to/from Europe.

Deregulation in air transport has had a major effect on airlines. In the West, flag-carriers are no longer existing and have joint into global Mega carriers. Airlines have concluded several types of cooperation agreements. At the same time deregulation has enabled Low Cost Carriers to start operations and to grow quickly.

A continued step-by-step opening of the air transport markets can be expected in future. There are also proposals to liberalise air freight services even before passenger services are fully liberalised. However, the interests of various states have to be taken into account as they often aim to promote the development of their own airlines and could thus delay this deregulation process. The continuing trend towards liberalisation also involves potential conflicts revolving around aspects like environmental regulations such as the European emissions-trading system in air transport. In the past, the agreement of such air transport treaties has led to an increase in the number of flights offered and the level of air traffic competition between the signatory states. Direct effects on the supply side of the air freight market therefore became apparent. By increasing the attractiveness of the supply, the volume of freight also increased. Taking the USA as an example, statistical analyses as part of an investigation by the World Bank and the Inter-American Development Bank show that in the long term (i.e. five or more years after the Open Skies Agreement came into force), the transport costs in the investigated period (1990 to 2003) reduced by an average of 9% and, as a result, the air freight trade volume between the countries involved grew by 12%. The analyses come to the conclusion, however, that there are differences in the effects for different groups of countries. Highly developed states and countries with an average income level enjoy many more positive effects on the air freight transport costs than less well-developed economies.

6 Flight Path 2050: A Vision for the ATS of the Future

The Aviation community agreed to establish the European Technology Platform, ACARE, in order to sustain the goals of the Vision 2020 for Aeronautics, and developing strategic research agendas (SRAs) implemented through outstanding research projects in FP7.

The vision and its ambitious goals are largely recognised by the aviation community including Member States and the European Commission. In response to this document, the European Technology Platform for Aviation, ACARE defined a new strategic agenda for aviation research and innovation (SRIA) providing the enablers, and the capabilities needed to reach the goals set out in Flightpath 2050, together with the required research and technology activities to develop the concepts, systems and services of the future ATS and cross-modal requirements.

This agenda should form the basis of all Research, Technology and Innovation activities performed in Europe.

Figure 5: ACARE achievements

The approach followed to develop the SRIA is summarised in the following picture.

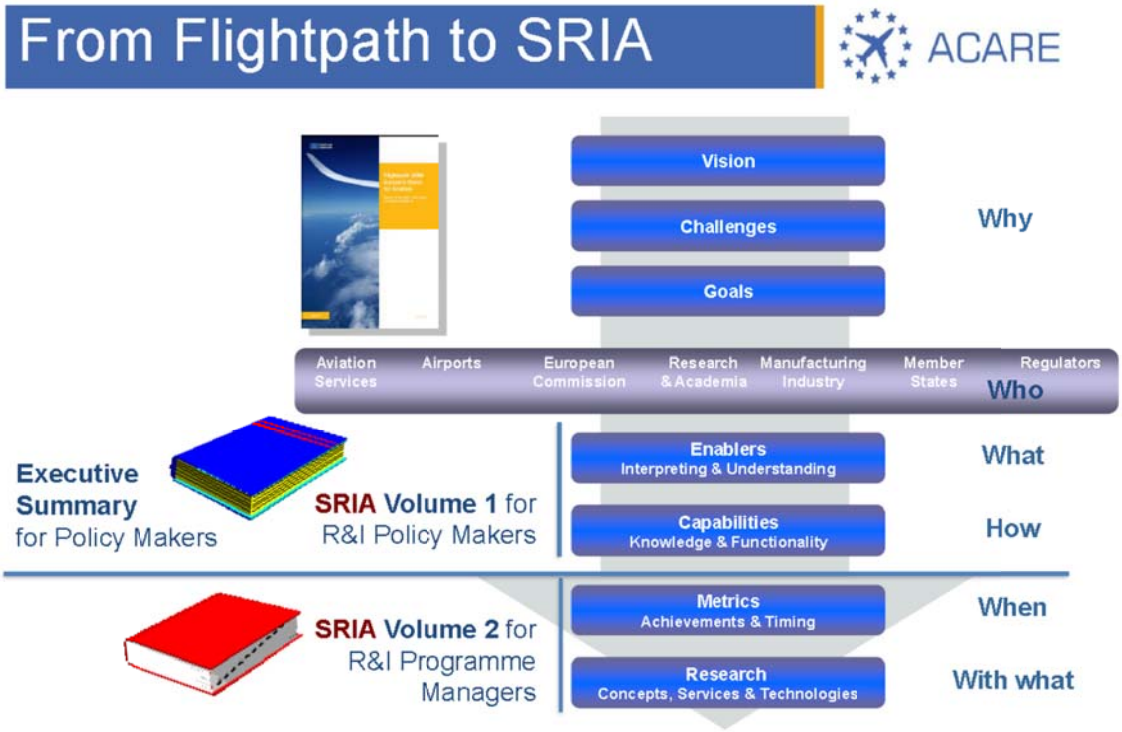


Figure 6: Approach to develop SRIA

Flightpath2050 and SRIA address all types of aviation in the future but the vision is very much related to passenger transport.

Starting from the key point: “Aviation is an Invaluable asset for Europe”, two main goals are set:

- Maintaining Global Leadership
- Serving Society’s Needs

These goals will have to be reached by

- Ensuring suitable and sustainable mobility of passengers and freight
- Generating wealth and economic growth
- Significantly contributing to the balance of trade and European competitiveness
- Providing highly skilled jobs and innovation
- Fostering Europe’s knowledge economy through substantial research and development (R&D) investment
- Contributing in many ways to global safety, security and self-reliance.

These actions are summarised in five challenges:

- Meeting Societal and Market Needs
- Maintaining and Extending Industrial Leadership
- Protecting the Environment and the Energy Supply
- Ensuring Safety and Security
- Prioritising Research, Testing Capabilities and Education

For each of these challenges specific goals are set and translated in R&TD needs.

Some important objectives are also defined for air cargo. These can be summarised as follows.

- Maintaining industrial leadership.
- Freight shippers can make informed choices to select optimal multi modal transport options
- Unmanned systems are an important way to transport air cargo.
- Seamless transport chains will allow air cargo within Europe to reach door to door destinations within 4 hours
- New emission standards like 75% reduction of CO_2 per FTK, 90% NO_x reduction and 65% noise reduction compared to the year 2000.
- Recycling of aircraft and emission free taxing.
- Safety target is less than one accident per 10 million flights.
- Security will have a minimal impact on seamless transport flows.
- The air transport system is resilient to external hazards.
- Flights arrive within one minute of the scheduled arrival time and the capacity of the European airspace allows for at least 25 million flights.

The new SRIA will be the reference for national, industrial and European priority setting of future research efforts.

7 The CargoMap approach to develop the RTD Roadmap

The aim of the CargoMap project is to prepare a roadmap for future RTD in the domain of cargo operations and aircraft development. New concepts should ensure a leading position of Europe in the future air cargo market.

CargoMap project, obviously adopted the Flightpath 2050 and the SRIA document as a reference.

The adopted approach to build the Air cargo technology roadmap is illustrated in the figure below.

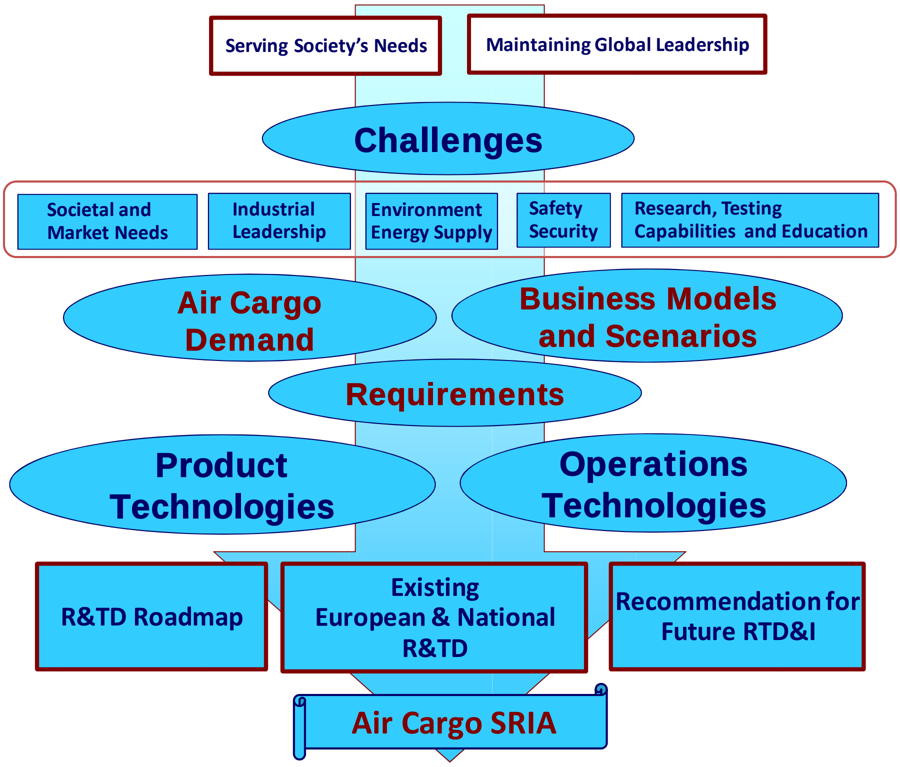


Figure 7: CargoMAP approach

As it will be better explained in the next chapters, the main characteristic of future air cargo is the short time for door to door delivery thanks to the high speed of aircraft.

But the fares in air transportation are high and need to be reduced to be able to compete with other transport modes. If cost can be controlled, the number of aircraft that the European industry can sell in the market will grow, which will strengthen the competitive position of the aircraft industry.

Air transport also needs to ensure flexibility to respond to new market demands. Seen the growing importance of the parcel market, frequency of service needs to be ensured.

These concepts and their relationship are illustrated below:

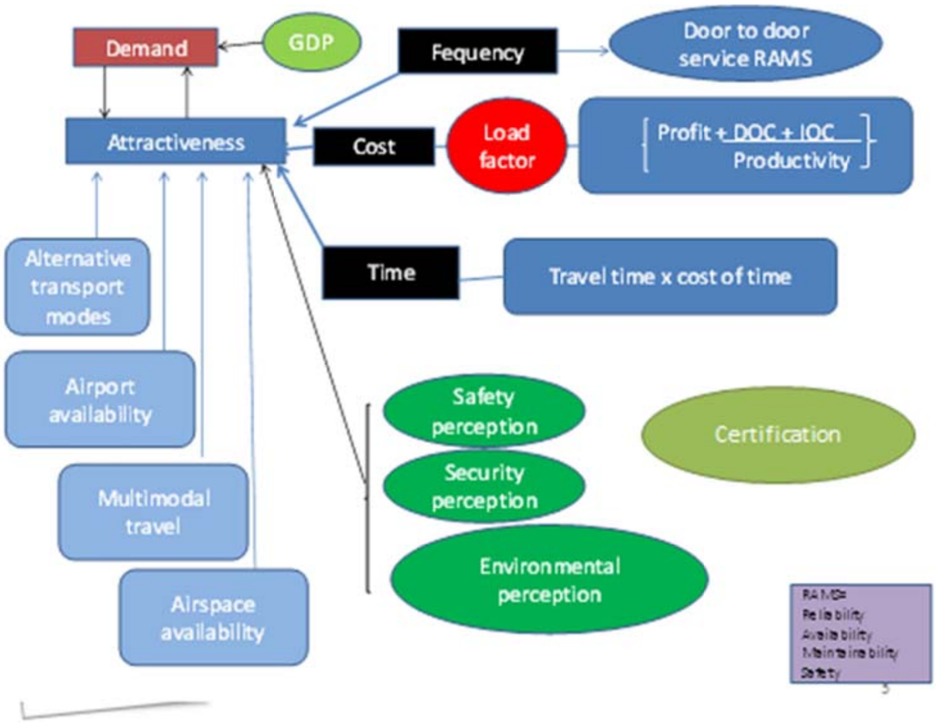


Figure 8: Concepts and their relationship

Cost of time is especially important for perishables, high value goods, parcels etc.

Fares are primarily depending on (direct and indirect) operating cost, productivity (= speed x capacity x aircraft utilization) and load factors. Whereas in passenger air transport the load factors are around 85%, which is very high compared to other means of mass transport (load factors for trains and busses are between 20 and 40%) the load factors in air cargo are currently as low as 46%. The industry is trying to increase the load factor by trying to avoid so called empty leg flights.

One option is to make several stops during a journey to pick up and deliver goods at several places. This method of operations was established in order to cope with certain route imbalances and is often called the triangular route.

IATA data show the recent low load factors, see figure below.

Figure 9: Recent load factors

source: IATA

Major elements in the cost equation are productivity and operating cost. If further cost reductions need to be achieved, this can be done by increasing productivity (increase the payload, increase speed of flying and/or increase the aircraft utilization) and /or by reducing both Direct Operating Cost and Indirect Operating Cost. DOC can be reduced by reducing fuel consumption (aircraft/ engine design and speed), crew cost (pilotless operations etc.), maintenance cost, low design and production cost reflected in low acquisition cost and amortization as well as low fees for airspace and airport usage.

The strong increase in oil related fuel cost is a significant factor in air transportation in general.

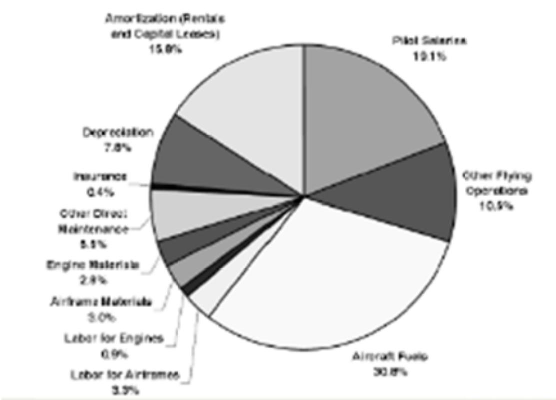


Figure 10: Cost distribution

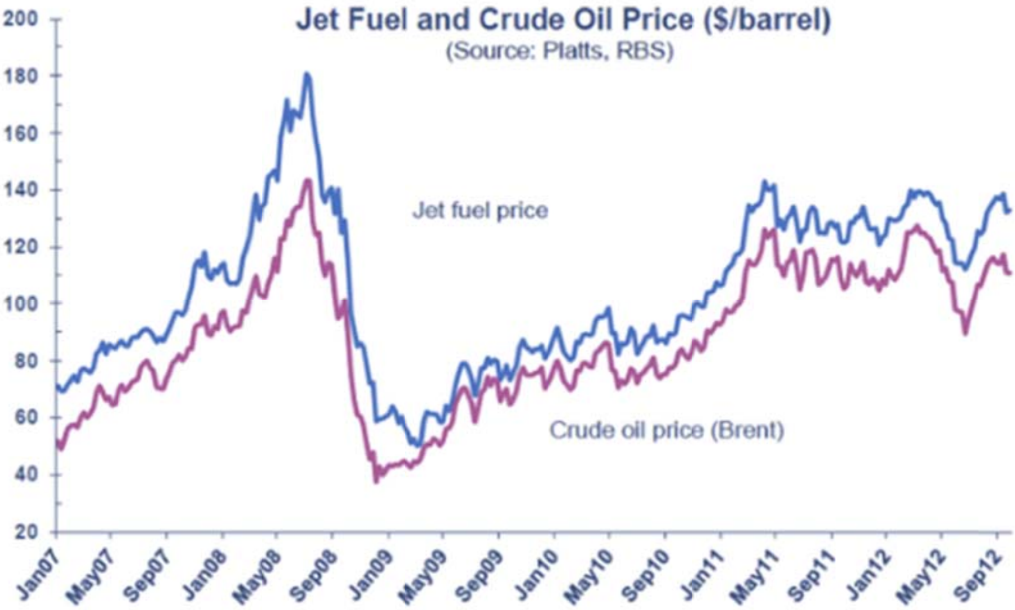


Figure 11: Jet fuel and crude oil price

All these parameters are taken into account for determination of possible future actions and aircraft design.

In the next chapters CargoMap will look into the air cargo market challenges and future business scenario's (the Why). It will discuss options for future market requirements (What) and propose several alternatives for future aircraft and operations (the What). From this Cargo Map will develop a RTD roadmap. This steps are shown in the next flowchart.

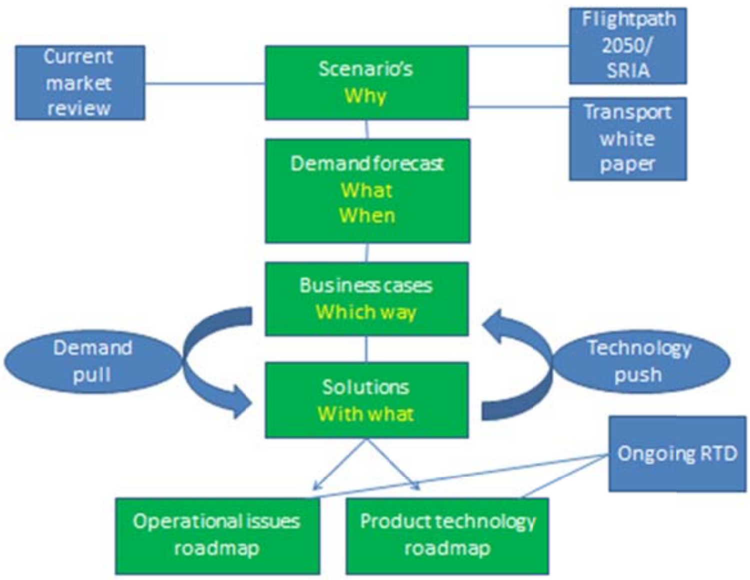


Figure 12: RTD Roadmap development methodology

CargoMap will identify RTD actions and initiatives already undertaken to finally define recommendations for the European Commission about RTD topics that need attention in Horizon 2020 as solutions can best be achieved by European action.

8 Cargo Industry Overview

The global air cargo market started as early as 1910 when the first batch of mail was carried from Albany to New York. Since then a lot has changed, but air cargo is driven by international trade, fostered by the removal of trade and physical restrictions as well as growing globalization of commercial activities. With the growing trend to outsource production to low labour cost countries as well as the rise in demand of luxury goods, due to a steady increase in GDP and a steep increase in middle class income in less developed countries, international trade is expected to grow with an increasing pace (Airbus, 2011). Air cargo has also benefitted from e-business. Nowadays it is quite normal to order goods via internet and have the goods shipped over longer distances. Whereas air mail has been the starting point for air cargo, the air mail volume is dropping thanks to internet connections.

This graph shows the direct relationship with GDP development. The elasticity factor is about 2- 2.5.

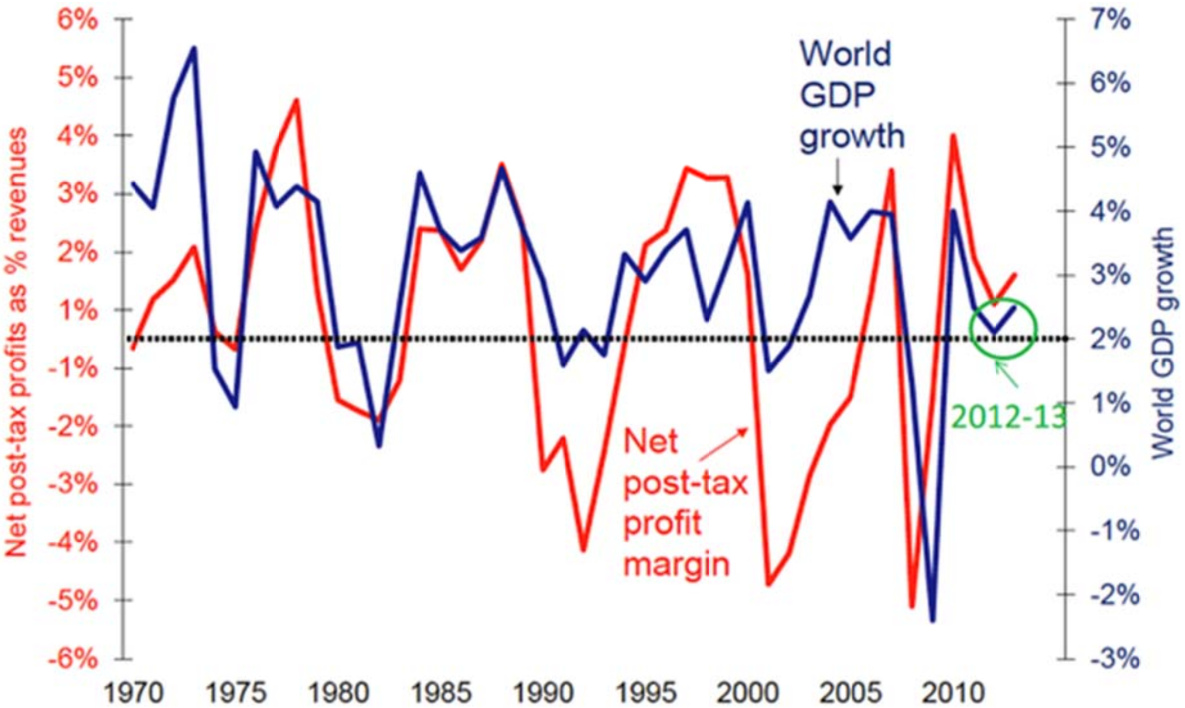


Figure 13: Direct relationship of Air Cargo Growth with GDP development

Airline profit margins and GDP growth (Source IATA)

Apart from the increase in GDP, the air cargo market is driven by novel business practice like lowering inventory levels. With the increase of outsourcing the air cargo market became much more volatile. Characterized by its high value, products typically shipped by air are the first cut back in harsh financial times. Therefore the global air cargo market is traditionally characterized by large up- and down swings.

The financial crisis that hit the world in 2008 had a hard impact on air cargo market. The economic crisis that followed in Europe has hit the air cargo market again hard and exports and imports were down. (Source IATA)

Figure 14: Air FTKs with respect to world trade volumes

Source IATA

(Note: During the Cargomap workshop external experts explained the difference in growth of air transport versus general world trade. Main reasons is declining imports from the far east and a shift from air transport to sea shipping of electronic equipment as the cost of sea shipping is substantially lower than air transportation. There are even signs of deglobalisation due to re-shoring of production.)

For example the trade between Europe and China was growing fast in the last decade but was severely reduced in the past years. The following figure (source KLM) shows the volume of air cargo on routes between China and Europe carried by European carriers.

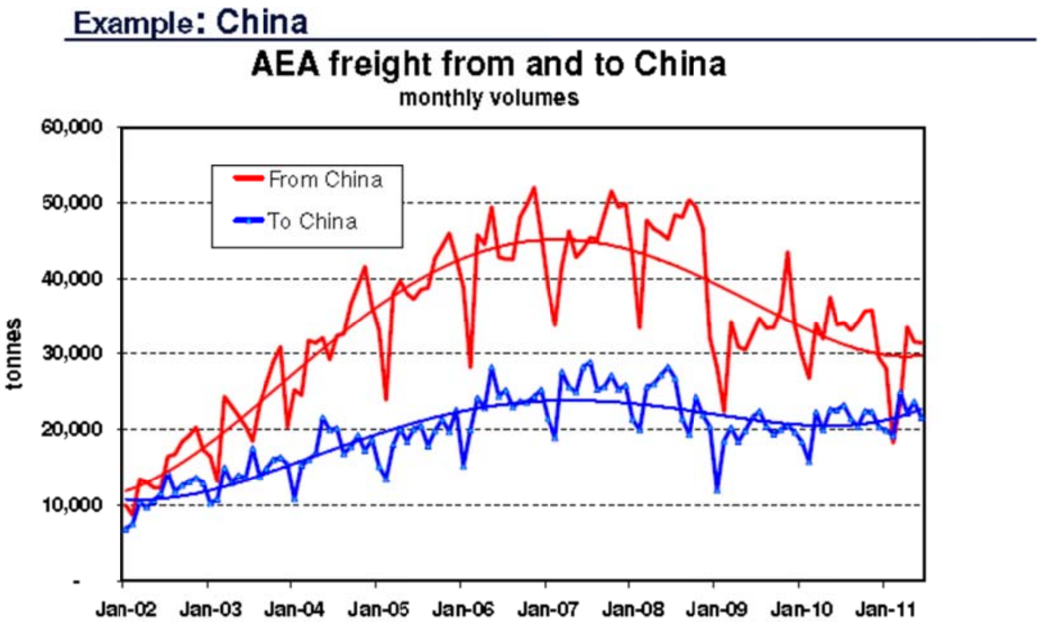


Figure 15: Air FTKs from and to China on 2011

Source KLM

What must also be understood is the position of air cargo in relation with other transportation means. Air cargo offers a premium product with high speed, high reliability, that can compete with surface transport. Air cargo is however more expensive.

Transporting goods by air is characterized by two main advantages:

1. Speed advantage

Air cargo offers a significant speed advantage over other means of transportation. This advantage increases with increasing distances. This is the reason why perishable and high value goods are transported by air. With the increase of Lean Supply Chain and the increased introduction of Just in Time (JIT) more and more manufacturers switch to delivery by means of air transport.

This graph (KLM, 2007 data) shows the comparison between Ocean shipment and air cargo shipment on long haul cargo routes in volumes and value.

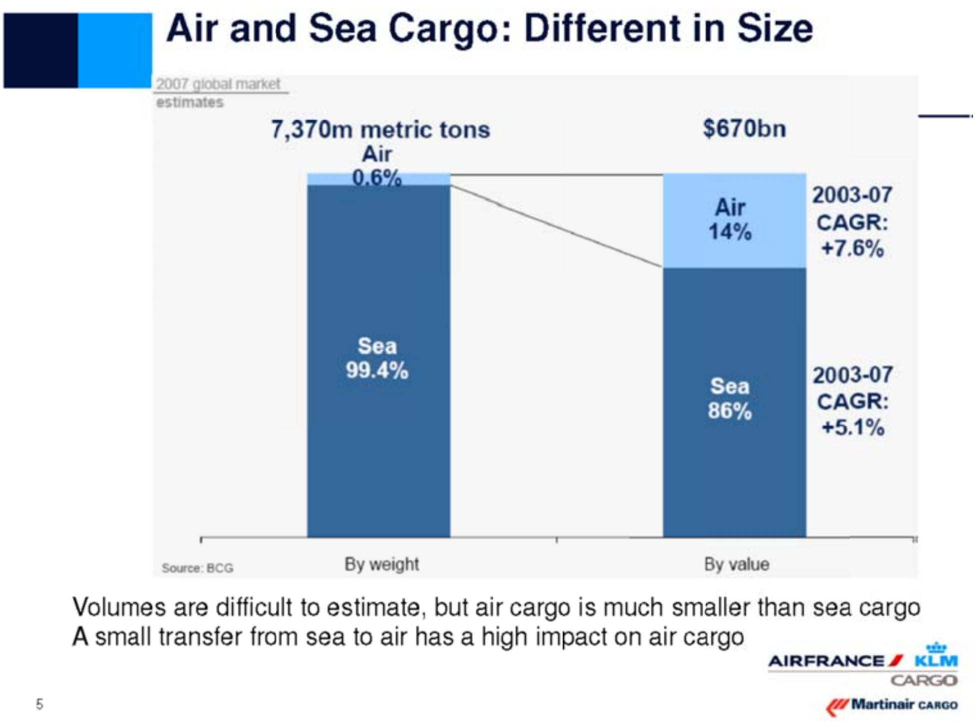


Figure 16: Share of cargo between Sea and Air

Source KLM

2. Geographical and infrastructural constraints.

In some less developed parts of the world air transportation is the only means of cargo transportation, due to a lack of infrastructure or geographical constraints. With the rapid growth of the People's Republic of China (PRC), an important question is if this growth can be supported by a parallel growth on an infrastructural level.

China is currently constructing 140 new airports and has an aggressive air transportation policy. China is also developing an extensive high speed rail network that is also to serve the cargo market. One of the issues is transporting coal in bulk to the industrial parts of China with high speed trains.

Figure 17: Rail map of China

9 Cargo Transport Modes

9.1 Road transport

At the European level, the density of road freight transport is obvious. Road transport has always been the most common way to carry goods. Thanks especially to its extreme flexibility (the capillarity of road infrastructure is remarkably higher than other modal networks). At its peak (2007, before the start of crisis), road freight transport accounted for some 1900 billion tkm in EU27, while maritime transport accounted for some 1500 billion tkm, and rail transport for 450 billion tkm. The modal split before the crisis was equal to a 45.9% share of total tkm for road transport, 36.7% for sea transport, 10.9% share for rail transport, the rest being split between inland waterways, pipelines and air transport.

During the first years of the crisis, the modal split has shifted towards road transport (reaching 46+ %), even though it must be underlined that this is more the result of a dramatic decline for cargo demand. After the peak of the crisis, though, other inland modes (rail and inland waterways) recovered more strongly than road. In 2008 the decline started, with a -2% rate compared to 2007, and it fully ran through 2009, at the end of which the road tkms had decreased of a -10% compared to 2008.

According to IRU (International Road Transport Union), at the global level (74 IRU members countries), the economic crisis generated a decrease in road freight transport of up to 30%, with domestic transport decreased by 10-20% in both tkm and revenues, international transport down by 20-30% in both tkm and revenues,

In the latest years the decline in Europe has somewhat levelled off, even if it is still on going, as shown in the following chart, in terms of tonnes.

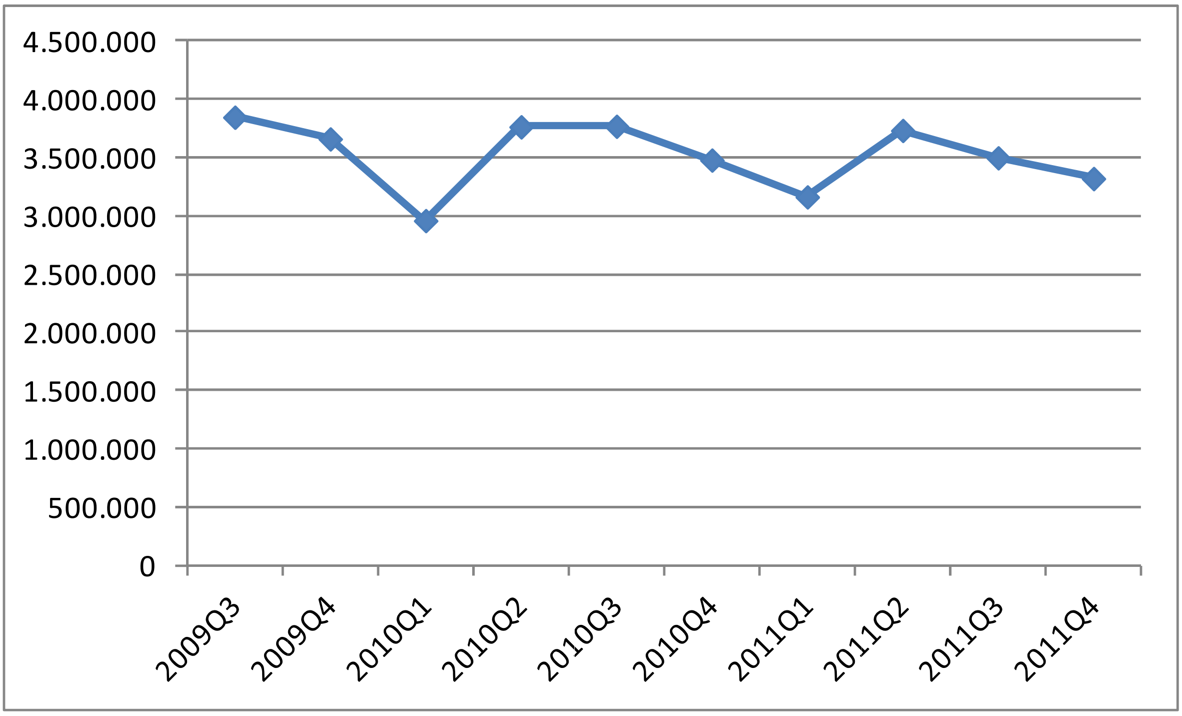
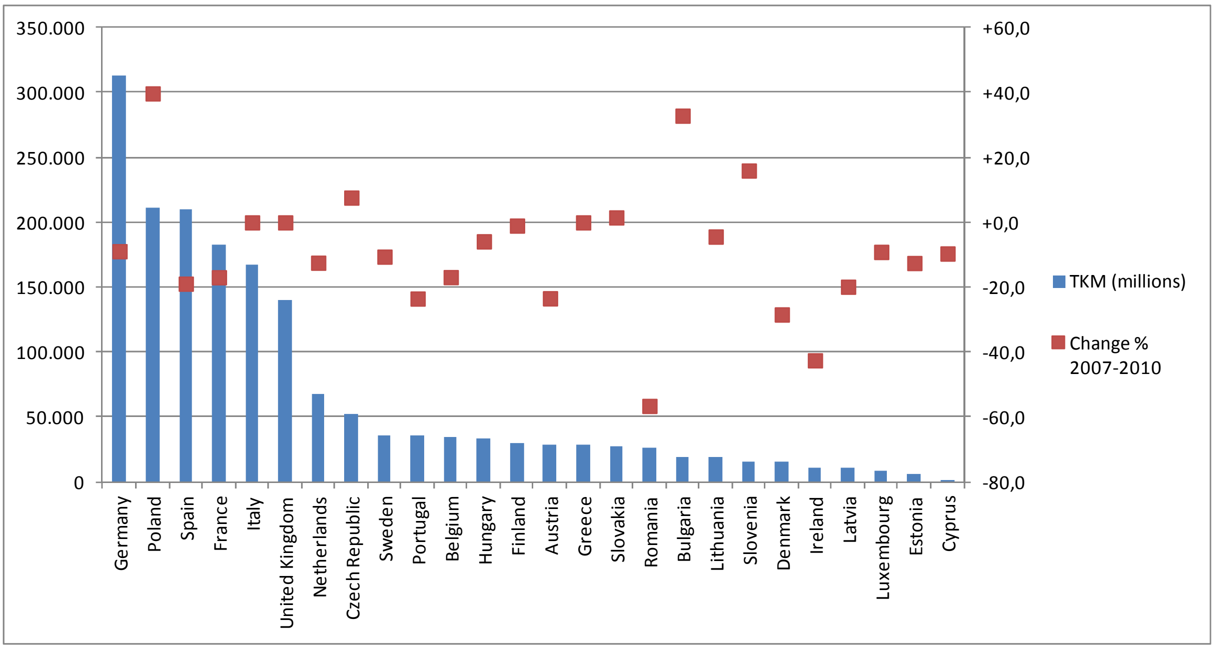


Figure 18: Evolution of tonnes by road (EU27 excl. UK)

Source: consortium elaborations on Eurostat data

The country details show the following results.



Data for Malta are not available; for Italy, Greece and United Kingdom data refer to 2009.

Figure 19: Road freight TKM by country and its evolution, 2007-2010

Source: consortium elaborations on Istat data

The most relevant country in terms of road freight transport has historically been Germany, in 2010 with over 313 billion tkm. A second group of relevant countries include Poland and Spain (over 210 billion tkm), France and Italy (over 160 billion tkm) and the United Kingdom (140 billion Tkm). Other countries all account for less than 75 billion tkm each.

In terms of evolution during the crisis, there are quite a few countries that have actually recorded positive growth rates, all are Eastern European countries, such as Poland which is the one that experienced the greatest growth during the period 2007-2010, close to 40.0 per cent; Bulgaria and Slovenia also had double digit growth rates. All other “powerhouses” of road transport have been experiencing a steady decline, which is particularly remarkable for Spain and France (-19% and -17% respectively), whereas Germany’s crisis records a one digit decline: -8.8%.

The share of road freight transport to/from third countries is currently minor. Intra-EU road freight transport accounts for 92% of all international activities by EU hauliers (in terms of tkm).

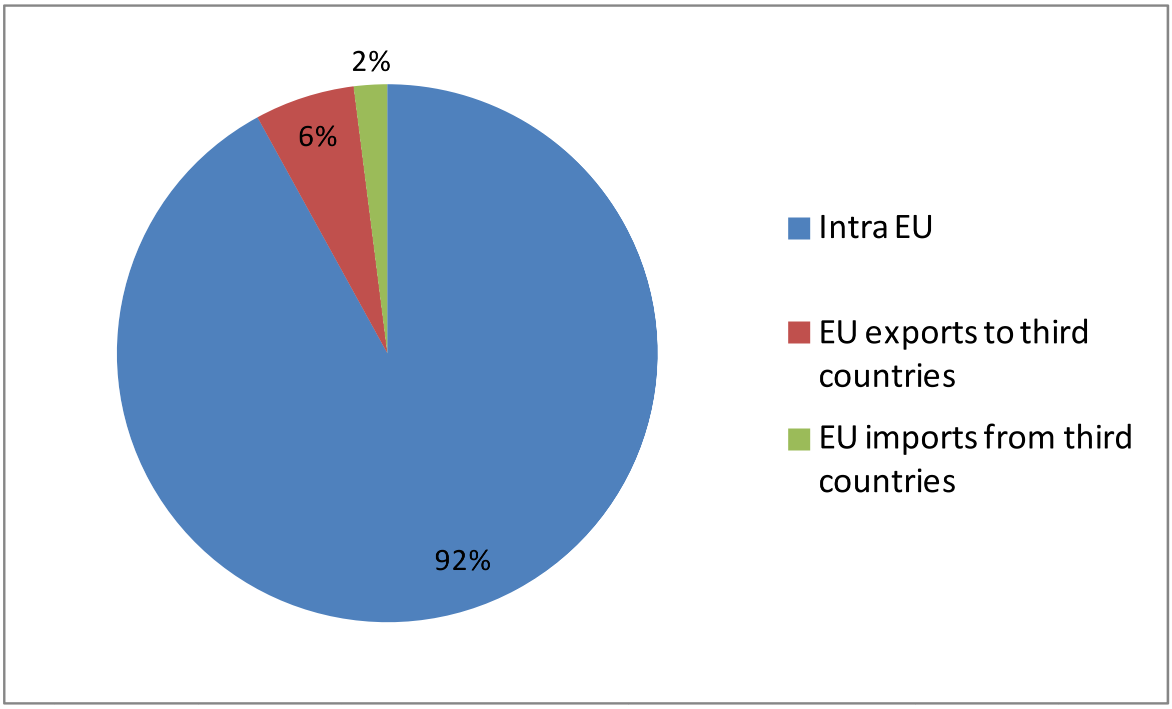


Figure 20: Road freight transport by EU hauliers by macro-area

Source: consortium elaborations on Eurostat data

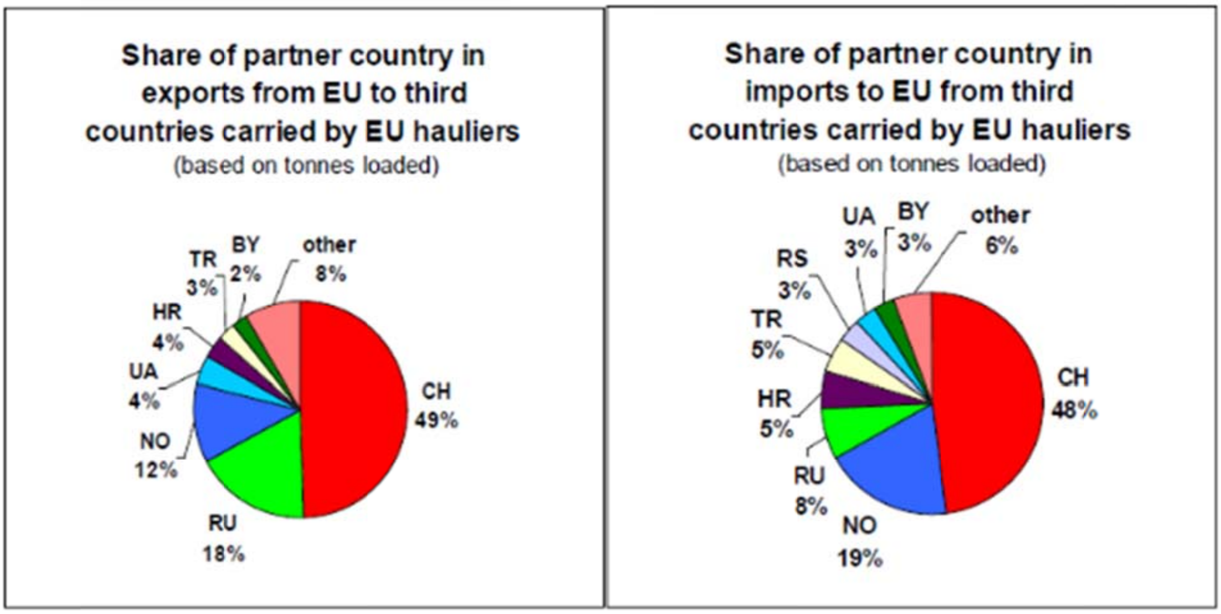


Figure 21: Extra-EU road freight transport by partner countries

Source: consortium elaborations on Eurostat data

As shown in the above figure, in terms of tonnes, the most important partner country of EU hauliers is Switzerland. Other relevant countries include Russia, Norway and Ukraine.

Business models

Transport generates important direct cost for the firms and it is a relevant strategic objective to minimize it. The current major business models for managing road transport consist of "Own account" transportation and "Hire and reward" transportation, depending on how shippers of goods organize the carriage; in the first model they execute the transport on their own, in the second model they resort to third-party transportation.

Usually, the "Hire and reward" model is more efficient than own account transport.

In their choice between "make" or "buy", firms take into account different drivers. The trend of the shippers to concentrate on their core business, together with the trend towards the optimisation of the whole transport system lead to greater specialization, and therefore to outsourcing of transport service. Hire and reward models are therefore the dominant ones.

Business models by tkm

As shown in the chart, third party road freight transport accounts for 85% of the total transport in the EU. This share becomes remarkably higher in the case of international transport (95% tkm), so much that it can be stated that the evolution of third party road hauliers / freight forwarders is the actual driving force of road freight transport. On the other hand, own account transport at the European level has shown a higher resilience to the crisis.

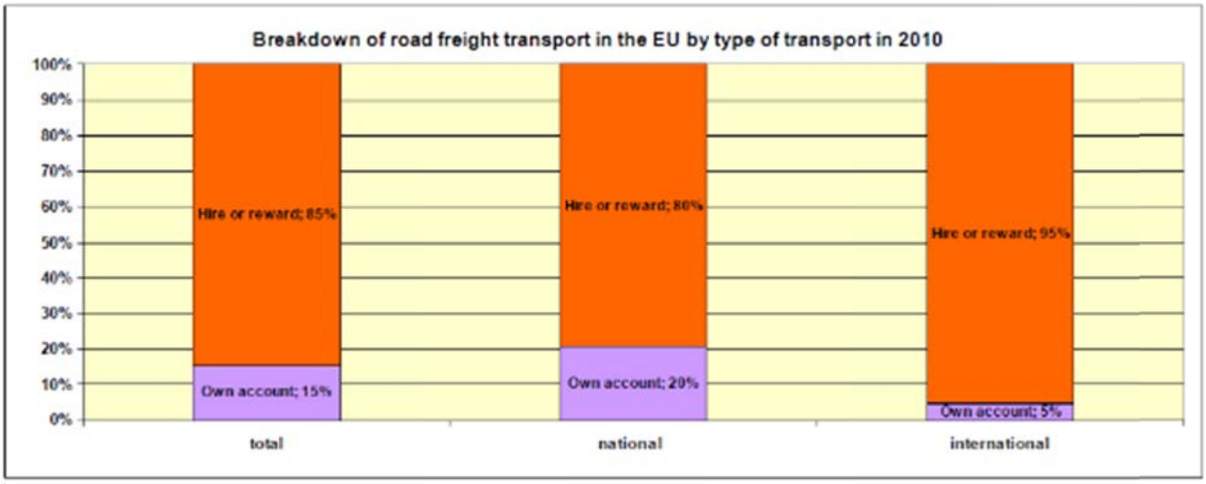


Figure 22: road freight transport in Europe

Source: EC, 2010

Between 2007 and 2009, the decline in own account road transport was equal to -2.3% only, whereas hire and reward transport decreased by 13.4% in the same period. Anyway, the crisis has been feeding the trend for all firms to specialise on their own core business and to drop ancillary activities (including own account transport), also because it leads to higher efficiency: own account transport generates a higher share of empty runs at all geographical levels, and the average load factor of road freight transport is higher for third party operators.

The general increase in size of the average road haulier is also evident, and it is driven by the rise of the importance of large pan-European "integrators", so that the top 10 land transport operators in Europe now account for 13% of total road freight turnover.

Rank	Company	Turnover M€ 2009	Country
1	DB Schenker	11292	DE
2	SNCF	7400	FR
3	DHL Freight	3065	GB
4	DSV A/S-	2468	DK
5	Dachser	2171	DE
6	Kuehne+Nagel	1896	CH
7	GEFCO SA	1588	FR
8	Norbert Dentressangle	1486	FR
9	LKW Walter Group	1230	AT
10	Rhenus AG	899	DE

Table 1: Top 10 land operators in Europe (road + rail) in 2009

Source: Transport Intelligence, Booz & Co.

The cost structure of road freight transport is illustrated in the following chart, for some relevant countries in Europe.

Operating costs of road freight transport: % of total, by country

	IT	DE	FR	ES	PL	AT	HU	SI	RO
Driver	34	33	39	34	23	35	28	31	25
Vehicle purchase	18	15	16	19	22	14	26	21	24
Fuel	21	23	21	23	26	19	28	22	37
Insurances	6	4	5	4	4	3	3	5	2
Taxes on vehicle	0	2	0	1	1	3	1	3	0
Pneumatic tyre	8	7	5	8	6	6	7	6	6
Maintenance	6	5	6	6	5	5	6	5	5
Toll charges	7	11	8	5	13	15	1	7	1

Table 2:Operating costs of road freight transport: % of total, by country

Source: Centro Studi Sistemi di Trasporto, 2008.

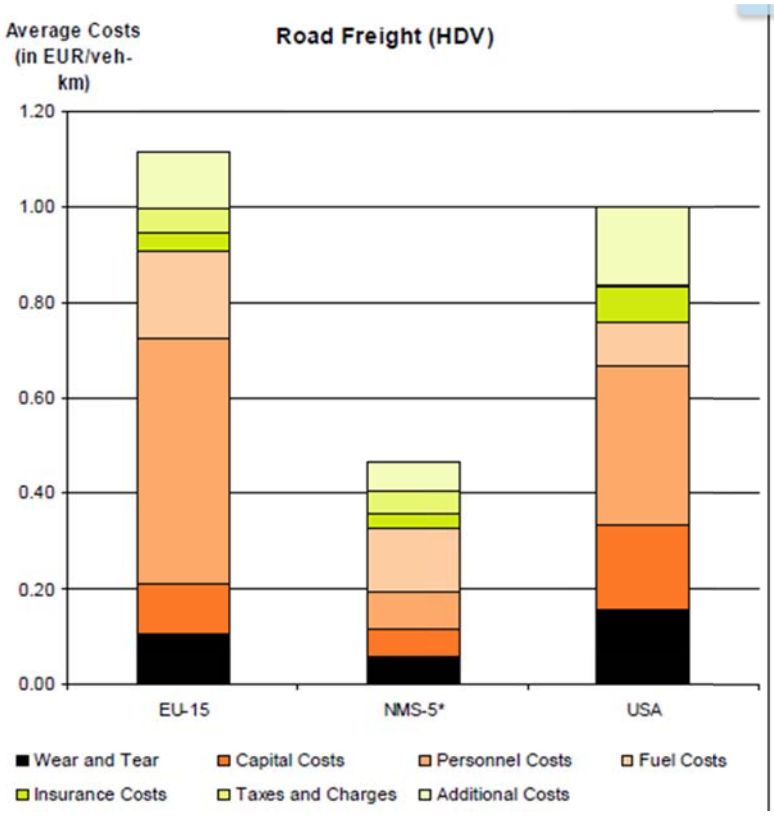


Figure 23: Average costs od road freight

As shown, road freight is mostly a labour-intensive operation, with the cost of drivers accounting for the highest share of the total operating costs. The cost referring to the vehicle purchase is the next great cost item in the operation of road freight transport. All other transport costs (insurance, taxes on the vehicle, tire consumption, maintenance) account for one digit shares, while the toll charges range from a 1% minimum in Hungary and Romania to a 15% in Austria (in Germany it is equal to 11%).

In general, current business models are especially based on Price competition.

Continuous liberalization leads to a constant increase of the degree of competition between road haulers, and this competition is mostly played on price. Turnover is generally considered as more important than margin and cost, so competitors' price become the standard and there is very little resistance to price reductions, the objective being mostly to increase the number of clients. This, in turn, leads to low profit margins, and a general financial weakness.

Drivers of evolution

As it turns out, **manpower** is the leading operating cost and therefore should be considered as a main "driver" of its evolution. Research shows that there is a lack of adequate workforce, both in terms of supply and in terms of quality. This is of course a main area of concern for the sector, especially considering that road freight transport is by far the main form of inland freight transport.

The reasons for the lack of attractiveness of jobs in the road freight transport sector are all related to its nature and the level of satisfaction that it generates in the workers:

- Safety is of course a major factor in keeping workers away from seeking employment in this sector; but it turns out to be mostly a perception issue, in that the average workplace fatality rate is lower than other sectors (in terms of fatalities at the wheel per thousand employed).
- A second deterring factor is the feeling of loneliness and eradication that stems from the continuous movement across territories that this job implies. Especially for longer range transport, being a truck driver means being far away from home for several nights in a row and with regular frequency.
- In shorter range transport, the high pressure on the pace of collection and demand deriving from just-in-time management principles is anyways a source of stress and physical risks.
- The average wage tends to be low, and it often set at the national guaranteed minimum wage
- Careers are slow if dynamic at all: office jobs and middle management positions are limited in number, compared to the driving workforce, so that a driver has a very low chance of having satisfying career prospects available.

All these factors contribute to unfavourable working conditions and low satisfaction levels. The evolution of such working condition is therefore a major factor influencing the attractiveness of the job, and therefore an efficient equilibrium between demand and supply, but above all the final quality of road freight transport supply.

A High Level Group on the Development of the EU road haulage market suggest that a relevant change in image of the sector can contribute overcome the shortage of drivers. Since the road transport market depends on qualified and reliable workforce, the recommendations for its development are that:

- The image of the profession should be improved so as to make it more attractive to a broader pool of workers. Awareness of freight vehicle driving as a profession should be raised, particularly among potential women drivers who have recently successfully entered the urban passenger sector.
- Career progression should be encouraged through measures such as those facilitating access to vocational training and internal mobility towards office and management positions.
- Access to the profession of driver should be made easier. The current cost of qualifications is a substantial entry barrier and there must be adequate support, on the side of both industry and public bodies, in both financial terms and training opportunities for those intent on entering the profession1.

Fuel costs are also a main driver. As mentioned, fuel is a major cost item; nonetheless, current business models are not focused on fuel savings, mainly because the process of Driver Fuel Efficiency is not subject to adequate control from the company. While other sectors and industries in Europe are in a constant effort to improve energy efficiency, fuel saving is not incentivized in the operations of a road hauler. The processes of optimization rather concern flexibility and speed of delivery, thus lowering the attention on fuel savings.

[1] Report of the High Level Group on the Development of the EU Road Haulage Market, June 2012, European Commission.

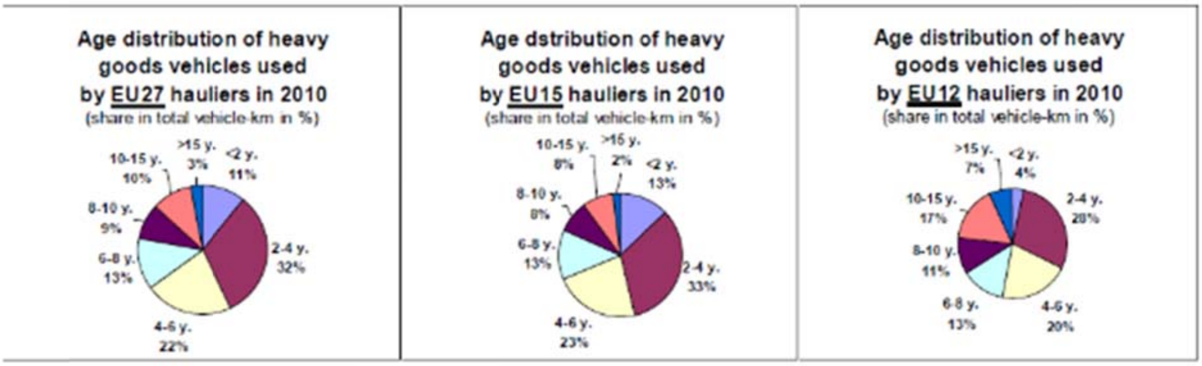


Figure 24:Age distribution of heavy good vehicles

Source: European Commission, 2010

In contrast, as shown in the figure above, the age distribution of the vehicles in use for road freight transport in the EU reveals that the overall majority of activity is being carried out by relatively modern vehicles. Despite the fact that economic crisis in 2008/09 had a major impact on the process, tolling arrangements in the EU which charge less for cleaner vehicles provide an incentive for fleet renewal. Obviously, transport providers pay very close attention to fuel efficiency when investing in new trucks so the fleet renewal is a great driving force towards the improvement of fuel efficiency.

Infrastructures and capacity are also a main driver of the road freight transport sector. At the European level, road congestion due to the historical growth of both freight and passenger transport is considered as a major area of concern that hinders the efficiency of the overall transport system. The trend of congestion is constantly increasing and it generates higher operating costs for operators, higher pollution, lower safety, and higher door-to-door transport times for shippers. New road-building, however, is not the only possible solution.

As shown in the following figure, the motorway network in Europe is the transport network with the highest rate of expansion (in terms of length) (while the rail network has increased in terms of High Speed tracks, the conventional rail network is decreasing).

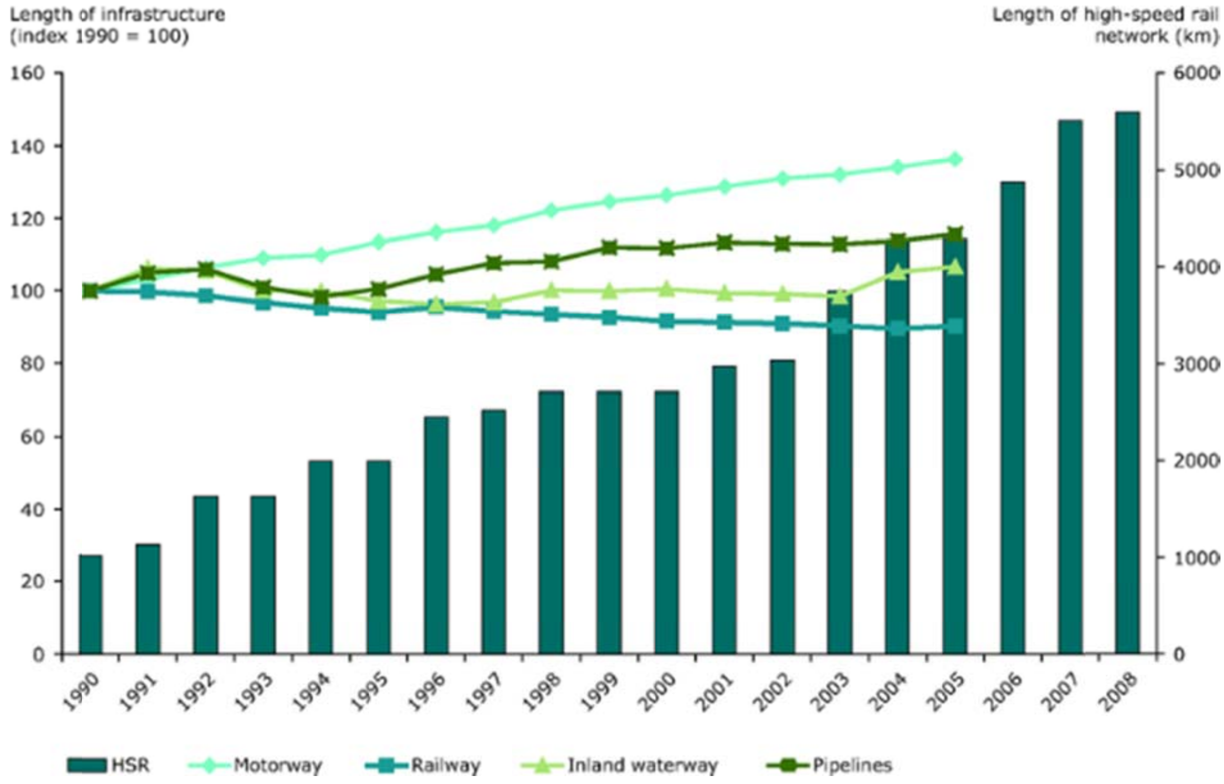


Figure 25: Evolution of the length transport infrastructures in Europe

Source: European Environment Agency, 2010

While infrastructure length does not exactly reflect capacity, the pace with which the road network has increased suggests that road capacity is in expansion – especially when one takes into account that additional lanes (a very common way to increase capacity of motorways nowadays) are not considered in the computation of "network length expansion". To support the development of the Trans-European Networks of Transport, the EU finances projects that help to remove bottlenecks and to build the missing links thanks to its Structural Funds and the newly created Connecting Europe Facility.

The growth of traffic outpaces the increase of network capacity. So other factors are relevant in the optimization of capacity, such as interconnectivity, limitation of physical bottlenecks such as alpine crossing, vehicle and traffic technology, and road pricing.

Innovation is of course a relevant driver of the evolution of road freight transport. It can contribute overcoming capacity issues, but that is not the only area where innovation is expected to affect road freight transport: quality, sustainability and energy efficiency have also to be included.

Innovation has to be looked at from both the technological and organizational point of view.

a) At the technological level, the most promising areas of innovation include:

- Truck design:

On one hand, the trend is towards aerodynamically efficient solutions: hindered by the current legislative framework, which only allows for spoilers behind the cabin and side-skirts covering the wheels of trucks and trailers, innovative solutions could allow more efficient truck shapes than the current common "box shape" and a reduction of the aerodynamic drag behind the trailer with removable tails.

On the other hand, some argue that Longer and Heavier Vehicles (LHVs) can help reduce congestion and pollution. The EMS (European Modular System) in being tested in some European countries: it combines standard tractor units and trailers into "road trains" of up to 25.25 m and 60 tonnes. Besides increasing capacity with a comparatively low additional cost, this system provides for lower CO2 emissions, less road congestion and higher safety. Concerns regarding this solution are based on the fact that it complicates the door-to-door chain with possible adverse long term effects on cabotage and induced road transport demand. Currently, the EU sets limits for the weight and dimensions of heavy duty vehicles in Europe in order to ensure safety on its roads; the maximum weight for trucks is 40 tonnes (44 tonnes when part of a combined transport operation), even though local exceptions are allowed according to specific contexts and situations.

- On-vehicle solutions in ancillary equipment, such as digital tachographs with GPS and road communication systems
- Control of vehicle fleet
- Improved maintenance techniques and regimes

Solutions which aim at contributing to traffic fluidity and reduction of congestion

- Intelligent infrastructure communicating with the truck
- ATM (Advanced Traffic Management)
- AVC (Automated Vehicle Control)
- EETS (European Electronic Tolls System) whereby road users (including truck drivers) can use a single unit in their vehicle in order to pay tolls electronically throughout Europe. It is foreseen that by the end of 2012, regional cross-border electronic toll services will be available for trucks above 3.5 tonnes.
- Standardisation of the interfaces of above-mentioned system, in order to enable the contemporary operation of different tools on a single architecture

b) At the organizational level, the most promising areas of innovation include:

- Fleet management
- External planning and control of vehicle fleets
- Personnel management
- Vehicle routing
- "Stage coach relays", aimed at increasing the attractiveness of driving jobs by setting up relays at specific points in the network, that will allow drivers to spend their night at home
- "Freight exchange", a process solution that allows the owners of freight and the owners of empty vehicles to meet in a common platform (physically or virtually) in order to reduce the empty returns issue by spotting and matching freight demand and load unit capacity. Application of ITS and global positioning systems will facilitate the location of potential cargo for transport thereby reducing empty runs, as well as improving vehicle routing with respect to collection and delivery.

The evolution of **trans-shipment nodes** is fundamental. Currently an area of major inefficiency from the operational point of view, they often represent the weakest link of the logistics chain. The efficiency of storage and transhipment operations can be improved by realizing better facilities and especially IT tools.

City logistics solutions are an innovative concept that concern short range transport of goods. Such solutions are meant to increase the social and environmental efficiency of urban freight transport. This issue is closely linked with the "last mile problem", i.e. the criticalities connected with the final part of the supply chain; the delivery of goods in the urban area is actually the most expensive and most polluting section of the whole chain. City logistics is "the process for totally optimizing the logistics and transport activities by private companies in urban areas while considering the traffic environment, the traffic congestion and energy consumption within the framework of a market economy".

Several experience in European cities have been recently implemented, and it is still early to derive general results in terms of contribution to the reduction of urban congestion and pollution, in that individual results are highly dependent on the framework conditions. This also hinders the transferability of the so called "best practices"; however, networking activities backed by the European Commission are increasing and a source of inspiration for the improvement of city logistic concepts.

Regulations and enforcement are relevant factors for the evolutions of road transport. There is a huge number of regulatory areas whose influence in the modal choice is relevant. In this section only a small relevant sample are presented. Regulations can affect the following characteristics of transport:

- Technical (regulations on standards, measures, etc.)
- Manpower (labour times, minimal wages, certifications etc.)
- Infrastructural (tolls, fees, opening hours, etc.)
- Insurance related (mandatory insurances, liabilities etc.)
- Tax related (tax system, VAT etc.).

The main regulatory areas which affect operating costs of road transport are:

- Subsidies to infrastructure costs
- Subsidies to environmental costs
- Subsidies to additional social costs (e.g. police, medical care)
- Regulations on the drivers' working hours
- Regulations on the traffic restrictions periods
- Regulations on the maximum dimensions, on the weight and other safety restrictions
- Regulations for market entrance
- Restrictions of the number of vehicles that can operate on specific sections of the network (e.g. in Austria or Switzerland)
- Taxation on fuel and on vehicles
- Infrastructure charges

The latter type of regulation is especially important, since, like illustrated above, toll costs account for almost a double-digit share of operating costs. Currently charges (and related taxes) do not reflect the actual costs of using infrastructures and send wrong signals to operators. The trend in such regulatory area in the EU is towards a progressive harmonization of policies between Member States, with the aim to reach an efficient charging system which shares the principle "polluter pays". The 2011 Eurovignette directive sets the EU principles for a more efficient charge structure that takes into account exhaust emissions and noise pollution as well. Eurovignette also allows Member States to charge higher tolls at peak times, and allows an extra toll charge in mountain areas under the main condition that the revenue is used for investment in alternative routes.

The regulations driven by environmental concerns are therefore a relevant driver for road freight transport, because road freight transport is one of the few sectors where CO2 emissions continue to increase mostly due to fuel inefficiency, with fuel consumption being on average 15%-20% higher than necessary. The so-called Euro-VI standard for engines, to be introduced in 2013 and mandatory as from 2014, is expected to reduce emissions by more than 60%.

The EU rules also govern moving dangerous goods like chemicals or flammable materials by road; such rules prescribe requirements like technical type-approval for vehicles, special training for drivers and uniform control procedures for checking the transport of dangerous goods both at the roadside and at operators' premises.

Enforcement of regulations is responsibility of each individual Member State. Considering cultural differences, enforcement practices vary a lot, but it is important that basic principles of enforcement be seen as universally applicable throughout the European Union. For example, the enforcement of working hours regulations is particularly important. Since 2005, drivers must respect an average maximum working time of 48 hours per week (averaged out over a four-month period), while night work cannot exceed 10 hours in any 24-hour period. No more than six hours can be worked consecutively without a break of at least 30 minutes. The infringement of working hours regulation allows operators to (illegally) reduce their most relevant cost item of up to 17% and (illegally) increase productivity at the expense of road competitors and other modes of transport.

9.2 Rail transport

The figure shows the evolution of freight transport in Europe by all modes.

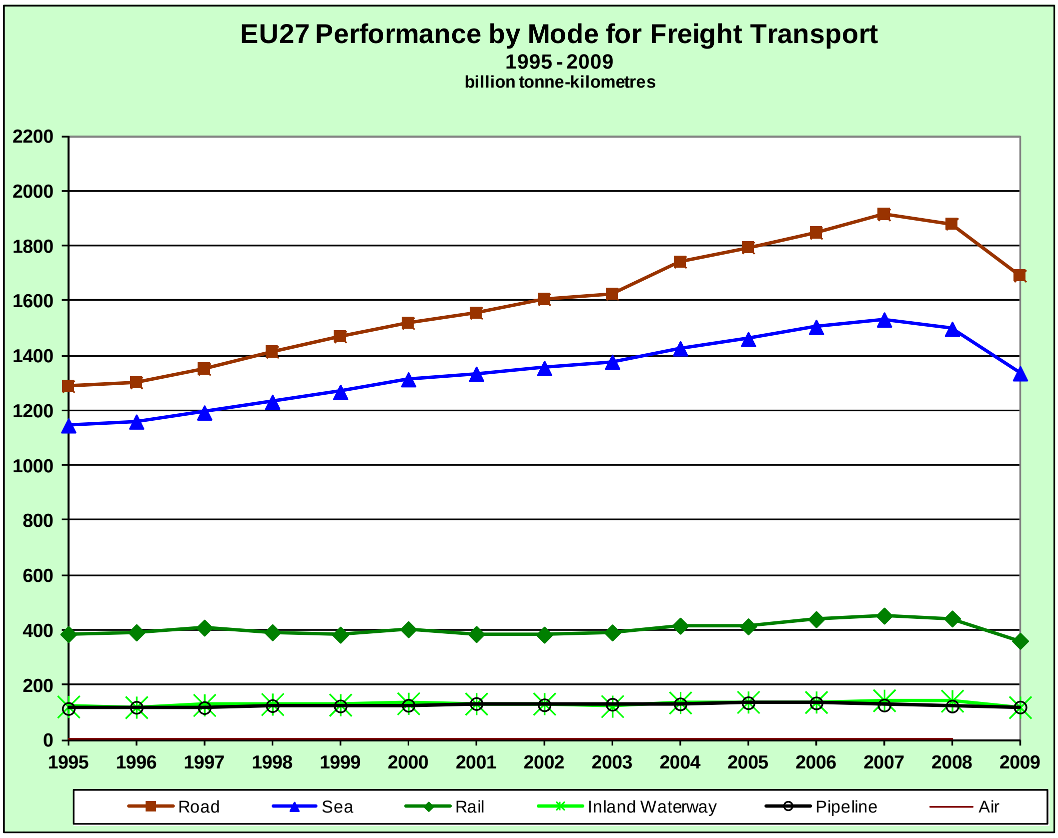


Figure 26:Evolution of freight transport by mode (EU27, billion tkm)

Source: Eurostat

The evidence is that rail freight transport has mostly been flat. In 1995, 386 billion tkm were carried by rail, and in 2005 the traffic was equal to 414 billion tkm. This represents an overall +7% growth in a ten year span; in the same period overall freight transport grew by +29%, road freight transport grew by +39%, sea transport by +27%, and IWW (Inland Waterway) transport by 14%.

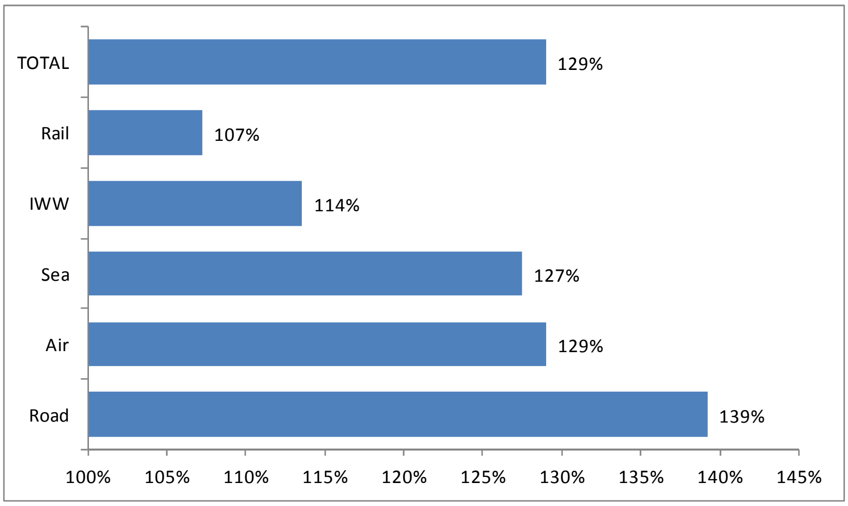


Figure 27: Growth of freight transport by mode (EU27, tkm)

Source: consortium elaborations on Eurostat data

Since 2005 the rail freight sector started to increase, a combined effect of the EU policies for the modal shift (especially in terms of competitiveness), and increased price competition of road transport having adverse effects on service quality.

Growth of freight transport by mode, 2005-2009 (EU27, tkm)

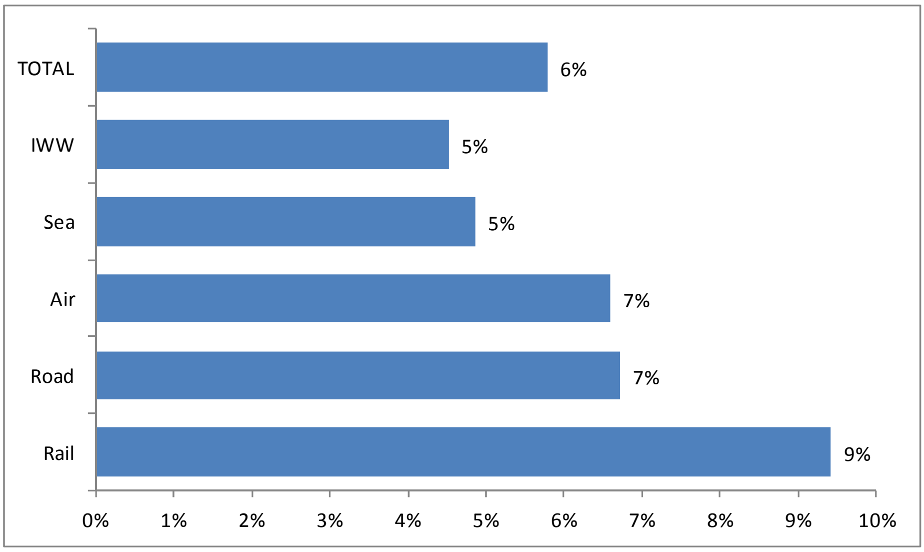


Figure 28: Growth of freight transport by mode, 2005-2009 (EU27, tkm)

Source: consortium elaborations on Eurostat data

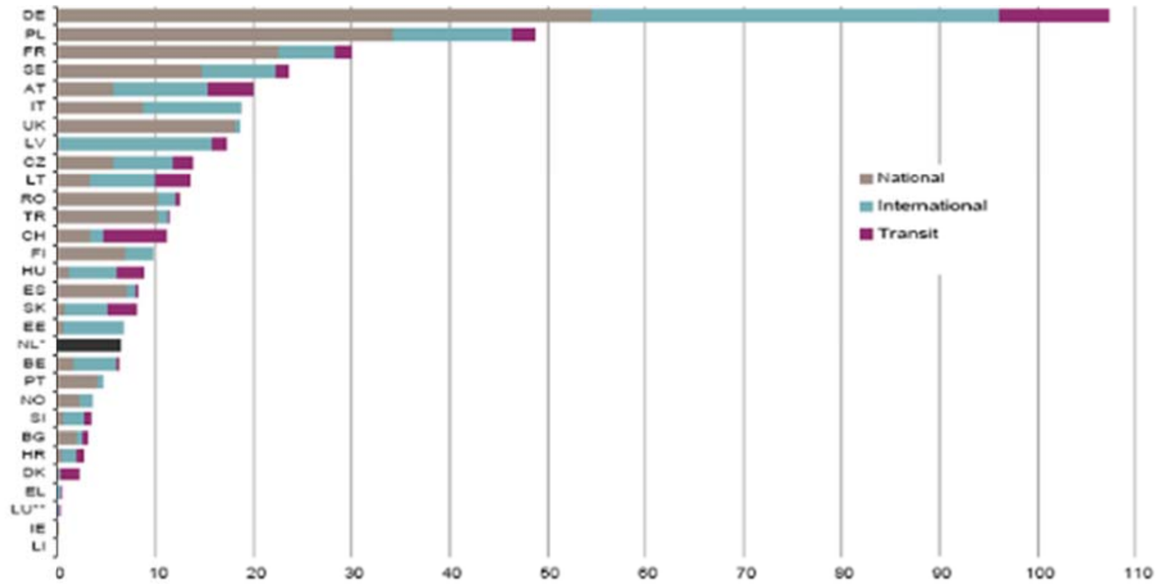
As shown in the figure above, the change of pace brought about unprecedented growth rates for rail, putting it at the top of the fastest growing freight transport modes in Europe, only to be stopped by the crisis, so that the modal split is now hardly growing (10% in 2009 versus road's 47%).

Rail freight traffic is obviously constrained, in terms of geography, by the existence of an adequate rail infrastructure, which is far less diffused than the road network.

Figure 29:Main rail freight corridors in Europe

Source: ERIM, 2007

The map above shows that most of the main corridors of rail freight transport go across Germany. In fact, Germany accounts for by far the highest amount of rail freight transport, and it is the country with the fastest growth in the latest seasons as shown in the figures below.



*NL: Only the total transport of the country is presented. The breakdown between national and transit transport is not available due to confidentiality.

**LU: 2009 data

Figure 30: Rail freight in Europe by Country, 2010, billion tkm

Source: Eurostat

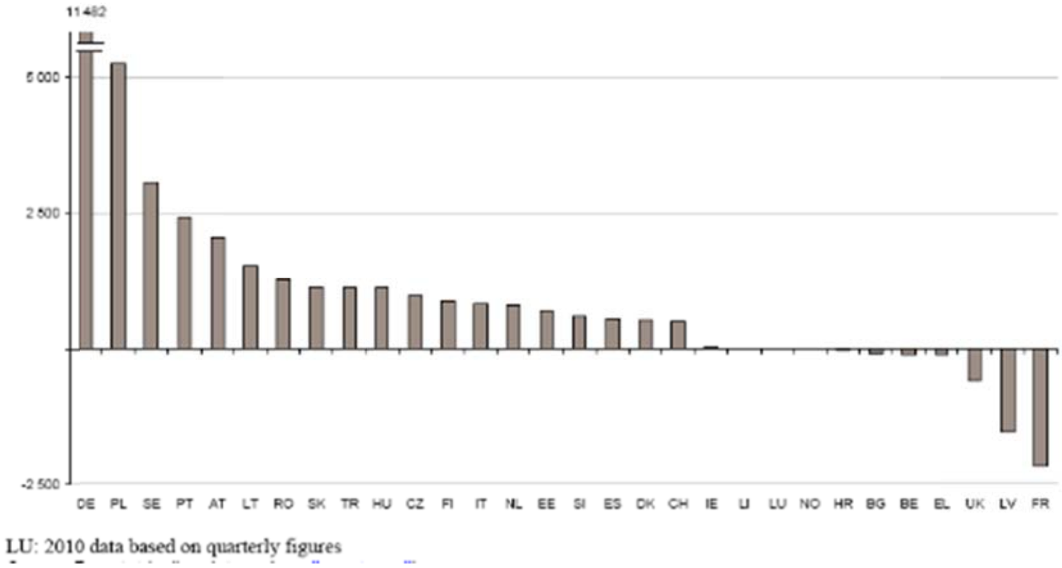


Figure 31: Rail freight in Europe by Country, change between 2010 and 2009, million tkm

Source: Eurostat

Germany, Poland, France, Sweden, Austria and Italy, in this order are the most important European countries in terms of rail freight transport, and of them Germany, Poland, Sweden, and Austria have experienced double-digit growth rates in 2010, with Italy at 4,6% and France the only decreasing market at -6,7%.

Business models

The general business model of rail operations is illustrated in this scheme: where the transport operator is responsible for either the terminal-to-terminal operation only (conventional rail, but also intermodal in some instances) or the larger part of the transport chain (intermodal). The defining difference between conventional rail and intermodal lies in the type of loading unit: in the latter mode of transport the goods are carried along the whole door-to-door via different modes but without changing loading unit.

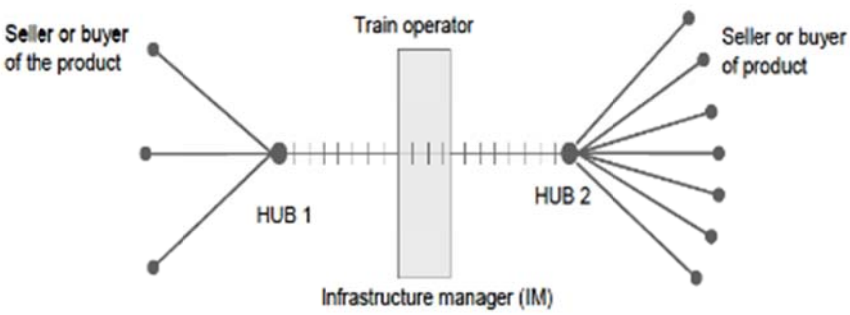


Figure 32: General business model

The typical loading units of intermodal transport have to be extremely standardised. All intermodal loading units can be moved between different modes without loading and unloading their contents, the most common ones being:

- Containers (that can be moved from ship to rail to truck to barge)

- Swap bodies (road- rail).
- Intermodal semi-trailers (road – rail) – while in many respects a more flexible piece of equipment, providing more opportunities to carry out different kinds and set up of transports, semi-trailers are less used in rail transport than containers and swap bodies. The main harmonisation need is in the field of crane ability of semi-trailers. This can be seen as a main pre-condition for the use of semi-trailers in intermodal transport.
- Air containers are also an intermodal unit, in that they can be moved between different modes, but their different shape, strengths and size compared to the general container makes it harder to conveniently stock them in transport means other than aircraft.

The minimum distance beyond which intermodal railway transport is considered competitive is around 500 km, even though on some high-density corridors (typically to/from seaports) this distance can decrease down to 200-300 km. This is because the additional costs deriving from the use of more modes – i.e. the transhipment costs, terminal costs and all other costs relating to the management of a complex operation – are justified if the longer distance allows to achieve scale economies deriving from the use of the most efficient mode, thus reducing transport costs. Schematically, intermodal transport cost is made up by a fixed part (independent from the covered distance) and a variable part which is proportional to the distance. Since the fixed part of all-road transport is way lower than that of intermodal transport (both road-rail and sea-rail), the competitiveness of intermodal transport is highly dependent on the variations of long-distance all-road prices.

The minimisation of costs and times of transhipment (i.e. the operations by which the intermodal loading unit is moved from a transport means to another for the changing of mode) is therefore essential.

Different combinations of actors, and different degrees of integration, can eventually be involved in the door-to-door chain, considering that individual operations are required by the first leg, the main leg, and the final leg, and all terminal operations (transhipment, storage, etc.) and can virtually be all executed by different operators.

The **Freight Forwarder**, while not necessarily being a transport operator, is the central figure of actor, in that he organises the transport and handles all documentary issues, such as customs declarations, freight documents or letters of credit. He handles shipments for payment always under the premise of trying to achieve the best possible transport chain for the customer. Furthermore he is responsible for the choice of transport modes and the arrangements for insurance or damage claim processing. While traditionally, the Freight Forwarders originally had no transport assets at all this role has changed. Instead of only acting as an intermediary, many Freight Forwarders actually became transport operators and had their own transportation assets, evolving into either Transport Operators that operate a certain section of the chain and buy other transport services from other operators, or eventually into **Freight Integrators**, who are big companies that organise and operate by themselves the whole door-to-door chain.

Challenges and drivers of evolution

As the European Commission put it, there are four main areas of concern that have been hindering the growth of market share of rail transport in Europe, especially in the international freight sector.

- Rail operators were still largely nationally based, with complicated arrangements requiring inter-company negotiations regarding through traffic between countries;
  - Lack of competitive pressure to reduce costs and improve services;
  - Inadequacy in the capacity and quality of infrastructure, particularly regarding the ability to operate high speed passenger and combined transport freight services on international routes;
  - The general problem of technical harmonization, which inhibits cross border operation of trains.

There are a number of trends in the rail freight transport sector that are relevant in order to understand the possible future evolutions of the sector. The EC funded SPECTRUM project[2] articulates them as follows:

- **More efficient use of existing infrastructure**: The passenger and freight traffic on the main railway lines is increasing, particularly around the big rail nodes. This is especially the case in Western Europe. Passenger transport is generally given priority over freight transport. The railway infrastructure often cannot be expanded rapidly. In Central and Eastern Europe, there is less congestion on the rail network. As regarding the availability of rail transport capacity, the Central and East European railway market offers more possibilities from the point of view of railway capacity. In any case, existing railway infrastructure needs to be used efficiently. For example, if a safety system such as ERTMS would be widely introduced, rail transport capacity will increase. In that case better and more dedicated transport solutions can be offered.
- **Interfaces between the operations**. Cross-border traffic in rail freight is steadily increasing. This is especially true for the European Union and the countries of the North American Free Trade Agreement which are becoming more and more economically integrated. In Germany, for example, more than 50% of all rail freight is international. In the traditional model, which originated in times when there was one national railway undertaking in each country, the national Railway Undertaking (RU) of one country collected the wagons for a neighbouring country from different origins all over its network at a border station to a neighbouring country. The wagons were handed over to the national RU of the second country and distributed by this RU to the different destinations in its network (see Figure below).

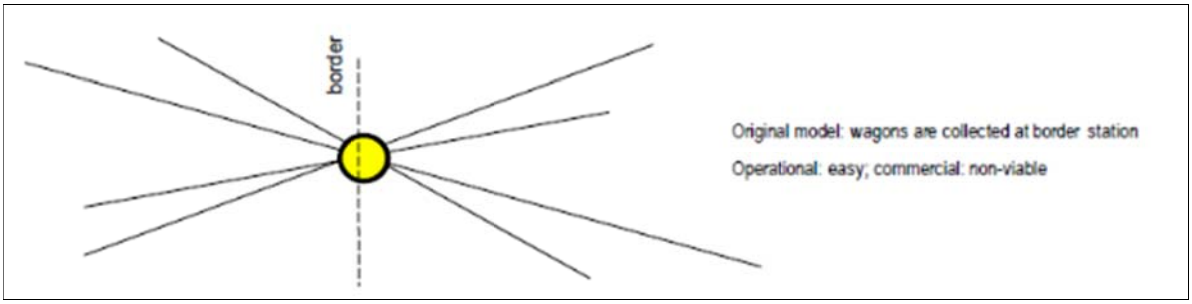


Figure 33: Traditional operational model for cross border traffic

The main problems of this traditional model were problems in communicating information between the different parties involved in the process. The national systems of planning train paths and dispatching trains were different, so a high degree of planning and coordination between the different RUs and

[2] SPECTRUM, Deliverable 1.1 Logistics Market Analysis, EC, 2012.

infrastructure managers (IMs) was necessary. In practice the communication and coordination were often not working at the desired level. Train delays and cancellations were often communicated too late or not at all. This lead to additional costs because train staff and locomotives had to wait at border stations awaiting instructions and authority to move and impacting on the amount of time they were productive.

Current operational models help to avoid these problems. The European and North American railways are increasingly using a new operational model of direct cross border trains. In this model the wagons of the neighbouring country are collected at marshalling yards within the countries. Direct cross-border trains connect these marshalling yards. These trains are mostly equipped with interoperable locomotives and don't stop at the border station. The next figure shows this operational model.

New operational model for cross border traffic

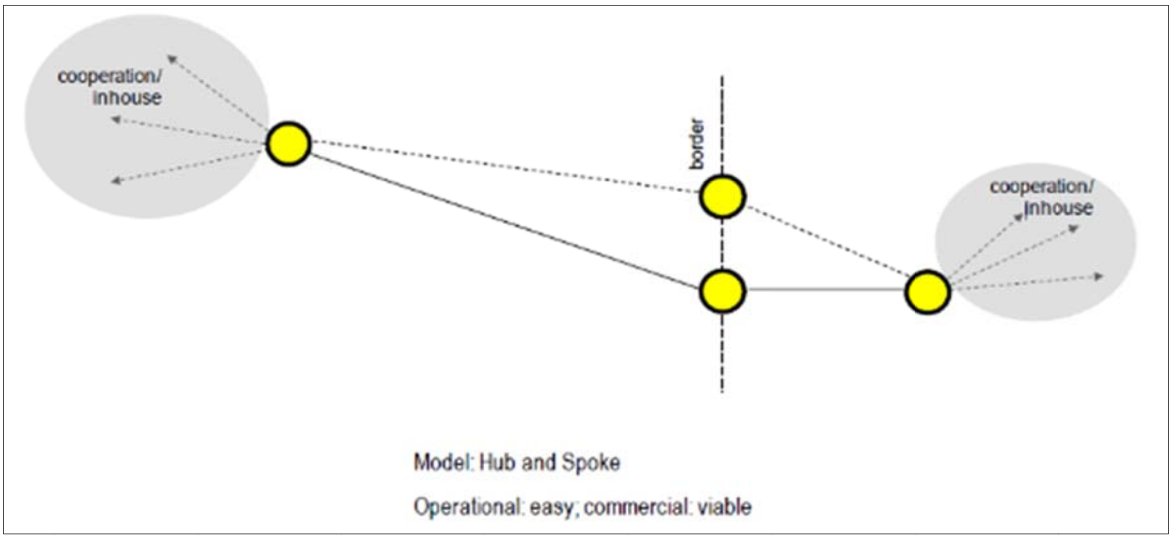


Figure 34: New operational model for cross border traffic

Source: Railistics

- **Increasing necessity to integrate passenger and freight transport**: Especially within Europe the densely used networks for mixed traffic face operational problems resulting from the different characteristics of passenger and freight transport (e.g. speed, acceleration and braking). The requirements of passenger and freight transport on the railway infrastructure are very different. On less heavily used lines, the common use of passenger and freight trains is normally not a big problem, but on heavily used main lines this can pose problems. The main problem is the different speeds of (generally faster) long distance passenger trains and freight trains, but also the different stopping patterns of regional trains calling all/many stations. It would be preferable for long distance freight trains to have no intermediate stops or be queuing as a result of interaction with regional or stopping passenger services. In most cases freight trains have to wait while passenger trains are passing. Another problem is that freight trains need more flexible timetables, because the actual departure of a freight train depends on many variables, e.g. the need of the shipper, the loading process and necessary waiting times because of passing passenger trains. Whereas passenger trains have a fixed timetable and should stick to it, in order to make the customer an attractive offer. Generally the ideal solution for these problems would be the effective separation of passenger and freight on different lines. This is often not possible. In these cases, a more flexible operation is often required. For freight trains there could be several freight priority slots distributed over the day. These slots can be used flexibly for freight trains if necessary. With this solution the differing requirements of passenger and freight trains can best be accommodated.

- **Increased use of telematics applications and planning and process software**. The importance of telematics applications and software solutions in rail freight is, as in other industries, steadily growing. One very important item is the ex-ante simulation in major railway infrastructure projects. In major projects of new construction and upgrading of rail infrastructure, the future operational needs should be defined and an operational concept should be developed and simulated on the planned new infrastructure. With this procedure, the real needs for the new infrastructure can be identified and the infrastructure can be designed and sized correctly. After this ex-ante simulation, the infrastructure should be re-planned. Without such a simulation the infrastructure is often not suitable for the actual operation after upgrading.
- **High-speed Systems**. High-speed freight trains may be competitive towards some airfreight. The Carex concept is that inter urban rail transport by using the European high-speed rail network to carry airfreight pallets and containers over distances of between 300 and 800 kilometres could be competitive. This would involve: (1) a "modal shift" from trucks and short-/mid-range aircraft to high-speed trains wherever competitive (2) the availability of airport-based air/rail terminals connected to high-speed rail links and (3) services tailored to suit the logistics chains and transport plans of integrators, with priority given to express freight in order to guarantee next-day delivery, followed by less urgent air cargo freight.

At the recent Air Baltic conference held in Katowice on 23 of April 2013 the impact of the potential high speed rail connections on air cargo was shown for the Baltic regions. (Anatoli Beifert), see figure below. The figure shows the cost of transporeting a 40 feet container from China to Europe. The cost of air transport is about 25000$ and the total trip length is about 5 days. Trucking would cost 10000$ but take about 20 days. The Sea shipping costs about 2500$ but takes some 28 days. The train would take even longer at 37 days and would cost 7500$.

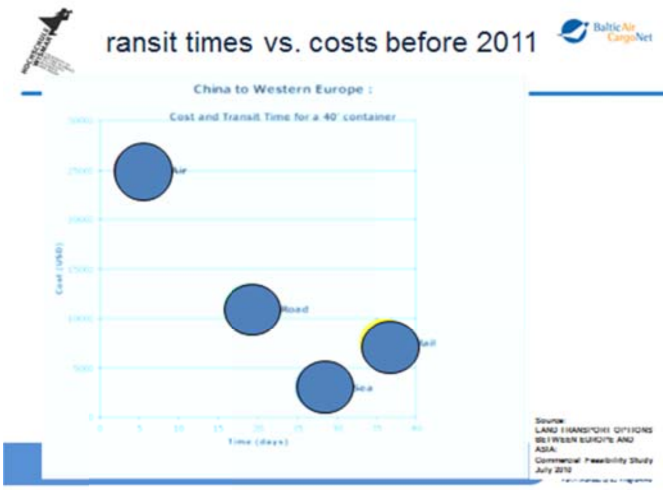


Figure 35: impact of the potential high speed rail connections

The next figure shows the potential effect of high speed rail cargo between China and Europe:

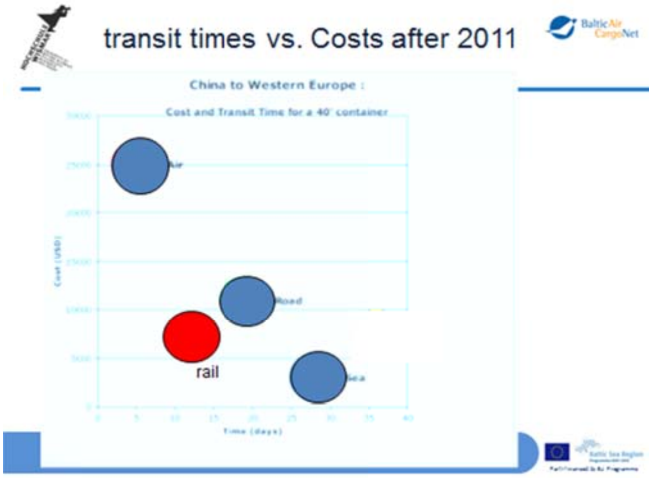


Figure 36: potential effect of high speed rail cargo in the Baltic area

Rail could become a real competitor to air transport on these overland long haul routes. The train could deliver goods within 2 weeks time. (However the experts during the Cargomap workshop also mentioned that some trains running between Europe and China simply disappear and never arrive their destination)

- **Promotion of dedicated rail freight corridors**. The evolution of the European rail network has been historically conceived and planned according to both a "corridor" approach" and a "network" approach. Since 2001 (with the Commission's White Paper) a "Dedicated Freight Network" concept has been explored in order to develop a network made partly of dedicated lines (at the international level) and partly of mixed traffic lines. The planning of a Dedicated Freight Network was indeed one of the three key actions envisaged in the 2001 White Paper, together with the integration of rail transport into internal markets, and the optimisation of the use of infrastructures by opening up the markets.

The concept of a Dedicated Freight Network consisting of international corridors has recently been replaced by the concept of a "European rail network for competitive freight", conceived in order to address the requirement of a more efficient provision of service by the rail infrastructure operators to the rail operators. This system still envisages an appropriate treatment of freight trains in terms of allocation on lines that cater also for passenger traffic, by introducing the concept of "priority freight trains", those that transport time-sensitive goods, in order to allow priority freight trains to have guarantees in terms of service provided by the infrastructure.

This is essential to enable them to gain in competitiveness with respect to trucks. The EU is working towards the creation of a rail network giving priority to freight, including the realisation of a number of international freight-oriented "corridors" - at least one in each EU Member State by 2012.

The Regulation concerning a European Rail Network for Competitive Freight (Regulation EC 913/2010) entered into force on 9 November 2010. The Regulation requests Member State to establish international market-oriented Rail Freight Corridors to meet three challenges concerning:

- The European integration of rail infrastructures by strengthening co-operation between Infrastructure Managers on investment and traffic management;
- A balance between freight and passenger traffic along the Rail Freight Corridors, giving adequate capacity and priority for freight in line with market needs and ensuring that common punctuality targets for freight trains are met;
- The intermodality between rail and other transport modes by integrating terminals into the corridor management and development.
- **IT cross-border traffic management**. The development of interoperable and attractive multimodal transport services rely more and more on the availability of modern tools that aim at ensuring the shift from "modes of transport" to "Intelligent Transport Systems" as foreseen by the EC. In today's logistics real-time status information on transport movements are essential, especially for transport modes, which show great irregularities, as this is still the case for most rail freight services throughout EU.

Moreover, the current status of cross-border rail freight operations, due to the lack of diffused cooperation between RUs, vastly increases the risk of delays, making the lead time for freight consignment very uncertain, thus hindering the attractiveness of rail freight.

The adoption of IT in cross-border traffic management is anyway a clear trend towards the simplification of train handover, a factor of cooperation between rail stakeholders.

- **Alliances forming.** Within Europe, alliances take shape. For example, Xrail is a production alliance for wagonload traffic and aims to render international wagonload traffic by rail more customer friendly and efficient. The alliance strives to increase the competitiveness of wagonload traffic in Europe significantly, thus helping take traffic off the roads and protect the environment. The alliance is made up of the following seven partners: CD Cargo, CFL cargo, DB Schenker Rail, Green Cargo, Rail Cargo Austria, SBB Cargo and SNCB Logistics. Xrail addresses the operation of international wagonload traffic between the rail freight operators. The alliance is not targeting block train transport or combined transport using swap bodies. The commercial part of wagonload traffic, such as customer liaison and pricing, remains the direct responsibility of each of the participating railway undertakings, who continue to compete with one another. However, all Xrail partners commit to maintaining the high standards of quality and service for the customers, as defined within the alliance.
- **Changes in the Railway Undertaking market**. The RU market is evolving at present into a market seemingly with a limited number of large undertakings (still linked to their respective national governments despite the requirements of the EC to adopt the reform packages of the past decade) and a large number of smaller niche players. DB Schenker, Rail Cargo Austria, SNCF, PKP Cargo, Trenitalia Cargo and Green Cargo are companies that belong at present to the select group of large RU that might survive in this competitive market. Most of these incumbent companies are not known for being very innovative. SNCF for example has been slow to adopt the necessary administrative, organizational and commercial reforms required and is losing market share to new operators in both the domestic and international markets. Many of the smaller railway undertakings are micro-operations based around a defined location or geographical area (shunting at a plant or facility), offer specific services (contractor shunting in public rail yards) or key line haul operations. Some rail freight undertakings offer third party contract traction services for train

line haul and have complied with rules governing this activity now allowed as a result of the reform packages. The playing field is not yet completely level despite the good offices of the various national regulators and the incumbents still retain significant behind the scenes power and influence which can constrain the new competitors. The emergence of new privately owned railway undertakings of varying types and capabilities suggests that there may well be rounds of consolidation for financial and competitive reasons. The emergence of regional operators under private ownership is a potential future development as operators exploit their freedoms in relation to operations and manpower compared with the incumbents who may be willing to cede such operations to lower cost operators.

- **Energy efficient driving**. The costs for energy are steadily increasing. Even railways as one of the most energy efficient modes of transport are hit by this development. Energy costs are therefore an increasingly important issue and the reduction of energy consumption increasingly the focus of Railway Undertakings (RU) in order to reduce costs and become more competitive. On the other hand there is an increasing pressure to reduce greenhouse gases to save the climate and to reduce other emissions out of ecological reasons. One possibility to reduce energy consumption is by designing more energy efficient vehicles and more efficient propulsion systems. The other possibility is more energy efficient driving. There are three ways to realize energy efficient driving: i) Training programs for drivers (theoretical and practical); ii) Special timetables indicating the driver the best time for acceleration and braking and the best speed; iii) Special on-board devices like advice systems for drivers or energy meters.

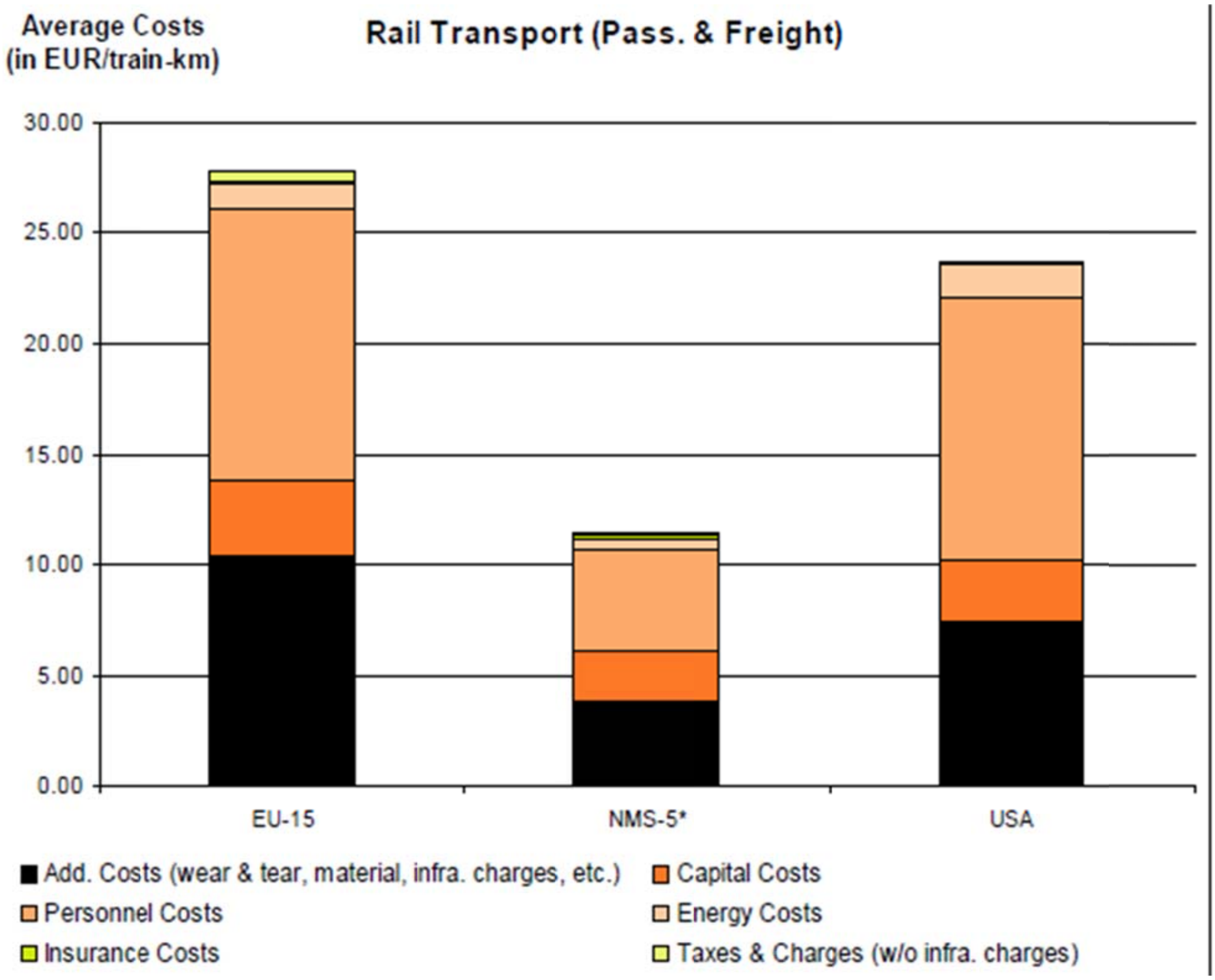


Figure 37: Rail transport (Passenger and freight)

9.3 Maritime transport

Traffic

More than 80% of world merchandise trade is transported by sea. It is the most relevant mode of transport in terms of competition with long haul air cargo since the geographical range of the two transport modes are overlapping, despite being mostly diverging in terms of commodity type.

This figure shows the long-run evolution of world economy, world trade, and global seaborne trade.

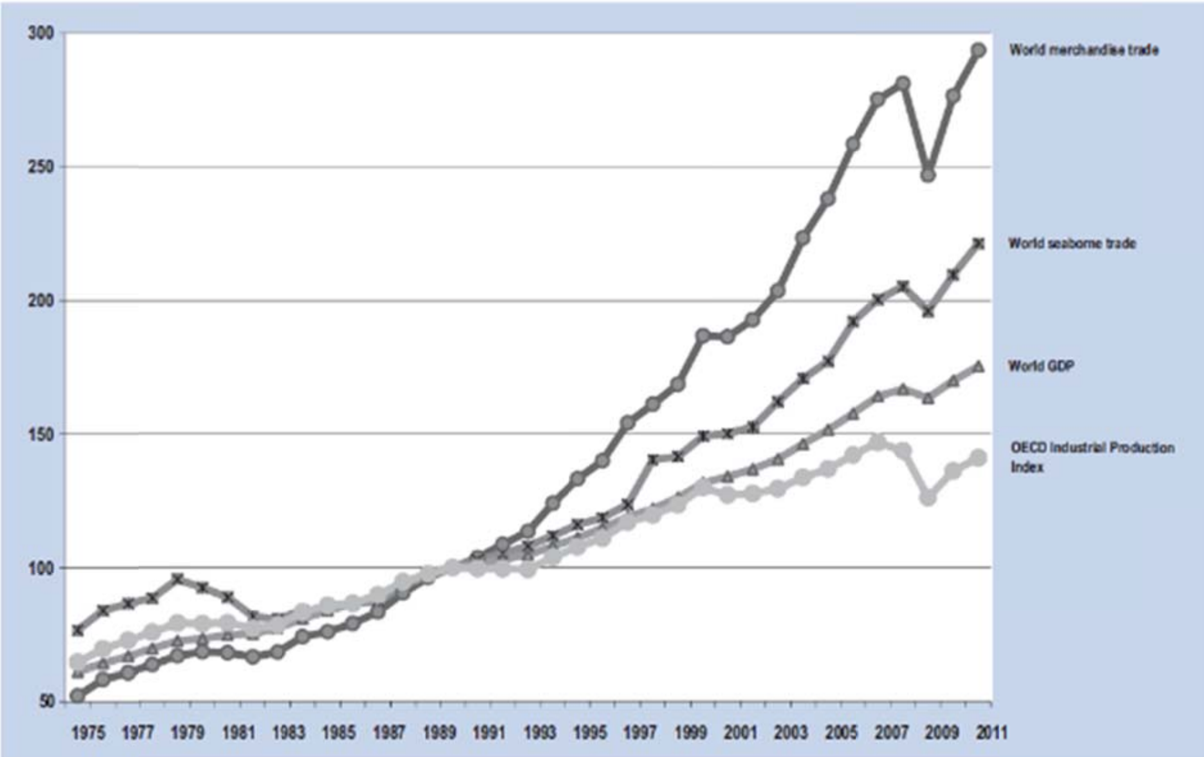


Figure 38: Evolution world economy, trade and seaborne flows, 1075-2011

Source: UNCTAD, 2011

The figure clearly shows the close relation between macroeconomic indicators (GDP, trade) and maritime traffic. In line with the economic evolution, world seaborne trade experienced an upswing in demand in 2010, growing by an estimated 7% at the global level. Total goods loaded worldwide are equal in 2010 to 8.4 billion tons.

The evolution of overall trade in Europe (EU) during the years of crisis (2008-2010) is illustrated in the following figure.

Exports from the EU experienced a strong decline in 2009 (-14.7%), but – similarly to the global trade – a remarkable bounce in 2010 (+18.2%). A similar evolution was recorded for EU's imports: -14.8% in 2009, +14.1% in 2010. The chart also allows to point out what geographical areas have been the drivers of such upswing: Japan and China grew as much as some +28% in terms of export, and +10% (Japan) and +27.1% (China) in terms of import.

Exports			Countries/regions	Imports		
2008	2009	2010		2008	2009	2010
2.6	-13.6	16.2	**WORLD**	2.9	-13.6	15.2
11.3	-22.4	16.5	**Developed countries**	11.6	-24.9	16.5
			of which:			
2.3	-24.9	27.9	Japan	-0.6	-12.4	10.3
5.5	-14.9	15.3	United States	-3.7	-16.4	14.7
2.9	-14.7	18.2	European Union	1.4	-14.8	14.1
0.4	-13.8	12.0	**Transition economies**	18.2	-28.8	17.8
3.2	-10.6	16.6	**Developing countries**	6.7	-10.0	18.7
			of which:			
-2.0	-11.2	8.6	Africa	10.3	-2.7	1.4
3.0	-15.7	13.7	Latin America and the Caribbean	-2.8	-16.2	13.8
7.2	-10.5	23.5	**East Asia**	0.4	-5.3	23.1
10.5	-13.6	28.3	*of which:* China	2.3	-1.7	27.1
7.7	-6.2	15.3	South Asia	20.5	-3.0	12.0
16.8	-6.6	22.4	*of which:* India	29.7	-0.8	11.5
1.5	-10.7	18.3	**South-East Asia**	8.2	-16.6	22.0
4.0	-6.0	6.5	**West Asia**	13.4	-14.2	10.1

Figure 39: Evolution of world overall trade, 1075-2011

Source: UNCTAD, 2011

The previous chart shows the growth (around 10% annually) for container traffic globally. Container traffic is the most relevant type of cargo for this study, since all other types of cargo (dry bulk, or crude oil and products) have a far less potential of attractiveness for air cargo because of their very low value/density ratio.

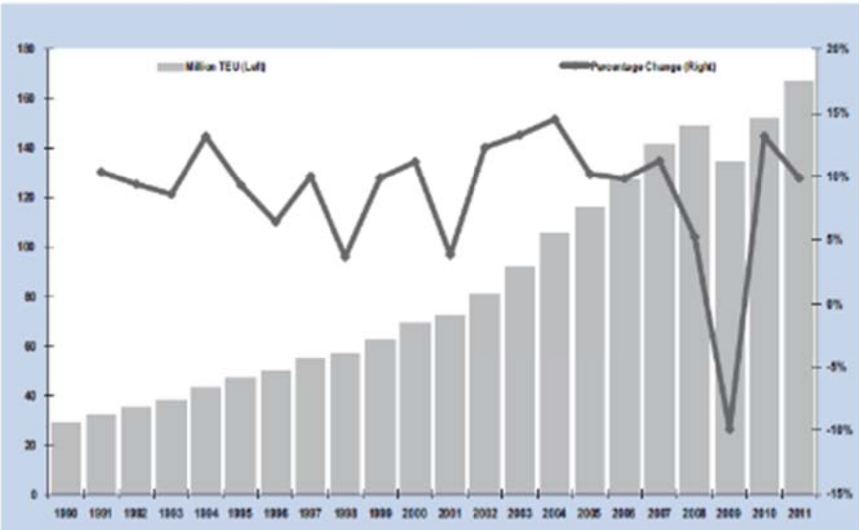


Figure 40: Global container trade, 1990-2011 (TEU and annual % change)

Source: UNCTAD, 2011

Estimated container flows on major East-West routes, 1995-2009 (TEU)

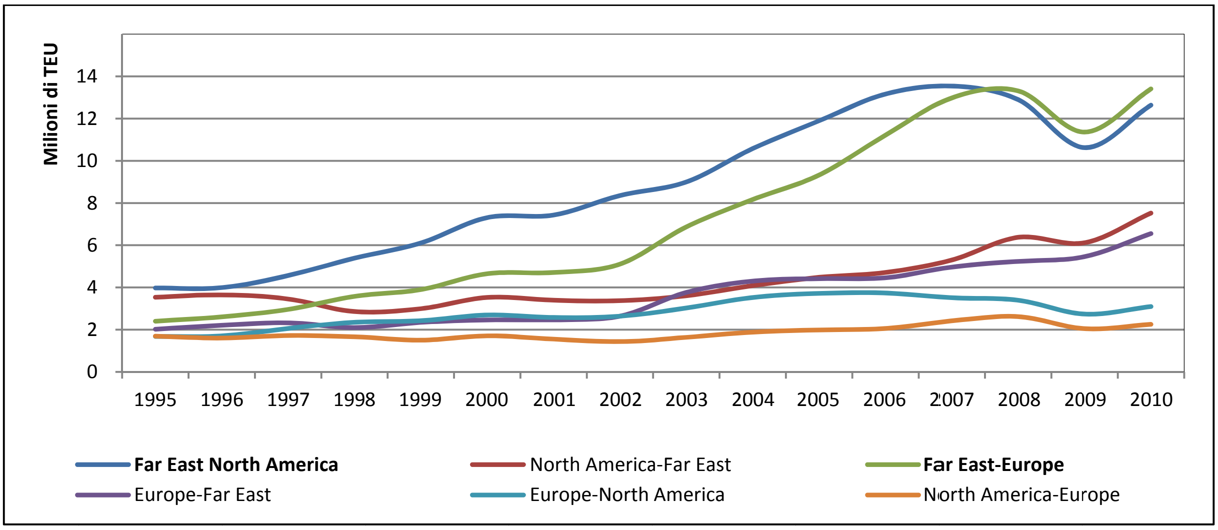


Figure 41: Estimated container flows on major East-West routes, 1995-2009 (TEU)

Source: Consortium elaborations on UNCTAD data, 2011

The geographical detail of container trade in the previous chart shows the relevance of the Far East – Europe route, which overall is four times more relevant in terms of TEU (Twenty-Foot Equivalent Units) than the North America – Europe route.

Europe's imports from Far East via container are actually the densest route in the world, with 13.3 million TEU in the 2008 peak, as opposed to 12.9 million TEU in the Far East – North America. Until 2007 the latter route was still more relevant in terms of TEU. The recovery from the crisis was faster in the Pacific route (+19% for Far Eastern exports to North America; +18% for those to Europe), so that in 2010 the Far East – North America route has gone back to being the densest one.

Business models

The following figure illustrates a general typology of door-to-door transport chain that involves international maritime transport of containers.

Maritime door-to-door logistic chain

Figure 42: General typology of door-to-door transport chain

Source: Eindhoven University of Technology, 2010.

Containers are carried from the first origin, via inland transport (in this case road transport) to a seaport, where they are stored and then loaded on the container ship for the main section of the transport chain. At the destination seaport, the container is unloaded and stored, waiting for the final leg of the chain: the road haulage to its destination.

The addition of a feeder route to the transoceanic one is an alternative which is economically convenient when a certain destination does not attract enough containers to make a dedicate line convenient, so the containers bound to that destination are loaded in a transoceanic vessel together with others (bound to other minor destinations). Containers are then shipped via smaller feeder vessels, with a “hub & spoke” type of network.

The most important transhipment ports in Europe are Rotterdam, Antwerp, Hamburg and Felixstowe in the Northern Range; and Valencia, Gioia Tauro, Algeciras and Malta for the southern range. In the trans-shipment perspective, shipping companies tend to choose ports which are less congested, and that can guarantee the presence of dedicated terminals and adequate services.

Business models in the market structure of containerized maritime transport have been evolving towards a growing industrial concentration, via a number of mergers and alliances between the biggest shipping companies; nowadays, the top 20 shipping companies account for 67.5% of the total market.

Rank	Company	TEU	Market share	Rank	Company	TEU	Market share
1	Maersk line	1.820.816	11,20%	11	OOCL	374.714	2,31%
2	MSC	1.762.169	10,84%	12	MOL	362.998	2,23%
3	CMA CGM	1.069.847	6,58%	13	NYK	352.915	2,17%
4	Evergreen	593.829	3,65%	14	K Line	347.989	2,14%
5	APL	591.736	3,64%	15	Hamburg Sud	335.449	2,06%
6	COSCO	565.728	3,48%	16	Yang Ming	322.723	1,99%
7	Hapag Llloyd	560.197	3,45%	17	HMM	285.183	1,75%
8	CSCL	460.906	2,84%	18	Zim	281.532	1,73%
9	Hanjin	447.332	2,75%	19	PIL	238.241	1,47%
10	CSAV	382.786	2,36%	20	UASC	178.599	1,10%

Table 3: Main container shipping companies (2011)

Source: Certet-Bocconi, 2011

Together with the trend to concentration, traditional carriers’ business model want to offer a bundle service, in which the intermodal transport is organized by them (not only the shipping part); their pricing is usually linked to private, personal negotiation that leads to global corporate contracts. However, a “low cost” business model is also growing, with operators offering a port-to-port service (point-to-point only, with no hub & spoke system), with web-based pricing with early booking advantages.

Trends, challenges and drivers of evolution

The average size of container ship is growing. In 2004 the largest vessels were able to carry up to 8238 TEU, in 2010 this figure grew to 14770 TEU (+79%). Since 2005 98 ships of 10000+ TEU have been delivered, and in 2014 140 new ships of 10000+ TEU will be delivered.

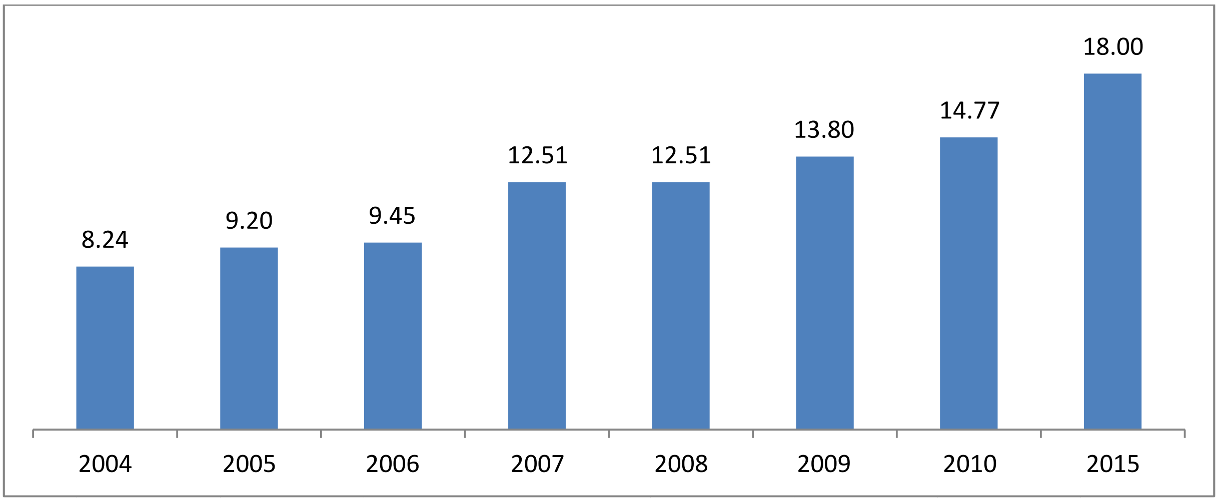


Figure 43: Evolution of the maximum capacity of a container ship (thousand TEU)

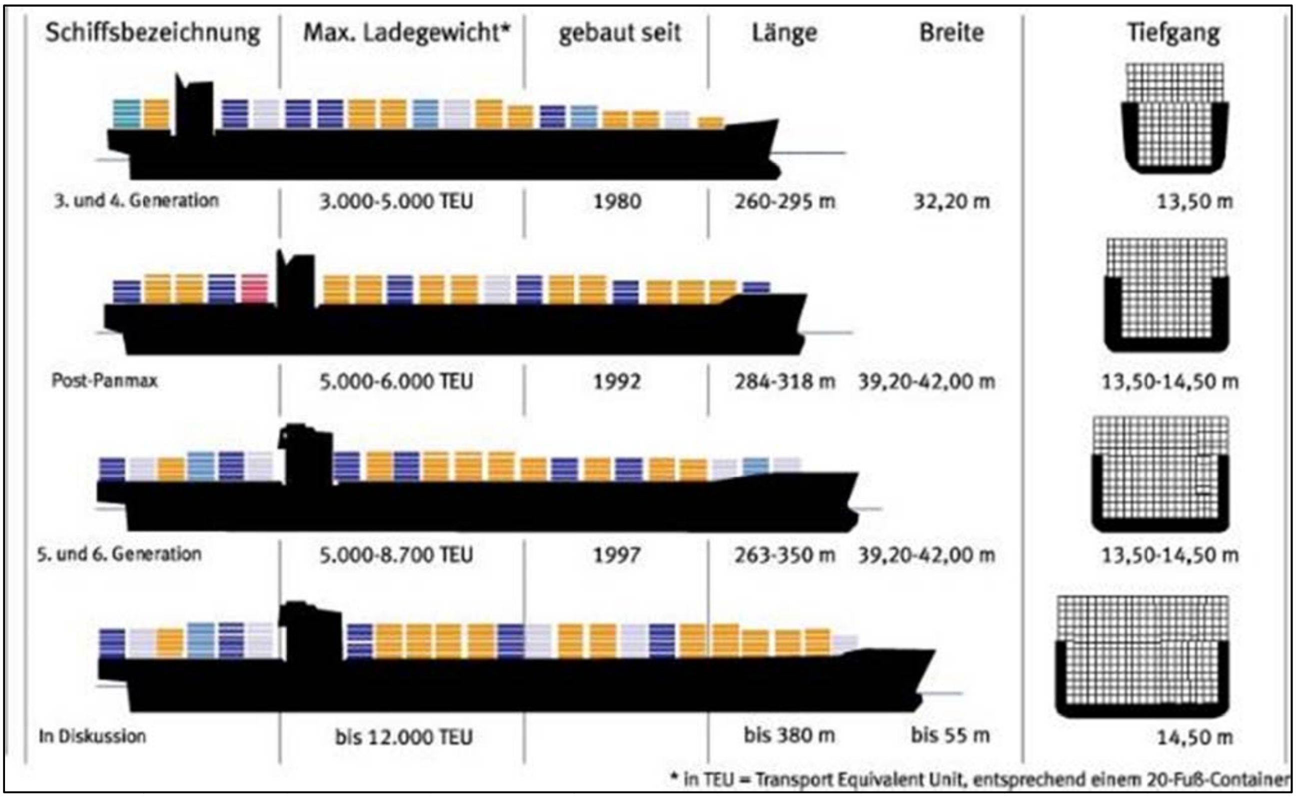
Source: Certet-Bocconi, 2011

This phenomenon is brining relevant consequences for world seaports. As container ships grow, container terminals need to improve their infrastructural endowment in order to keep them adequate to ensure mooring and loading/unloading operations, in order not to become capacity bottlenecks and lose in the port competition.

Empty boxes. The repositioning of empty containers is a relevant challenge for the international maritime transport sector. The remarkable imbalance of flows in global trade generates the presence of empty boxes, thus increasing costs and making it more difficult for operators to operate efficiently. Estimates by Drewry quantifies such costs in some 20 billion USD (2009), deriving from the movement of some 50 million TEUs of empty boxes. Their landside repositioning cost an additional 10 billion USD, so that the overall cost of empty boxes reaches 19% of the industry's income in 2009.

Maritime piracy. In 2010, the total number of attempted acts of armed piracy was equal to 489 worldwide, a +20% increase from 2009. Besides the obvious risks of physical security for the crews and for the environment, piracy generates a number of additional costs for shipping companies: higher insurance rates, higher operating costs because of the rerouting of ships in order to avoid the most dangerous spots, additional costs security equipment and staff.

The main driver of change is of course the **demand deriving from global merchandise trade and economy**. The world economic situation has brightened in 2010 compared to the deep financial crisis of 2008-2009, but a number of areas of concern still undermine the prospects of a sustained recovery and a stable world economy – mainly sovereign debt problems in many developed regions, and fiscal austerity.


Schiffsbezeichnung
Max. Ladegewicht*
gebaut seit
Länge
Breite
Tiefgang
3. und 4. Generation
3.000-5.000 TEU
1980
260-295 m
32,20 m
13,50 m
Post-Panmax
5.000-6.000 TEU
1992
284-318 m
39,20-42,00 m
13,50-14,50 m
5. und 6. Generation
5.000-8.700 TEU
1997
263-350 m
39,20-42,00 m
13,50-14,50 m
In Diskussion
bis 12.000 TEU
bis 380 m
bis 55 m
14,50 m
* in TEU = Transport Equivalent Unit, entsprechend einem 20-Fuß-Container


EVER GIVEN


ITAL FLORIDA
TRIESTE

9.4 Air Cargo

9.4.1 Air Cargo Key Players

Overview

It is important to point out the air cargo industry extends well beyond air carriers. The global air cargo operating system is characterized by a network of relationships among carriers, brokers, handlers, motor carriers, integrators, airports, freight forwarders, customers, suppliers, manufacturers and logistics service providers. The overall air cargo transport network of professions is presented in the figure below, each profession dependent upon the other for its growth and survival. Moreover, today's air cargo environment is becoming increasingly integrated and ground-linked, characterized by door-to-door service from shipper to customer, as opposed to just airport-to-airport. And, time-definite services are also becoming expected by supply chain members making it imperative that all key players operate in an integrated, reliable fashion.

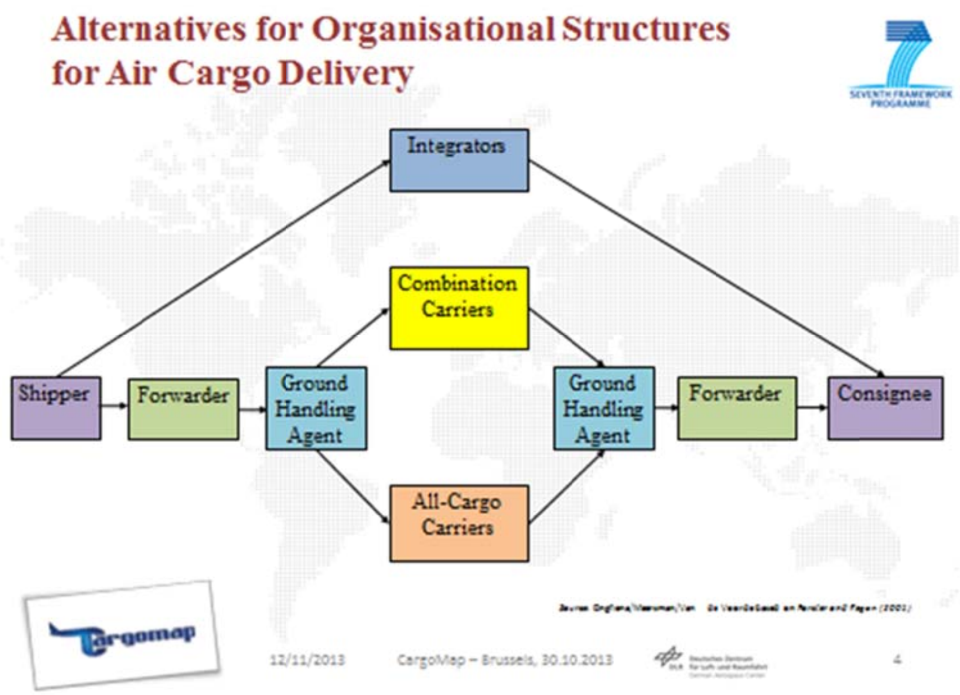


Figure 44: Key Players in the Air Cargo Market

Source: Kasarda et al. (2004),

The Industry players in details

1. Shippers

The shipper constitutes the initial link in the air cargo chain. His or her role is to set in motion the domestic or international shipping process. This function may be executed by the manufacturer, the holder of the merchandise, or the import/export company.

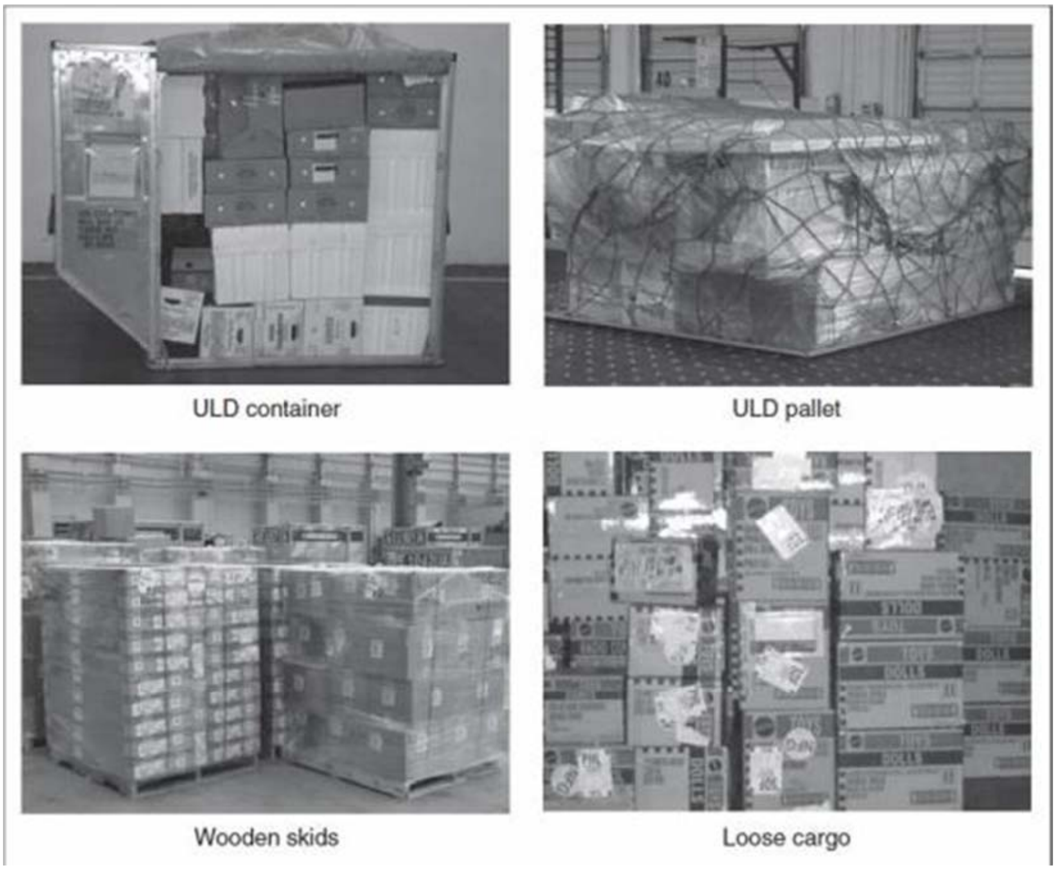
- Main objectives

  The shippers main objectives are customer satisfaction (the consignee) and limiting the length of time assets are immobilized. Where a shipper is also the manufacturer, an additional objective is to concentrate on their core business and increasingly sub-contract shipping, distribution, assembly lines, delivery and back-up functions to other vendors (value-added services).

- Key Issues

  To achieve these objectives, shippers require value-added transport and logistic services from the manufacturer to the consumer. The shipper must be able to assure guaranteed, reliable service and continuous feedback throughout the air logistics chain. It is important to have the capability to monitor the progress of goods until they are delivered to the customer.

Key issues to industry growth and development are essentially related to intermodality and efficient logistics services – EDI/tracking in addition to simplified customs procedures.



2. Forwarders

For the purpose of this document, the term Forwarder includes all functions dedicated to the realization of shipping, e.g., consolidation, customs brokering, trucking, but excludes airline activities.

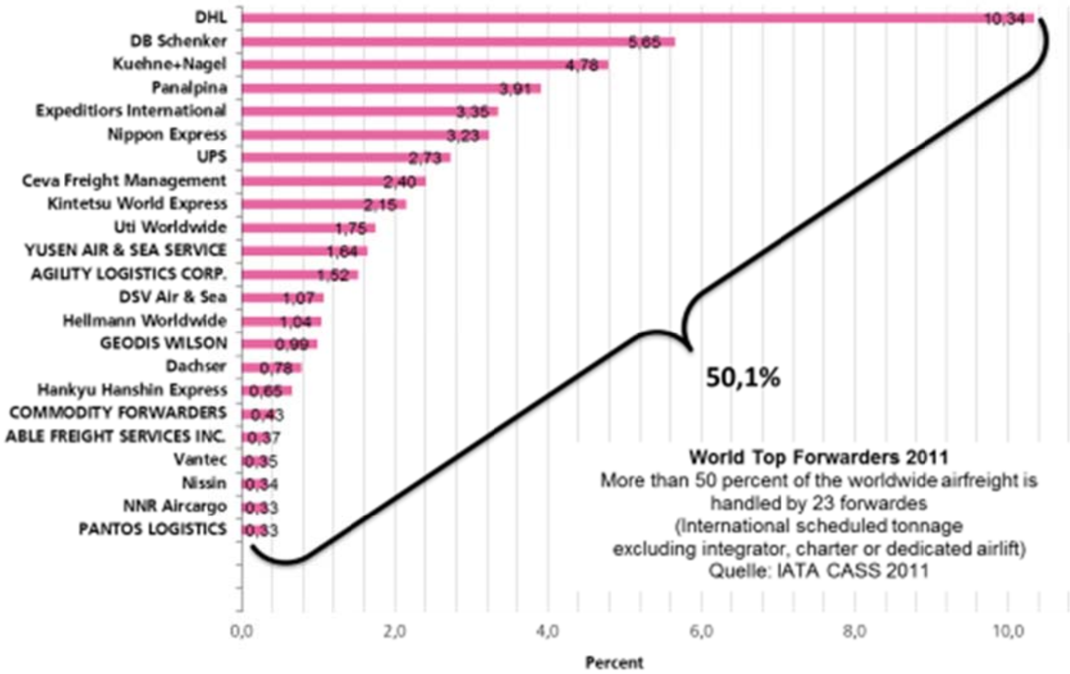
The Forwarder is no longer simply a pure shipping agent. His business development is now governed by the need to provide value-added services required by the reorientation of the manufacturers on their core business.

- Main objectives

  Forwarders should aim to adapt to the quality and productivity requirements of shippers today.

- Key Issues

  Therefore, key issues for forwarders include procedures and performance standards, tariff structures, customs procedures as well as, booking and tracking methods.



World Top Forwarders 2011
Source: DLR and IATA CASS Data

3. Airlines

Airlines whether passenger/cargo or all cargo, naturally strive to offer total customer satisfaction. That customer satisfaction is required by both forwarders and shippers themselves.

- Main objectives

  In terms of products and destinations, cargo airlines aim to render their flights profitable by positioning themselves within the highest yield markets. On the other hand, combination carriers (e.g. belly freight) aim to fill hold space through effective air cargo pricing policies.

- Key issues

  Key issues for airlines include traffic rights, environmental issues, procedures and performance standards as well as, customs procedures.

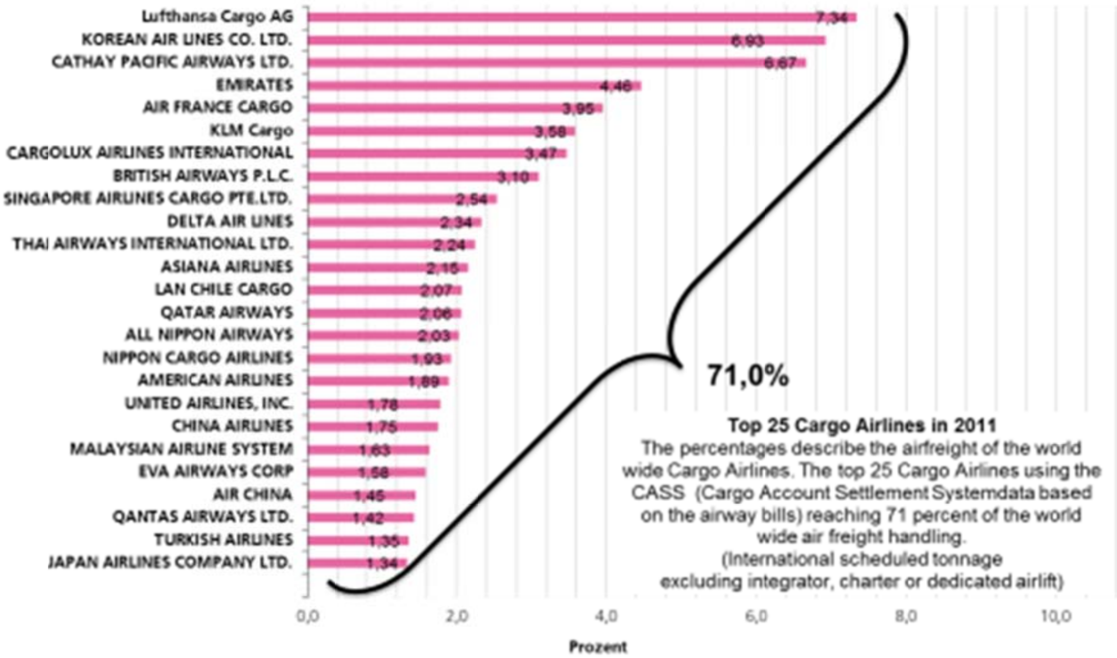


Figure 45: Top 25 Cargo Airlines 20

Source: DLR and IATA CASS Data

4. Air –Integrators

Integrators provide tailor-made door to door express services with guaranteed delivery times. They integrate both forwarder and airline functions within the air cargo chain.

- Main objectives

  Integrator's main objectives are centred upon achieving total shipper satisfaction through limiting the length of time assets are immobilized.

- Key Issues

  Key issues effecting integrators development are similar to those of the airlines notably, security, environmental constraints, and traffic rights, but also include the availability of efficient and simplified customs procedures as well as, performance standards.

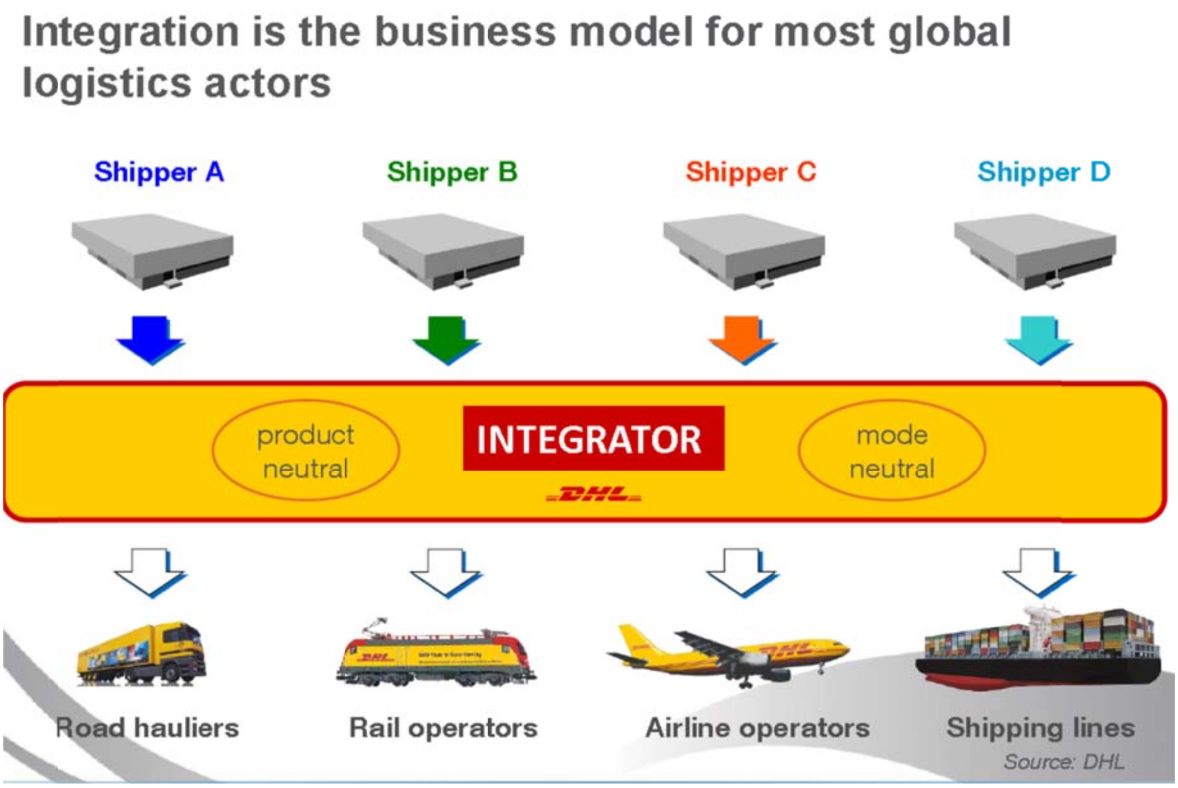


Figure 46: Business model - Integrator

Source DHL

5. Airports

The airport role moves away from its essential passenger service orientation and becomes a major factor in community growth, economic development, and a link to the global market place. The air cargo function is key to participation in global markets. Its service requirements differ from those of passengers. In this instance, the airport plays a leadership role where they can provide solutions.

In the case of customs, individual airlines can make little progress in service improvements, reduction of delays or extension of services. Airports however, as representatives of this community, have the obligation to be the catalyst and spokesperson for those serving the airport and those finding its cargo services crucial to economic health. Airports can seek improvement in the interests of industry, the carriers, the community, and specifically the shipper. This becomes an important role in the business health of the airport service area.

Air carriers and forwarders are often headquartered elsewhere and their interests are therefore, dispersed. Only the airport has a single-minded interest in local prosperity and the need to be competitive. Airports must assume the lead and take on this responsibility.

New problems arise in air cargo operations. The growing role of intermodal service focuses new attention on airport access. Physical and commercial relationships with ground transport operators are a new and growing challenge.

- Main objectives

  To become a central logistic tool serving the economic interest of its region, airports must provide logistic centres that including cargo carrier terminals, freight forwarder warehouses, integrators' hubs, and regional distribution centres. Airports must contribute to an area's economic development, quality of customer service, and provide adequate links to world markets, as well as providing for intermodal integration.

- Key issues

  Key issues for airports are adequate security, simplified customs procedures, adequate cargo access, environmental impact, planned growth, and global visibility.

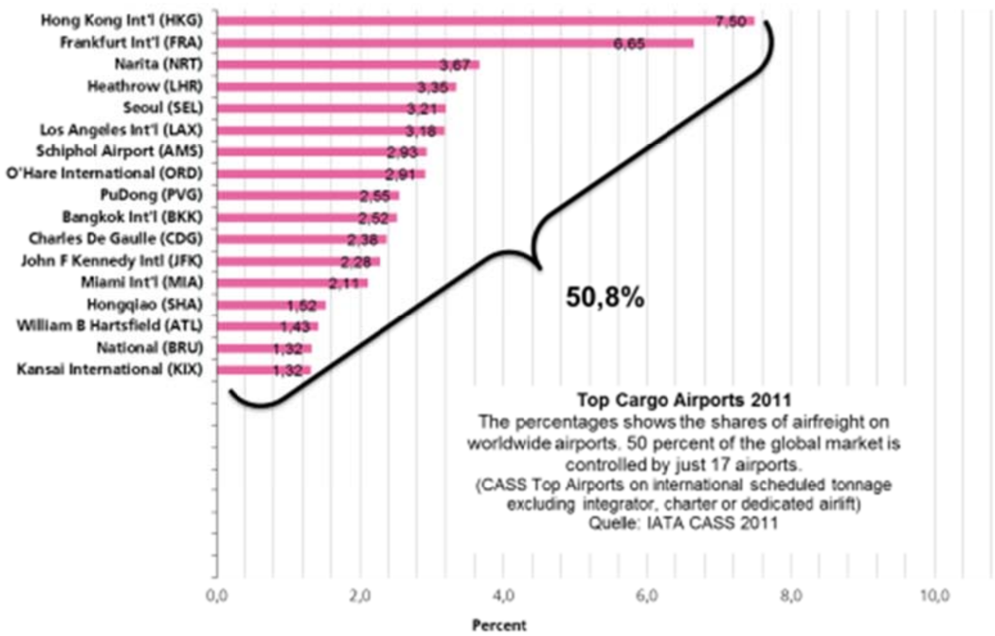


Figure 47: Top cargo Airports 2011

Source: DLR and IATA CASS Data

9.4.2 Air Cargo goods

In general, goods of any kind can be transported by air (provided it is physically possible to load them onto a plane in terms of their size and weight).

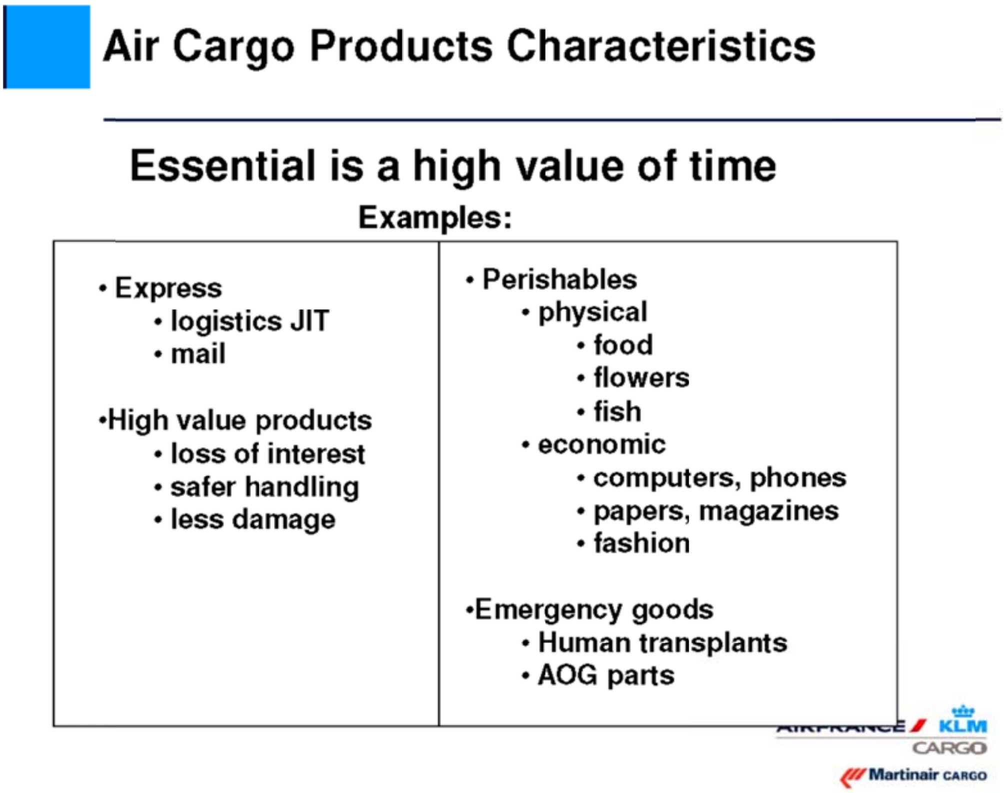


Figure 48: Air Cargo product characteristic

Source KLM

Due to the performance and cost features of air freight transport, however, three categories of commercial goods are particularly suitable as air freight: Industrial goods, parcels and goods where time is a key factor.

High-value goods are highly suitable for air freight because they are generally dispatched in smaller quantities and consignment sizes, have high security requirements in terms of loss, damage and theft risks and tie up significant amounts of capital. Companies such as Boeing assume that goods worth 16 USD/kg or more are suitable for air freight. The actual average air freight goods value tends to be much higher though. An evaluation of foreign trade statistics for the USA and Japan from 2006 results in a price/weight ratio of 97 to 139 USD/kg. IATA analyses confirm goods values in this range, as do the investigations commissioned as part of the forecast of Germany-wide traffic integration 2025 by the Federal Ministry of Transport, Building and Urban Development (BMVBS).

In the case of higher-value goods such as office machinery and electro-technical products, the transport costs account for an average of 1.3% to 1.5% of the overall production value, while, in contrast, the proportion for bulk commodities like ores and building materials is significantly higher (6 to 7%). Higher-value goods are therefore also much less sensitive to the higher air freight transport costs compared to other modes of transport.

Over 80% of the freight items transported by air are lighter than 30kg. Their share of the overall weight-based freight volume is around 15%. The densities of the transported consignments vary considerably and are very dependent on the routes and markets considered. The average load weight per cubic metre is around 150 to 200kg.

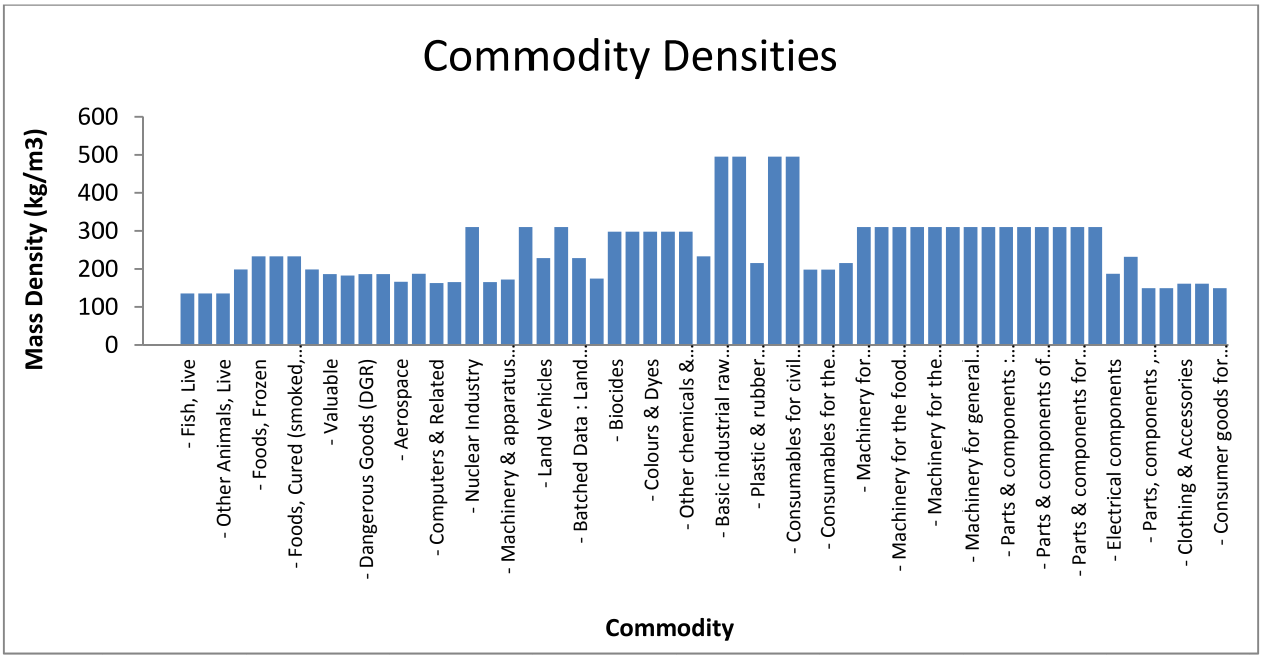


Figure 49: Commodity density

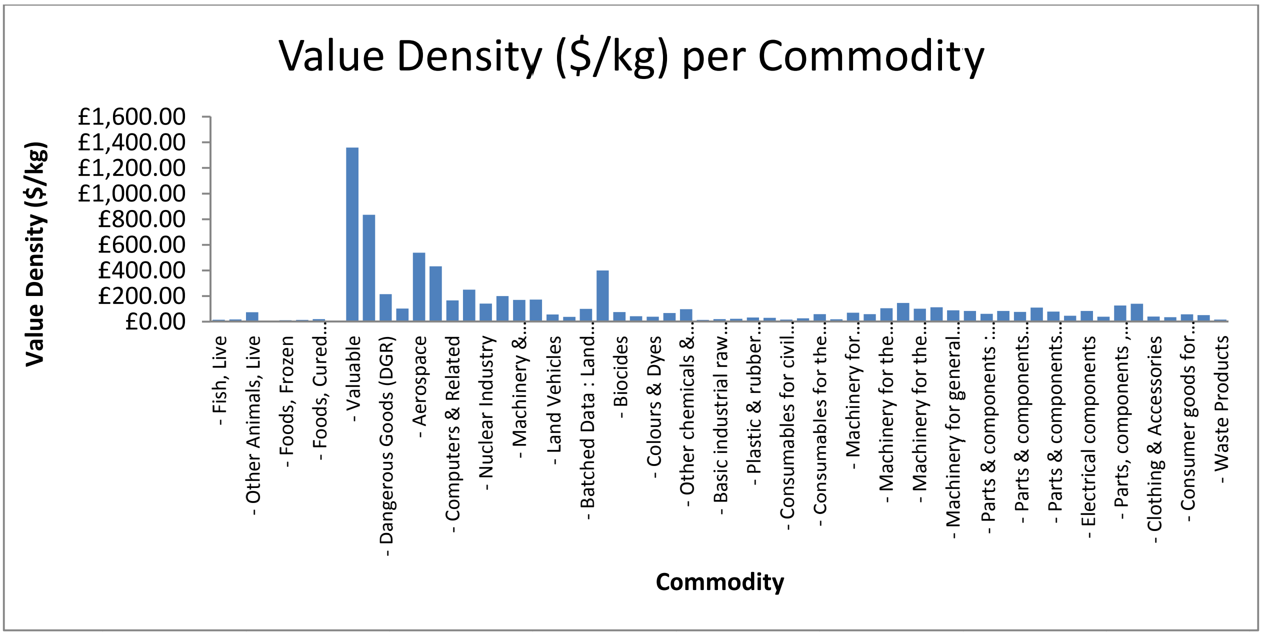


Figure 50: Value density

Source TU Delft

The tendency in recent years towards high-value, urgent consignments, special freight with special transportation requirements and goods with a high volume/weight ratio makes transport by air very attractive and thus has an effect on the demand for air freight transport.

Very generally speaking, the air freight market can be divided up into two groups of customers. The first group consists of customers for whom air freight is only a backup solution in case of production disruptions, supply bottlenecks or repair situations. The largest group considers air freight as an essential part of their marketing and sales strategies and goods conveyance by air therefore takes place on a regular basis.

Businesses operating in the *automobile, machine, plant and tooling construction* fields are the largest overall senders and recipients of air freight. The automobile industry, for example, regularly relies on air freight to transport replacement and supplier parts or, in emergencies, to supply the production lines. When compared to the total transport volume, these industries' use of air freight forms a relatively small proportion. However, the total trade volume of these industries has reached such a high level that the use of air freight transport is also increasing. One example of this is the Volkswagen Group. In 2004, the Group's global freight flows in sea container transport amounted to 141,447K EUR. The Volkswagen Group transported 22,808t of goods (a volume of 136,000m³) by air in the same year. This is equivalent to around 5,000K EUR or 220 fully loaded Boeing 747-400 freight aircraft. The air freight proportion compared to sea transport is, however, only 3.5%.

The *electronics industry* is another important industry with an affinity to air freight. The regularly transported goods comprise a variety of products such as telecommunication equipment, semi-conductor technology and integrated circuits. Air freight transport pays for the manufacturers of these products despite the high costs because the goods have very short product lifecycles and therefore quickly become obsolete, and they have a very high value/weight or value/volume ratio. Entertainment electronics from the Far East are generally transported by sea. Only particularly high-value products, new market launches and unexpectedly high demand form reasons for choosing the air freight option.

In the *chemical industry and plastics processing*, the goods transported by air are those which possess a limited physical durability, have special transportation requirements (e.g. temperature, humidity) or have a high value. Examples include medical and pharmaceutical products, perfume products and cosmetics. Many of these products are classed as hazardous and are therefore subject to the IATA Dangerous Goods Regulations, such as combined loading bans or exclusive transport on purely freight aircraft.

Similar to the previously mentioned cases, the *textile and clothing industry* only uses air freight on a scheduled and regular basis for very high-quality products. These goods are often subject to frequent seasonal volume fluctuations due to summer and winter collections.

One special group of goods is the perishable and urgent goods from the *agricultural sector*. The products in this market segment are of greatly differing physical natures and thus often require special transport conditions which often leave air freight as the only option. Aircraft cargo holds frequently carry live animals such as horses and chicks, fruits, cut flowers and fish and seafood. These goods can make up a considerable proportion of air freight on some routes, such as fruit and vegetables from Africa (Kenya, Senegal, South Africa etc.) to Europe and the Middle East and from South America (Brazil, Chile, Argentina, Peru) to North America and Europe.

Among the other industries which regularly use air freight are printing and publishing, mail order and e-commerce, jewellery and financial sector institutions.

The high importance of industries with an affinity to air freight in global trade and the increasing internationalisation of value chains in these industries will lead to increased demand for air freight services and therefore lead to growth in air freight transport volume. The changes described for goods structures reinforce this trend as they have a direct positive influence in the development of demand. In future, countries outside North America and Europe (especially Asian countries) will also offer more and more goods in such variety and of such quality as those in the west.

There may be a gradual shift in goods that we traditionally carried by air cargo as computers become less expensive and the capital cost during transport on these goods are thus reduced.

The following figure shows the current development in air cargo goods in the future (excluding air parcel services).

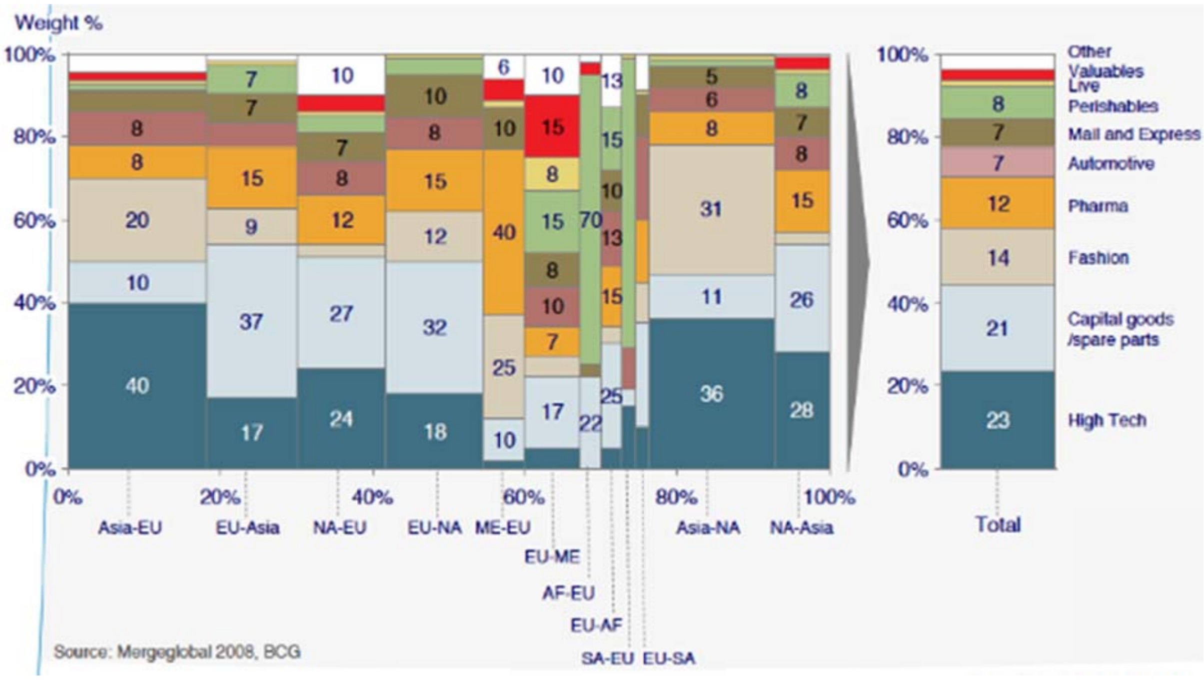


Figure 51: Developmpent in air crago goods in the future

Type of product	Market share
High tech	23%
Capital goods	21%
Fashion	14%
Pharmaceutical	12%
Automotive	7%
Mail and Express	7%
Perishables	8%
Other/Live/Value	8%

Figure 52: Type of good and market share

Air Cargo volume

Total Air Cargo FTK has not recovered from the economic crisis yet. The illustration below (source IATA) shows the Air FTK's versus total world trade.

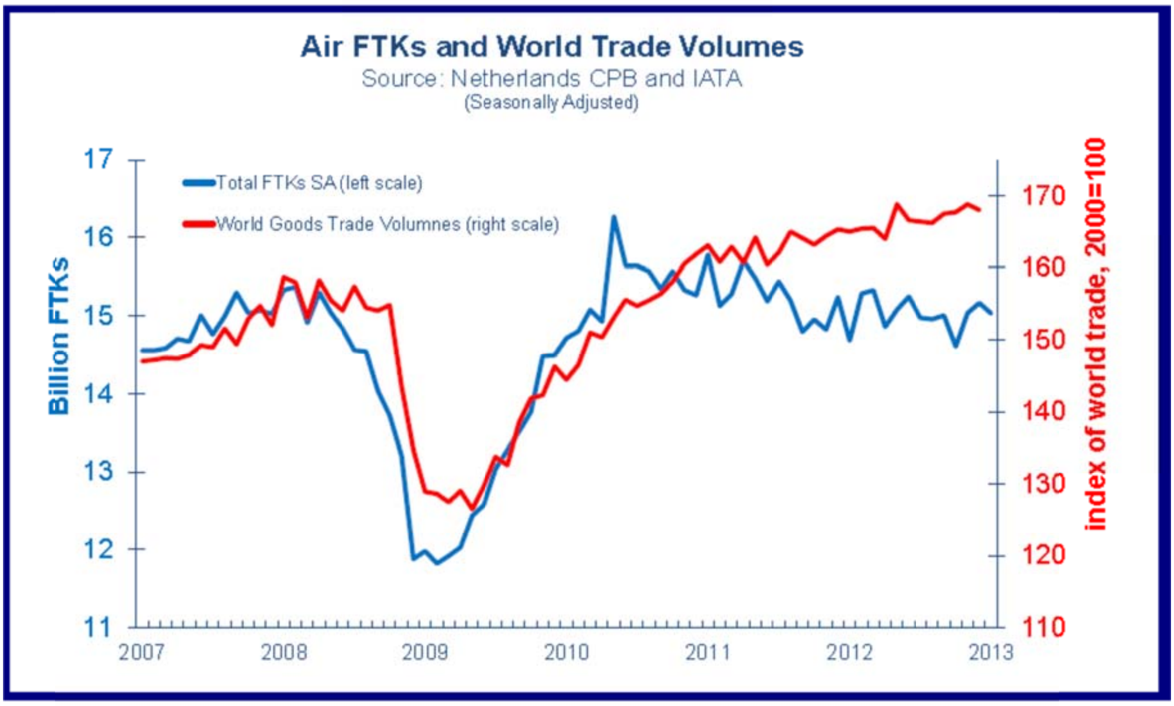


Figure 53: Air FTKs and World Trade volumes

There is an imbalance in import and export within the continents. As a consequence air cargo operations are facing inefficiencies due to empty legs. The largest differences are in the export from Asia to Europe and North America. These two routes are also the largest airfreight routes. In 2010 the worldwide growth was approximately 20%.

Figure 54: Import and Export within continents

9.4.3 Air Cargo aircraft

Air cargo is carried in different aircraft:

- All freighter aircraft
- Passenger aircraft carrying belly freight
- Combi aircraft
- Special cargo aircraft derived from military aircraft

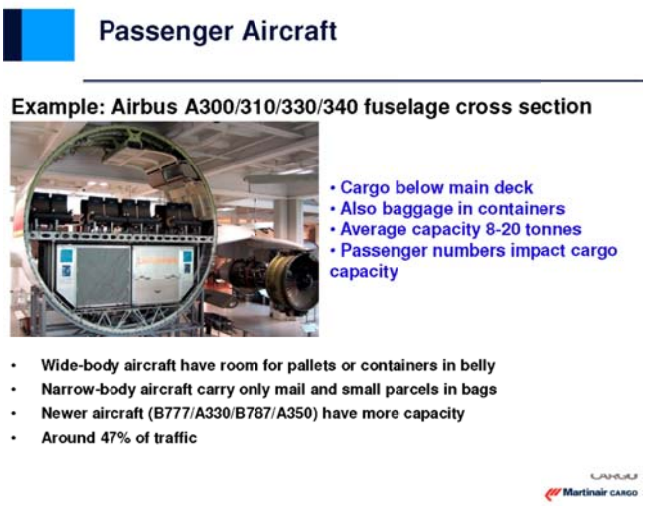


Figure 55: Aircraft types

Source KLM and Antonov

The division between freight carried by full freighter aircraft and freight carried in the belly of passenger aircraft is shown below. The latter flights are not ideally scheduled for cargo movements. For example, the time at which cargo aircraft operate is usually on a cheap time slot.

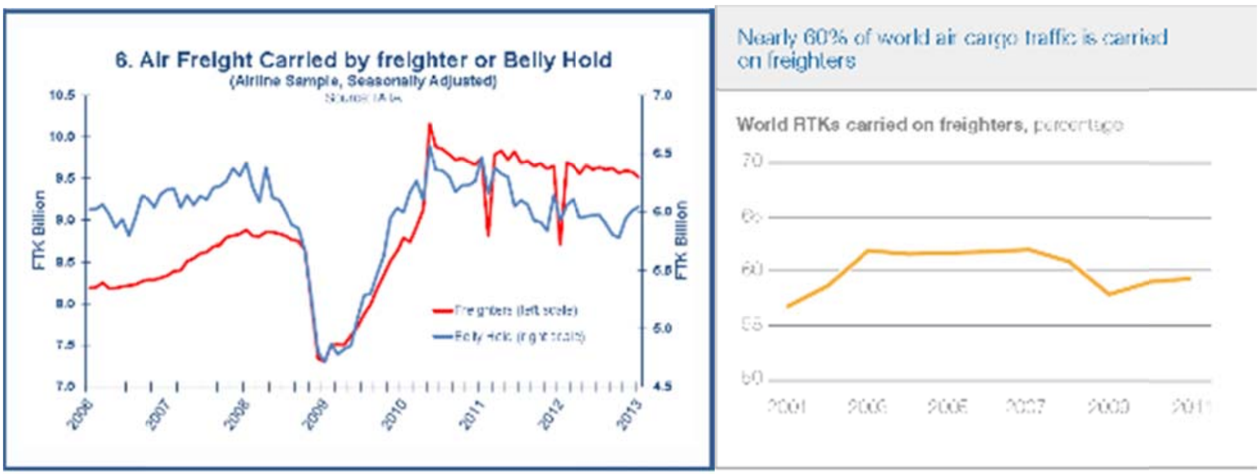
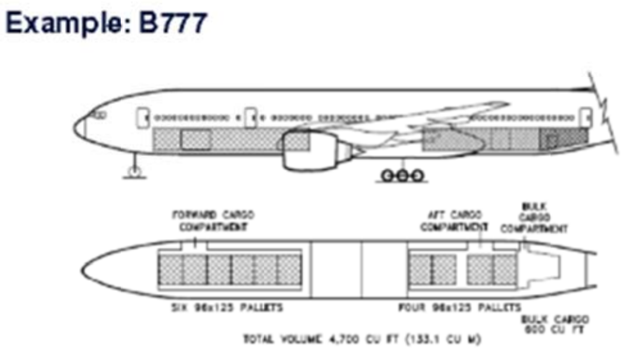
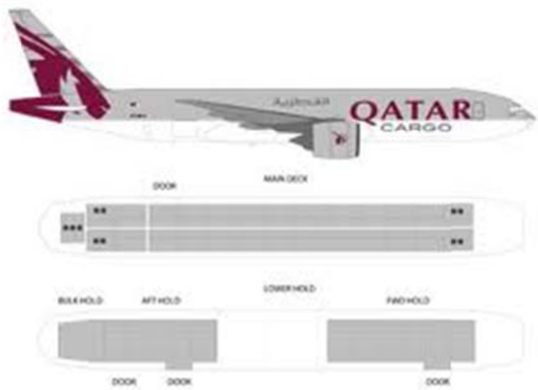


Figure 56: Air freight division

	Belly share
EU-EU	10%
EU-Asia	50%
EU-PRC	50%
NA-NA	10%
NA-Asia	50%
NA-PRC	50%
EU-NA	50%
Asia-Asia	30%
Asia-PRC	40%
PRC-PRC	30%





Military purpose built aircraft are manufactured with defence applications as a primary goal. Former military very large capacity aircraft such as the AN-124 and AN-225 are still used for specific charter transport. Operators also use tactical transport airplanes (C130 Hercules etc.).

The purpose built civil cargo aircraft are practically inexistent.

Conversion aircraft are aircraft that originally were not specifically designed to carry cargo. Nearly all aircraft used in the cargo market have originally been designed to carry passengers.

Examples of such conversions are larger doors, the cancellation of windows or the strengthening of floor. Generally, reconverted aircraft are considered as the cheap solution, giving older passenger aircraft a second life.

Purpose built freighters

These include the following:

- Antonov AN225
  This is a very specific kind of aircraft, since there is only one in the world. This aircraft is able to lift about 250 tonnes of freight.

- Ilyushin IL76
  The Ilyushin is designed as a commercial freighter aircraft. It can lift about sixty tonnes of freight over a maximum distance of 3,700km.
- Lockheed C17
  As was the case with the Ilyushin, the Lockheed C17 is also a purpose built aircraft dedicated for the military. The maximum payload is about 72 tonnes and corresponding maximum range is 4,400km.

<u>Converted freighter aircraft</u>

- Airbus ACF
  Airbus Freighter Conversion GmbH is the division that converts the A320/A321 family into freighters (Airbus, 2008). It is not directly a part of Airbus, but they are strongly related through EADS (European Aeronautic Defence and Space Company). The Airbus A330 is also derived freighter aircraft with a maximum payload of 64 tonnes and maximum range of 7,400km (Jane's).
- Boeing BCF
  Boeing converted freighters are produced in all sizes. Currently Boeing converts B747- 400s, B757, B767-300s, B-777 and even MD-11s. The maximum payload of the B777F is around one hundred tonnes and the maximum range is around 9,000km. The cargo version was launched in 2005. The Macdonald Douglas MD-11F is derived from the passenger aircraft version called the MD-11. This model replaced the DC10. Some performance measures for the MD-11F are a maximum payload of 84 tonnes and a maximum range of over 7,000km.

Regionals Aircraft in this segment are for instance the Antonov AN-26, which is slightly cheaper but can carry less cargo load: 5.5 tonnes and the ATR - cargo from Alenia Aermachi.

Besides these many B737, MD 80, Fokker 50 and HS 146 aircraft are being converted.

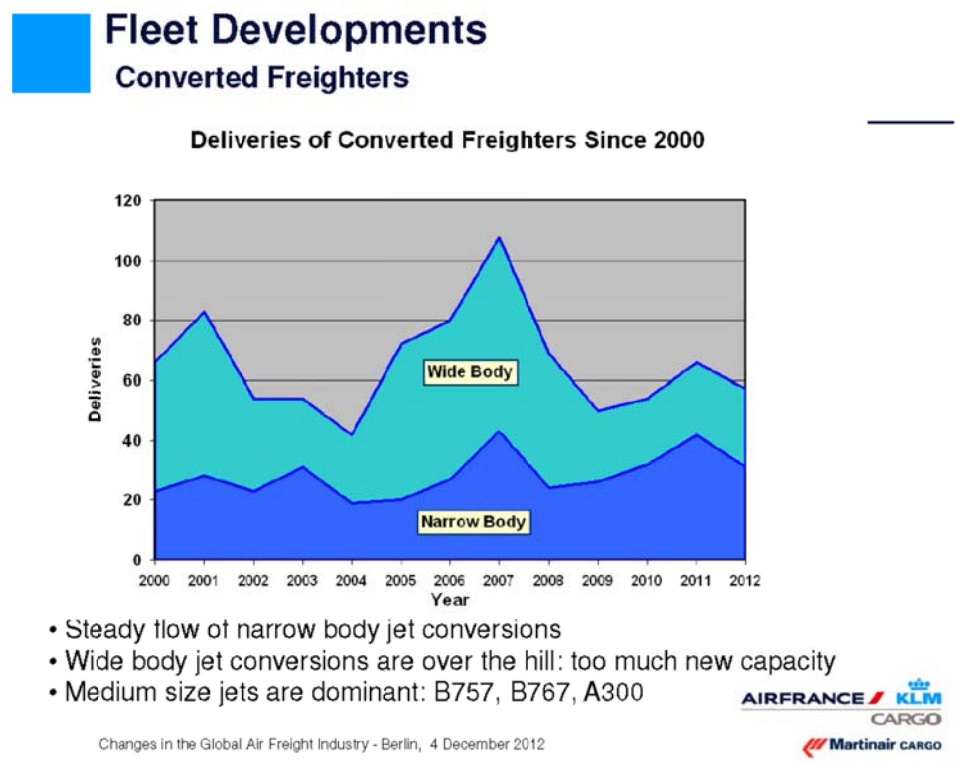


Figure 57: Fleet development - Converted freighters

Source KLM

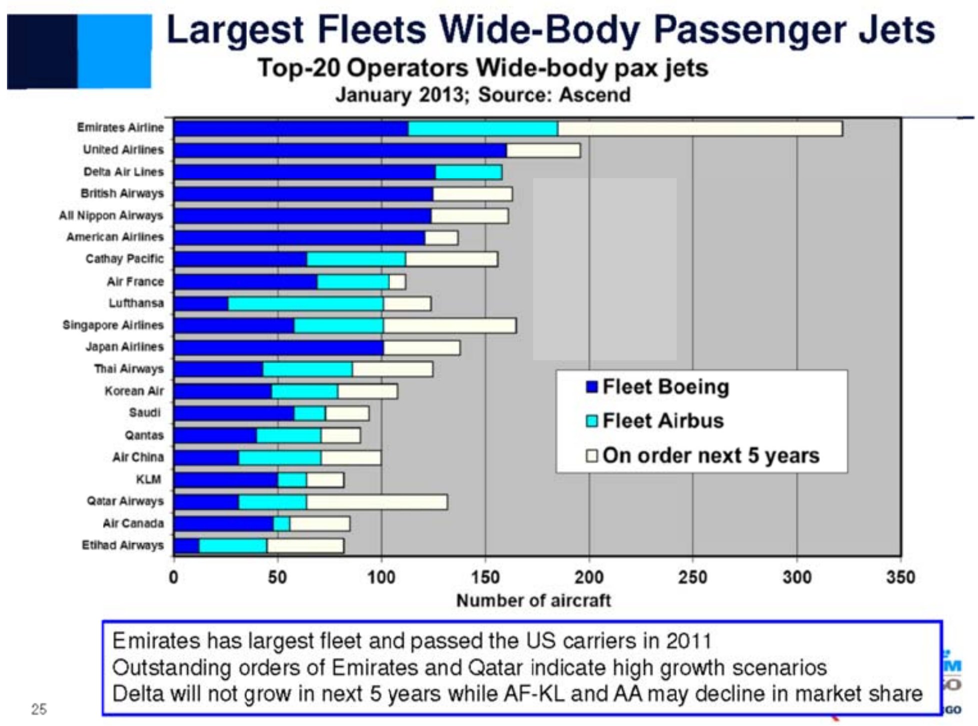


Figure 58: Largest fleets wide-body passengers jets

Source KLM

9.4.4 Cost Comparison (long/medium/short haul)

Long haul cost comparison

The majority of air cargo is carried on long haul routes.

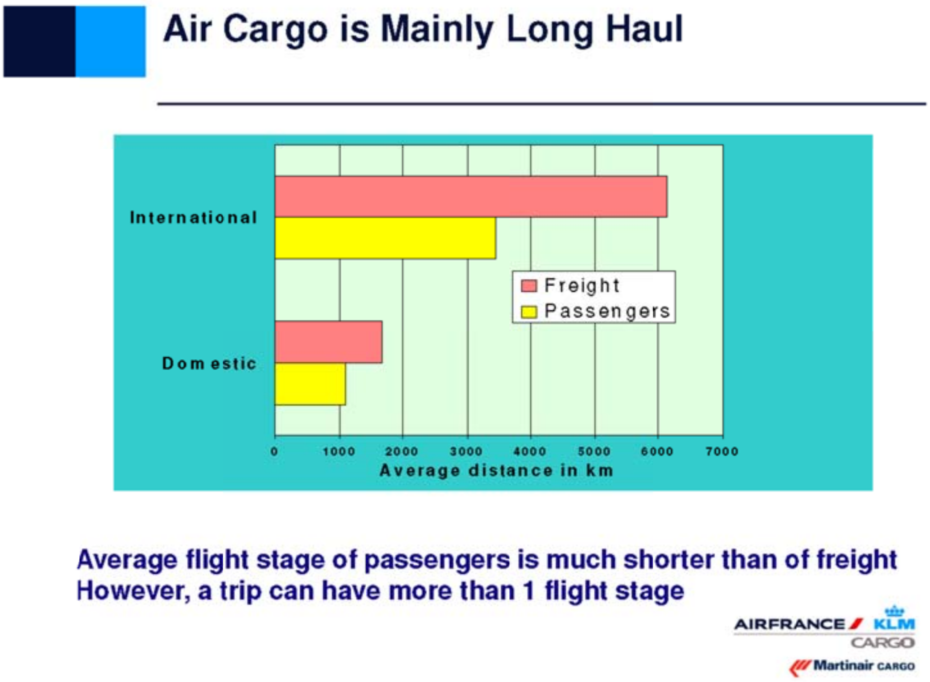


Figure 59: Average distances on air cargo

Source KLM

It is not easy to compare the cost of door to door delivery via Ocean shipping and long haul air cargo as the metrics differ and cost comparisons should also take into account the cost of warehousing and inland transport.

One good analysis was found on internet and performed by DELATA in 2006 by comparing the door to door cost of shipments from Africa to the USA referring on the same weight and volume (see Appendix A). In Figure 60 the resulting comparison of shipping cost is presented.

Figure 60: Comparison of shipping costs

Source US Aid Africa

Compared to passenger air transport, there are fewer well-supported studies which deal with the price elasticity of demand. This table provides an overview of publications which are about the ascertainment of these price elasticities.

Although the studies are different in the time periods and geographical areas they investigate, they can still provide some evidence of the actual price elasticities. The studies mostly show an interval, and not so much a precise point estimation of price elasticity, as differences in the capacity offered on different routes, for example, also result in fluctuating elasticities.

Study	Analysed airline and freight type	Sample size	Price elasticity in demand
Wang et al. (1981)	Combined passenger/ freight airlines	USA, 1950 to 1977	-2.33 to -2.50
	Freight airlines		-0.42 to -0.84
	Both types (aggregated model)		-1.47 to -1.60
Talley/Schwarz-Miller (1988)	Combined passenger/ freight airlines	USA, 1983, 22 airlines	-1.318
Oum et al. (1990)	Both types	Not mentioned	-0.82 to -1.60
Ernst & Young (Ed.) (2007)	Standard freight	Not mentioned	-1.60
	Express freight		-0.80

Figure 61: Overview of studies on price elasticity in demand for air freight transport

Source: Own chart based on Hellermann (2006):

The relative demand for air freight services reacts to relative changes in transport costs inelastically. This is partly due to there being little potential to shift air freight on long haul to other modes of transport due to the goods' value, urgency and physical nature. Altering logistics concepts is also often not possible in a short period of time. There are finally also other costs besides those purely for the transport such as the costs of tying up capital during the transport time, storage costs, insurance costs and packaging costs which all determine the choice of transport mode. The demand for freight transport services is not independent: it is derived from commercial activity and the trading of goods an objective decision on the choice of transport mode can therefore only take place on the basis of an analysis of all the service features affecting costs and earnings. In order to depict the total costs for transport with different transport modes, a distribution cost analysis can be applied.

Medium/ short haul cost comparison.

CargoMap also looked at cost of air transport as well. It estimated the cost of different transport modes and the results are shown in figure 62 as freight transport cost in Dollar Cents per ton-mile for short/ medium range transport.

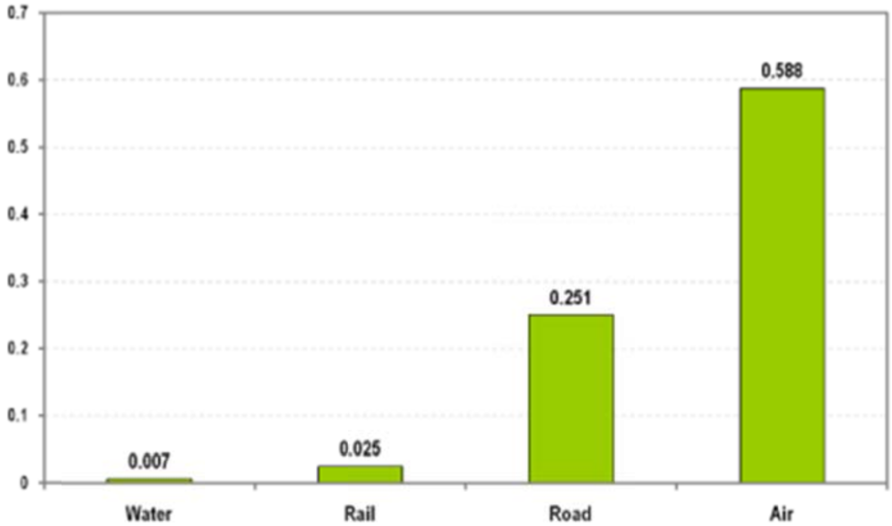


Figure 62: Cost of different transport moeds

CargoMap also looked into the cost per Kg for different types of goods; see figure 63.

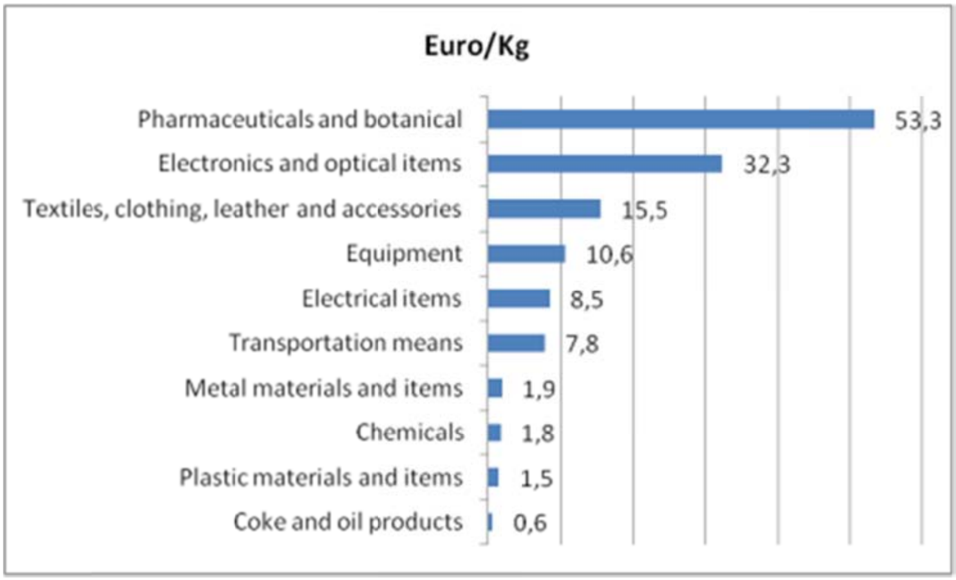


Figure 63: cost per Kg for different types of goods

CargoMap looked into the modal shift for short to medium haul transport based on price and time sensitivities for different products; this is shown in the tables 4 and 5 below.

Commodity type	Value of time (Euro*ton*hr)
Bulk building materials	0.25–0.5
Chemicals	0.25–0.5
Coal and minerals	0.25–0.5
Oil products	0.50–1.00
Metalwork	0.60–1.25
Plastics and fertilizers	0.75–1.5
Agricultural products	0.75–1.5
Non-perishable food	1.00–2.00
Perishable food	2.00–4.00
Equipment	2.00–4.00
Other items	2.00–4.00

Table 4: Time sensitivy of goods

Commodity type	Price elasticity range
Aggregate commodities	0.70-1.10
Assembled Automobiles	0.50-0.70
Chemicals	1.00-1.90
Corn, Wheat, etc.	0.70-1.00
Foods	0.50-1.30
Lumber, Wood, etc.	0.10-0.60
Machinery	0.10-1.20
Primary Metals and Metallic Products	0.30-1.10
Paper, Plastic and Rubber Products	1.10-3.00
Refined Petroleum Products	0.50-0.70
Stone, Clay and Glass Products	1.00-2.20
Textiles	0.40-0.80

Table 5: Price sensitivy of goods

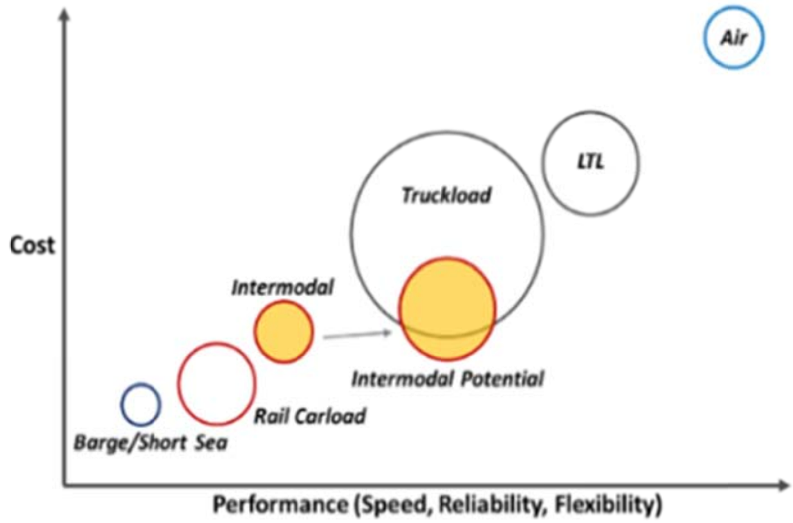


Figure 64: Performance vs. costs

In Figure 64 the performance versus costs for the different transport modes is shown. The Air shipping mode is clearly showing a much higher performance even though the cost is higher.

9.4.5 World fleet of dedicated freighter

According to the market forecast 2012 by Boeing and Airbus, there are currently about 1,600 dedicated freighter aircraft. Airbus predicts a substantial growth in number of aircraft; see Figures 65.

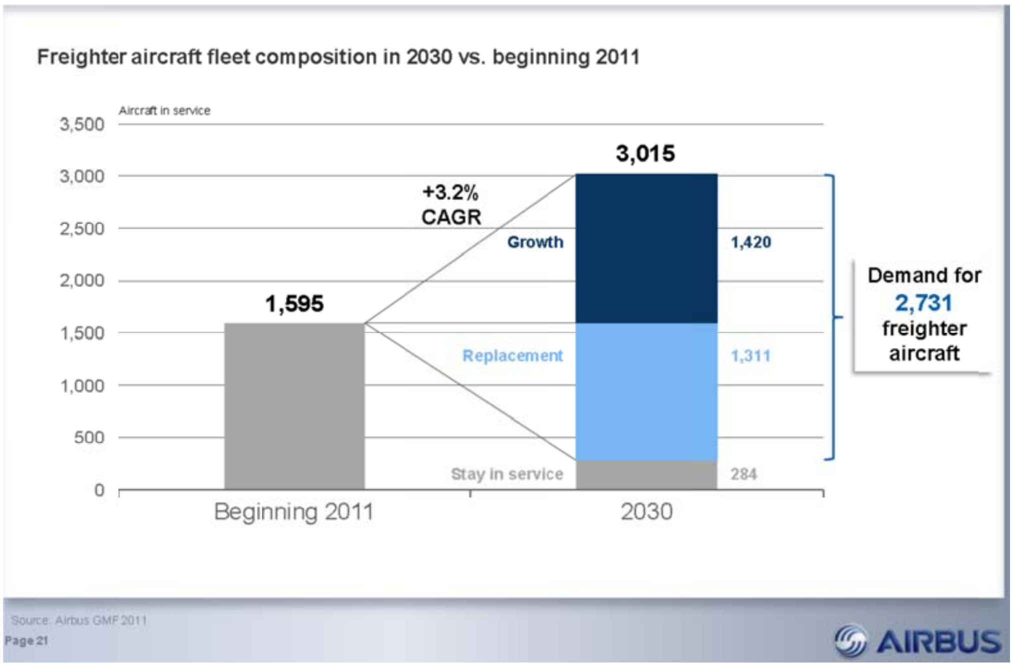


Figure 65: freighter aircraft fleet compostion in 2030 vs. 2011

A division between aircraft needed for the replacement and growth market is illustrated below (Airbus data), see figures 66-67.

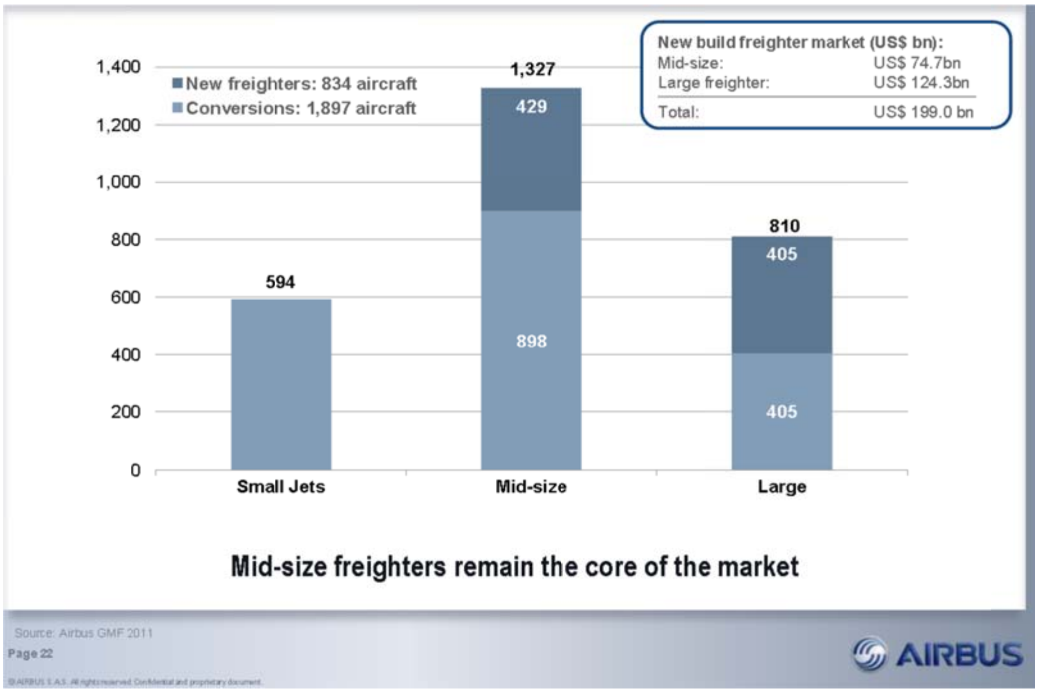


Figure 66: Aircraft division needed for replacement and growth market

Figure 67: Aircraft division needed for replacement and growth market

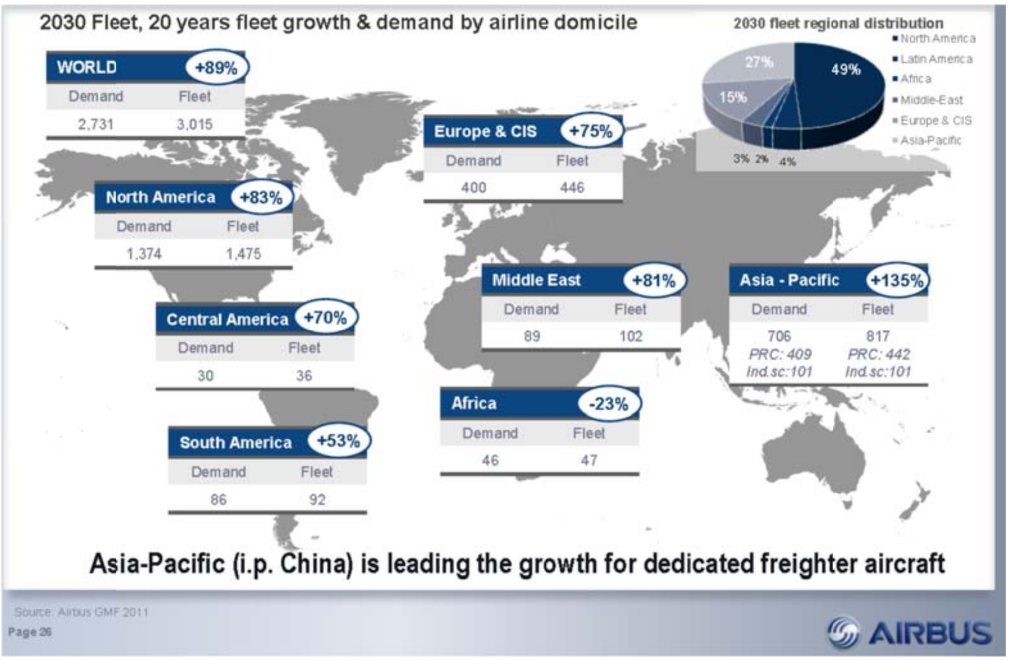


Figure 68: 20 years fleet growth and demand

In the next twenty years, the number is set on an approximated 3,000. (Airbus). This means that the amount of cargo aircraft has to be doubled.

The traffic growth is predicted to be about 5% per year; see Figure 69 for details.

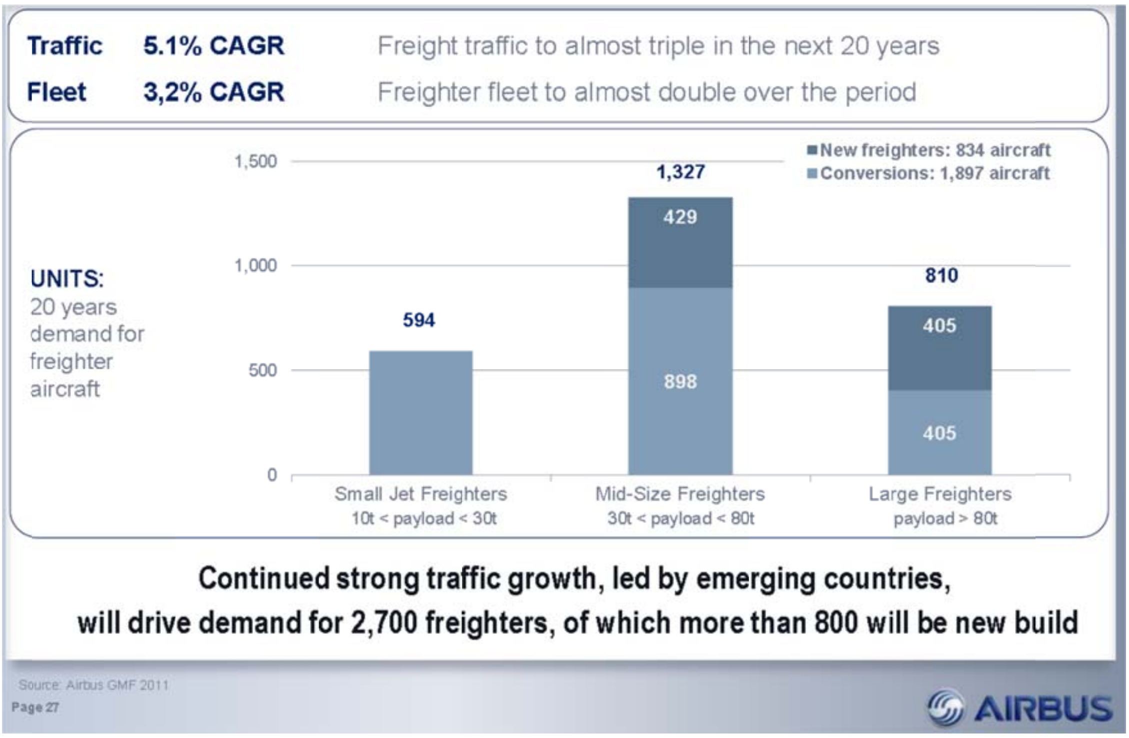


Figure 69: Traffic growth

10 SWOT Analysis for the competitiveness of Freight Transport

10.1 Road Freight Transport

	Positive	Negative
Internal	Strengths The **flexibility** ensured by the current business model allows operators to cater for the speed and reliability requirements crucial to the sector, and great variation and adaptability to the shippers' needs. The majority of **operators are private**, which historically makes them more innovative and quick to reply to market evolutions. **All types of goods** are suitable for road transport. Around 40% of road cargo is represented by palletised goods, 22% by solid bulk, 7% by liquid bulk, and 6% by containers. Because of the low share of fixed costs of their business model, road transport is **very competitive in short range transport**.	Weaknesses Road transport is **not competitive for long distances** (600-700+ km) due to the large share of variable costs in its business model. Road transport is **less environmentally friendly** compared to other transport modes. A **shortage of drivers** is currently a remarkable trend in the sector, and its reasons, nested in its business model, make it hard to overcome. **It generates high value of external costs** (road accidents, high occupancy of land, noise, pollution, congestion, etc.) Difficulty in transport of dangerous goods DGR. Many permission are necessary.

	Positive	Negative
External	Opportunities Despite the recent crisis, the **long term trend of GDP and trade is certainly increasing**, which will determine a growing demand in the middle and long run. **Technology improvements** have the possibility to (i) offset the increase of fuel costs, (ii) to improve operational conditions, (iii) to respond to congestion threats, (iv) to comply with increasing environmental concerns. New organisations in the sector of **urban freight distribution** are increasing and spreading in order to respond to growing pollution and congestion concerns in urban areas.	Threats **Road congestion** is upraising and the response in terms of infrastructure capacity is difficult due to environmental concerns and increasing constraints of public budgets. **Congestion in cities** makes road solutions in urban freight distribution prone to unfavourable regulation. **Fuel costs**. The growing trend of oil prices are a serious threat for the competitiveness of road transport vs. rail. **Environmental concerns** push the political agenda towards measure that incentive the modal shift away from the road **Protectionism** between countries may become an option due to increased imbalance of global merchandise trade **National regulations hinder road transport efficiency** when, for example, traffic rules prevent drivers from one country driving trucks from a second country in a third country. **Trend for internalisation of external road transport cost resulting in higher cost of transport.** Higher tolls on wider range of road types. Higher excise duty on fuel in order to compensate external cost of RT.

10.2 Rail and Intermodal Freight Transport

	Positive	Negative
Internal	Strengths Rail transport is traditionally **safer** than road transport. Rail transport is **more environmentally friendly** compared to other modes of transport. Rail transport has a **cost advantage** over other modes of transport in certain conditions and ranges. This is partly due to government intervention by subsidizing rail transport. Rail is competitive for the transport of a lot of goods type, but especially for **high density, low value goods** on such as dry bulk, on middle-long distances. Relatively low value of external costs. Lower than in case of other surface transport modes land occupancy, noise and fatal accidents cost.	Weaknesses The **last mile problem** puts rail transport in a weaker competitive field than road transport. **Service quality problems** (reliability, security and journey time) and a lack of co-operation complicates international transports. Decision makers and most operators have a **national focus**, which makes it hard for international rail traffic to gain market share. Business models and operational practices are generally outdated. Rail traditionally lacks dynamism, reliability, flexibility and customer orientation. There is a **general weakness of financial conditions** of rail operators, most of which were public until the advent of privatisations. Rail transport is traditionally **not competitive for low density, high value goods**, or good that require speed of delivery.

	Positive	Negative
External	Opportunities **Growing globalisation** determines an increasing trend for longer range transport demand. **Innovation in technology and organisation** of rail transport are aiming at allowing for an increasing number of commodities to be shifted from road to rail. By virtue of his environmental friendliness, the **political agenda** is generally favourable to the improvement and increase of rail freight traffic. The **liberalisation** trend is opening new geographical markets for rail operators. By the same token, increasing relations with Russia (*European Neighbouring Policy)* is paving the way to opportunities for transcontinental rail freight transport. The **growing containerisation** of freight is a benefit for rail and intermodal transport.	Threats **Infrastructure capacity** is difficult due to social acceptance and increasing constraints of public budgets. **Training workforce**, which is fundamental due to increasing technological change, is insufficient and the shortage of workers make it unattractive. There is a lack of a European-wide **training system in intermodal transports**, with transport knowledge often being focused on the road mode A **lack of awareness of the possibilities of intermodal** along with difficulties to get the necessary information make the decision to favour freight integration a difficult one. The availability of **containers** (as the preferred unit for intermodal transportation), and their standardisation and adaptation to intermodal transport's current needs is a main barrier.

Source: consortium elaboration

10.3 Maritime Freight Transport (containers)

	Positive	Negative
Internal	Strengths Maritime transport has virtually **no competitor for long range transport** of goods, including containers, except high value ones and those that require high speed. The **capacity of container vessels** is growing and will allow traffics to grow favourably. Big shipping companies and big ports are characterised by **a high level of competence**. Companies are seeking **vertical integration** practices (managing terminal operations and land transport also) that allow economies of scale. Fleet sizes and **vessel sizes** are growing. Internal cost level comparable with air transport.	Weaknesses The **repositioning of empty containers** wastes money for up to 19% for the industry's income. Container terminals are space demanding. **Capacity constraints in ports** are an area of concerns especially in traditional European destinations. The low attractiveness of life at sea may cause a **shortage of workers**. The development on bigger ships favours bigger capacity with the same frequency (In aviation increased demand results in more frequent flights)
External	Opportunities **Growing globalisation** and the increasing importance of Eastern Asian economies determine an increasing trend for longer range transport demand. **Innovation in technology** are allowing the implementation of new systems of feedering from large mega carriers. The growing trend towards **containerisation** (for instance, cars) will attract even more types of good.	Threats **Inland forwarding** is often the weak link which hinders the efficiency of the door-to-door chain. Growing **maritime piracy** is a major source of security and cost-effectiveness issues. **Protectionism** from Russia may be paving the way for huge investments in transAsian railways.

Source: consortium elaboration

10.4 Air Cargo Transport

	Positive	Negative
Internal	Strengths Speed Reliability Security (safety) No path congestion Low external costs. Low land occupancy. No competitor in long distance transport of perishable goods.	Weaknesses Costly for all distances of transport, thus **not price competitive** except for a very limited range of goods. **Not intermodal** due to the low degree of usability of air containers. **Spatial mismatch** in the door-to-door chain **Weak economics** of most carriers
External	Opportunities **Liberalisation** of the market Global growth of economy and trade Globalisation of procurement, production and distribution **New logistics concepts**: major modifications in the distribution paths of freight in urban areas. **Capacity increase** in many extra-European airports Fuel efficient design The trend for minimising of valuable goods size – increase of specific value (electronic hardware)	Threats **Security** issues and requirements Growing **oil prices** and fuel costs and ETS Externa**l shocks** Airport congestion Night restrictions Ground waiting times (**clearance**) **Under-representing** of Cargo sector in the policy making processes. Possible staff shortage

Source: consortium elaborations

11 Outcome of the Questionnaires to the Air Cargo Stakeholders

The CargoMap consortium sent out a large number of questionnaires to stakeholders in the hope to get a better feeling for future expectations of these stakeholders and to investigate their opinions regarding the possible future concepts emerged from the SWOT analysis.

The response to the questionnaire was disappointing: in total, only 13 answers were received. Answers were received from:

- Airlines: 3 (note these were networked carriers, no dedicated cargo operators/ integrators)
- Outsized cargo airline: 1
- Forwarders/ shippers: 7
- Media: 1
- University: 1

However, the coverage of the answers was quite good so it is worthwhile to look into the results. D2.1 and its annex illustrate the questionnaire and the detailed results. Here the summary of conclusions is reported, divided by type of market (long – medium – short – very short haul) and with a section dedicated to questions on R&D.

11.1 Long haul (> 6000 km)

All agree that the focus of air cargo will be high value cargo, where value/density and time to market is relevant. Also air transport can be used for high value or time critical oversized cargo. It is interesting to note that airlines feel that the HUB-airports are strategically best located to serve the customers whilst forwarders and shippers do not fully agree. They would like to see some airports nearer to the final customer.

Airlines do not see a need for novel aircraft that fly slower at lower cost**. For them speed thus time is the most important parameter.** Slower aircraft may also require more crew. The operators (forwarders) however see the potential of new aircraft that **fly slower at lower cost.** One of the arguments used was that intercontinental shipments take 5 days for door to door delivery, and the flying does not represent a large portion of that total time from door to door. They see lower cost as a main advantage. They see a market for these aircraft over long distances, for example to China, Africa and South America.

One of the main ideas for CargoMap is to use different types of containers (that would require different aircraft configurations). Basically both airlines and forwarders and shippers agree that a new type of container would be a good solution. However one forwarder noted that the flexibility should not be lost: freight cannot be held up because the container needs to be filled up first. So the volume of shipments should be large enough. However all see the benefit of more containerized packaging as it would reduce the need for repackaging.

On the question how future distribution should be organized, the airlines and some forwarders see the HUB airports as the best solution. However many forwarders and shippers would like to use more smaller airports for long haul air cargo, situated nearer to the final customer. One airline and the outsized cargo transporter saw benefits in the amphibious plane option.

Nearly all respondents indicated that the size should be bigger than the B747 or B777. The bigger the better. Very large aircraft could fly at 400km/hour or 800 km /hour. Cost per tonne should be between 2.500 and 1.500 Euro. Frequency should be at least one intercontinental flight per day in principle.

11.1.1 Summary

It has been observed that basically two options for long haul cargo exist: via air cargo which is fast but expensive or via sea shipping which is slow but cheap.

Opinions were asked on whether a market exists for something in between: a slower moving aircraft at intermediate cost levels. Such an aircraft could have a speed of for example 400Km/hour and could be pilotless to reduce cost even further.

Whereas airlines see time/speed as the essential parameter for long haul flights, the forwarders/ shippers see an advantage of trading speed for lower cost.

	Time/Speed	**Cost**	**Frequency**
Pro	In total door to door delivery, the air transport part is not the dominant factor	Substantially lower cost will be an advantage	Frequency of flights needs to be assured
Con	Time is money; flying longer may require more crew which increases cost		Some high value, time critical goods may require smaller aircraft with intercontinental range

Table 6: Summary of conclusions related to novel slow flying aircraft long haul aircraft

The idea to use different containers with a more multi modal application is well received and should be pursued.

	Time/speed	Cost	Frequency
Pro	No need for repackaging in the distribution chain saves time	No need for repackaging saves cost	
Con		The proposed novel containers would require novel airplanes and ground infrastructures	In order to achieve a good load factor, the container needs to be full. Small shipments need to wait until the container is fully loaded. Pallets are more flexible

Table 7: Summary of conclusions related to the proposed novel air containers

It is not so clear whether future air cargo should focus on HUB airports or smaller airports via direct routing. The idea of amphibious planes that can land in places where no airport congestion is relevant was not well received.

	Time/speed	Cost	Frequency
Pro		HUB's are efficient distribution centres	
Con	Advantage to reduce time needed for trucking	All depends on the cost of flying compared to road transport	Frequency of flights may need to be adjusted

Table 8: Summary of conclusions related to the location of airports: Focus on HUB's

In general the market stakeholders see the need for very big aircraft on long haul routes. Aircraft should be bigger than B747 or B777 in order to reduce cost. Only the academic partner sees a need for small intercontinental aircraft.

11.2 Medium haul (1000-6000 km)

CargoMap investigated if there is a need to develop a new type of dedicated cargo plane to serve the inter European freight services. Whereas the respondents were outspoken on long haul transport, the respondents were less engaged in the questions related to medium and short haul transport, and the responses were more diversified.

Future medium haul air cargo would basically ship the same high value/ high priority goods as on long haul. Respondents see the need for more air cargo transport to and from the Middle East, Eastern Europe, Turkey and Russia. The range of those medium haul aircraft would need to be 2000 km or more.

For shorter flights (between 1000 and 2000 km) most respondents do not see the need to develop new aircraft as they believe the transport cost would anyway be higher than for trucking. Especially forwarders favour trucking in view of the low cost. Only Lufthansa sees a potential if cost would be comparable to trucking. One forwarder also stressed the need to lower CO_2 emissions for novel airplanes. One transport planner sees a possibility to substitute trucking by rail transport (although the speed of cargo trains in Europe is less than 16km per hour on average).

The cost of trucking is so low that many believe air transport cannot compete. Implicitly the forwarders do think that road congestion may be solved in future.

If new aircraft were to be developed it is essential that these can operate at night and make use of night slots of European airports. There were as many respondents pro as there were con in relation to QVTOL and QSTOL.

On the question if derivatives of military aircraft would create an opportunity the reactions were again mixed. Some respondents see a potential, others believe that military aircraft are too expensive to operate. Future civil aircraft should be as simple as possible to keep the cost down.

In general cost becomes the most dominant factor on medium haul routes. This is perhaps also the case as alternative transport modes are available, especially on the shorter distances.

Most respondents do not believe that air transportation on shorter routes up to 2000km can compete with trucking. The respondents implicitly assume that congestion on European main roads will be avoided. The time advantage does not seem to count even when using QVTOL or QSTOL aircraft.

There may be a need for novel airplanes with a range of more than 2000km assuming that these aircraft would be extremely silent and can operate from airports at night.

If new aircraft were to be developed it is essential that **these can operate at night** and make use of night slots of European airports. There were as many respondents pro as there were con in relation to QVTOL and QSTOL.

On the question if derivatives of military aircraft would create an opportunity the reactions were again mixed. Some respondents see a potential, others believe that military aircraft are too expensive to operate. **Future civil aircraft should be as simple as possible to keep the cost down.**

11.2.1 Summary

In **general cost becomes the most dominant factor on medium haul routes**. This is perhaps also the case as alternative transport modes are available, especially on the shorter distances.

Most respondents do not believe that air transportation on shorter routes up to 2000km can compete with trucking. The respondents implicitly assume that congestion on European main roads will be avoided. The time advantage does not seem to count even when using QVTOL or QSTOL aircraft.

There may be a need for novel airplanes with a range of more than 2000km assuming that these aircraft would be extremely silent and can operate from airports at night.

11.3 Short haul (< 1000 km)

The question CargoMap addressed was: is there a need to provide new forms of air cargo services, especially for parcel services and mail as well as for cargo to more remote locations on short haul routes?

Most respondents are not involved in short haul transportation. But it seems that the time advantage and flexibility/ frequency offered by trucking would favour the trucking option assuming that aircraft would need to use regional airports. One suggestion was even to use car-trains for tucks. Besides, express goods can be transported in the bellies of regional aircraft.

Small aircraft could be used if these would be QSTOL/QVTOL aircraft that can land in cities and at final customers' destinations. But then again it is a question of cost of flying compared to trucking. The size of the aircraft remains unclear. Some would favour an aircraft that could carry standard 20/40 feet containers (also to have a better interoperability with long haul aircraft), some do not see the need for it.

Perhaps it was a bit disappointing that none of the respondents focused on a totally different concept of operations for cargo handling, linking short, medium and long haul.

Novel QSTOL or QVTOL aircraft could be used but this would probably require a totally different set up of the air cargo supply chain.

Summary

If the current business model for transportation is used, trucking is the favoured means of transport for short distances in view of time, frequency/ flexibility and cost.

11.4 Very short haul (<200 km)

CargoMap wanted to investigate if a need exists to provide air services to replace trucking and to replace urban ground traffic, for instance by using small unmanned air vehicles to deliver parcels (the "pizza boy drone").

Only 5 respondents answered the questions and all see trucking as the most appropriate means of transport. Local distribution centres are seen only relevant for food supply.

None of the respondents were familiar with ideas to use small unmanned flying vehicles for door to door delivery.

CargoMap referred to the NASA idea of a drone delivering pizza's at home, but the idea is not well known. Furthermore other sources are sceptical in view of the liability issues in case the drone would fail.

11.5 Research needs

The purpose of the CARGOMAP study is twofold:

- Is there a market for novel air vehicles? - and if so,
- What are the technical issues involved?)

Thus, suggestions for future research and innovation actions were asked to the stakeholders.

Nearly all respondents advocated that the European commission should create incentives to improve the air cargo market and related technologies. Focus should be on long and medium haul aircraft. New business models should be investigated, for which the European Union should take the lead. As air cargo is by definition a global activity, new business models, aircraft and infrastructures need a global approach. Therefore only on a political level changes can be proposed as individual players will only optimize their system which may not lead to an optimized system of systems. European initiatives could solve this chicken and egg problem.

Whereas the most critical factor in long haul is time to delivery, the cost factor is seen by the market as the most critical factor in medium/ short haul.

The main issue of time to delivery is not so much the flight time but the remaining part of the freight travel. Thus the focus should be on improving the process on ground including all elements (e.g. business model, packaging, border formalities,

Research should be focused on lowering the cost of air transportation (new configurations, structures, aerodynamics, engines) and especially on the low fuel consumption and alternative aviation fuels. The noise issue is also to be taken into account.

12 Air Cargo Demand and Future Trends

12.1 Air Cargo Demand

The amount of international trade has grown by more than 70% in 10 years.

As shown in the table below, flows with China have more than tripled in the last 10 years. In this case as well, despite the EU's exports growing at a higher rate than imports, the balance with China is negative, with a deficit that is even higher than the overall trade balance of the EU. The trade with USA have been also increasing but only in terms of exports, while imports have been decreasing.

Other relevant partners for the EU include: Russia, which has more than doubled its flows to/from EU-27, and now totals 308 billion Euro with a trade deficit for the EU; Japan, with 116 billion Euro and a (diminishing) trade deficit; Turkey, in which case the EU passed from a slight trade deficit in 2001 to a trade surplus in 2011, for 120 billion Euro of overall trade.

	2001			2011		
	EU-27 exports to partner	EU-27 imports from partner	Balance	EU-27 exports to partner	EU-27 imports from partner	Balance
Argentina	5 099	5 761	-662	8 319	10 673	-2 354
Australia	15 660	9 583	6 078	30 808	11 782	19 026
Brazil	18 570	19 602	-1 032	35 728	37 855	-2 127
Canada	22 391	18 574	3 817	29 618	22 868	6 750
China	30 665	82 000	-51 335	136 230	292 235	-156 004
India	12 950	13 462	-513	40 425	39 394	1 032
Indonesia	4 579	11 610	-7 031	7 348	16 171	-8 824
Japan	45 521	81 134	-35 613	48 961	67 479	-18 518
Mexico	15 336	7 727	7 609	23 816	16 277	7 539
Russia	31 602	65 874	-34 272	108 422	199 287	-90 866
Saudi Arabia	13 507	13 165	342	26 399	28 125	-1 727
South Africa	12 584	16 354	-3 771	25 636	17 773	7 863
South Korea	15 840	23 265	-7 426	32 456	36 115	-3 659
Turkey	21 869	22 085	-215	72 665	47 596	25 069
United States	245 594	203 298	42 297	260 693	184 323	76 370
World (extra-EU-27)	884 707	979 143	-94 436	1 531 929	1 687 732	-155 803

Table 9: EU-27 trade in goods by partner, 2011, Euro millions

Source: Eurostat

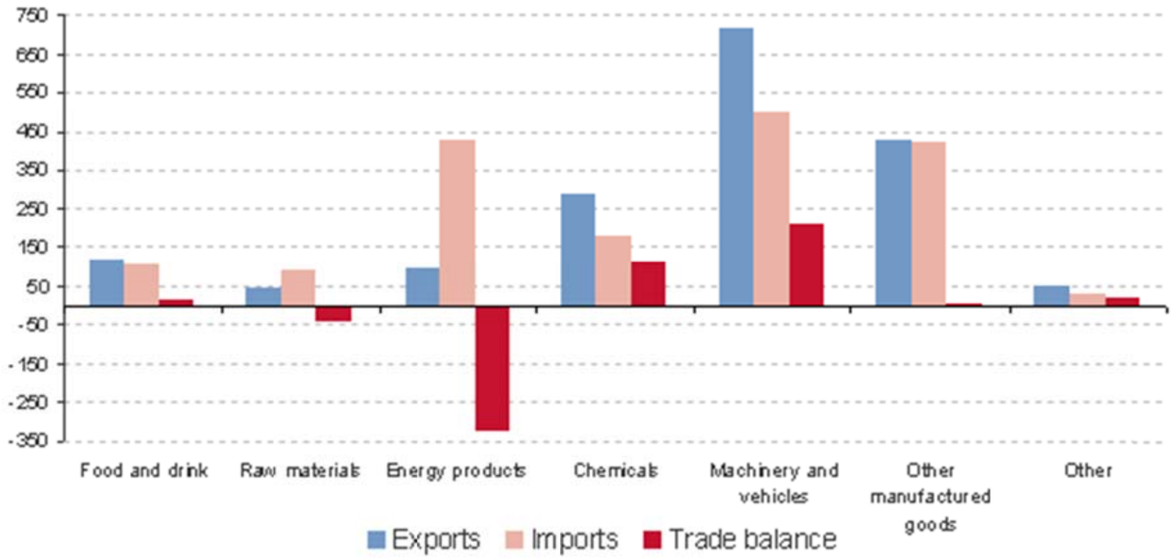


Figure 70: EA-17 trade in goods by type of goods, 2011, Euro billions

Source: Eurostat

In terms of weight, air cargo does not seem to be very relevant, with a share of 0.6% of the total tonnes transported intercontinentally, opposed to 75% by sea, 6% by road and almost 4% by rail.

But switching to values, air cargo assumes its importance, because of the high unit value of the type of goods transported. The figure below shows that air transport accounts for almost 23% of the total value of goods shipped to/from Europe, whereas maritime transport accounts for 51%.

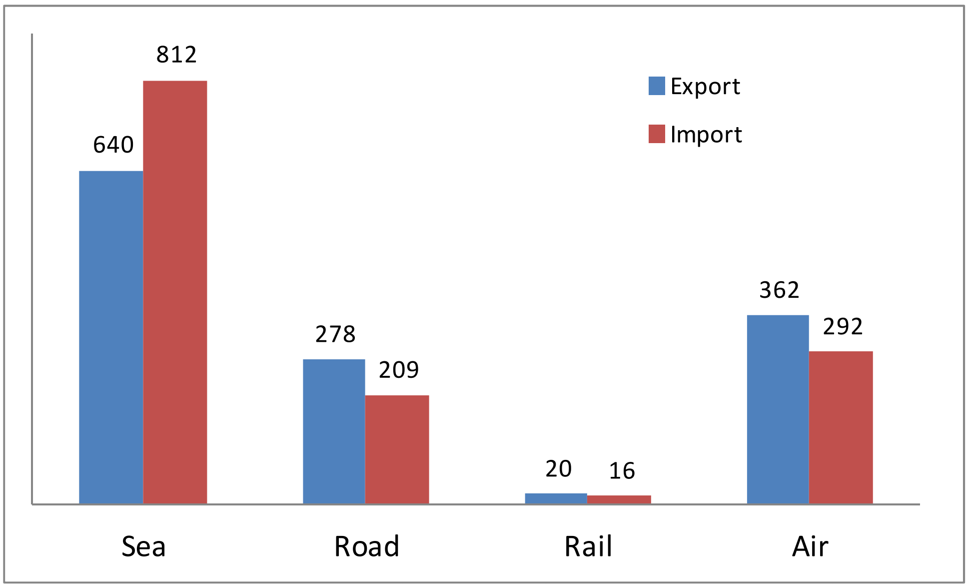


Figure 71: External EU-27 transport of goods by mode, 2010, billion euro

Source: Eurostat

As concerns **flows within Europe**, the total goods transport activities in the EU-27 are estimated at 3831 billion TKM in 2010.

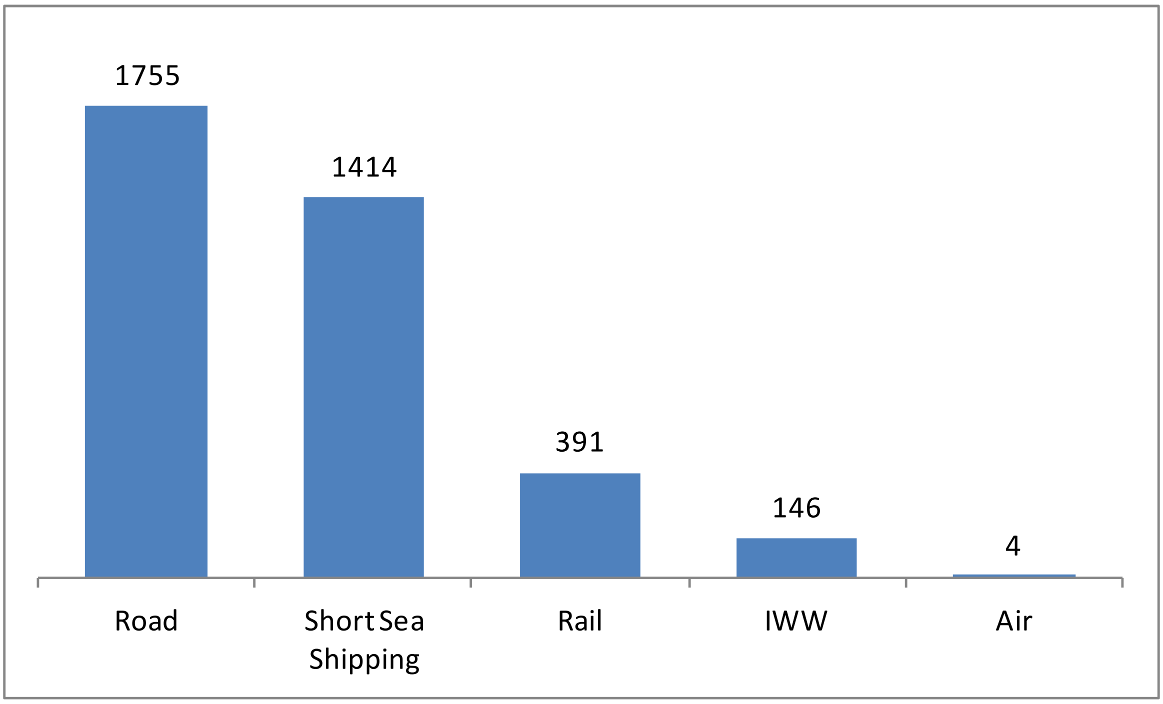


Figure 72: Intra-EU27 transport of goods by mode, 2010, billion tkm

Source: Eurostat

This clearly shows that air cargo is a residual solution when it comes to carrying goods on the short range. This derives from the cost disadvantages, but when thinking about "step changes" it opens up the biggest room for improvement for the air cargo world, since even a very small (0.2%) shift of transport from the other modes would mean a doubling of air cargo activities.

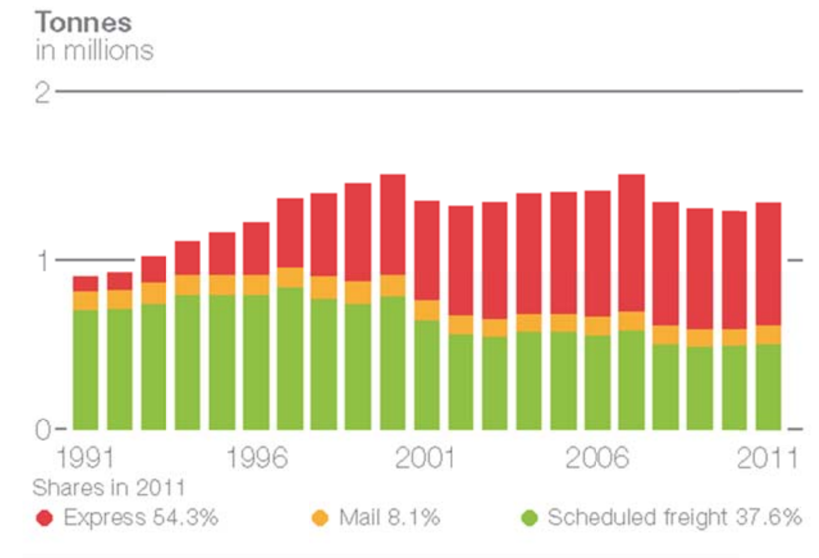


Figure 73: Division of express, mail and scheduled freighters

Source Boeing

Air cargo operations in Europe are increasingly dominated by Express parcel services. Air cargo within Europe is modest in volume as illustrated by this Boeing chart below

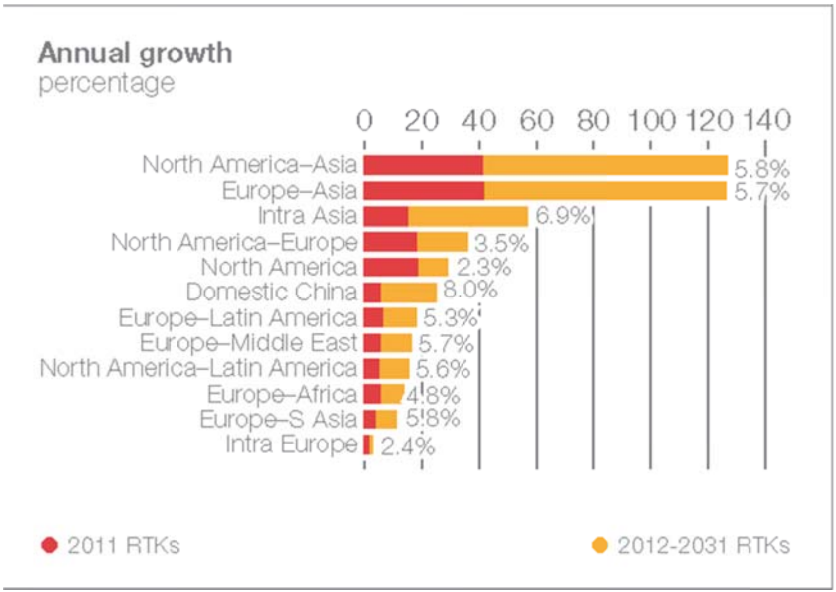


Figure 74: Express parcel services within Europe

Source Boeing

For the scope of this research the long term forecasts are more relevant, since they are needed for facility planning. Operators purchase and OEM's design new aircraft based on long term forecasts. The latter is the reason that especially the two largest OEM's, Airbus and Boeing, create their own forecasts as the basis for their long term planning. Airbus has published its methodology to forecast aircraft demand for the next 20 years, but none of the organisations that publish forecasts publish the underlying data. That makes it difficult to assess the sensitivities in the demand forecasting models.

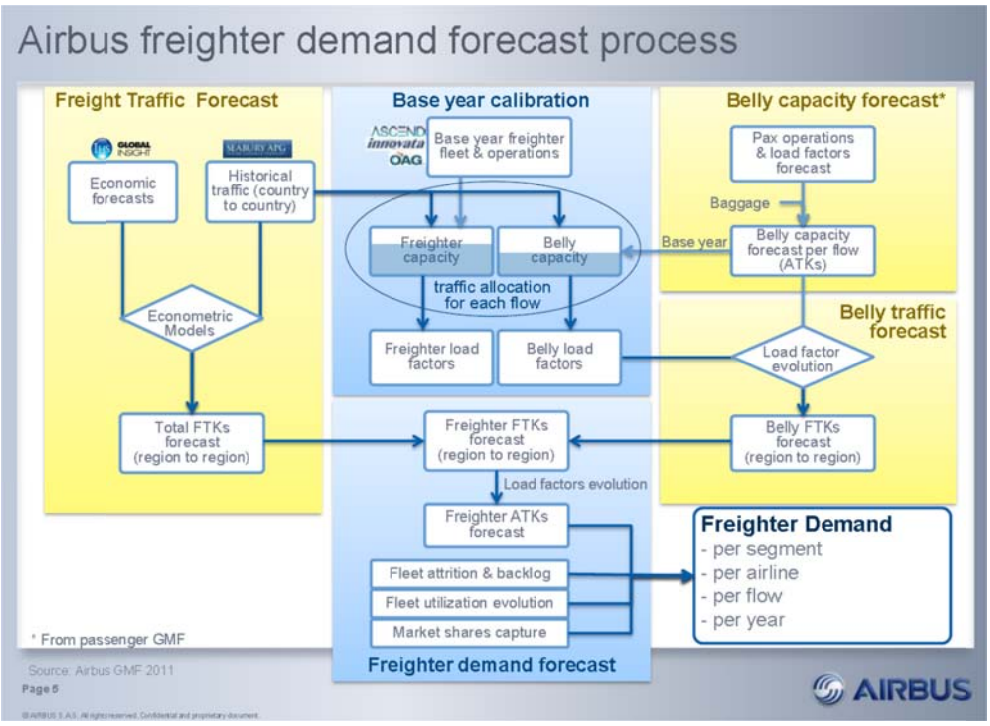


Figure 75: Freighter demand forecast process

Econometric models based on linear or exponential regression are tools and widely applied in statistical forecasting. One problem that often decreases accuracy over time is that some parameters are often correlated with each other. This is in general not a problem for the forecast, as long as the relationship of these parameters does not change. In the words of Morrel: “The result is only as good as the forecasts of explanatory variables and some of these are not easy to forecast.” This makes it easier to use econometric models as forecasting tools, rather than to explain the relationship between parameters. This is mainly due to statistical problems and uncertainty about the correlation. For this reason many forecasts do not include freight rates as a parameter, although intuitively such a parameter should be included in the model.

Both Airbus and Boeing make efforts to forecast future cargo demand. Boeing publishes their results once every two to three years, while Airbus usually publishes in general more often, the latest version of its forecast was published at the end of 2011 (Airbus, 2011).

The Boeing report of 2009, shows in a clear way all negative and positive effects on air cargo traffic growth. At the core of the figure are the most important drivers of world and regional economic growth, with positive and negative aspects represented on the outside of the circle. As was stated previously, there is no attempt to distinguish any interrelation between the different aspects represented. However there is one major trend worth mentioning, due to its relevance for this research. This is the continued close relationship between passenger and cargo airports and the rise of 42 mega-hubs around the world which will link the economic regions with each other (Airbus, 2011).

Figure 76: Forces and constraints for air cargo growth

(Source Boeing, 2009)

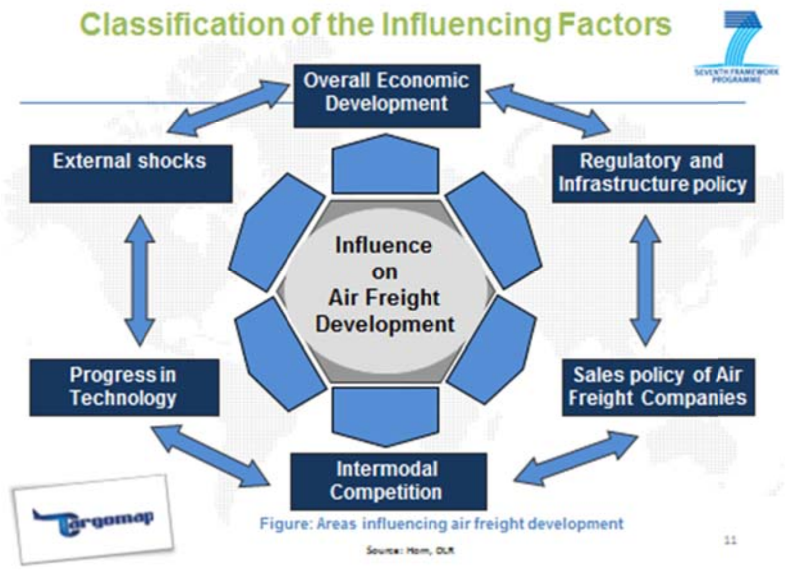


Figure 77: Influencing factors

Source CARGOMAP

The following Figure provides an overview of the most important companies and institutions which put together forecasts for the future development of air freight transport.

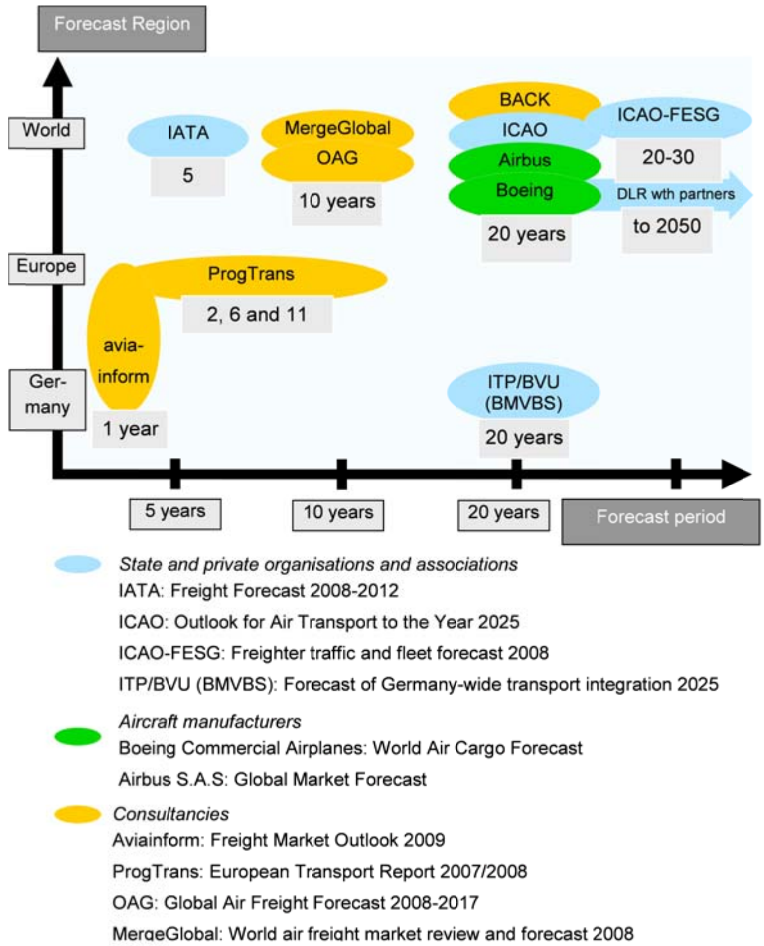


Figure 78: Overview of air freight forecasts

source DLR

12.2 New transport concepts

By 2010, there is the intention of introducing new transportation concepts which could potentially also compete with air freight transport. These include FastShip Atlantic, in particular, and the Eurasian land bridge in rail freight transportation between China and Europe.

12.2.1 Fast-Ship Atlantic

The company FastShip Atlantic wants to use fast ships with a capacity of 10,000t or around 1,400 TEU and a speed of 38 knots on the Philadelphia–Cherbourg route initially. This should make transit times in house-to-house traffic, e.g. between Chicago and Frankfurt, from seven days for full containers or eight days for consolidated containers possible while reducing units prices per ton by 70% in comparison to air freight transport. The FastShip Atlantic project involves high investment and running costs for the fast ships. Considering the high oil price to be expected in future and the lack of experience with the concept, only time will tell whether the forecasted financial savings will actually be achieved. In order to utilise the time advantage of fast North Atlantic crossings, new technologies will also be necessary for freight handling at sea harbours so that competitiveness is also upheld landside. Furthermore, the availability and geographical location of the sea harbours will tend to require more time for transporting goods to and from the harbours than is the case for airports when considering the network coverage by airport infrastructures in North America and Europe. With the initially planned two return runs a week, the time coverage is also much lower compared to the daily departure frequencies in air freight transport and the available freight capacity on many passenger flights between North America and Europe. This therefore limits the potential to transport perishable or urgent goods.

12.2.2 Eurasian land bridge for rail freight transport

In January and October 2008, two container trains managed the 10,000km-long railway line from Beijing to Hamburg in 15 and 17 days during a test run. This about halves the transit time compared to sea container transport. Many goods can be more cheaply transported by rail than by air. The goods transportation over the Eurasian land bridge allows for cost savings of 70 to 80% for a 20-foot container compared to air freight. Interest in this project has been expressed by companies including those in the automobile, chemical, household appliance and machine engineering industries. The railway companies involved seek to offer timetabled (i.e. weekly) operation of this transportation axis starting February 2009.

The Eurasian land bridge for rail freight transport, also known as the Trans Eurasia Express, fails to offers a substitute to air freight transport when comparing the performance and costs.

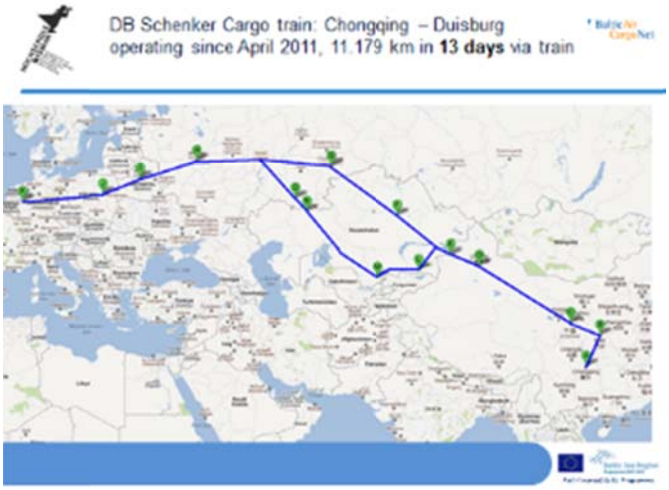


Figure 79: Trans-Eurasia express

12.2.3 The trans-Eurasia express

The Trans Eurasia Express is an alternative to the already existing sea/air transport which involves the combined use of sea container shipping and aircraft during the main phase of transportation. On the way from the Far East to Europe, the consignments are generally **shipped by sea from the Asian country of origin to Dubai in the Middle East before the goods are then loaded onto a plane for continued transportation to Europe**. The transportation time from Shanghai harbour to a European destination airport is around 15 days, not including the runs to the harbour and from the airport and is therefore comparable to the transit times on the Trans Eurasia Express.

The transport costs when using the railway (2,800 to 3,300 EUR/TEU) should be lower than in sea/air transport (6,400 to 8,000 EUR/TEU) according to calculations by the Fraunhofer Working Group for Technologies in the Logistics Services Economy [*Fraunhofer Arbeitsgruppe für Technologien der Logistik-Dienstleistungswirtschaft*]. Competitive prices can only be achieved on the Eurasian land bridge, however, when there is enough demand in both transport directions and an improvement in the interoperability in cross-border rail freight transport.

12.3 Possible substitution issues

On the continental and national level, mainly road freight transport and, to a lesser extent, rail freight and combined road/rail freight are an alternative to transport by aircraft. The competitive relationships are, however, different in different geographical regions and countries. The key influencing factors include the type of infrastructure available in a country for overland and air transport and the distances to be overcome. Due to their massive land areas, transport distances in countries like Russia, China and the USA are much greater than in many European countries. As a result, air freight transport is of higher importance in such big countries for inland transport too.

Europe has very well-developed infrastructure for road transportation. Due to the cost advantages of road freight transport, combined with the dense road networks, a large share of goods declared as air freight is transported in trucks as a substitute for aircraft on the roads to and from the air freight hubs such as Frankfurt am Main, Paris Charles de Gaulle and Amsterdam. The proportion of Road Feeder Services (RFS) in air freight export is estimated at around 37% and 22% in import. Every week in Europe, 8,000 RFS runs connect a network of almost 900 city pairs.

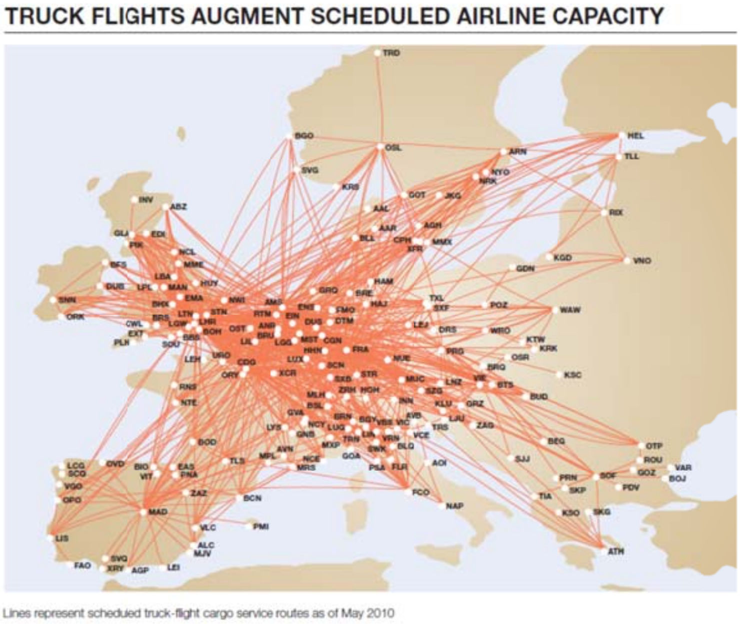


Figure 80: Truck flights in Europe

There are also plans to involve railway freight transport in the air freight transport chain. Starting autumn 2008, one pair of trains is to begin running between Leipzig/Halle (DHL's European air freight hub) and Frankfurt am Main pulling wagons which have been specially converted to carry air freight load units. The intention is to reduce the current burden on the road networks. Paris Charles de Gaulle is also due to receive a high-speed connection for freight runs to and from the airport from business regions in a catchment area within a 300 to 800km radius. The relative cost/benefit ratio for the transport modes determines the intensity of competition within these segments. Transporting goods by air is the most efficient, but also most expensive transport mode when considering the direct transport costs. Increasing transport distances, increasing degrees of specialisation and the urgency of the goods increase the relative efficiency of air freight transport.

To summarise, there are four fields of competition in the air freight market. These are shown in the following Figure.

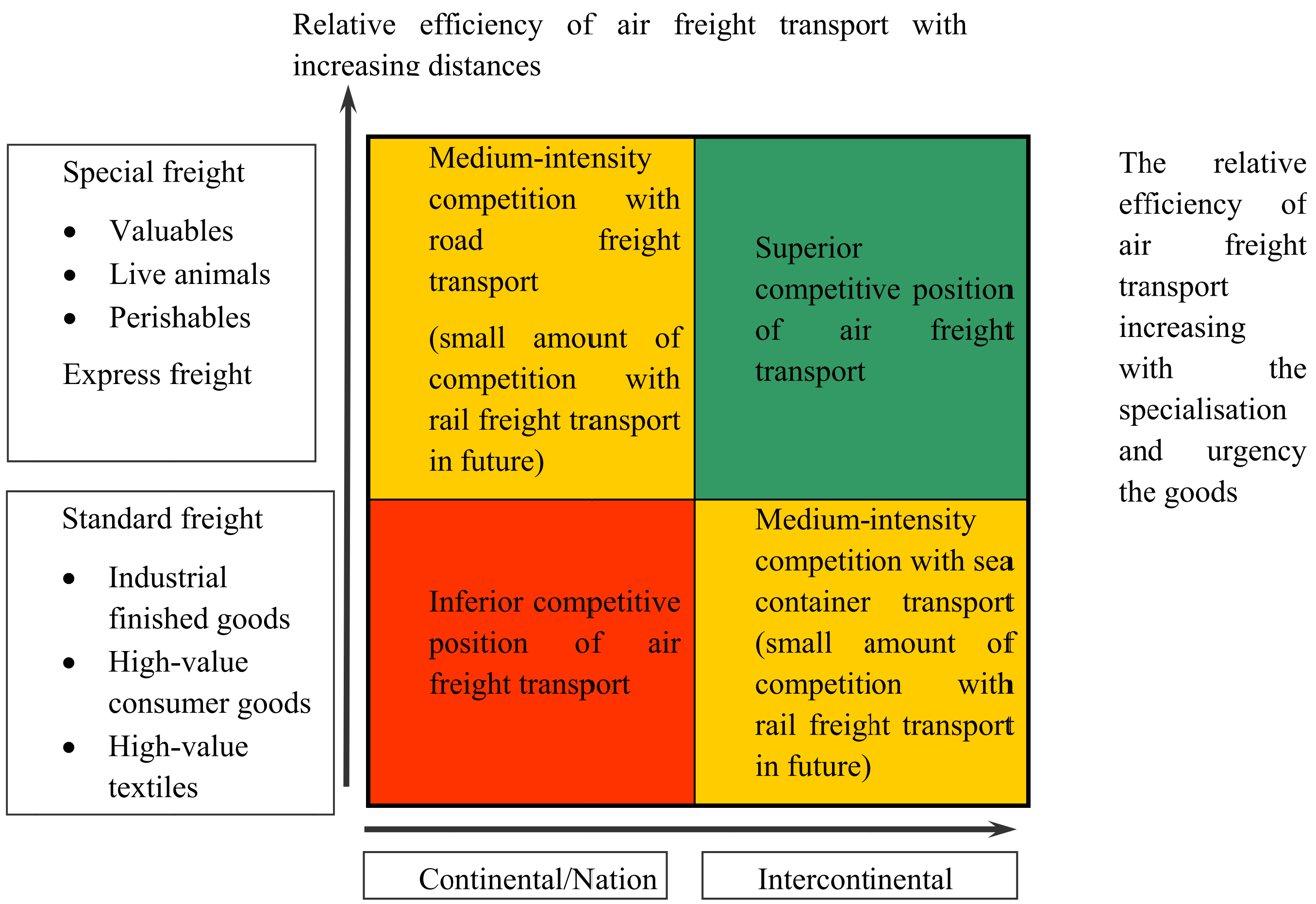


Figure 81: Competitive relationships between air freight transport and other transport modes

Source: Original chart based on Schneider (1993)

12.4 Future competition with new air cargo entrants

The Emirates, Dubai, Abu Dhabi and Qatar, located at the south of the Persian Gulf, are massively extending their airports and the aircraft fleet of the airlines based there (Emirates Airlines, Etihad Airways and Qatar Airways). They are therefore becoming of increasing importance in international air transport.

The Emirates intend to become less dependent on the oil and gas markets by entering and promoting their potential in other economic sectors such as tourism, finance and logistics. This is especially true for Dubai, whose hydrocarbon sector now only amounts to around 6% of this Emirate's economic performance. The regional boom on marketplaces such as Saudi Arabia, Qatar and Kuwait has an over-proportional effect on the United Arab Emirates trade hub and Dubai. The sectors reporting especially high growth figures also include the transport business / logistics and therefore air transport.

With their considerable investments in airport infrastructure and airlines, the Emirates want to establish themselves as an interface in traffic and trade between Europe, Africa and the Far East. This Middle East region seeks to achieve this goal by exploiting its convenient geostrategic location between the important economic centres Europe and Asia. Long-haul aircraft can also reach destinations in North and South America and Australia from here without having to refuel.

The figure below shows the scale of planned expansion in freight handling capacities. The total of investments in the Middle East sums up to around 40 billion USD.3 Dubai is expanding its existing Dubai International Airport to handle an annual 5 million tons of freight and 40km away in the Dubai World Central Project the completely new Al Maktoum International Airport is under construction. This new airport is due for final completion in 2030 and will have a total of six runways for take-offs and landings and an annual terminal capacity for 12 million tons of air freight. This project is unique in the world today and the scale of the available freight capacity is generally equivalent to six times that of Frankfurt am Main airport's freight volume in 2007. In combination with the planned Dubai Logistics City, the free trade zone and the sea harbour, this could become the largest integrated multi-model logistics platform in the world. Other Emirates at the Persian Gulf are also pursuing such development objectives.

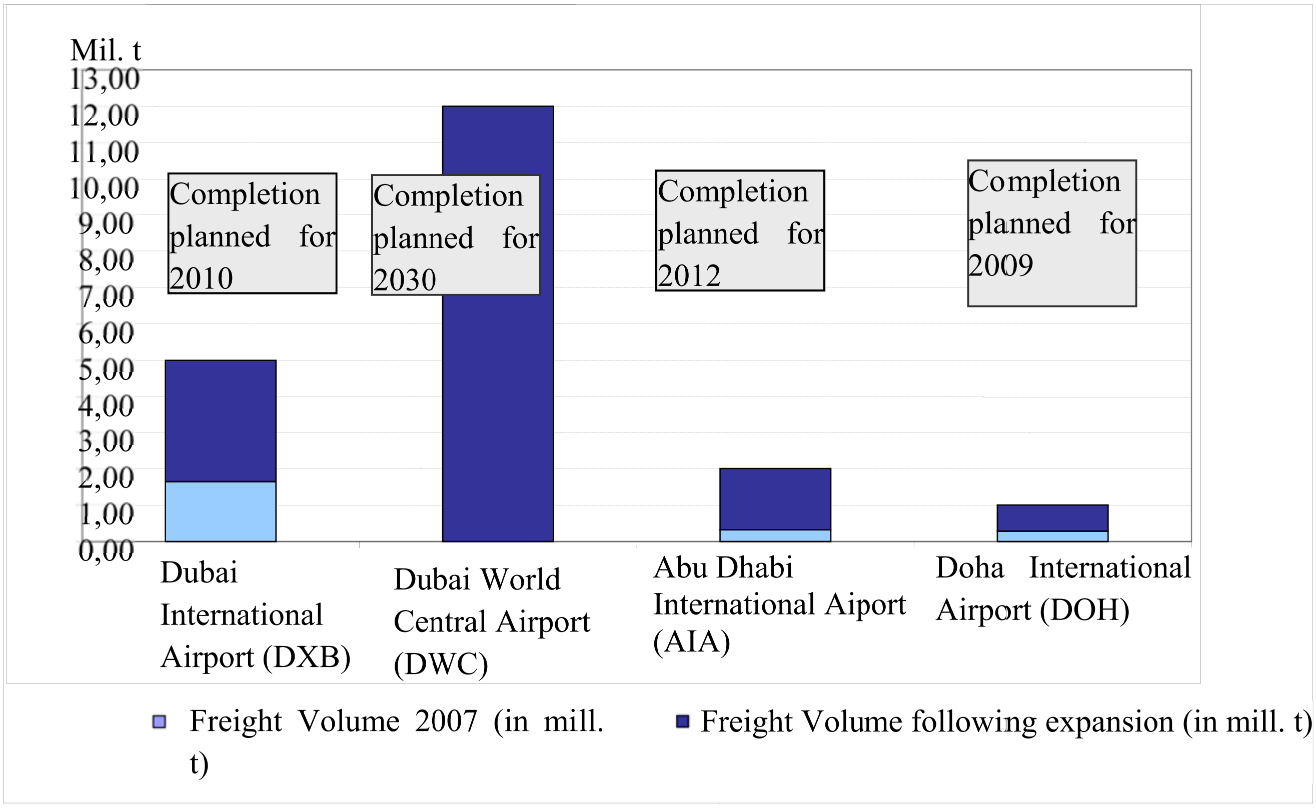


Figure 82: Airport expansion plans in the Middle East

Source: Original Graph, Data Basis: ACI (Ed.) (2008), Dubai International Airport (Ed.) (2008), Dubai World Central (Ed.) (2008), Abu Dhabi International Airport (Ed.) (2008), New Doha International Airport (Ed.) (2008)

Parallel to the airport extensions, the domestic airlines' fleets are also being expanded, as can be seen in the figure below. Middle East airlines currently account for around 9% of the long-haul air transport capacity, but they also account for nearly a quarter of all aircraft to be supplied on a global level in this segment over the next ten years.

3 Cf. Flanagan (2007): p. 98.

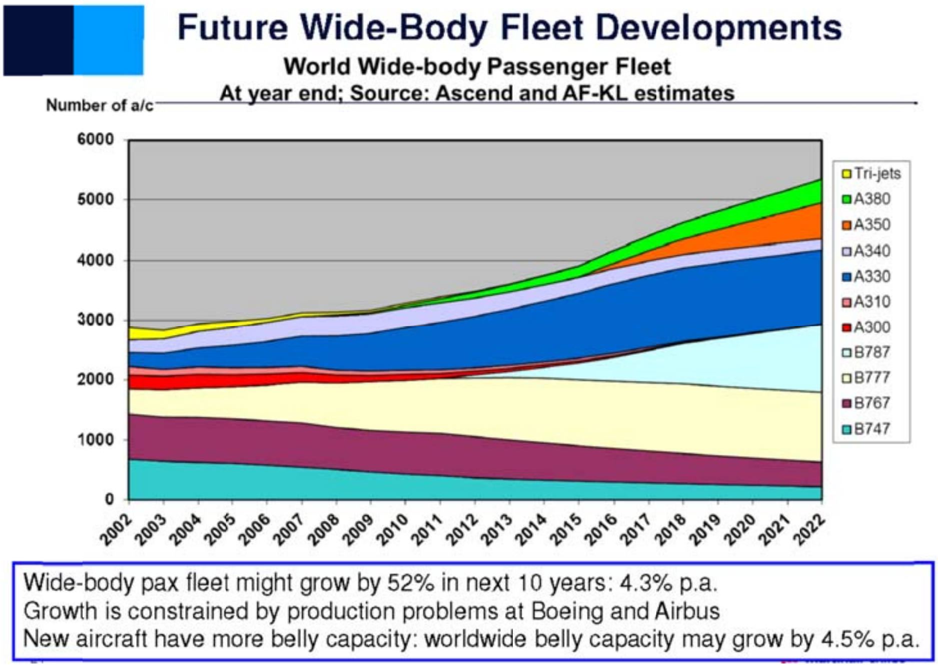


Figure 83: Future wide-body fleet developments

The investments are mainly in passenger aircraft in which freight transport is possible in the lower deck and belly cargo hold. The Airbus A 380 has only a modest belly freight capacity of 15 tons. There were also new freight aircraft ordered, including ten Boeing 747-8F and eight Boeing 777F for Emirates Airlines.

The fleets of the airlines examined are characterised by a high level of performance and competitiveness. Thanks to their low average age, the aircraft are technologically very

modern and are highly fuel-efficient, which offers a great cost advantage at this time of high kerosene prices.

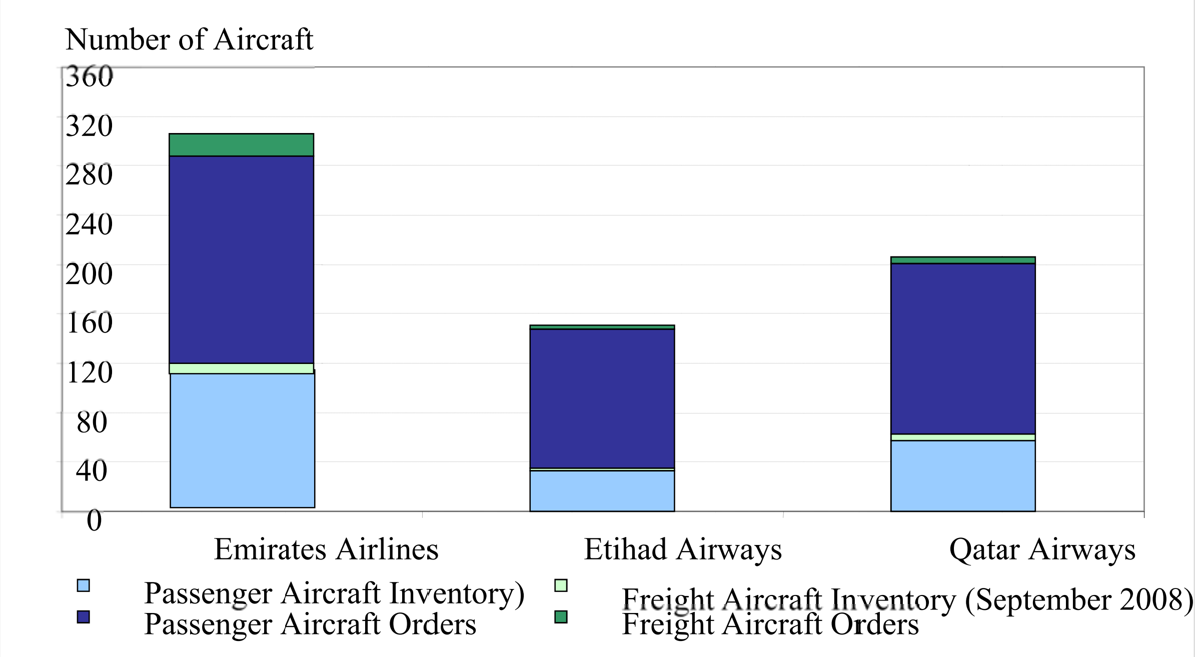


Figure 84: Fleet expansion plans of Middle East airlines

Source: Original Graph, Data Basis: Boeing (Ed.) (2008c), Airbus (Ed.) (2008), AeroTransport Data Bank (Ed.) (2008)

Besides the expansion plans in the Middle East, Asian countries such as China and India are also driving on the expansion of airports, for example in Shanghai and in Mumbai, and of the airlines based there. Shanghai Pudong International Airport is scheduled to become China's largest freight airport and enable the handling of 4.5 million tons of freight as of 2015. Nevertheless, the Chinese and Indian airports will not feature the same development speed and direction with regard to their hub functionality for long-haul traffic as can be expected in the Middle East in the short to medium term.

With regard to a medium to long-term forecast for air freight transport, it is essential that the developments in the Middle East are included. It proves difficult to depict and forecast their effects only in a quantitative form. The emergence of the Middle East airlines and airports bears consequences for the competitive situation of the established airlines in Europe, Asia and Australia and the associated hub airports. Despite the high growth rates in air transport (especially on routes to and from Asia), the capacities currently under construction most likely cannot be fully utilised only by newly created traffic volume. There is a risk of overcapacity for passenger and freight traffic, especially in phases of weak demand for air transport services. Protectionism in certain countries could result in a restriction of air traffic rights which limits growth opportunities.

Based on the strategic orientation of the airlines in the Middle East it can be assumed that they offer a high quality standard in service provision combined with somewhat lower transport prices for air freight goods in comparison to competitors like Lufthansa Cargo and Air France/KLM Cargo. The cost basis for the Middle East airlines is much lower thanks to their lower tax burden, lower airport fees at their home airports and the availability of low-cost fuel.

Particularly in the air freight market, there are tendencies that air freight forwarders, who usually are responsible for the choice of airline, will transfer volume to these emerging airlines. However:

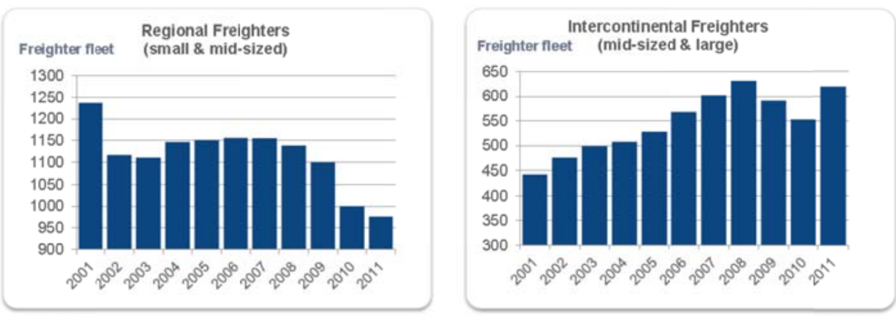
- The routes between Europe and Asia with stop-offs in the Middle East are often longer than direct flights over the polar regions.
- Change connections and the associated waiting times, as well as inconvenient arrival and departure times in the night hours, are considered by passengers when choosing flights
- Purely air freight transport between airports offer hardly any differentiation characteristics for the airlines, whereas conveying passengers offers the opportunity to provide different kinds of in-flight services.

Consequently, the established airlines could potentially be in a position to add more value for air freight customers compared to the expanding competitors from the Middle East and Asia by offering better quality in ground clearance services and freight handling through physical and IT integration of interfaces in the air freight transport chain and by offering additional logitics services.

12.5 The Airbus global forecast 2011-2030

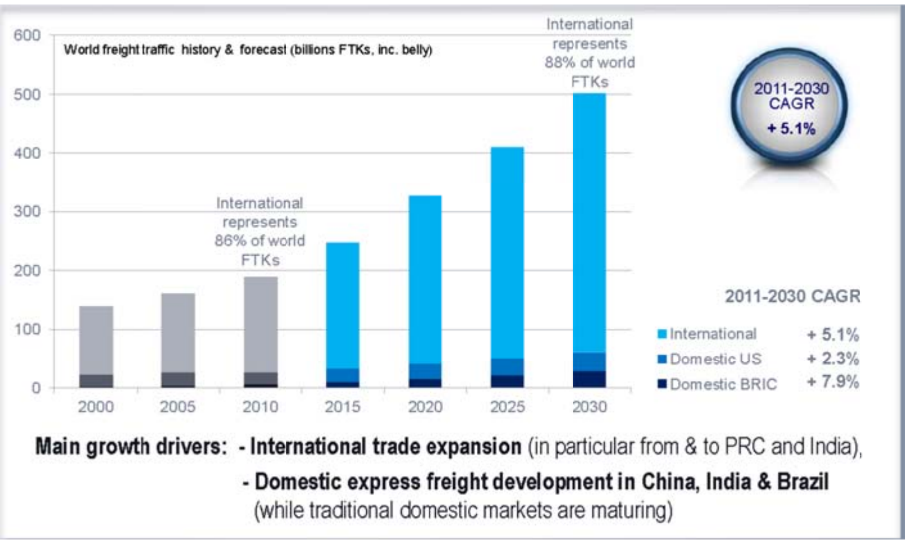
- 20 years freighter aircraft demand forecast (jet freighters > **10 tons**)
- Traffic forecast modeling **150 distinct traffic flows**
- Fleet build-ups covering **207 freight carriers**
- Freighters fleet divided in **3 segments:**

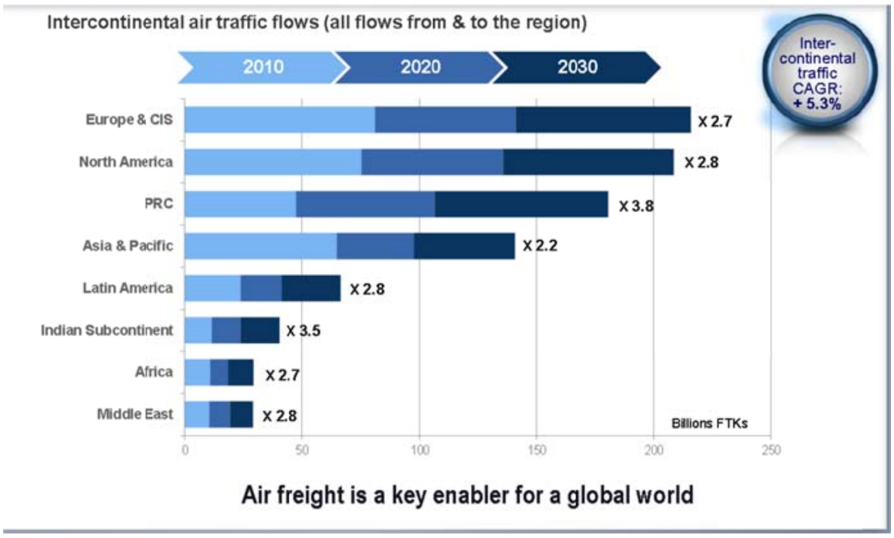
Segment	Payload	Aircraft types in service
Small Jet Freighters	10 to 30 tonnes	BAe 146, DC-9, 727, 737, TU-204
Mid-Sized Freighters	30 to 80 tonnes	DC-8, 757, 767, 747 Combi, DC10, A300, A310, A330
Large Freighters	Over 80 tonnes	MD-11, 777, 747

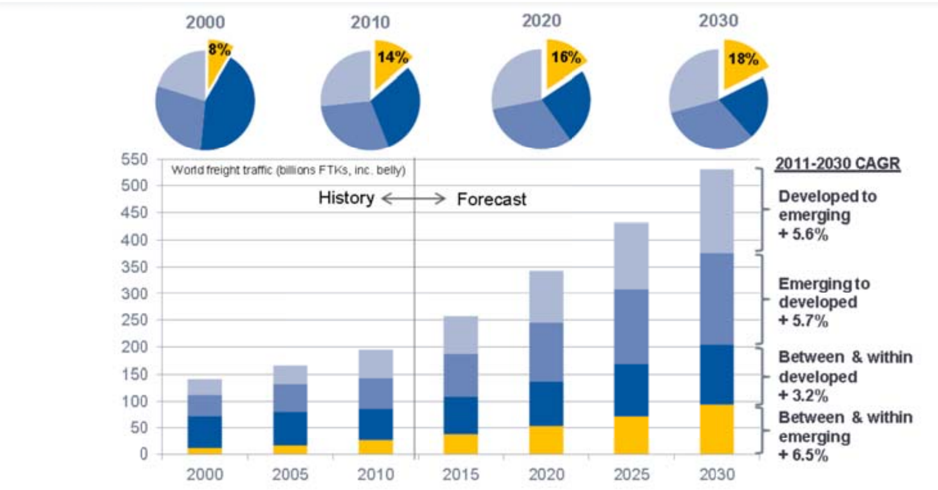


Change in air freight environment drives shift from small-jet to wide-body freighters

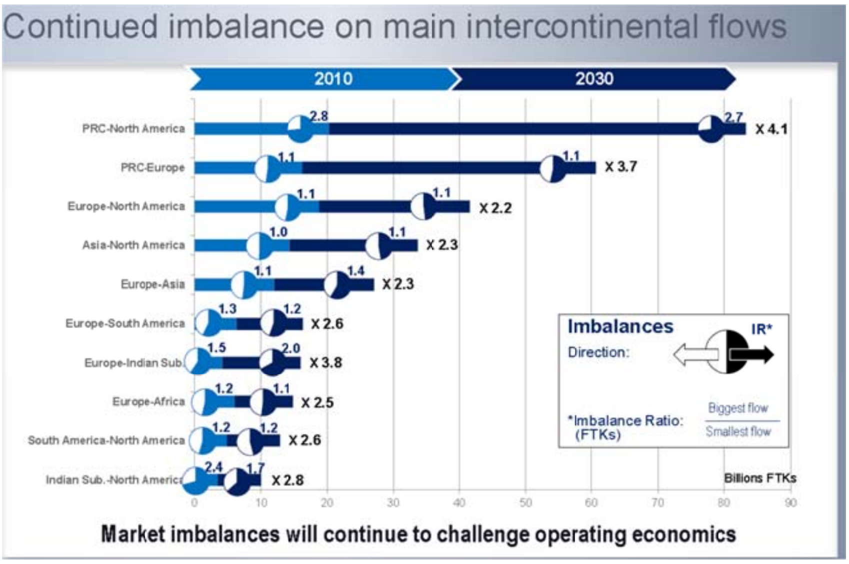
Segment		Aircraft type in service
Regional Freighters	Small and Mid-size	BAe 146, 727, 737, TU-204, DC-8, DC-9, DC10-10 757, 767-200, A300, A310
Intercontinental freighters	Mid-size & large	DC10-30, 767-300, DC10, A330, MD11, 777, 747



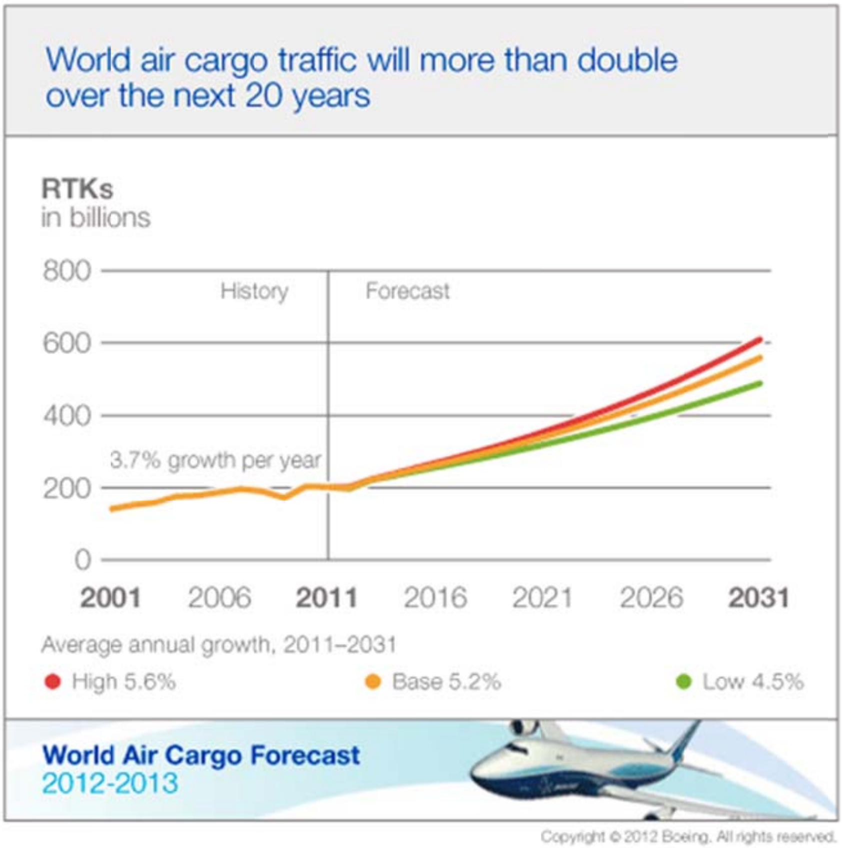


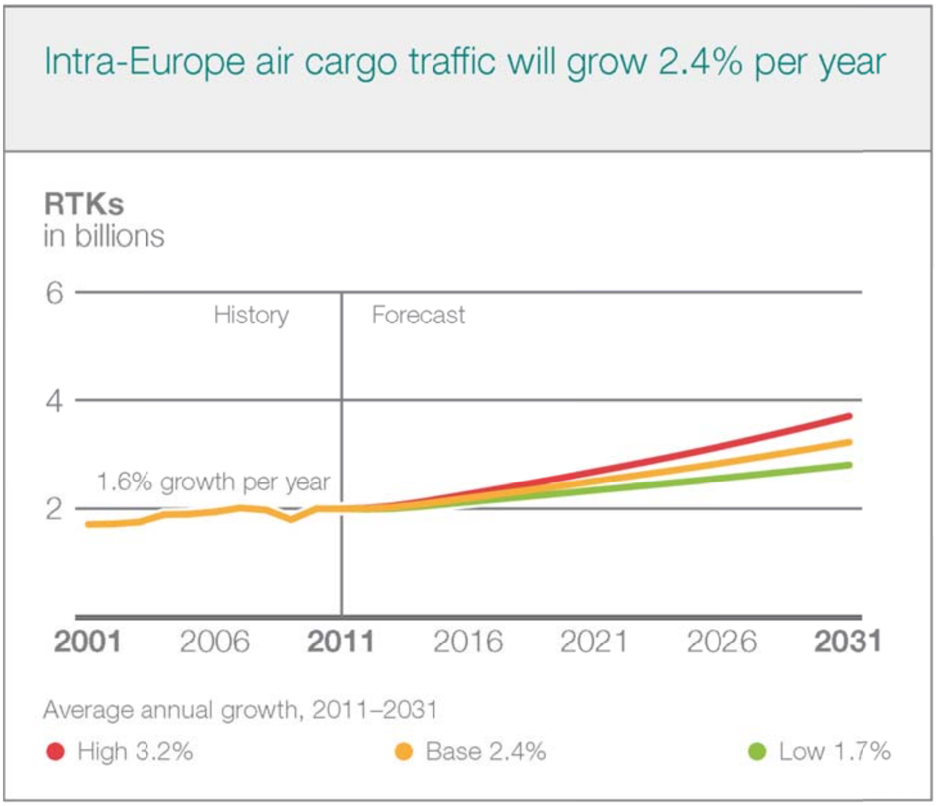


... and therefore demand for dedicated freighters



12.6 The Boeing global forecast 2012





Historical and forecast air cargo growth rates

	Historic 10 years 2001–2011	Forecast 20 years 2011–2031
World	3.7%	5.2%
Intra-North America	-1.5%	2.3%
Latin America–North America	1.8%	5.6%
Latin America–Europe	3.2%	5.3%
Europe–North America	1.5%	3.5%
Intra-Europe	1.6%	2.4%
Middle East–Europe	9.5%	5.7%
Africa–Europe	3.2%	4.8%
Asia–North America	4.3%	5.8%
Europe–Asia	6.2%	5.7%
Intra-Asia	4.5%	6.9%
South Asia–Europe	6.1%	5.8%
Domestic China	10.9%	8.0%

World Air Cargo Forecast
2012-2013

12.7 Bauhaus, TU Munchen and Airbus forecast 2011- 2030

In 2011 an interesting joint study was made based on 3 different scenarios.

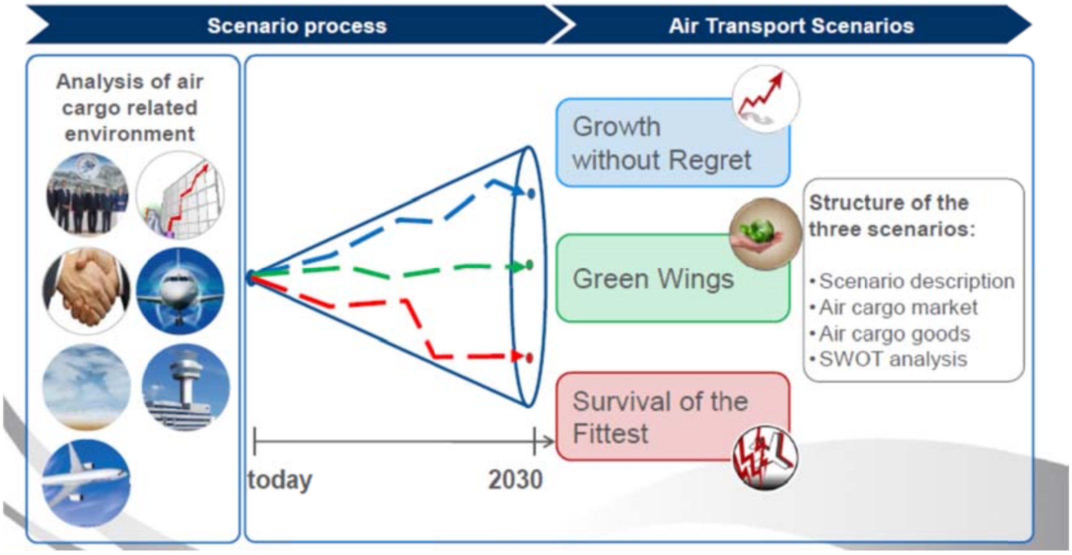


Figure 85: Forecast 2011-2030 based on 3 scenarios

The green scenario assumed a high focus on greening with a substantial government interference in the market. GDP growth was assumed to be modest at 2-3%, resulting in an average growth in air cargo of 4% per annum globally.

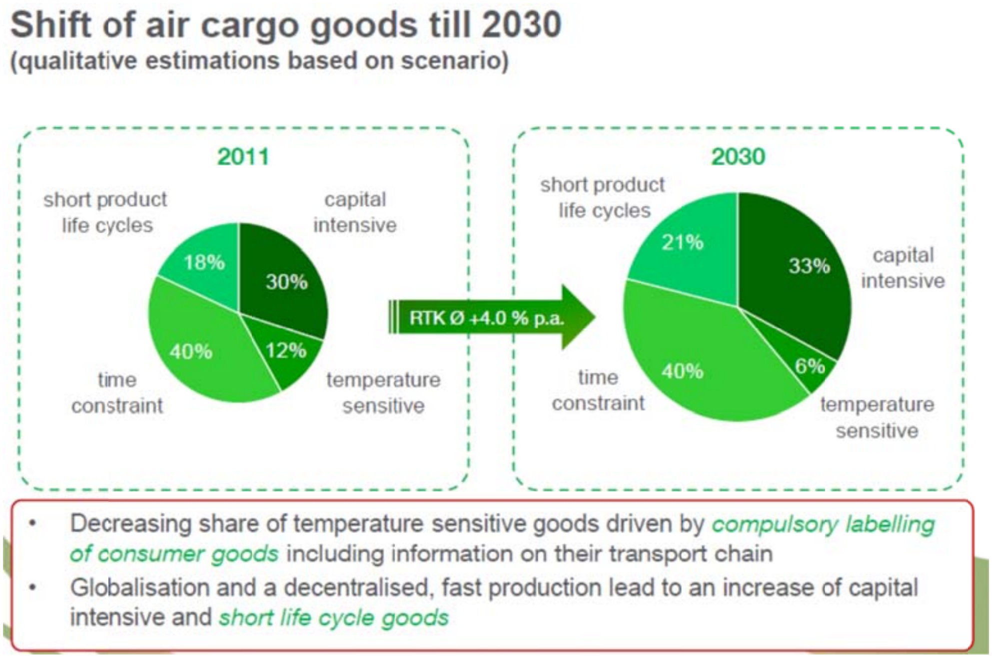


Figure 86Shift of air crago goods till 2030

The unstable scenario (so called "survival of the fittest") assumed a strong regional focus and unrest in the world. This would result in low GDP growth rates of 1% per year and global air cargo growing at the same percentage. Here cost of transport is more important than fast time of delivery.

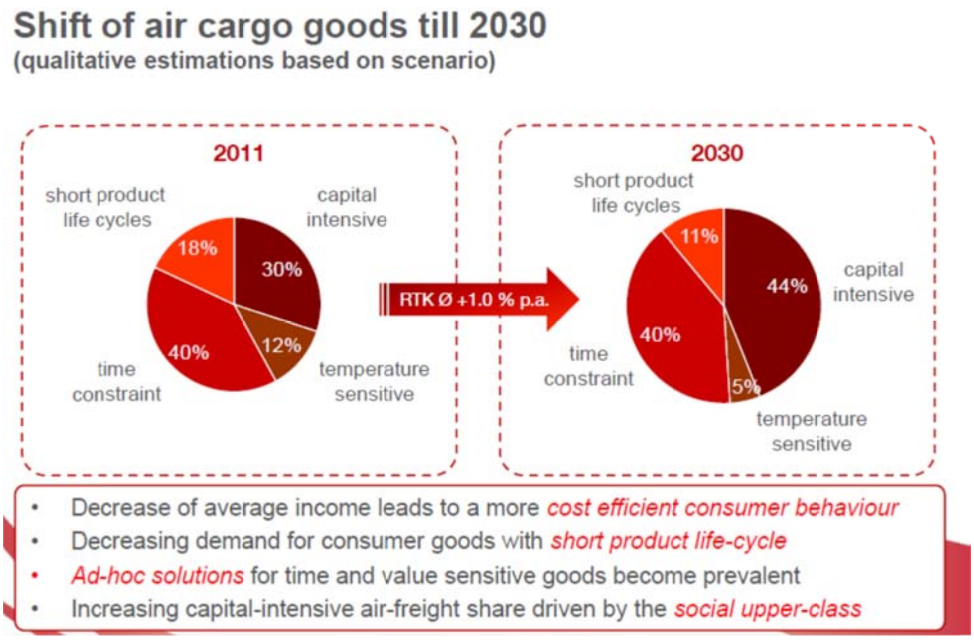


Figure 87: Shift of air crago goods till 2030

The growth scenario assumed a global recovery with GDP growth of 2-5 % per year and air cargo growth of 5-6% per year. As there would be a strong middle class, luxury goods would be in high demand. So time of delivery becomes more important.

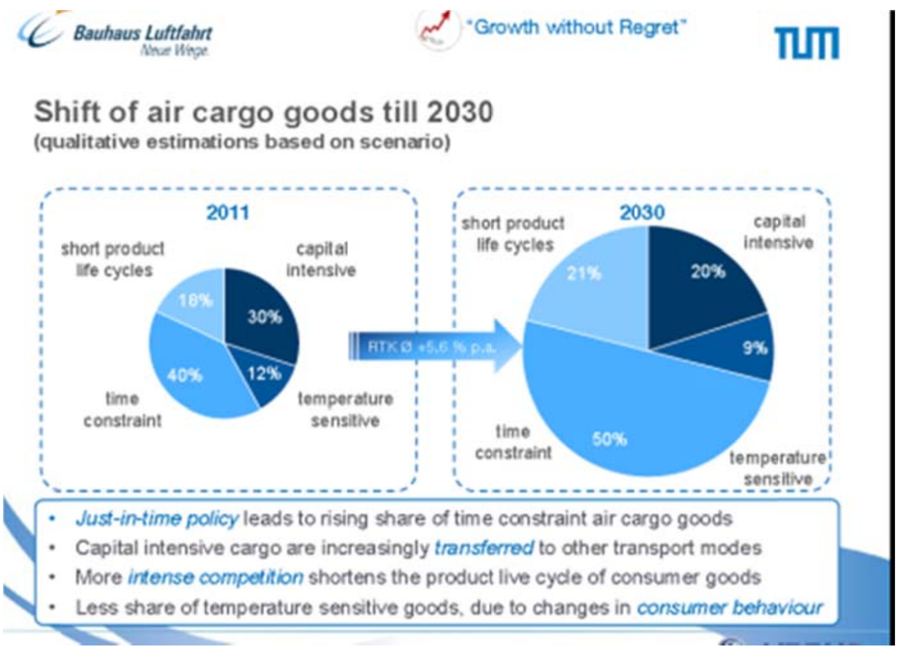


Figure 88: Shift of air crago good till 2030

Scenario building is interesting, perhaps primarily because it forces the scenario builder to think about all factors that influence developments. Most of the time the results of the scenario exercises are disappointing and prove to be wrong as it is often based on extrapolation. In real life an economic crisis is happening every 8 years the cause of which cannot be predicted.

12.8 TUD forecast

In the frame of the CargoMap project TU Delft also published a market forecast for 2028.

The forecast focused on transport range.

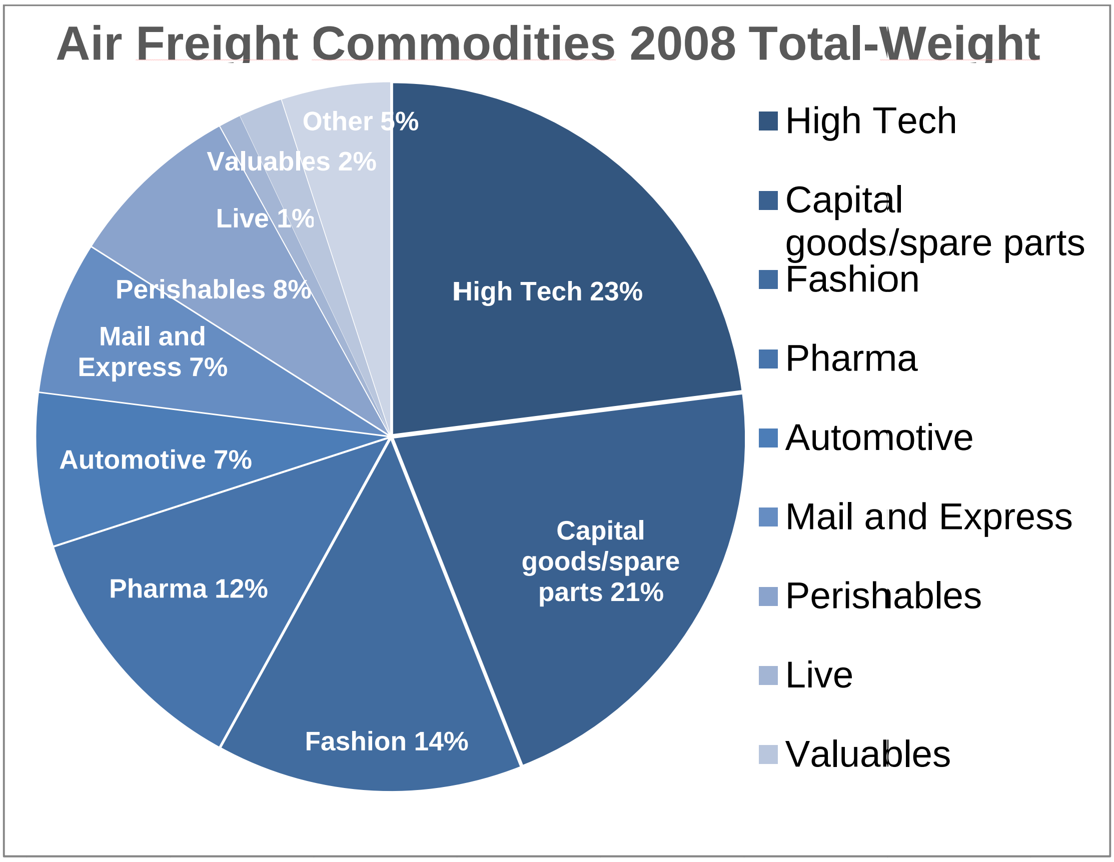


Figure 89: TUD forecst

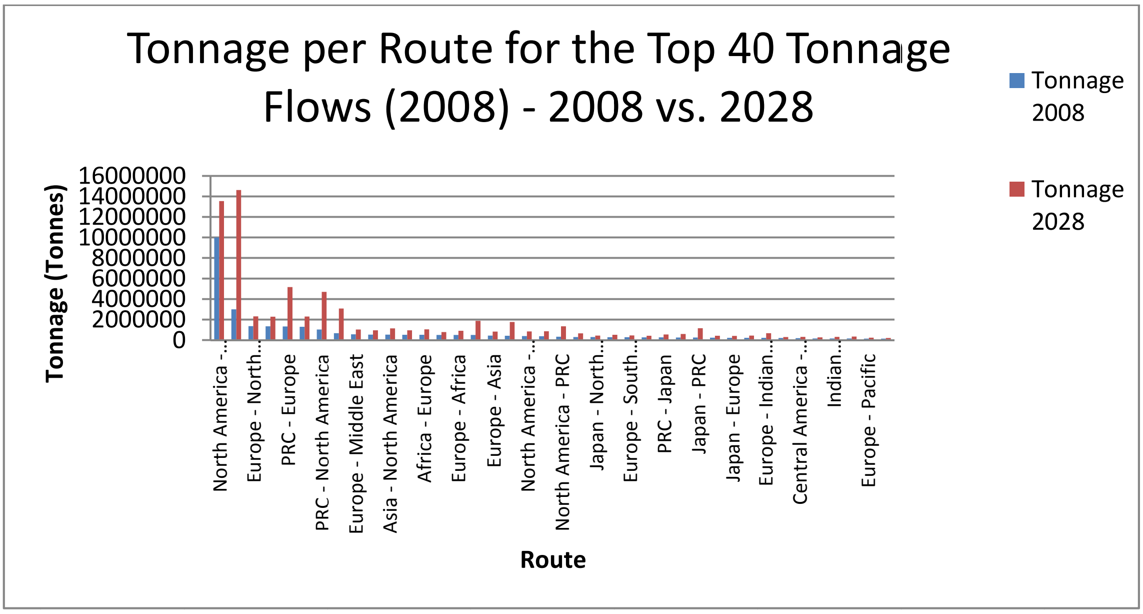
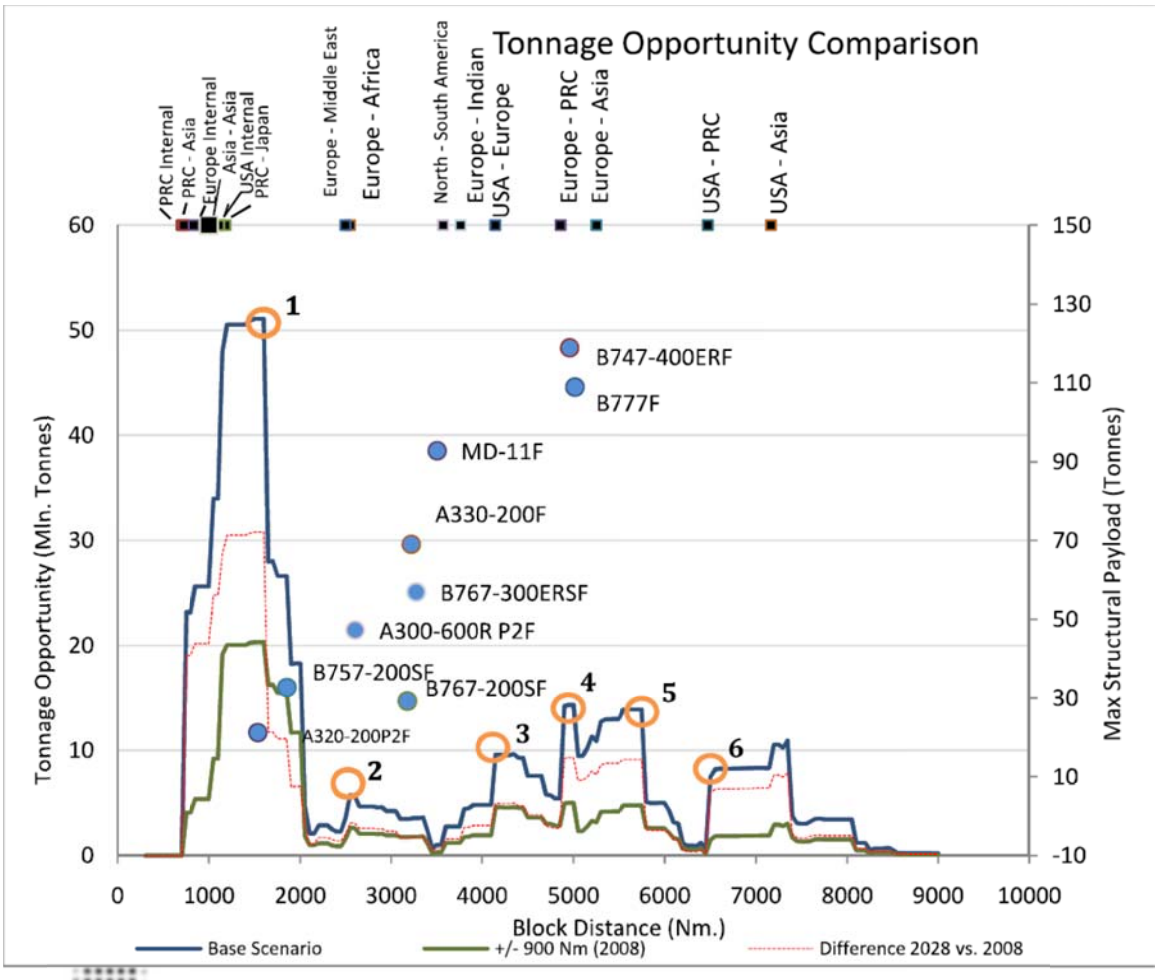


Figure 90: Tonnage per route for the Top 40 tonnage



: Tonnage Opportunity vs. Sector Length (2008 and 2028)

Figure 91: Tonnage opportunity comparision

The analysis showed a substantial growth potential also on short haul routes. However air transport needs to compete with trucking on short haul.

As trucking is about 50 times cheaper than short haul air transport, the challenge is to design aircraft that would be faster and substantially cheaper to operate.

12.9 The CargoMap forecast for Europe

The construction of a baseline scenario was aimed at quantifying the overall amount of goods transported in the future time horizons (up to 2050) in order to define the volumes at stake in the competition between modes of transport.

As an attempt at the defining an "as is" scenario, the baseline scenario elaboration adopts a comprehensive approach that relies on a combination of projections of historical trends and forecast which take into account the global outlook of main economic drivers.

The figures below show the past trends in EU-27 transport demand from 1995 to 2010. The transport demand is measured in terms of tonnes kilometre for freight transport by transport mode.

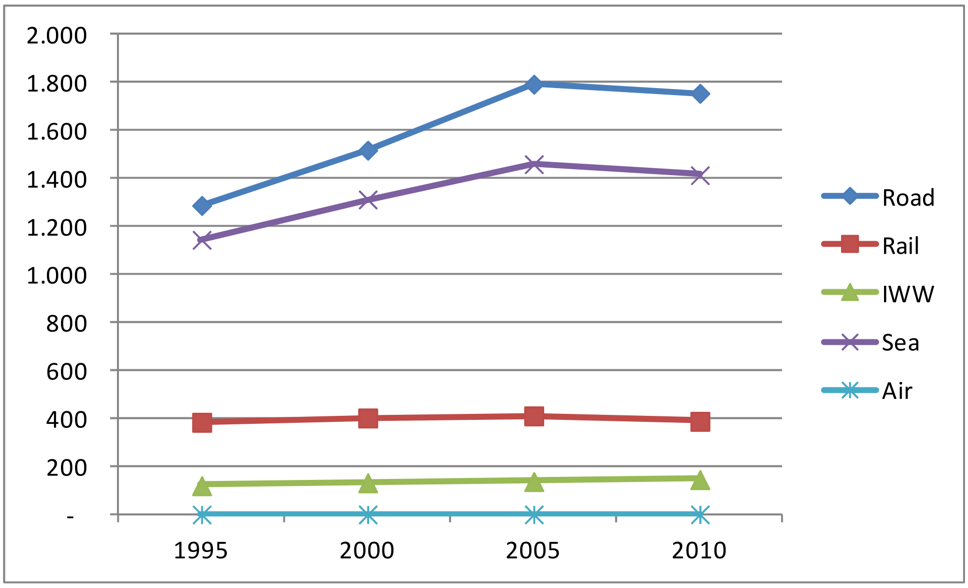


Figure 92: EU27 freight transport by mode, 1995-2010, thousands mio tkm

Source: Consortium elaborations on Eurostat data

The overall goods transported (pipeline transport is excluded) have therefore increased from a total 3060 thousands mio tonne-kilometres in 1995 to 3499 in 2000, to 3946 in 2055 and to 3831 in 2010, after a peak at 4173 thousands mio tkm in 2007, with an average growth of 1.5% per year in the 15-year span. In the last period, as evident from the chart, due to the deep economic crisis, the total volume of goods has decreased.

The consequent historical trend projection, which is calculated on the overall transport of goods regardless of transport modes, is presented in the chart below.

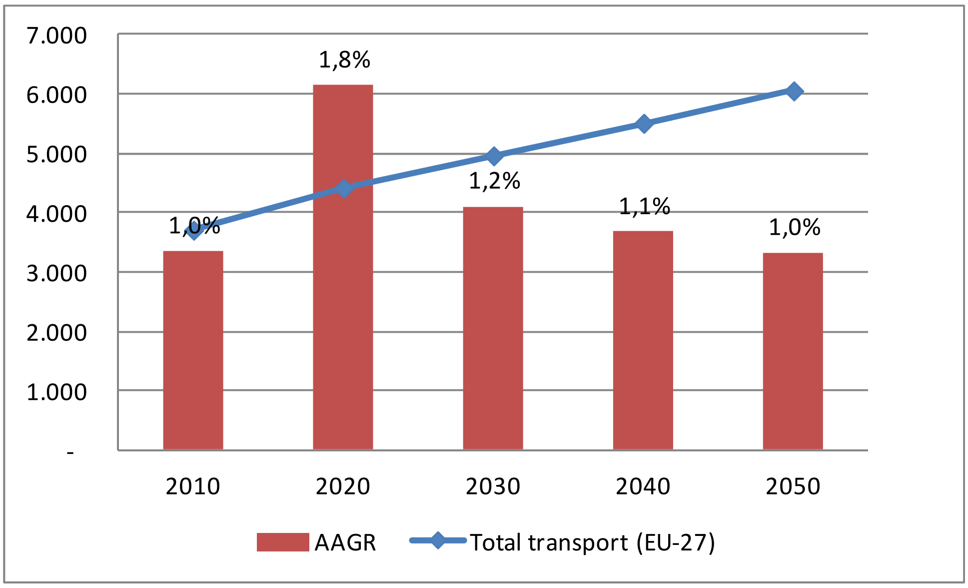


Figure 93: EU27 freight transport, historical trend projection to 2050, thousands mio TKM and AAGR

Source: CARGOMAP elaborations

On the other hand, available forecasts for global trade asses that world trade (defined as the sum of world exports and imports of goods and commercial services) is set to expand at an average rate of 6.1% p.a. between 2010 and 2030, and by 4.4% p.a. between 2030 and 2050.

In terms of geographical markets, the expectations for Europe in terms of growth rates of total trade are therefore as follows.

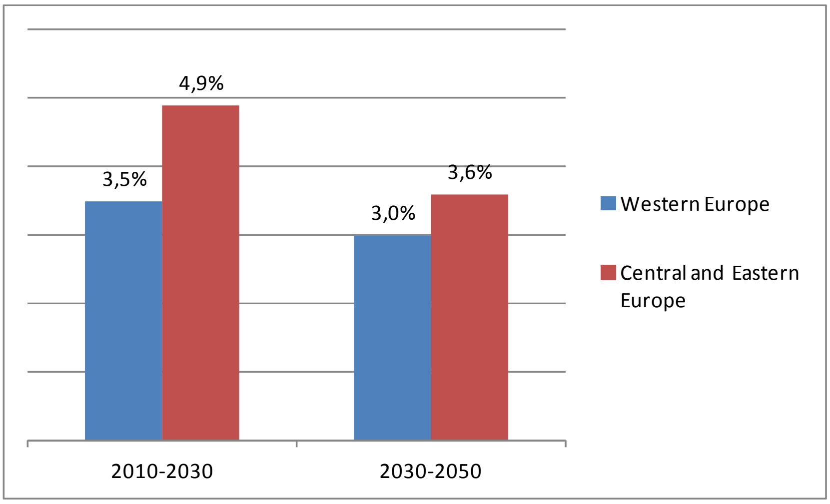


Figure 94: Europe's global trade long term growth rates

Source: CARGOMAP elaborations on Citi GPS data

Considering the two types of forecast as a prudential and optimistic scenario respectively, we elaborate a baseline scenario based on the current transport volumes, the historical trends of tkm and the trade outlook, which assess the overall tkms transport to/from and within Europe at 6319 billion in 2030 and 10109 billion in 2050.

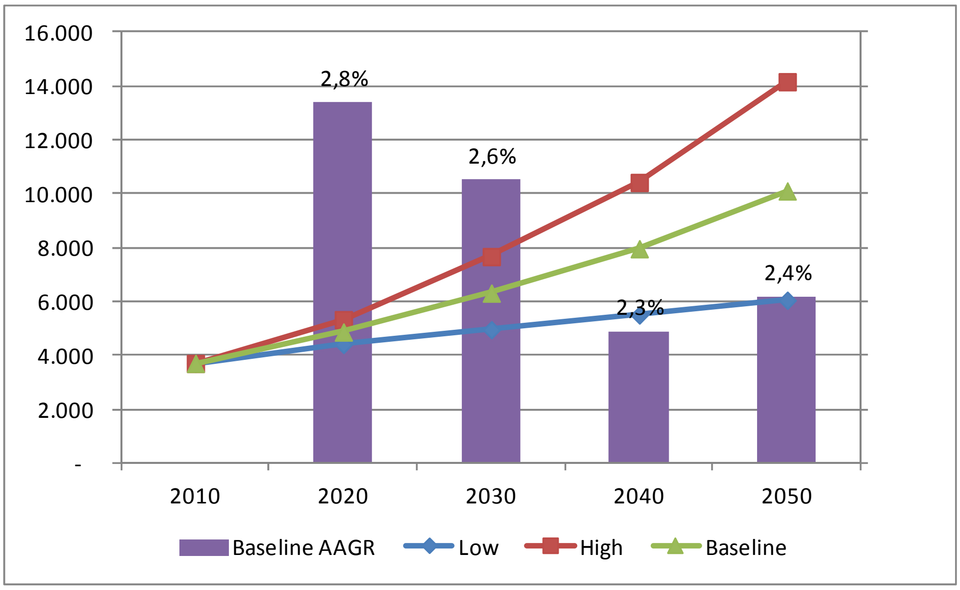


Figure 95: Baseline scenario of freight transport for Europe, 2010-2050, thousands mio tkm

Source: CARGOMAP elaborations

This result is consistent with the assessments of the recent TRANS vision study (2009), which expects freight traffic in EU-27 to grow annually by 2.0% to 2020, 1.9% to 2030 and 1.4% to 2050 – taking into account that this forecast (lower than our baseline scenario) only includes transports within EU-27 and with neighbouring countries.

As concerns the internal European market and the commodity segmentation, future tasks in this study will look into the development of a particularly relevant category of goods (LDHV, low density high value goods), in the internal European market with more detail.

A word of caution: Experience has shown that all forecasts need to be treated with some caution. There may be unforeseen factors that will results in discontinuities. The recent experience has shown this.

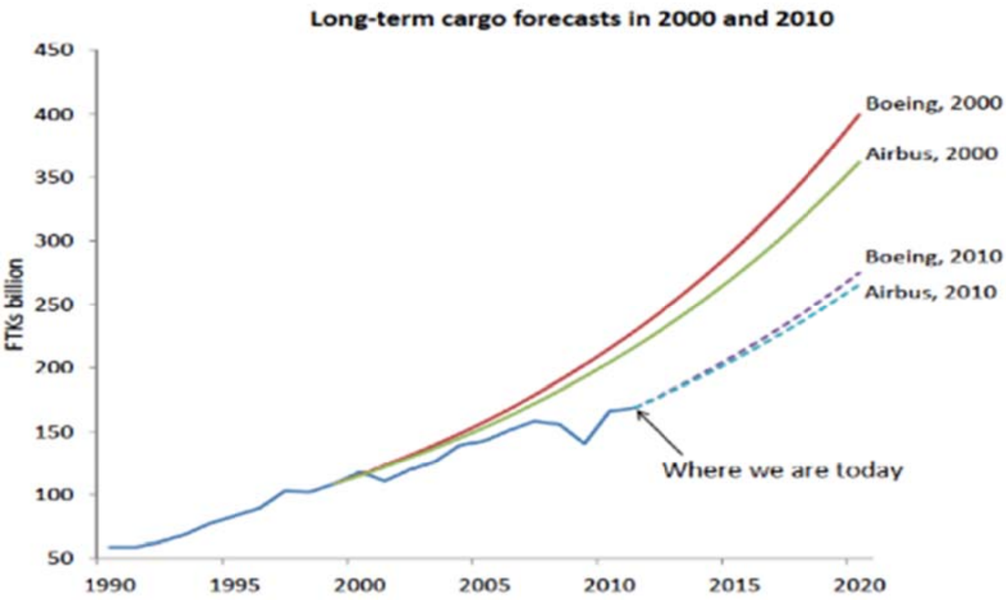


Figure 96: Long-term forecast in 2000 and 2010

Source KLM

12.10 Adaptation to City-pair Level for global forecasts

It is necessary for the accurate assessment of operational performance to estimate the demand forecast up to a city-pair level. All of the currently available methods describe an aggregation level of this detail as too uncertain and no literature was found with any methodology regarding this problem. Therefore a method has been developed within the scope of this research that aims to provide the necessary data making use of a stepwise approach.

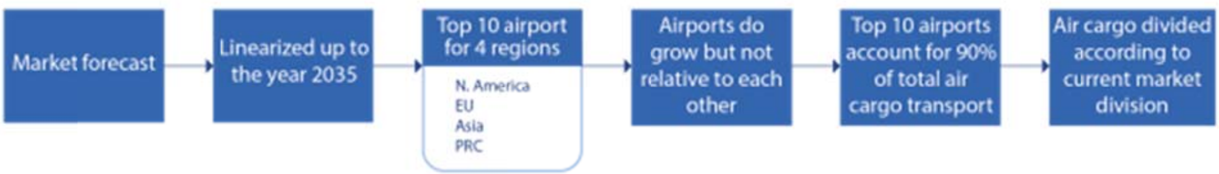


Figure 97: Representation of the calculation steps to arrive at a city-pair detail level

For the selection of market forecast data several options are available. Next to the public available long term forecasts of Boeing and Airbus, there is also the possibility to use forecast data of one of the commercial parties, such as Merge Global and Seabury. However, in the context of this research it is chosen to continue on the analysis of Carlier (2011).

12.11 Selection of Airports

From current market studies and forecasts it can be concluded that the five most important regions account for over 80% of total air cargo.

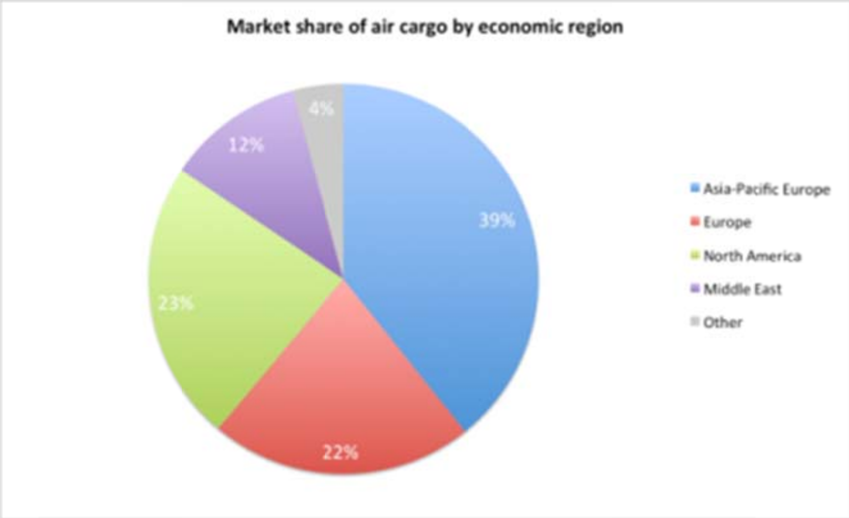


Figure 98: Market share of air cargo by economic region in 2012 (Airbus, 2012)

All forecasts expect this to remain it this way for the coming decades. Although also the economic region of Latin America is undergoing significant economic growth, in perspective of air cargo it will remain a very modest total share. For this reason the market analysis here is limited to the four regions most important regions:

- North America
- Europe
- Asia & the Middle East
- PRC

All other economic regions are outside the scope of this research. Results and conclusions from the current analysis can however be translated to these regions.

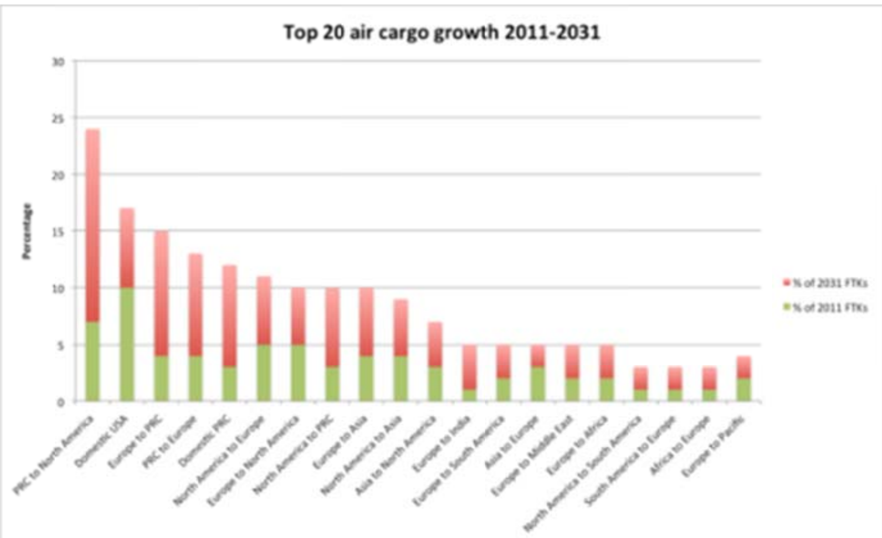


Figure 99: Top 20 air cargo growth predictions

Airbus GMF 2011-2030

Once the economic regions for analysis are selected, the analysis has to be expanded to reach airport level. Within the context of this research the ten largest cargo airports of each of the four largest regions are shown. In the case of Europe the three largest airports are already responsible for over 65% of all air cargo traffic in 2010 (Airbus, 2011).

North America	Europe	Asia and the Middle East	PRC
Memphis International Airport	Aéroport de Paris Charles de Gaulle	Seoul, Incheon International Airport	Hong Kong International Airport
Louisville International Airport	Frankfurt Airport	Dubai International Airport	Shanghai Pudong International Airport
Miami International Airport	London Heathrow Airport	Narita International Airport	Taiwan Taoyuan International Airport
Los Angeles International Airport	Amsterdam Airport Schiphol	Singapore Changi Airport	Beijing Capital International Airport
O'Hare International Airport	Luxembourg-Findel Airport	Bangkok, Suvarnabhumi Airport	Guangzhou Baiyun International Airport
New York, John F. Kennedy International Airport	Cologne, Konrad Adenauer Airport	Tokyo International Airport	Shenzhen Bao'an International Airport
Indianapolis International Airport	Liege, Bierset	Kansai International Airport	Hongqiao International Airport
Newark Liberty International Airport	Leipzig, Halle	Doha International Airport	Chengdu Shuangliu International Airport
Hartsfield, Jackson Atlanta International Airport	Brussels, National/Zaventem	Kuala Lumpur International Airport	Hangzhou Xiaoshan International Airport
Dallas/Fort Worth International Airport	Milan Malpensa	Chhatrapati Shivaji International Airport	Kunming Wujiaba International Airport

Table 10: Overview of main airports per region

The 2035 cargo tonnage between the different economic regions, as well as the average cargo density of these transportation streams, follows from the work of Carlier (2011). The same assumptions that have been previously applied by balancing all transportation streams have also been applied to the average densities between economic regions. Although large differences in these densities are forecasted, for simplicity reasons it was chosen to assume equal densities between city-pairs within the context of this research.

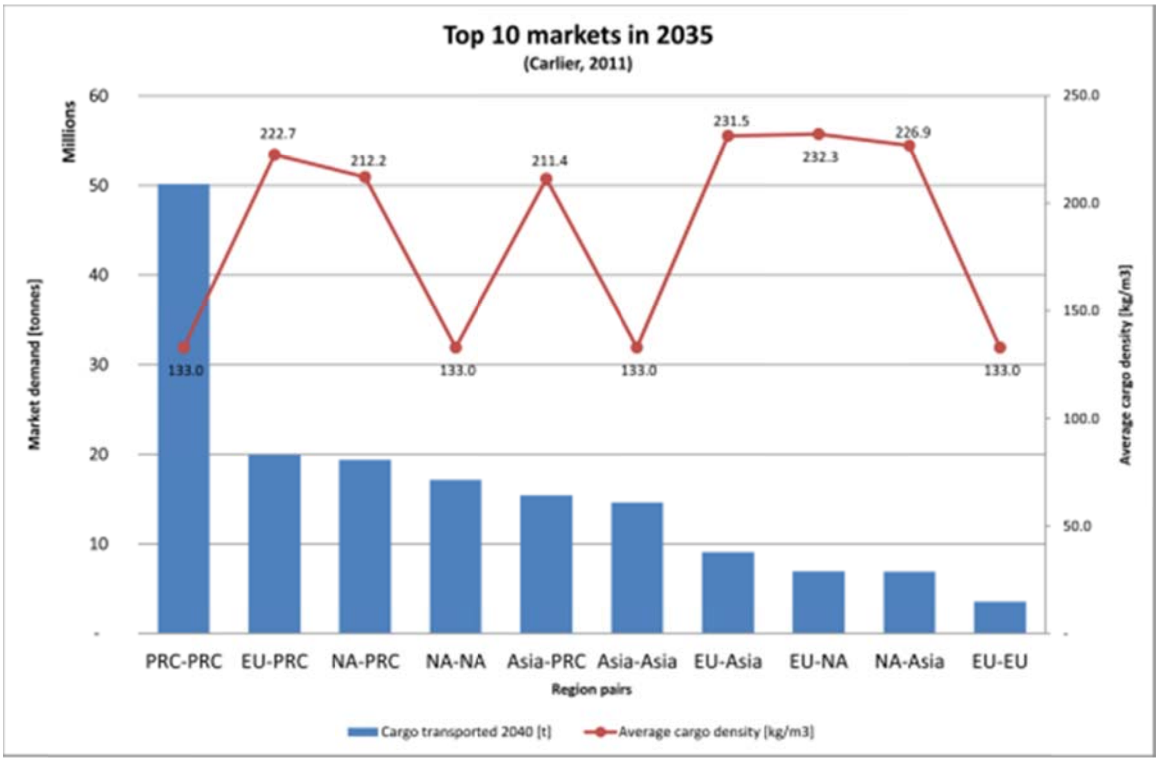


Figure 100: The average cargo density in the top 10 economic markets of 2035

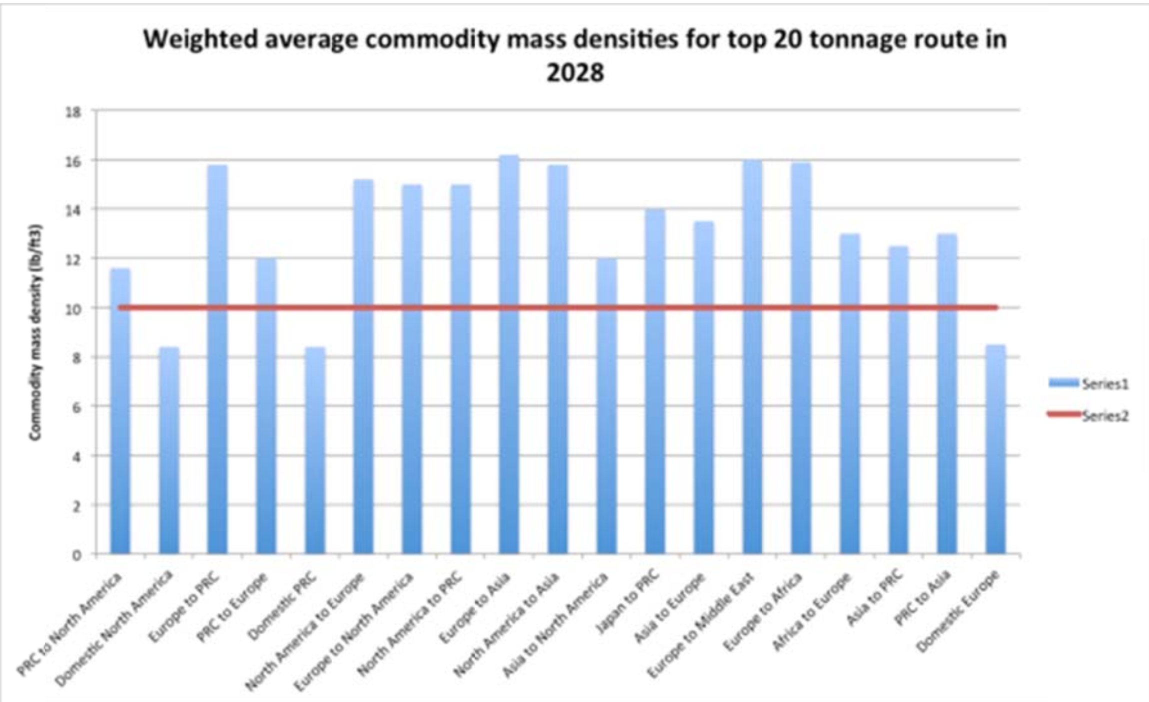


Figure 101: W eighted average mass density for top 20 cargo flows

Carlier, 2011

12.12 Focus on Peaks in Demand Forecast

Carlier (2011) discusses several tonnage opportunities for different range characteristics. He distinguishes several peaks of which the two most important are discussed below:

1. The first and by far largest peak in tonnage opportunity is for the short to medium range markets up to approximately 1,600nm. This is due to the fact that many of the large internal markets are situated

within this range, as well as the very large transportation flow between Asia and the PRC. The reasons for the size of this peak are mainly due to the high growth expectations for China and to a lesser extend due to some other Asian countries.

2. The second big tonnage opportunity can be defined for a range between 4,000 and 6,000nm, which includes all routes between North America, Europe, and Asia, and the PRC respectively.

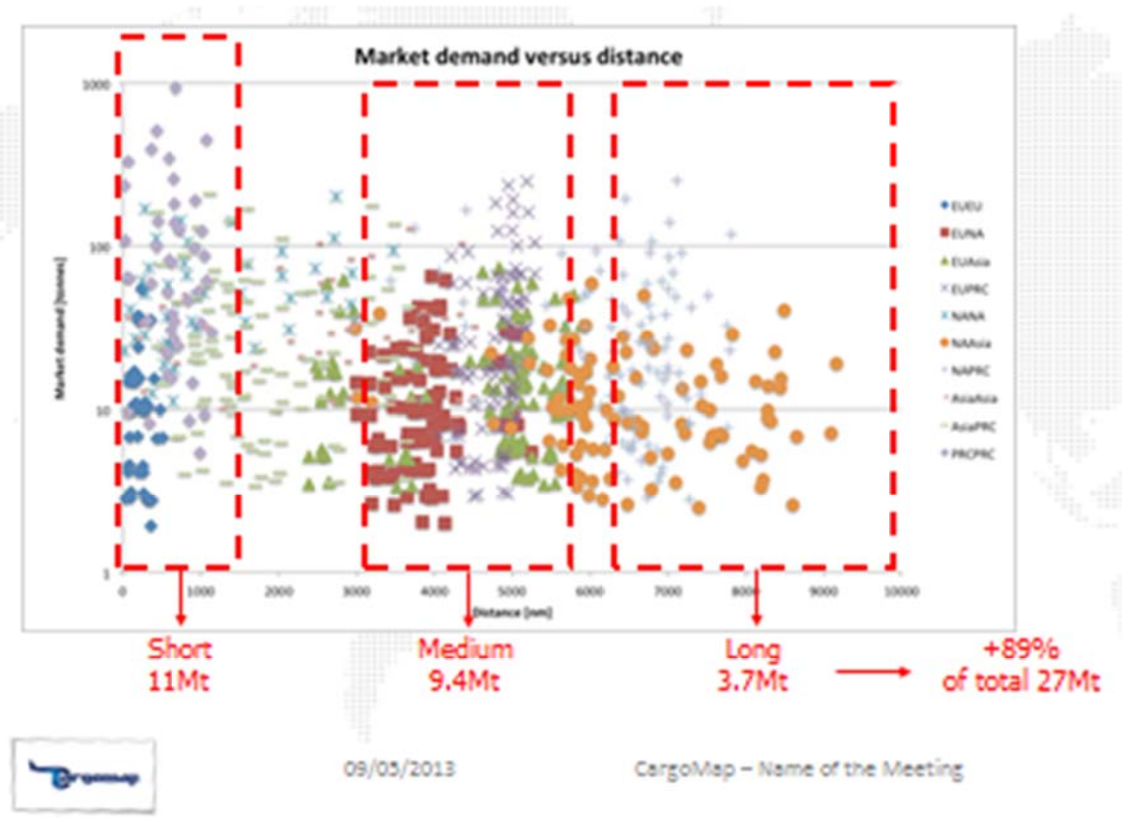


Figure 102: Market demand versus distance

12.13 Influence on Air Cargo of future factors

Social media

Whereas parcel shipments are likely to increase, surface mail will be largely replaced by email due to advanced social media. The same holds true for books and papers.

Figure 103: Influence of social media

3D printing

A new development may alter the need for shipments in the future. The 3D printing process which will allow local production of goods based on designs from abroad. This could mean a revolution especially for the local production of (spare) parts and later on food products and drugs. Currently 3d printing is only at the start of the development. Cost are still high and applications are still in the infant state. However it may result in a step change that could alter flows of goods all over the world.

Figure 104: Influence of 3D printing

Re-storing

Many companies from Europe decided to shift actual production to Asia. As wages increase the difficulties with doing business in Asia and the transport cost become more imporatnt. This results in some companies pulling back production from Asia and starting production in European low cost countries like the mediterranian countries and Eastern europe. This may result in a higher demand for regional transport in stead of long haul transport. This could imply that air transport over distances of 2000 KM becomes more important than in the past.

Near sourcing

If central European companies look for possibilities to shift production to lower cost countries they may opt to chose Southern or Eastern European countries from the outset. Again this creates a need for medium range transport. Trucks may not be the ideal transport mode and although pland exist for freight rail connections all over Europe, in reality the resources are not available to realize this on the short run. That means opprotunities for medium range air transport.

Synchro modality

As was stated before Integrators provide a door to door service by using inhouse means, like aircraft, vans and trucks. The service is fast but expensive.

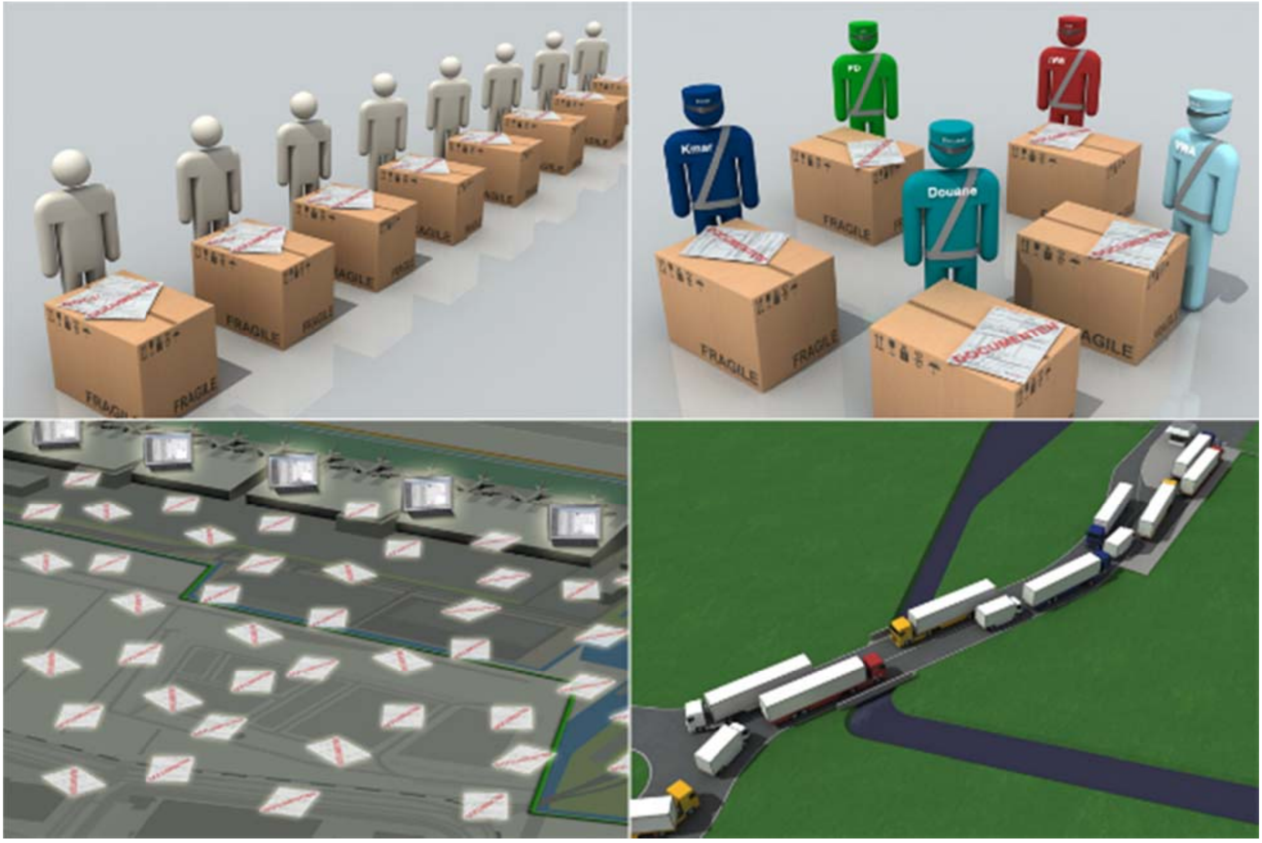
Other goods are handled via shippers, forwarders (the organizer), ground transport, airport ground handling and airlines, then ground handling, forwarders, ground transport and finally receivers. Especially customers (shippers) would like to see a much closer cooperation within the transport chain. They would like to see a transparent process that is customer centred, not organisations centred. They would like to see speed ,service and reliability, transparency in cost, predictability, a single invoice, information where goods are at all time, a single contact and clear agreements. They also like to see easy transfer between the players in the chain. Basically an integrated process as with cargo integrators and express service but at much lower cost. There is a remarkable ressemblance with the ideas for intermodal transport for passengers.

The demands could be met in different ways. IT technology (e-freight) could help to make the whole process transparent.

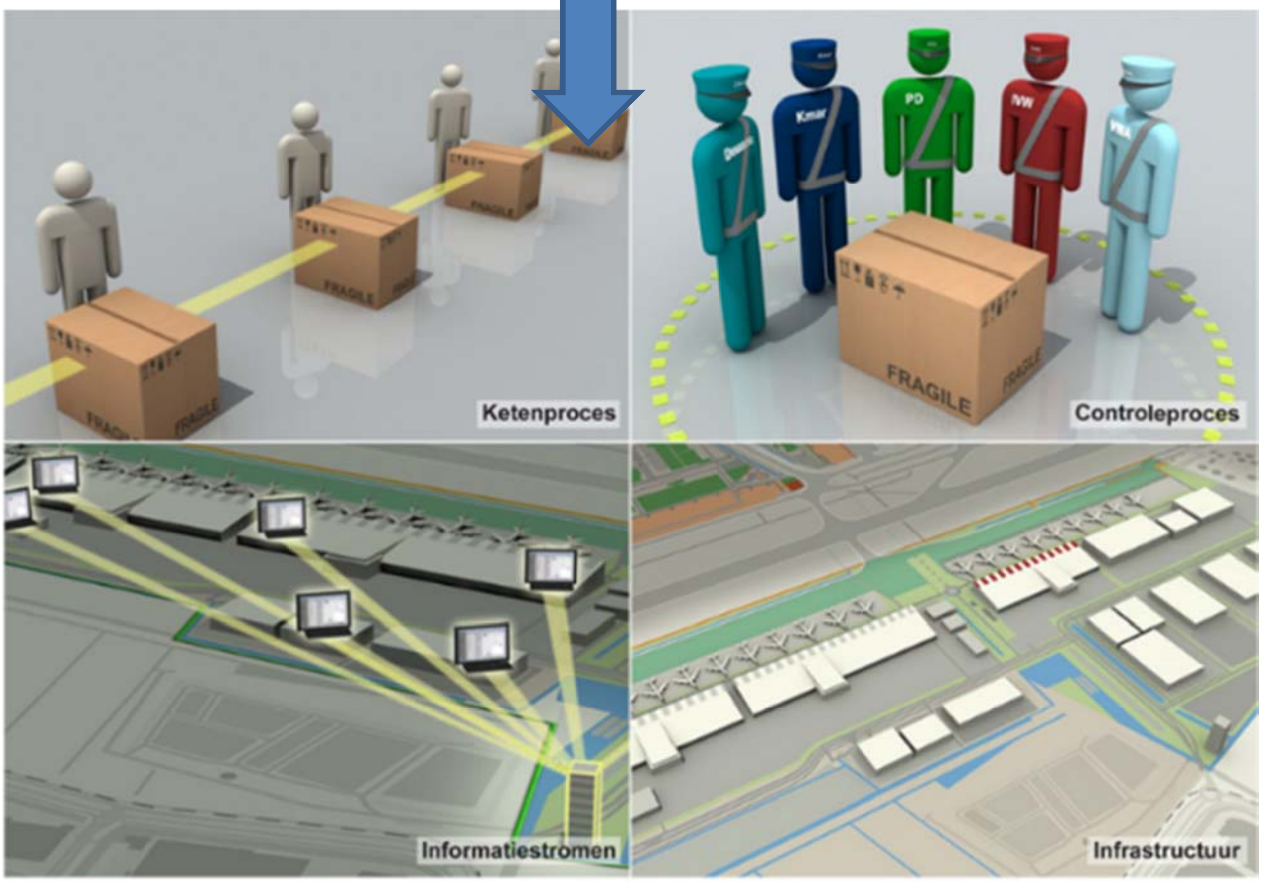
Figure 105: IATA e-freight

E-freight would also make the whole transportation chain paperless. For years it has been tried to implement e-freight in air cargo but progress is extremely slow.

There are national initiatives like the Smart Gate concept that has been introduced at Schiphol airport where bureaucracy has been reduced and government involvement of air cargo is channeled only through the customs service.



Before..



..And after.

Figure 106: Smart gate concept at Schipol airport

The idea is to rationalize the whole chain of activities to speed up the transport chain, to make it less costly and more transparent.

If e-freight is to be implemented it requires a good IT-infrastructure. It also calls for close cooperation between airlines, ground handling and trucking under the direction of forwarders. This is sometimes called synchro-modality.

The alternative is to reduce the number of players in the chain. What if airlines would integrate some of the functions and become responsible for the whole transport chain. There would be the single point of contact for forwarders and responsibility to deliver goods door to door within a certain time. In fact we already see some airlines operating their own trucking department.

(Note: During the Cargomap workshop the option to reduce the numbers of players in the transport chain was explictly mentioned by the experts. Regular air cargo operators would like to offer the same type of services as parcel service providers do but at lower prices.)Whatever solution is preferred it is obvious that should be a business case for the participants in the transport chain. And there is a need for better IT-tools. In this respect European research can help to develop European systems based on European standards. (note that intermodality in cargo may be easiere to realize than in passenger transport where there may be even more organisations involved that may not be focused on airline passengers allone and have quite different business models).

13 Air Cargo in the Future ATS – Vision and Requirements

Although air cargo is mentioned in Flightpath 2050 and the SRIA, little details are provided on the future air cargo business.

In this chapter - on the base of the collected information for current business models, technical adopted solution, and foreseen air cargo demand - a vision of the air cargo development is presented. The three possible scenarios are defined for the short, medium and long term.

On the base of the SWOT analysis for air cargo some requirements are derived. These requirements are meant to better exploit strength and opportunities, and to overcome weaknesses and threats.

13.1 Vision for Short Term (2020)

13.1.1 Summary

In the short term no major changes in the air cargo industry business models, operations, and aircraft are expected.

Small improvements are expected with the introduction of some IT technologies, e-freight, ATM reorganisation, conversion of modern aircraft for long/medium haul.

As the economic downturn comes to an end, the demand for (long haul) air cargo and passenger transport will establish itself again. This may result in a stronger share of belly cargo compared to full freighters. However the cargo capacity of aircraft like the A380 (15 tons) is very limited which means that there will be growth in the air cargo operations using the B777 and dedicated air cargo aircraft.

Long haul belly freight is depending on frequencies and destinations of passenger services. The all cargo freighter aircraft is seen as more flexible. However prices will be dictated by belly freight in the near future. This calls for clever routing of all freighter operators to increase load factors and thus lower cost.

Closer cooperation of all freighter operations may be the best answer to avoid empty leg flights.

The competition will still be fierce between different transport modes. New business models like the “TransEurasia Express” may become more popular.

Competition from the ME and Turkey will increase based on price competition. If market prices stay low we may even see a trend that combination carriers will source out the cargo business to all cargo operators.

Threats due to external shocks exist.

13.1.2 Market

The international market is likely to grow again. Intra-European transport will grow but at a lower pace. However re storing and near sourcing may result in higher regional cargo demand. (Note: the experts at the Cragomap workshop made it clear that air cargo would benefit from a new wave of consumer electronics)

13.1.3 Business models

Strong competition from belly freight is likely to remain. Legacy carriers may join creating mega carrier organisations. Possibly, the networked carriers will focus in intercontinental passenger routes and long haul whilst LCC may become stronger in the medium/short passenger haul traffic; the LCC could act as feeders for networked carriers. The networked carriers may want to operate their medium haul passenger service as LCC but this approach would require a different business model, focusing on profit centres without a large overhead. It is unlikely that LCC will get engaged in belly freight cargo as turnaround times may not allow cargo to be carried unless it is all containerized.

13.1.4 Competition

Competition will stay fierce. New carriers from the ME, China and Turkey will set the price. Cargo operators will try to further reduce empty legs by flying to different locations during the same trip.

Parcel services are likely to grow. There may also be a shift in types of goods transported on long haul routes.

Any significant change on medium or short haul cargo transport is not expected due to competition from trucks that will be difficult to beat.

Despite all efforts to increase rail cargo, it is unlikely that there will be a substantial shift to rail as the capacity of the rail system is limited and high speed rail connections may be completed much later than expected as a result of the economic crisis. Already a number projects for high speed rail connections planned in Portugal and Poland have been stopped.

E-commerce will be further developed which will also mean a strong impact on forwarders and shippers. Paperless shipping and “smart gate “concepts are expected to be implemented which will reduce time spent at warehouses for goods.

13.1.5 Modal shift

No substantial modal shift is expected.

13.1.6 Aircraft

No new aircraft are expected in the near term.

Up to 4 years ago it was expected that Airbus and Boeing were to launch an all new aircraft as a successor of the A320/ B737 aircraft family. Several concept studies were made. Novel engine concepts were investigated including the un-ducted fan. These aircraft were supposed to be ready by 2020

Figure 107: Conceptual studies by Boeing and Airbus

In reality, these companies have decided to install improved engines on the existing aircraft models and to continue the production of the A320 and 737 as 320 NEO and 737 Max. It is questionable if the companies will decide to introduce an all new regional aircraft by 2025 already as the new A320 and B737 aircraft represent stae of the art technology.

Currently there are no step changes in technology that would allow substantially better all new aircraft to be developed in 2025. Even if all possible technical solutions that are being addressed would be combined the new product would still not justify the financial risks of developing a new aircraft. There are improvements in the pipeline but the combined effect of these improvements did not justify the enormous cost of developing an innovative configuration and/or a new aircraft fully equipped with innovative technologies. The only exception has been the Boeing 787 Dreamliner.

On the long haul market the derivatives of relative modern aircraft like the A330/350 and B777/787 will dominate the market.

On the medium haul there will be derivatives and conversions as well.

In the short haul market we may see new small efficient aircraft to be introduced. The current Piston powered aircraft like the Cessna Caravan, PC-12, BN Islander etc. may start to be replaced by more modern aircraft for short haul traffic if a suitable new engine can be developed.

13.1.7 Regulation

In 2016 the EU should put a new regulation in place to enable the use of unmanned air vehicles in the European airspace. However a serious attempt to replace courier services with UAS is not expected before 2020.

13.2 Vision for Medium Term (2035)

13.2.1 Summary

A change of economic condition may be expected in the different macro blocks, with a change of air cargo networks and flows.

Time constraint goods might take the biggest share of air cargo in 2030.

Innovative technology needed for a step change in aircraft products will be developed and in a validation/demonstration phase.

Some new aircraft might be introduced for Medium and Long Haul.

For Medium and Short the use of regional airports and V/STOL innovative aircraft will be a welcome addition to road transport.

There may be more hybrid transport solutions. For this concept universal containers will be needed.

Starting from around 2035 air cargo aircraft could be operated without pilots. It is assumed that the technology is available to make safe and secure pilotless aircraft.

By 2030 the gas turbine technology will be totally mature. Other engines will be developed like super conductive electrical engines that will start to power part of the fleet assuming that batteries can be substantially better by then..

Bio fuels will be more affordable and a welcome addition to kerosene. The most promising biofuels will be based on algae production as the feedstock of other (cellulose or sugar based) sources will be very limited assuming no food production for humans is endangered. Algae based biofuels need to become substantially cheaper to be attractive however.

Sufficient funding should be available to do research and to design and manufacture novel aircraft.

Global standards enable the development of novel vehicles. Regulation is to be easily adapted to new technological developments.

13.2.2 Markets

The intensity of cargo flows may change as economies evolve; in the figures below the intercontinental cargo flows are represented for 2011 and as expeted for 2030 (**Source: “Agility Logistics”)**

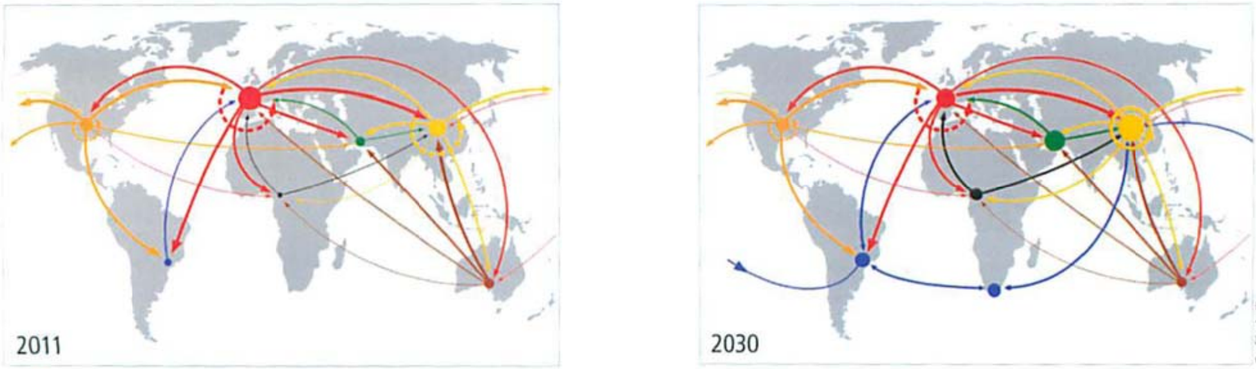


Figure 108: intercontinental cargo flows for 2011 and for 2030

The world population will more and more be centred in big cities, a trend that has been going on for some time now.

Possibly the shift in economic centre will have shifted more to China and India with South America and Africa being good runner ups. Still the US and Europe will be able to continue a strong economic position based on innovative designs and technology. As China becomes more expensive due to the increase in salaries, some production will shift back to the USA and Europe. This production will be highly automated and cost efficient using robotics. This production will still require regional distribution in Europe.

The regional market for aviation will be growing as road congestion may favour air transport. Novel designs in VTOL and STOL aircraft may be introduced.

13.2.3 Business models

It is difficult to tell how the market will look like in 2035. But one may expect that there is still a demand for all cargo and parcel services. There may be a shift between legacy and low cost carriers.

As far as the types of goods transported by air, we may see a shift whereby high tech goods can be split into high tech–high cost and high tech-low cost. High tech-low cost will probably be transported by surface transport in future. Below is a picture received from KLM which illustrates the possible trend expected by KLM. It shows that some high tech goods could be transported by other modes as the cost of electronics is constantly being reduced.

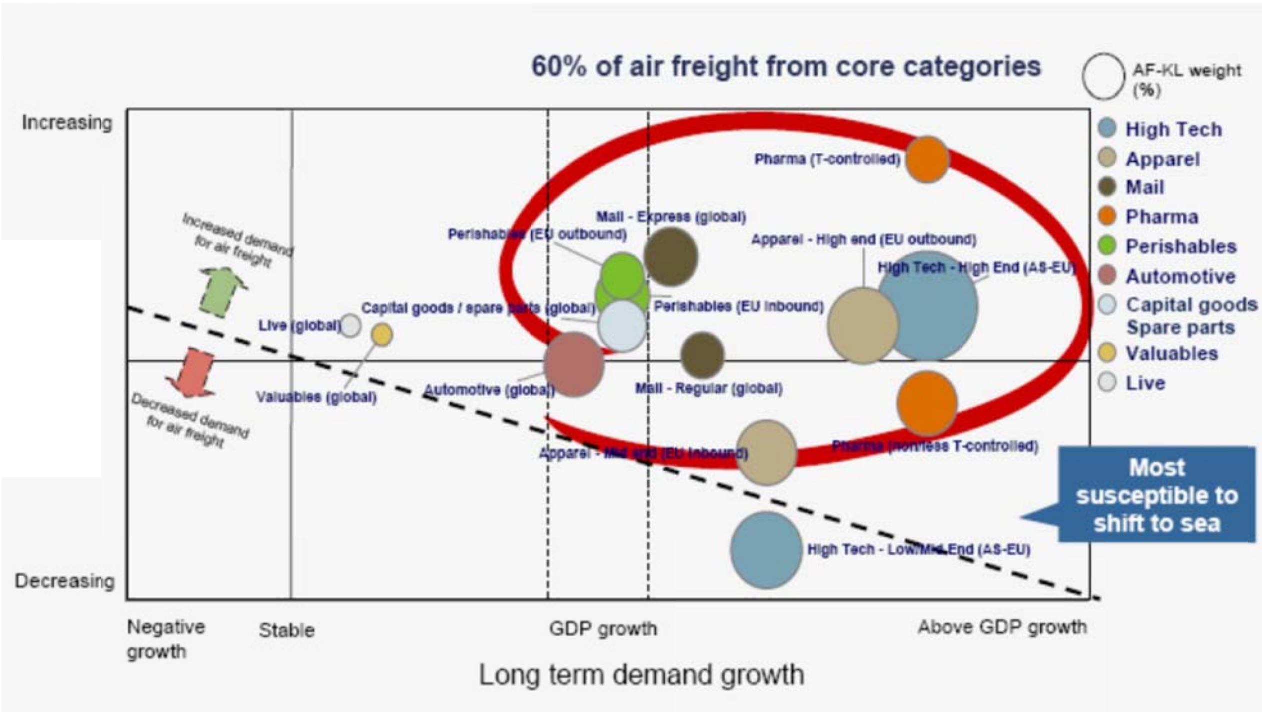


Figure 109: Market outlook for2035

Such a shift would be consistent with the expectation in the analysis done by Bauhaus/ Airbus/ TU Munchen. Here also, it is expected that time constraint goods will take the biggest share of air cargo in 2030.

Fast delivery would not by definition mean that aircraft should fly faster. Focus should be on streamlining the whole door to door delivery process.

13.2.4 Competition

Competition will come from new IT options. Still it is expected that with increasing wealth, the parcel services will grow.

3D printing may result in less capital intensive goods having high priority as assumed in the fore mentioned Bauhaus study. But at the same time constrained goods may increase.

13.2.5 Modal shift

A real modal shift is not expected although intermodal transport chains will be more important. The inflexibility of rail transport will created less competition than is expected by some. The use of regional airports and V/STOL (Vertical/ Short take-off and landing) aircraft will be a welcome addition to road transport.

There may be more hybrid transport solutions. For this concept universal containers will be needed.

13.2.6 Aircraft

NASA identified new technology developments to be accomplished by 2030; these can be summarised as follows:

- Composite fuselage (Δfuel burn= -3%)
- Composite wing and advanced subsystems (Δfuel burn= -5,8%)
- PRSEUS Concept (Δfuel burn= -4,1%)

- Advanced engine ((Δfuel burn= -6,7%)
- HLFC for wing and nacelle (Δfuel burn= -12,1%)

IATA made an inventory of all known developments in aircraft design in 2009. This inventory is shown in the next figure. It is clear that none of the technologies identified creates a step change in aviation. Only by combining several technologies a substantially better aircraft could be designed.

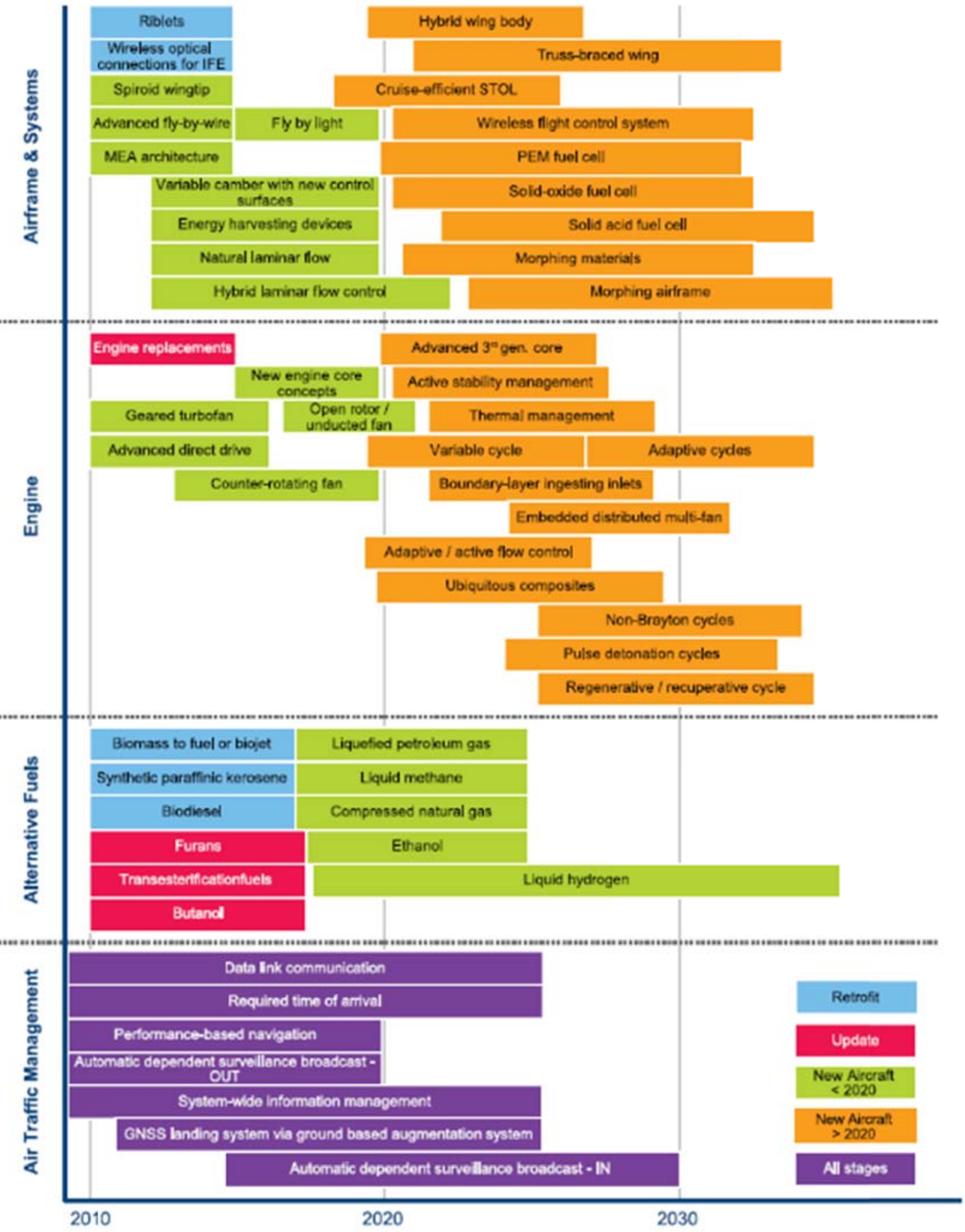


Figure 110:Developments i aircraft design in 2009

Besides technology development in some areas are reaching the limit of the law of diminishing returns. And in some cases the desired improvements reach to physical limits like in aero engine development. Although the inducted fan looks still a promising option the noise associated with these engines needs to be further reduced before the engine can be accepted in the market. The current turbofan engines are already extremely efficient and it is hard to make cost effective improvements.

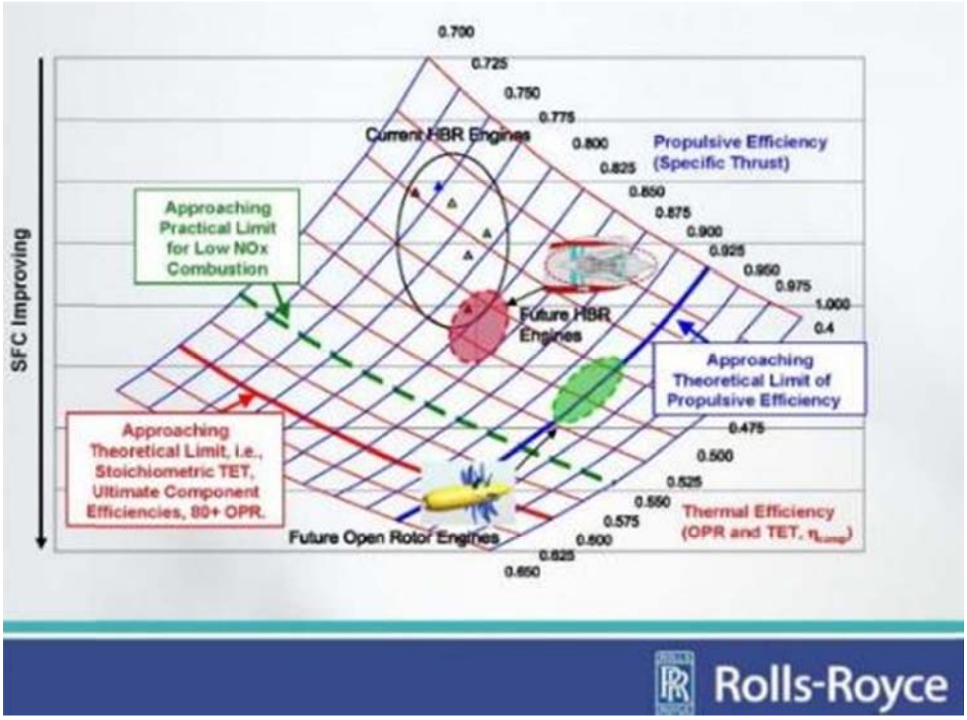


Figure 111: Approaching limits according to Rolls Royce

Airbus may want to close the gap that exists between the A380 and A350 where currently only the B777 is on offer.

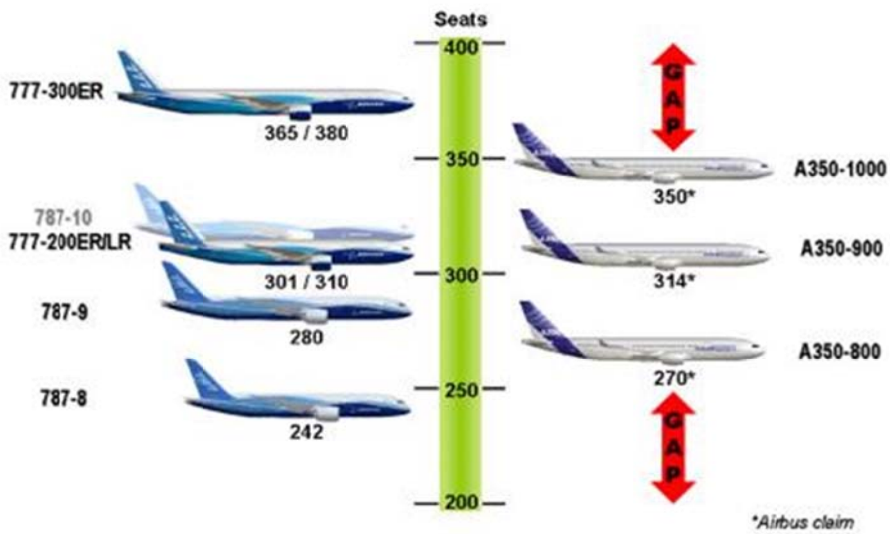


Figure 112: Airbus and Boeing aircraft familiy

A replacement of the A350 type family of passenger aircraft should by 2035 be justified assuming sufficient new technology is available. This includes the mature boxed wing layout and blended wing body aircraft. These new aircraft could be double deck aircraft in view of the desire to keep frequency high whilst coping with the airport shortage problem. If double deck aircraft will be used on long and medium haul, belly freight capacity will be limited which will open the way to new all cargo aircraft.

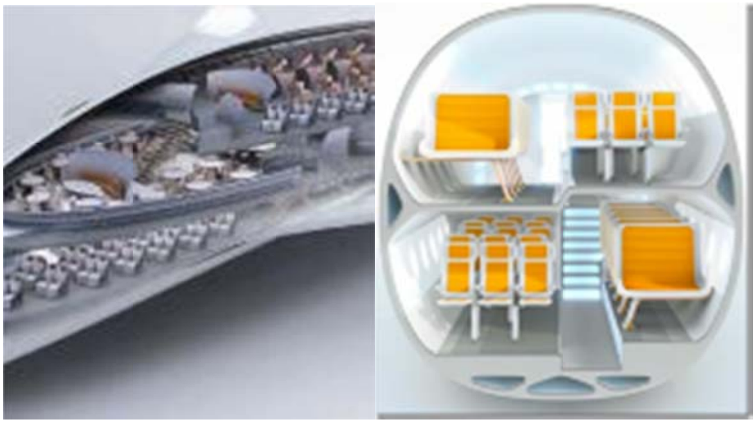


Figure 113: New aircraft types

Besides by then there will be new military aircraft like the replacement of the C-5 aircraft. These could be Blended Wing Body freighters which would be the launch of BWB technology. (Current USAF proposals look also at the stealth characteristics of the C5 replacements, as shown in the illustration below).

Figure 114: New aircraft types

By this time, unmanned aircraft technology will have matured. The safety levels will have gone up from the military 1:10.000 accident target to the commercial aviation target. That makes cargo planes to be the first application of this technology.

In the timeframe till 2035 we may see a whole new generation of dedicated medium/short haul air cargo aircraft. In fact, novel short range aircraft, personal aircraft and compound helicopters may be expected.

Figure 115: New generation of medium- and short-haul aircrafts

As intermodal connections are becoming more important to save time, air transport should be more integrated in the multi modal transport chains. That means amongst others that repackaging should be avoided as much as possible by using standard containers that can be used in different modes of transport. Current large aircraft have a round hull to enable a pressure vessel. Future aircraft should allow optimal use of container transport.

13.2.7 Regulation

New regulation should be in place for a fast adoption of innovative technology into new products.

A threat could be the discussion about the use of belly freight for safety reasons. If a new regulation will not allow the use of belly freight this will imply a real shock for air cargo industry and a complete change of business models and fleet reorganisation will be needed. This will have an impact also on passenger transport aircraft.

13.3 Long Term 2050

13.3.1 Summary

The most important objectives defined in Flightpath 2050 and addressed in the SRIA are:

- The 4 hour door to door delivery in Europe
- The stringent environmental and safety targets
- The customer oriented decision tools for transport
- The high degree of automation

These long term goals have to be taken into account also for the long term air cargo roadmap.

Specifically designed innovative cargo aircraft and rotorcraft will be developed in EU with zero pollutant emissions, very small noise foot print, and low environmental impact all along the life cycle.

Towards 2050 Europe will have developed alternative fuels like Liquid Natural Gas and Hydrogen to provide power to transport vehicles.

Novel equipment will be available including solar cells mounted on aircraft wings to generate internal power as well as fuel cells which help to make the aircraft “all electric” without the need of bleed air from engines.

The air cargo has the same safety and resilience level of the passenger aircraft and operations.

Free flight and/or free routing are the standard for operations including air cargo.

Fully automated cargo aircraft flying according to autonomous flight rules.

Airports have adopted their rules to allow aircraft bigger than 80x80 meters to be accommodated

A completely new and integrated air cargo industry will be developed capable of door to door service with a seamless freight flow. Adoption of the complete chain of long/medium and short haul aircraft will be in place including very short haul for door to door service.

Customer will be fully aware of alternatives and freight status.

E-freight will be a standard.

13.4 Additional requirements for future developments of Air Cargo

Referring to the SWOT analysis given in chapter 9, and developed in the WP2 of the CARGOMAP project, it is possible to define requirements for the future to improve the strength of air cargo operations, reduce the weaknesses, create new opportunities and turn threats into opportunities.

As stated earlier, the demand for air cargo transportation is depending primarily on the development of GDP. The preference for air transport versus other shipping methods will depend on time to delivery, cost and frequency and reliability of service.

13.4.1 Use the strengths

Speed	Increase the speed of delivery. o The whole transport chain door to door should be improved. o Design faster aircraft; the cost and environmental impact associated with this option could be explored. Low speed aircraft. o This could be an attractive option for some goods to reduce cost and the amount of time critical goods is likely to increase.
Frequency/Reliability/Access	o Depending on the future market there could be a case for more frequent deliveries. This may require smaller aircraft to serve that demand. o Reliability has been one of the big advantages of air transport. Reliability can be improved by making flight operation more resilient to external hazards and by reducing the number of steps in the total transport chain. o Air cargo operations should be able to be delivered virtually everywhere. (Near) door to door delivery by air could be realized. This opens the way to the use of small/regional airports and small aircraft and also to flying urban delivery systems.
Safety and Security	o Special attention needs to be given to cyber war in the future to ensure safe and secure transport operations
No Path Congestion	The increase of air traffic, the use of hubs, night flight limitations

	may create airport congestion. In order to avoid this various requirements may be set: o Develop aircraft with a low noise footprint to allow night operations. o Use of small airports for medium short haul and thus development of appropriate aircraft and change in the current air cargo practice for operations.

13.4.2 Overcome the weaknesses

High costs	o Direct and indirect operating cost of air cargo should be drastically reduced whilst productivity of aircraft should be increased. (*new configurations, structures, aerodynamics, engines with low fuel consumption and alternative aviation fuels use*) o High load factors need to be ensured by creating the right classes of aircraft including family concepts and by optimizing operations.
intermodality potential	Air transport should be part of Intermodal transport. o Customer oriented IT systems are required to enable forwarders to plan, redesign and evaluate their transport plans in an optimal way. o Adaptations to aircraft are required to allow multi-modal transport, reducing the need for repackaging.
Spatial mismatch in the door-to-door chain	One possible solution is to become less dependent on airports. o On long haul flights this could mean creating an airport in the sky from which smaller airplanes could deliver goods near door to door. o The alternative for shorter delivery flights is to seek cheap VTOL and STOL solutions that will enable (nearly) door to door delivery whilst having very low noise emissions.

13.4.3 Exploit the opportunities

Liberalisation of the market	One major element in market development is to set global standards. The current system operates well but new entrants in the air transport market may want to set different standards. o Standards need to be reviewed constantly to see if the standards still fulfil the purpose. o The 80x80 meter box of airports might be revised; currently this prohibits deploying very efficient large aircraft as the span of their slender wings would exceed the current airport limits. o New standards have to be applicable on a global scale via ICAO.
Advanced IT technology	Whereas step changes in aviation occur every 16 years, in IT this happens every 10 month. Aviation should fully explore the benefits of new IT possibilities.

Global growth of trade and globalization	Depending on the geo-political developments, global trade will grow. o Air cargo transport should tailor its services to new demands
New concepts in urban logistics	The urban environment is up to now not a domain for air cargo o New small UAS systems may change this on the condition of being safe. The liability issue will become a major obstacle for the deployment of these systems.
Capacity increase in extra-European airports	o Competition will always be there. Competition should however be based on a level playing field.

13.4.4 Turn threats into opportunities.

Rising oil and fuel costs	o Alternative fuels and advanced engine concepts are needed to ensure low cost operations.
External shocks	o The advantage of aviation is the ability to respond to external developments in a flexible way without having to rely on massive financial government support. This ability should be exploited.
Airport congestion	o We need to think in a creative way to enable aircraft to use the surface. Already the VTOL/STOL options were mentioned. We can also think in terms of amphibious aircraft using the shore lines to deliver goods.
Night restrictions	o If aviation wants to play a significant role in future it needs to develop very low noise flight procedures (CDA, Steep approaches etc.) as well as silent aircraft.

14 Overview of current research and policy initiatives

14.1 EU Scenario

A specific deliverable has been developed in CARGOMAP Project "D3.1 Report on going or planned research". In this section some key elements are provided; for details the specific deliverable should be consulted.

Research projects contributing to the theme of air-cargo sector can be broken down into the following sub-themes:

- Sub-theme 1: Air -cargo in intermodal transport.
- Sub-theme 2: Innovative modes and UAS in air-cargo transport
- Sub-theme 3: Environmental issues
- Sub-theme 4: Security
- Sub-theme 5: Air Traffic Management
- Sub-theme 6: Information and Communication Technologies
- Sub-theme 7: Operations Research and Policy support actions

A short summary of the analysis of the current EU research is presented here below; in the following tables for each subtheme the relevant funded projects are listed.

4.1. Sub-theme 1: Air-cargo intermodal transport.

The subject is quite covered by EC funded projects (see following Table). Main reason is that optimization process in supply chain management is still developing, and it is still far from its maximal potential efficiency. This topic for air transport development is seen to be very important, especially if new ICT technologies in logistics like RFID are taken into consideration.

4.2. Sub-theme 2: Innovative approaches and Unmanned Aerial Systems in air cargo transport.

The area of novel technologies is covered by few projects. The topic concerning generically unmanned air vehicles is also the focus of some projects.

4.3. Sub-theme 3: Environmental issues.

The problem of environment is also relevant from the air freight point of view. Anyhow, only few projects were found to refer strictly to this problem. The reason is that almost all activity in this area is focused on passenger transport.

4.4. Sub-theme 4: Security issues.

Problem broadly covered. It is also one of the most financially supported domains. Not only related to air cargo research, detection of dangerous materials was eagerly financed by the Commission in recent years. It is expected that security related initiatives will be still one of the most priorities in EU transport strategy.

4.5. Sub-theme 5: Air traffic management.

This domain is concerning a very broad area of knowledge. Only one project was found to be relevant to air cargo. It has to be noted that research in Air Traffic Management mainly concerns passenger traffic and is focused on traffic efficiency improvement. The activity concerning cargo management at airports is rather poorly reflected in European research.

4.6. Sub-theme 6: Information and Communication Technologies

It is not easy to find a direct connection among research activities in this field and air cargo. Anyhow, the already mentioned RFID technology is an example of developed relevant technology.

4.7. Sub-theme 7: Operations Research and Policy support actions.

Few initiatives aiming at providing tools, methodologies as well as data concerning transport and logistics are funded. The definition of a European strategy in the air cargo area is very complex; one difficulty is that many different actors of the air cargo supply chain are involved and it is not easy to get solid and open data for forecasting the demand.

Challenge	Area	PROJECTS						
		Sub-section 1: Air cargo intermodal transport	Sub-section 2: Innovative modes and UAS in air cargo transport	Sub-section 3: Environmental issues	Sub-section 4: Security	Sub-section 5: Air Traffic Management	Sub-section 6: Information and Communication Technologies	Sub-section 7: Decision support actions
CHALLENGE 1								
Meeting societal and market needs	Customer-centric mobility	Baltic.AirCargo.Net KOMODA						AIMS ASSEMBLING TRANSTOOLS
	Integrated transport	Baltic.AirCargo.Net BESTFACT iCARGO KOMODA PROMIT ICARUS PARCELCALL RECORDIT	Airships as…				CASAGRAS GRIFS	AIMS ASSEMBLING MOTOS
	Aviation services	AirportNet CHS				ACE		
CHALLENGE 2								
Maintaining and extending industrial leadership	Policy							
	Technology				FLY-BAG2			CAESAR EUTRALOG
	Innovation		ESTOLAS MAAT RECONNECT VEATAL					CARGOMAP

Relevancy level	
	High
	Medium
	low

Figure 116: Overview of EU scenarion in regard projects

CHALLENGE 3								
Protecting the environment and energy supply	Air vehicle	BESTFACT iCARGO	ALICIA FANTASIE	AWINET2000+ GHG-TRANSPORD				
	Air transport system		iFLY	COFRET				
	Sustainable energies							
CHALLENGE 4								
Ensuring safety and security	Digital society				EUROSKY		CASAGRAS GRIFS	
	Automation	Balti AirCargo.Net PARCELCALL	iFLY ALICIA INOUI SOFIA		EUROSKY EXPLO-NOSE LOTUS OPTIX SNIFFER TINA			
	Customer experience	AirportNet			ATOM DOGGIES I-SENSE PREVAIL	ACE		

Figure 117: Overview of EU scenarion in regard projects

14.2 International Scenario

As air cargo plays a leading role in the transportation system as a critical enabler of trade and wealth it requires that its procedures, processes and its supporting standards become aligned with today's challenges and opportunities.

Basically the following regulations serve as the basis for the air cargo operations:

- Chicago Convention (Convention on International Civil Aviation, 1944) contains the basic principles relating to international transport of dangerous goods by air.
- Warsaw Convention: it regulates liability for international carriage of persons, luggage or goods performed by aircraft for reward.
- Montreal Convention (Convention for the Unification of certain Rules for International Carriage by Air Signed at Montreal, 1999): it re-establishes urgently needed uniformity and predictability of rules relating to the international carriage of passengers, baggage and cargo.
- Annexes 1 to 18 of the Convention on International Civil Aviation

14.2.1 Regulation

The modernization of the global air cargo regulatory framework and the establishment of partnerships with the leading international State and industry agencies enables ICAO to take over the previously mentioned demand. The main objectives controlling all these activities are the followings (ref. [1]):

- Air cargo and mail security and facilitation.
- Maintaining or improving all aspects of air cargo safety.
- Evolving from paper-based to electronic solutions.
- Minimizing air cargo's environmental footprint.
- Liberalizing market access for air cargo services.

<u>Air cargo and mail security and facilitation</u>

The regulation and guidance materials in regard security and facilitation of air cargo and mail are the following:

- ICAO Annex 17, Aviation Security
- ICAO Annex 9, Facilitation
- Doc 8973, Aviation Security Manual
- Doc 9957, Facilitation Manual

The *12th revision of Annex 17* (adopted on 16 November 2012) applies stricter security standards in order to enhance the overall security of air transport operations all around the world. These new procedures put emphasize on more extensive screening of freight and mail before loading them to the aircraft and better protection from illegal intervention between the security control and the departure of the aircraft.

The aim of the '*one-stop-security concept*' is based on the recognition that the equivalency of the security regimes (within ICAO Member States) allows the incoming baggage and cargo to the transfer onto a connecting flight without being subjected, once again, to the same security controls as the point of origin. Currently, Annex 17 only explicitly allows these kind of arrangements to be concluded in respect of certain security controls.

Maintaining or improving all aspects of air cargo safety

The below materials are related to the maintenance and improvement of air cargo safety:

- Regulation and Guidance Materials
- ICAO Annex 18, Safe Transport of Dangerous Goods by Air
- Technical Instructions for The Safe Transport of Dangerous Goods by Air (Doc 9284)
- Emergency Response Guidance for Aircraft Incidents Involving Dangerous Goods (Doc 9481)
- Dangerous Good Training Manual (Doc 9375P1)

The '*Known shippers*' programme was implemented by United States Department of Homeland Security (DHS) to ensure the safety of air traffic within the United States. Its goal is to eliminated anonymous shipment of freight on both passenger and cargo flights originating within the USA.

Canada also started an '*Air Cargo Security Programme*' which "to ensure that air cargo shipments are protected from the threat of terrorism and to help exporters move cargo securely and efficiently" (ref. [2]).

Evolving from paper-based to electronic solutions

The 'Convention for the Unification of Certain Rules for International Carriage by Air' document guides the evolvement from paper-based to electronic solutions.

The e-freight programme's was initiated by IATA. Its main goal is to replace the paper based documentation with the exchange of electronic data and messages. It became an industry-wide initiative involving carriers, freight forwarders, ground handlers, shippers, custom brokers and customs authorities.

Minimizing air cargo's environmental footprint

The *Kyoto Protocol* to the United Nations Framework Convention on Climate Change (UNFCCC) is an international agreement that sets binding obligations on industrialised countries to reduce emissions of greenhouse gases. It was adopted by Parties to the UNFCCC in 1997, and entered into force in 2005 [2].

In parallel with the Kyoto Protocol some countries introduced an *Emissions Trading System* which is a system where the total amount of emissions is considered and allowances (in the form of permits to emit CO_2) can be bought and sold to meet emission reduction objectives [1]. Beside the European Union Emissions Trading System (EU ETS), also the United States, Japan, Australia has started a similar programme. ICAO is to coordinate different initiatives.

The 'New guidance material to replace Circular 303 Operational Opportunities to Reduce Fuel Burn and Emissions' document deals with the environmental sustainability of air cargo.

The new noise certification standard, which regards the new aircraft designs, was introduced on 1 January 2006. ICAO's '*Balanced Approach*' provides a clear process for the management of noise problem on an airport-by-airport basis that ICAO urges to be implemented by all regulators worldwide.

Liberalizing market access for air cargo services

The following materials guarantee guidance and regulation support to the liberalization of the market:

- Reports of the Sixth Worldwide Air Transport Conference (including conclusions and recommendations on item 2.1/2)
- Doc 9587, Appendix 5, Template Air Services Agreement (TASA)
- Annex III on air cargo services
- Doc 9626, Manual on Regulation of International Air Transport

The commercial sides of international air transportation are covered by bilateral agreements between countries, however these agreements sometimes do not differentiate between passenger and cargo flights although these latter has a different traffic structure. The result of this that the cargo airlines often face restrictions at some airports.

In regard the '*Granting of traffic rights*' one attitude ICAO could take into account is the development of a specific international agreement that enables the further liberalization of all cargo services.

IATA is working on common standards and industry initiatives together with its member airlines and representatives from the air freight supply chain. In this order IATA established several work groups and committees on the fields of:

- strategy & policy,
- operations & handling,
- security, customs & trade facilitation,
- and e-Cargo.

14.2.2 Research

Several companies/ institutes are running research programmes on the field of aviation and air freight.

The International Air Cargo Association (TIACA) supports innovation and research projects in order to improve air freight transportation thorough its 'Research and Education Committee'.

The *Boeing Company* runs several research projects in order to map the future expectation of its customers in regard the future airplanes.

In the Unites States of America the *Federal Aviation Administration* (FAA) is in charge of the researches. They cover several areas such as Airports, Environment, or airport systems (ref. [3])

The *Air Cargo Advance Screening (ACAS)* pilot project is a joint effort controlled by the Transportation Security Administration (TSA) and Customs and Border Protection (CBP) Agency in the United States of America. Its aim is to test and implement baseline requirements that carriers pre-file information on all air shipments in advance of loading using CBP's Automated Targeting System (ATS).

Currently the pilot includes amongst others American Airlines, Delta, Lufthansa, and British Airways, DHL Global Forwarding, FedEx Trade Networks, BDP International, SEKO and Kuehne + Nagel.

In Australia the *Australian Government's Department of Infrastructure and Transport* supports the external researchers and research organisations in order to make sure relevant research is being translated into policy-making.

15 Air Cargo Roadmap

In this chapter the Air Cargo Roadmap developed by the CAGOMAP project is presented.

It is structured in three chapters:

- Innovative Air Vehicles to serve the future air cargo market
- The Issue of a new air cargo container
- The synchro/inter-modal initiatives
- The Research Roadmap

A clear reference to the short (2020), medium (2035) and long (2050) term is provided for the proposed air vehicles and research topics.

15.1 Innovative air vehicles to serve the future air cargo market

CargoMap proposed and analysed a number of alternative solutions that may serve future demands in air cargo. These solutions relate to types of aircraft, operational concepts and new business models.

CargoMap has identified 18 different types of aircraft configurations that could serve the air cargo market starting from 2030.

In the following table these proposed solutions are listed highlighting the relevance with respect to three major key performance indicators:

- Speed
- Cost
- Frequency

Additional remarks are also provided.

Then the 18 solution are presented in more details and a qualitative evaluation is performed in order to score the best options. The evaluation is made adopting the metric defined in the following table.

Proposal	Key Parameter	Time	Cost			Productivity			Frequency
		Higher speed to delivery	High Load factor	Lower DOC	Lower IOC	Higher Speed	Larger Capacity	Increased Utilization	Higher Frequency of service
Reference A/C	Payload (tons)	ref	ref	ref	ref	Ref	ref	ref	ref
Proposed A/C	Payload (tons)								

Table 11: Evaluation table - template

Here, the qualitative evaluation is made assigning to each parameter a value ranging from "----"up to "+++".

The proposed evaluation can be improved in future by providing the scoring on the base of some computation instead of quantitative evaluations.

Type	Speed focus	Cost focus	Frequency focus	Remarks
Long haul				
Very large WIGE aircraft, payload 680 tons		☺		Could also be an amphibious aircraft
Very large subsonic aircraft, payload 300 tons		☺		Also for outsize cargo requirements
Novel subsonic aircraft based on BWB technology, payload 100 tons		☺		Same speed as today but at reduced cost. Use of standard containers. Should be developed into a family concept.
Slow flying aircraft with payload of 100 tons		☺		Will be very environmentally friendly
Supersonic cargo aircraft	☺		☺	Speed range could go from M1,3 up to M 2,5
Hypersonic air cargo aircraft	☺		☺	Could fly between Mach 5 and 8
Morphing subsonic aircraft able to perform formation flights		☺		Aircraft would be able to fly in close formation of a few wingspans
Small aircraft that could be joined in flight to gain fuel efficiency and allow small cargo volumes to be delivered			☺	Aircraft would depart at different locations, join up in the air to create an efficient large flying body and leave the formation near to the destination
small aircraft with intercontinental range			☺	Aircraft would fly dedicated to high value cargo

Type	Speed focus	Cost focus	Frequency focus	Remarks
Medium / short haul				
10. New large medium haul aircraft with > 100 tons capacity		☺		
11. Large Airship		☺		Type of HULA airship
12. New regional air cargo aircraft with a capacity of 50 tons		☺		
13. Tilt rotor aircraft with a capacity of 20 tons	☺		☺	The speed would be improved due to an almost door to door delivery
14. Advanced rotorcraft with payload of 10-20 tons	☺		☺	Make use of advanced VTOL/STOL concepts The speed would be improved due to an almost door to door delivery
15. Advanced small aircraft	☺		☺	Could make use of fanwing concept
16. Advanced small aircraft	☺		☺	10 tons payload
17. Replacement of Cessna caravan type of aircraft		☺		4 tons payload
Urban flying vehicles				
18. UAS systems	☺	☺	☺	

15.1.1 Very large WIGE aircraft

A ***W***ing ***I***n ***G***round ***E***ffect (***WIGE***) aircraft can be very big as it benefits from lift generated by the boundary layer above the ground or sea. In the past there has been research on WIGE aircraft in Europe. However only the Russian companies actually produced these kind of aircraft.

The US industry has proposed very large WIGE aircraft for strategic transport of the US military recently. It would fly close to the earth at speeds of about Mach 0.39. It could haul up to 680 tons of cargo.

The advantage of such an aircraft would be the enormous load that can be carried.

Disadvantages would also exist:

- Such a large payload would mean that frequency of service is less than current practice in aviation
- The aircraft needs quite stable sea states to operate
- The low speed would require more crew on board unless it can be flown without a pilot

As it is expected that time critical goods will become more important in air cargo, this aircraft would only be able to fill a very specific part of the market demand. It would basically serve the market of large capital goods.

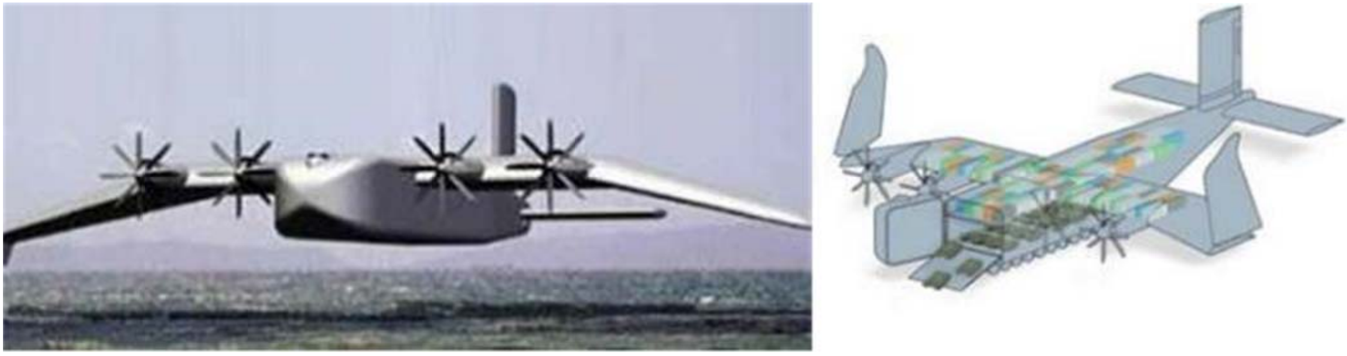


Figure 118: Pelican aircraft (Boeing)

Figure 119: WIGE aircraft concepts

Source: Beriev and Out of the Box

The qualitative assessment of this configuration is presented in the following table:

Proposal	Key Parameter	Time	Cost			Productivity			Frequency
		Higher speed to delivery	High Load factor	Lower DOC	Lower IOC	Higher Speed	Larger Capacity	Increased Utilization	Higher Frequency of service
Reference A/C B777	Payload (tons) 100 tons	ref	ref	ref	ref	Ref	ref	ref	ref
Proposed A/C WIGE	Payload (tons) 680	---	--	+	--	---	++++	---	----

Table 12: Qualitative assessment - WIGE

The WIGE biggest advantage is the huge payload. This would result in lower cost per Kg shipped but there are some drawbacks: longer time to delivery, higher crew cost, high acquisition cost due to limited production run, lower utilization and possibly lower load factors, lower frequency of flights. The aircraft will require new ground infrastructure.

15.1.2 Very large subsonic aircraft

The very large aircraft would be able to carry in the order of 300 tons of payload. Currently no engines exist that could power such an aircraft unless a large number of engines is used. Production would be limited which could also result in high DOC.

The aircraft could be a single fuselage or dual/ triple fuselage. It could be an amphibious air craft as no airport would currently be able to handle such an aircraft.

Possible configurations could look like it is shown in the next pictures.

Figure 120: Very large subsonic aircraft concepts

Sources: Out of the Box, NASA, Boeing

The qualitative assessment of this concept is presented in the table below:

Proposal	Key Parameter	Time	Cost			Productivity			Frequency
		Higher speed to delivery	High Load factor	Lower DOC	Lower IOC	Higher Speed	Larger Capacity	Increased Utilization	Higher Frequency of service
Reference A/C B777	Payload (tons) 100 tons	ref	ref	ref	ref	Ref	ref	ref	ref
Proposed A/C Large subsonic cargo plane	Payload (tons) 300	Same as ref	-	--	--	Same as ref.	+++	--	--

Table 13: Qualitative assessment - Very large subsonic aircraft

The aircraft would focus on a heavy load whist flying at the same speed as the current generation of air cargo aircraft. Depending on the configuration the aircraft would be expensive to develop and operate. But if production could be combined with a military application or if existing fuselages could be merged, the development cost could be reduced. Therefore it is difficult to estimate the DOC as it all depends on the configuration chosen. The development of dedicated engines should be avoided to reduce development cost. The airport infrastructure may need some modifications to accommodate such a heavy aircraft.

Cost per Kg ferried may be lower than current aircraft, depending on the volume of trade and the load factor.

15.1.3 Qualitative assessment - WIGE

This concept is focusing on a very efficient aircraft to replace the B777 type of aircraft. It would be a Blended wing body type of airplane. The airplane would have a modular concept so that a family of aircraft could be developed to tailor the aircraft to market needs.

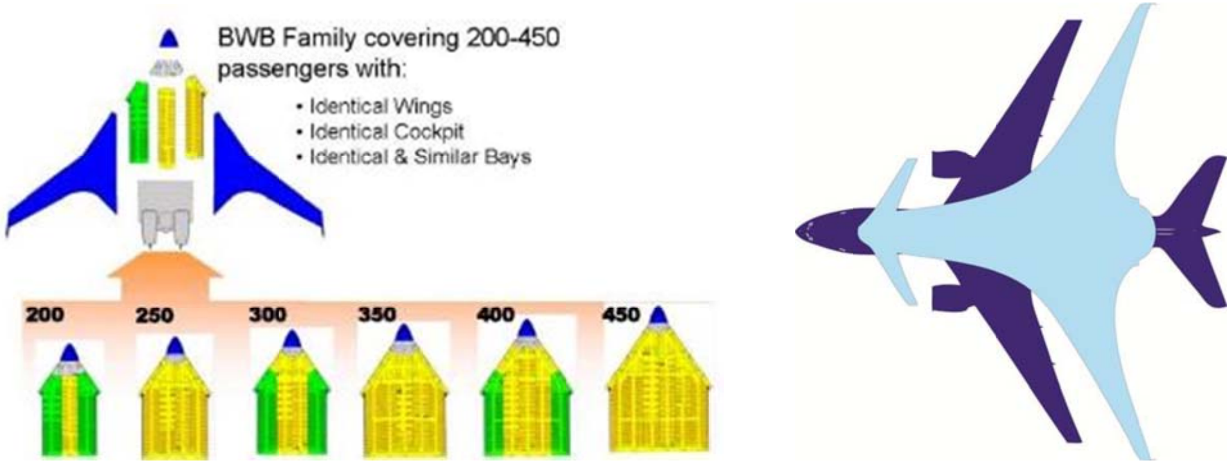


Figure 121: Very efficient subsonic aircraft

Illustration: Boeing and the Ahead project (BWB and B777 dimensions)

The size would be the same as current aircraft, thus the aircraft would fit in the current 80x80 meter box.

If the aircraft would be a pilotless aircraft, the need for a pressurized hull would be absent if appropriate containers are used. That would make the aircraft simple and cheap to produce. It could be optimized for container transport (either carrying cargo or passengers).

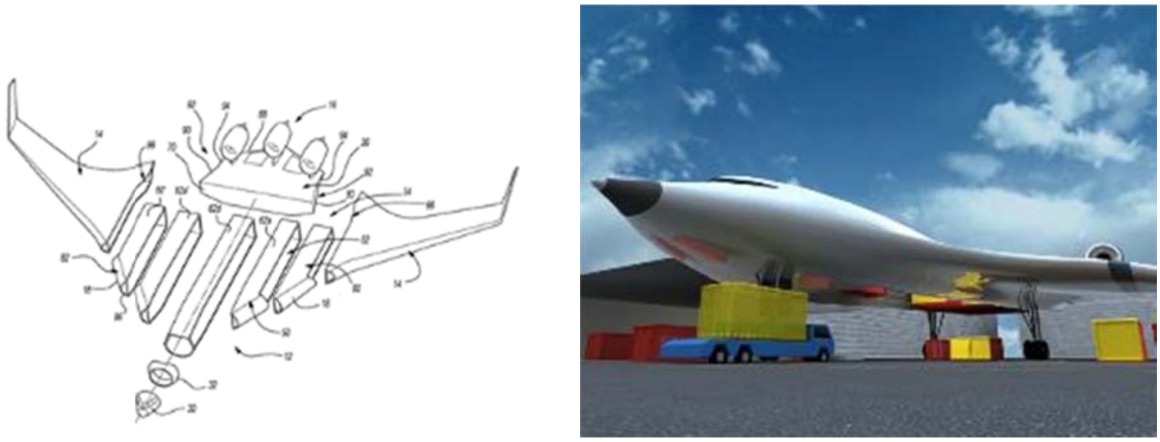


Figure 122: Very efficient subsonic aircraft concepts

The use of standard containers would reduce the need for repackaging which could speed up the actual delivery time even if the aircraft does not fly at a higher speed.

At this point in time already some research is performed on the BWB aircraft configuration. Special interest exists in the pitch up behaviour of the configuration. The aircraft could be a double deck lay out so that a combi-aircraft could also be developed.

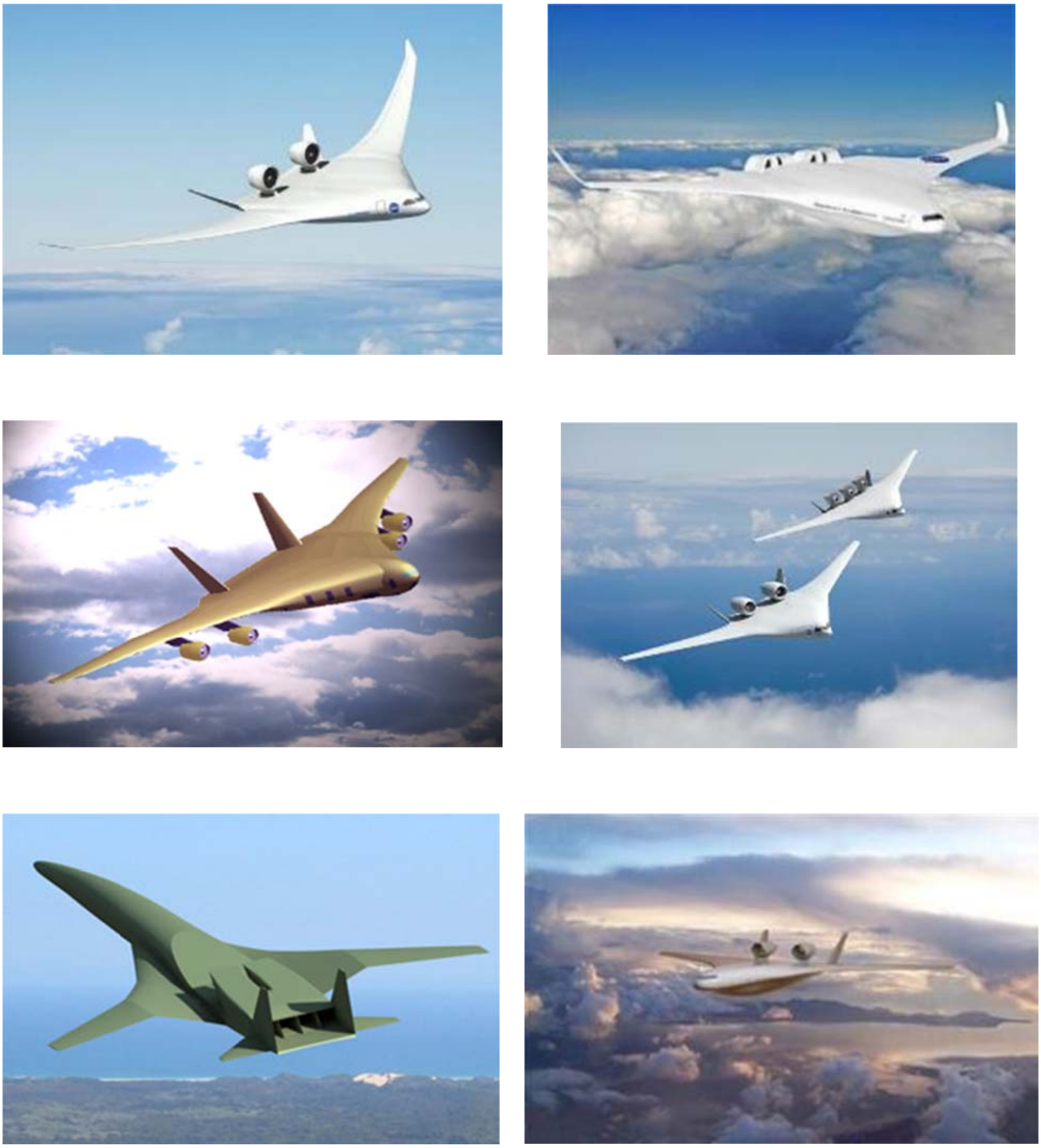


Figure 123: Very efficient subsonic aircraft concepts

Pictures by Boeing, Cranfield, Airbus, Tsagi, NASA

The qualitative assessment is presented in the following table.

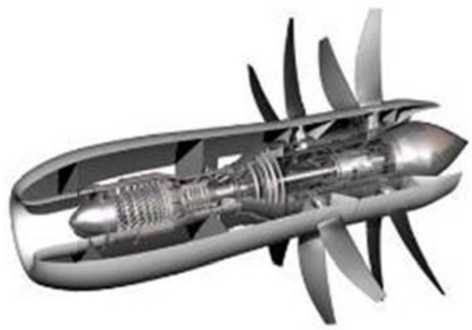
Proposal	Key Parameter	Time	Cost			Productivity			Frequency
		Higher speed to delivery	High Load factor	Lower DOC	Lower IOC	Higher Speed	Larger Capacity	Increased Utilization	Higher Frequency of service
Reference A/C B777	Payload (tons) 100 tons	ref	ref	ref	ref	Ref	ref	ref	ref
Proposed A/C Efficient cargo plane (BWB)	Payload (tons) 100	+	+	+++	++	same	+	+	+

Table 14: Qualitative assessment - Very efficient subsonic aircraft

Based on the Qualitative assessment the BWB aircraft configuration looks very promising. The cost of flying would be substantially lower than current aircraft. Loading and off-loading would be simple thanks to lifts that give direct access to the cargo hold. This would reduce turn-around times. As the aircraft could have a square fuselage rather than a tube, the internal volume of the aircraft could be used in an optimal way.

15.1.4 Slow flying subsonic aircraft

The aircraft would be designed to reduce emissions. Flying lower and slower may reduce GHG emissions. The aircraft could make use of unducted fans that are currently under development and would represent the optimum configuration of the turbofan engine with lower SFC even if the propellers will produce more noise than ducted fans.



.

Figure 124: Slow flying subsonic aircraft concepts

Illustration by OoB, Bauhaus and Safran

The qualitative assessment is presented in the following table.

Proposal	Key Parameter	Time	Cost			Productivity			Frequency
		Higher speed to delivery	High Load factor	Lower DOC	Lower IOC	Higher Speed	Larger Capacity	Increased Utilization	Higher Frequency of service
Reference A/C B777	Payload (tons) 100 tons	ref	ref	ref	ref	Ref	ref	ref	ref
Proposed A/C Slower aircraft	Payload (tons) 100	+/-	Same as ref	++	Same as ref	--	Same as ref	Same as ref	Same as ref

Table 15: Qualitative assessment - Slow flying subsonic aircraft concepts

The analysis shows that although the aircraft speed is lower, the time to doorstep delivery may not be reduced so much. The cost would be substantially lower due to lower fuel cost.

15.1.5 Supersonic cargo aircraft

The only supersonic civil airliners that we produced in the past were the Concord and the TU-144. Both had a very limited payload, but high speed (Up to Mach 2.5). The TU-144 was used in Russia to transport mail from Siberia to Moscow.

As the cost of supersonic flight are high because of the high fuel consumption of the engines at the time of operations, the aircraft mentioned above were withdrawn. They served a very small segment in the air transport market.

Thanks to improved aerodynamics and very powerful engines, military fighter aircraft can reach supersonic speeds (super cruise) without using afterburners. However the fuel consumption is still very high in that case.

Over the past years much research at NASA has been devoted to the reduction or even elimination of the sonic boom. Latest research results show that the noise on the ground can be reduced but the sonic boom cannot be avoided. That means that acceleration to supersonic speeds can only occur over water or uninhabited areas.

It is expected that supersonic aircraft could be developed to serve the high end of the passenger market and especially the business market. A [illegible] he cargo market will require supersonic flying.

Figure 125: Supersonic cargo aircraft concepts

Picture by Boeing and ADSE

The qualitative assessment is presented in the following table.

Proposal	Key Parameter	Time	Cost			Productivity			Frequency
		Higher speed to delivery	High Load factor	Lower DOC	Lower IOC	Higher Speed	Larger Capacity	Increased Utilization	Higher Frequency of service
Reference A/C B777	Payload (tons) 100 tons	ref	ref	ref	ref	Ref	ref	ref	ref
Proposed A/C Supersonic	Payload (tons) 100	+++	--	---	--	++++	--	++	+

Table 16: Qualitative analysis - Supersonic cargo aircraft concepts

The environmental consequences of flying at high speed are unknown but are expected to be substantial compared to subsonic aircraft.

One interesting option which has not been given much attention lately is an aircraft flying at Mach 1.3 instead of Mach 2.5. These aircraft would be much more fuel efficient than aircraft flying at higher speeds and still provide the advantage of higher speed, thus the possibility of higher daily usage, at much lower cost than traditional supersonic aircraft flying at Mach 2.

15.1.6 Hypersonic cargo aircraft

Some research is going on related to hypersonic aircraft (wave riders, aircraft skimming the atmosphere, space planes). Most of the research is military oriented, aimed at developing bombers to reach every point on earth within 2 hours. Surprisingly the European Commission has invested relatively large sums of money in hypersonic aircraft research for passenger aircraft flying at Mach 5-8. The research was initiated by ESA aimed at alternative ways to launch spacecraft without using rockets. Such transport would be a very expensive way of travel and it is unclear why the Commission is spending scarce resources for this type of research.

The environmental impact of these types of aircraft is still unknown, but it can be assumed that it will be severe.

It is unlikely that cargo would have such a high priority that hypersonic transport would be needed.


Figure 126: Hipersonic cargo aircraft

Illustrations USAF and DLR

The qualitative assessment is presented in the following table.

Proposal	Key Parameter	Time	Cost			Productivity			Frequency
		Higher speed to delivery	High Load factor	Lower DOC	Lower IOC	Higher Speed	Larger Capacity	Increased Utilization	Higher Frequency of service
Reference A/C	Payload (tons)	ref	ref	ref	ref	Ref	ref	ref	ref

Proposal	Key Parameter	Time	Cost			Productivity			Frequency
		Higher speed to delivery	High Load factor	Lower DOC	Lower IOC	Higher Speed	Larger Capacity	Increased Utilization	Higher Frequency of service
B777	100 tons								
Proposed A/C Hypersonic	Payload (tons) 100	+++	--	---_	---	+++	---_	+	+

Table 17: Hipersonic cargo aircraft

15.1.7 Morphing aircraft suitable for formation flight

The idea for formation flight stems from birds. It is expected that flying within a few wingspans from each other aircraft might save up to 20% fuel due to drag reduction. The following aircraft would benefit from the upward lift created by the vortex of the aircraft flying in front. In order to compensate for the a-symmetrical lift the wing would need to be morphing.

Figure 127: Morphing aircraft suitable for formation flight

Aircraft would fly in formation over long distances and at a suitable point the formation would break up to allow aircraft to fly to their final destination. Research already showed that a large part of the current long haul flights could be flown in formation. Due to the time zones in the world, many aircraft depart on international routes more or less at the same time.

The advantage of fuel reduction should be compared to the disadvantage of having to form a formation that could reduce flexibility of cargo flights as operators would need to wait until a formation is created.

Although fuel can be reduced the installation effects (additional production cost, weight and maintenance) of a morphing wing has to be taken into account. This means that a good cost benefit analysis is needed.

Although formation flight could have big advantages for passenger aircraft, the benefits for all cargo aircraft need to be investigated further as there are not so many cargo flights unless the cargo aircraft can join passenger aircraft in the same formation.

The qualitative assessment is presented in the following table.

Proposal	Key Parameter	Time	Cost			Productivity			Frequency
		Higher speed to delivery	High Load factor	Lower DOC	Lower IOC	Higher Speed	Larger Capacity	Increased Utilization	Higher Frequency of service
Reference A/C B777	Payload (tons) 100 tons	ref	ref	ref	ref	Ref	ref	ref	ref
Proposed A/C Formation Flight	Payload (tons) 100	Same as ref	Same as ref	+	Same as ref	Same as ref	Same as ref	Same as ref	Same as ref

Table 18: Qualitative assessment - Morphing aircraft suitable for formation flight

15.1.8 Joined small aircraft

This concept was the initiator of formation flight proposals. Rather than flying in a formation to benefit from the wake of the preceding aircraft, in this concept aircraft could actually be joined together in the air. Such a formation could look like this:

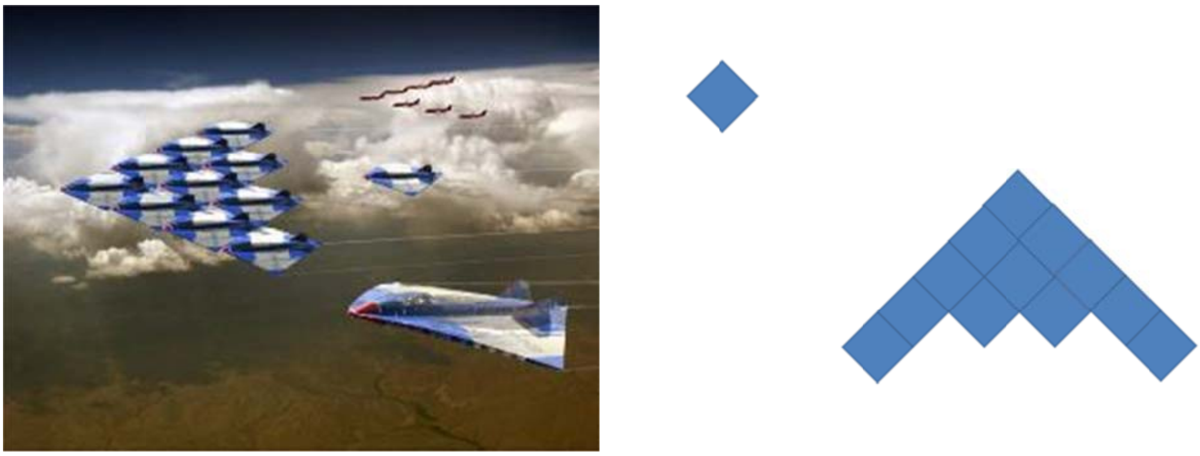


Figure 128: Joined small aircraft concepts

There are numerous issues to be investigated:

- Is it feasible to join in flight as turbulence behind the aircraft may make it impossible to link aircraft in flight

- Or should aircraft take off in formation and leave the formation in flight as soon as they are near their final destination. (If aircraft would need to take off in formation the combined aircraft cannot be bigger than 80x80 meters.)
- How can a rigid structure be created from coupled aircraft
- What is the optimal load the smaller aircraft should carry
- How big should the aircraft be

The small size of the aircraft would be make it suitable to carry high priority cargo and parcels. This high priority would come at a high cost. Having the future business models in mind this could be interesting for high priority items like spare parts. However these could in future also be produced locally using 3D printing.

The qualitative assessment is presented in the following table.

Proposal	Key Parameter	Time	Cost			Productivity			Frequency
		Higher speed to delivery	High Load factor	Lower DOC	Lower IOC	Higher Speed	Larger Capacity	Increased Utilization	Higher Frequency of service
Reference A/C B777	Payload (tons) 100 tons	ref	ref	ref	ref	Ref	ref	ref	ref
Proposed A/C Joined Small Aircraft	Payload (tons) 100	+++	++	----	Same as ref	Same as ref	----	--	+++

Table 19: Qualitative assessment - Joined small aircraft concepts

15.1.9 Small long haul aircraft

A final concept could be a long haul aircraft that would carry small loads. The payload would be high value and high priority. Payload could range from 40 tons to 10 tons.

Again the advantage is the high speed of delivery but the cost would be very high. So the aircraft would serve a very special market.

In general it is not likely that the amount of very high cost items would justify to develop a dedicated aircraft. It is more likely that if a demand develops, the aircraft would be a derivative of existing smaller aircraft.

Figure 129: Small long haul aircraft concepts

The qualitative assessment is presented in the following table.

Proposal	Key Parameter	Time	Cost			Productivity			Frequency
		Higher speed to delivery	High Load factor	Lower DOC	Lower IOC	Higher Speed	Larger Capacity	Increased Utilization	Higher Frequency of service
Reference A/C B777	Payload (tons) 100 tons	ref	ref	ref	ref	Ref	ref	ref	ref
Proposed A/C Small long haul	Payload (tons) 100	+++	++	----	Same as ref	Same as ref	----	--	+++

Table 20: Qalitative assessment - Small long haul aircraft

15.1.10 Large medium haul aircraft

This concept is an aircraft for large capacity. This approach would lower the cost per Kg of freight. In the past this concept was also promoted by Airbus to enable an easy way to cross the Alps and to open up the economic regions in Eastern Europe.

The use of large aircraft would require the use of regional airports and local transport to the final customers. This hybrid transport option would combine the best possible low cost options.

The success of this option depends on the volume of air cargo to be transported.

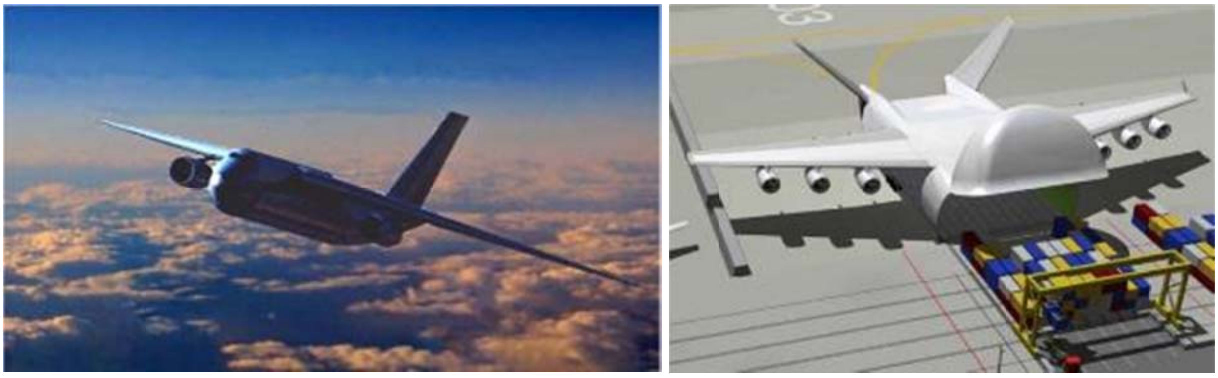


Figure 130: Large medium haul aircraft concepts

Illustrations by TU Delft and Airbus

The quantitative assessment of this concept is shown in the following table.

Proposal	Key Parameter	Time	Cost			Productivity			Frequency
		Higher speed to delivery	High Load factor	Lower DOC	Lower IOC	Higher Speed	Larger Capacity	Increased Utilization	Higher Frequency of service
Reference A/C B777	Payload (tons) 100 tons	ref	ref	ref	ref	Ref	Ref	ref	Ref
Proposed A/C Large medium Haul (Cargoliner)	Payload (tons) 120 and more	+	-	+	+	Same as ref	++	-	--

Figure 131: Quantitative assessment - Large medium haul aircraft

15.1.11 Large airship

For several years the idea to use an airship has been popular with those who promote flying with low emissions.

Several projects were started to develop novel rigid airships but all failed. The cost of operating an airship are extremely high. It needs special ground infrastructure and water to create ballast when cargo is off-loaded.

Quite recently the Walrus HULA (Hybrid Ultra Large Airship) had been proposed in the USA on request of DARPA as a possible vehicle to satisfy military needs. DARPA said that advances in envelope and hull materials, buoyancy and lift control, drag reduction and propulsion have combined to make this concept feasible. Technologies to be investigated in the initial study phase included vacuum/air buoyancy compensator tanks, which provide buoyancy control without ballast, and electrostatic atmospheric ion propulsion. In the end Congress killed the program by refusing to fund it.

On the other hand, since its demise, a commercial partnership involving Boeing and Canada's SkyHook International Inc. has arisen to create the JHL-40 HLV, a craft whose characteristics closely parallel the intended Walrus demonstrator. Other commercial ventures are underway by firms like Lockheed Martin and HAV, and a couple of small DARPA and NASA contracts under much more modest programs are developing key components and technologies required for any HULA military transport. In 2013, Aeros rolled out a 75m airship demonstrator that was partly developed with these public funds.

Aeros unveils the 75 meter, 36,000 pound "Dragon Dream" airship prototype, built with funding from DARPA, OSD, and NASA. Dragon Dream uses Aeros' system of helium compression to vary its buoyancy, along with vectored propellers and body shape in order to produce lift. A rigid structure made of carbon fibre and aluminium is covered by silver Mylar polyester. Tests have been conducted indoors, and an outdoor test is expected in 2013.

Figure 132: Large airship

The proposed airship would be able to haul 500-1000 tons at a speed of 90-160 Km per hour. Inherent to the use of airships are the operational limitations. As weather change is likely to be the result of global warming, the useability of the airship may be very restricted.

Also the airship would need to be able to cross the mountains in Europe like the Alps and the Pyranees.

It is still difficult to estimate the cost of operating the HULA. The DOC may be very low per Kg but the infrastructure cost are probably high resulting in high indirect operating cost.

The qualitative assessment is shown in the following table.

Proposal	Key Parameter	Time	Cost			Productivity			Frequency
		Higher speed to delivery	High Load factor	Lower DOC	Lower IOC	Higher Speed	Larger Capacity	Increased Utilization	Higher Frequency of service

Proposal	Key Parameter	Time	Cost			Productivity			Frequency
		Higher speed to delivery	High Load factor	Lower DOC	Lower IOC	Higher Speed	Larger Capacity	Increased Utilization	Higher Frequency of service
Reference A/C B777	Payload (tons) 100 tons	ref	ref	ref	Ref	Ref	Ref	ref	ref
Proposed A/C HULA	Payload (tons) 500 and more	-----	++	---	---	-----	++++	-----	------

Table 21: Qualitative assessment - Large airship

15.1.12 New regional aircraft with a payload of 50 tons

The aircraft would a successor of the B767 type of aircraft (payload 52 tons) and the A400 type (40 tons). The aircraft could be based on a BWB aircraft concept.

An alternative could be an aircraft that could integrate cargo containers.

Figure 133: New regional aircraft with a payload of 50 tons

Compared to the concept number 10, the aircraft would allow more flexibility as the cargo load would be smaller. It is envisaged that the aircraft could be powered by super conductive electro engines as currently explored by Bauhaus and others. At the moment the batteries are not efficient enough to power an aircraft but future battery development may allow the concept.

Figure 134: New regional aircraft with a payload of 50 tons

Bauhaus Illustration

The qualitative assessment is shown in the following table.

Table 22: Qualitative assessment -

Proposal	Key Parameter	Time	Cost			Productivity			Frequency
		Higher speed to delivery	High Load factor	Lower DOC	Lower IOC	Higher Speed	Larger Capacity	Increased Utilization	Higher Frequency of service
Reference A/C B777	Payload (tons) 100 tons	ref	ref	ref	Ref	Ref	Ref	ref	ref
Proposed A/C New regional A/C (Airlifter)	Payload (tons) 50	Same as ref	+	++	++	Same as ref	Same as ref	Same as ref	Same as ref

15.1.13 Tilt rotor aircraft with a capacity of 20 tons

Tilt rotor aircraft were developed to meet military requirements. These aircraft combine the VTOL characteristics of the helicopter with high cruise speed. Tilt rotor aircraft enable door to door delivery but the development cost and the operational cost are high whilst noise is a critical issue. Sufficient experience has been gained with the V-22 operations to ensure safe operations.

Several concepts have been developed to improve the tilt rotor technology. The proposed aircraft could have the same payload as the B737/ A 320 class of aircraft. For air crago operations the aircraft would need a square fuselage to be able to carry standard containers.

Although the concept is attractive the operational cost may be high which would not satisfy the request for very low cost. The minimum requirement would be to halve the cost of current solutions for regional transport.

Several concepts exist: swivel the engines, the wing or part of the wing.

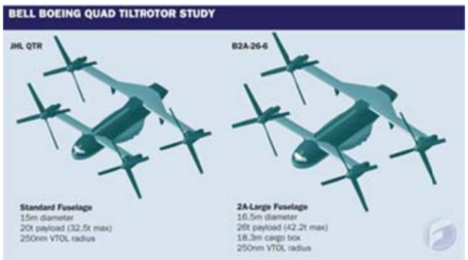


Figure 135: Tilt rotor aircraft with a capacity of 20 tons

Picture by Bell Boeing, OoB

The quantitative assessment is shown in the table below.

Proposal	Key Parameter	Time	Cost			Productivity			Frequency
		Higher speed to delivery	High Load factor	Lower DOC	Lower IOC	Higher Speed	Larger Capacity	Increased Utilization	Higher Frequency of service
Reference A/C B777	Payload (tons) 100 tons	ref	ref	ref	Ref	Ref	Ref	ref	ref
Proposed A/C Tilt Rotor (Airlifter)	Payload (tons) 50	++++	++	---	++	--	Same as ref	+	++

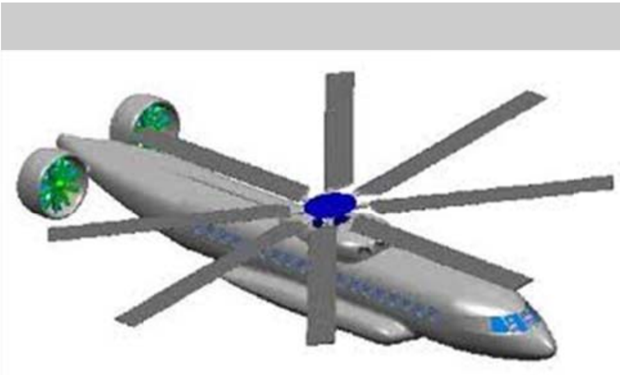
Table 23: Quantitaive assessment - Tilt rotor aircraft with a capacity of 20 tons

15.1.14 Advanced fast rotorcraft

The helicopter allows on the spot delivery. However the helicopter has some drawbacks as well: high cost, low speed and some safety issues related to the dead man’s curve.

Several concepts have been developed over the years to increase the forward speed of helicopters: The compound helicopter, disc rotor, the stowed rotor, the stopped rotor where the rotor acts as a wing, swivel rotor etc. Some of these concepts need further development to see if low cost solutions are feasible. Noise is also an issue.

One cost effective solution is the Autogyro where the rotor turns thanks to forward speed of the craft. As the rotor is not powered the construction is much simpler than a helicopter. The disadvantage of the autogyro is the need for a short runway to take off and land. In the USA a new interest exists to develop autogyros for parcel services, which would enable near door to door delivery at much lower cost than helicopters.



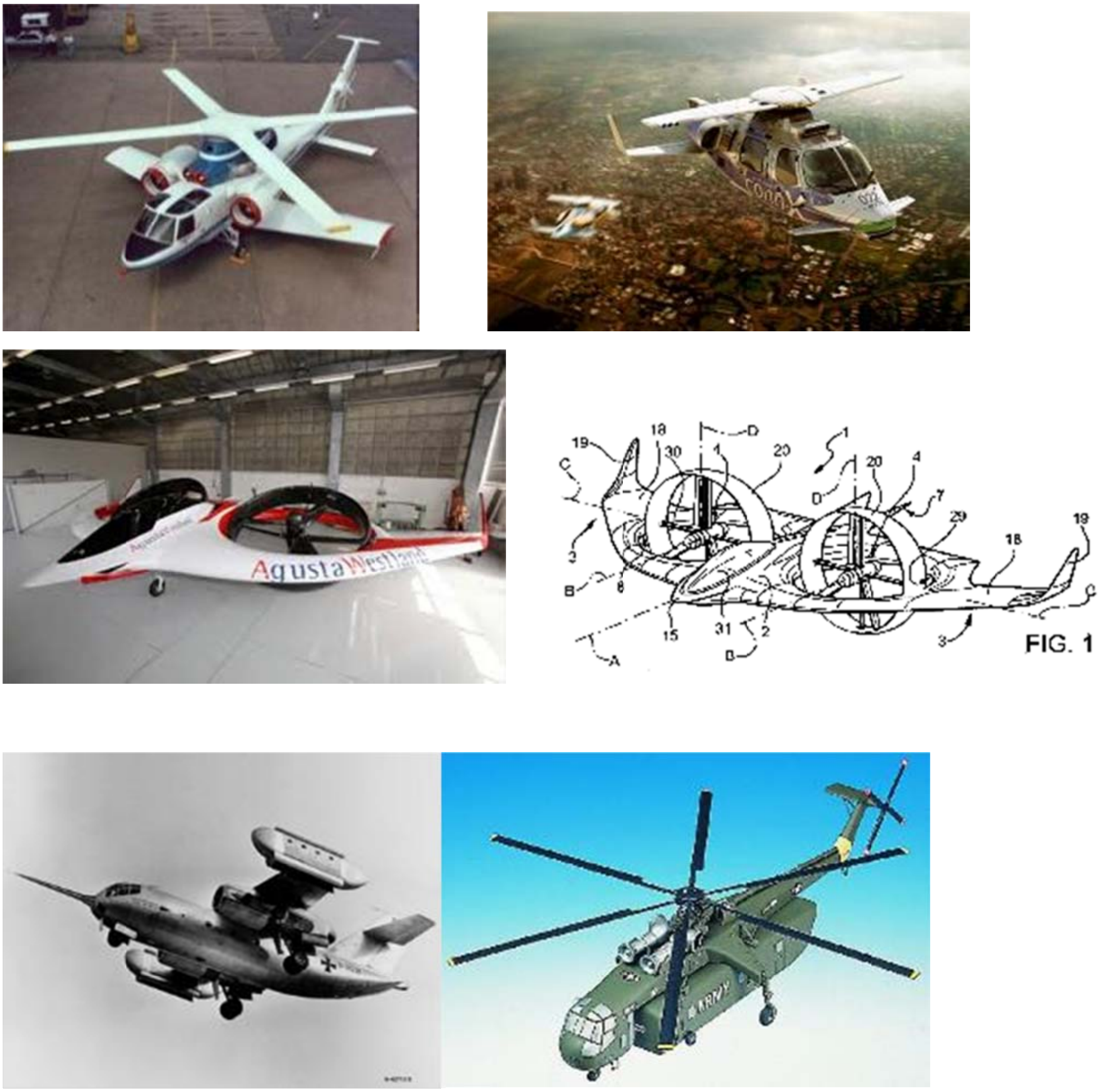


Figure 136: Advanced fast rotorcraft

Some examples of proposed configurations by Eurocopter, Bell, Sikorsky, Dornier and others

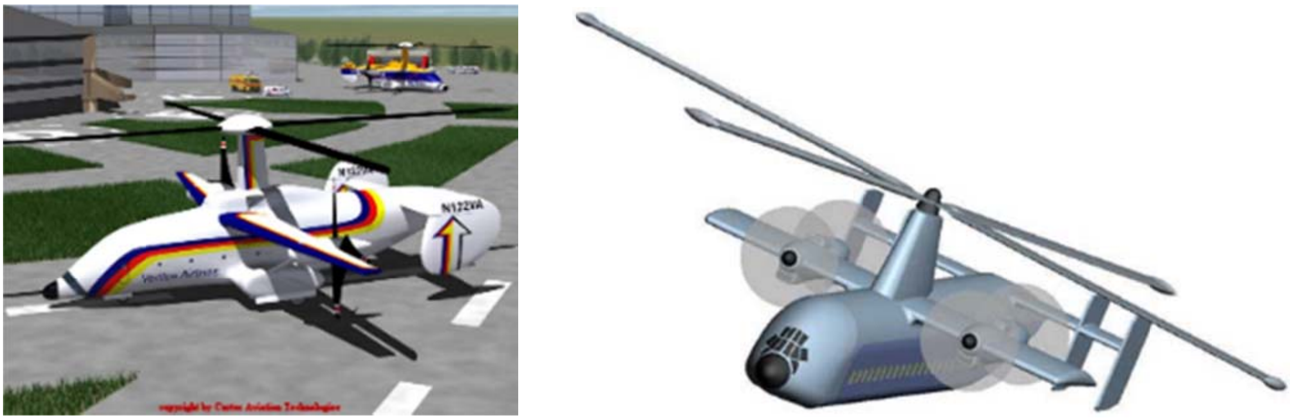


Figure 137: Future autogyro planes

Proposals for future autogyro planes

Research into alternative configurations has been given little attention in the past. More research is needed to design novel cargo planes based on one or more of the above mentioned concepts.

The quantitative assessment is shown in the table below.

Proposal	Key Parameter	Time	Cost			Productivity			Frequency
		Higher speed to delivery	High Load factor	Lower DOC	Lower IOC	Higher Speed	Larger Capacity	Increased Utilization	Higher Frequency of service
Ref. truck	Payload (tons) 144 tons	ref	ref	ref	Ref	Ref	Ref	ref	ref
Proposed A/C Fast Rotorcraft	Payload (tons) 10 or 20	+++	++	---	--	++	-	+	++

Table 24: Quantitative assessment - future autogyro planes

15.1.15 Advanced small aircraft using the fan-wing concept

There is renewed interest in the fanwing concept. This could enable a short take-off and landing performance at lower cost than the helicopter. Much has still to be assessed: Is the concept feasible, will it enable larger payloads to be carried, what are the operational cost etc. More research is needed to understand the potential of this concept.

Figure 138: Advanced small aircraft using the fan-wing concept

The aircraft is supposed to have a speed of 100 Knots/hour. One design option is to carry a 20 feet container.

The quantitative assessment is shown in the table below.

Proposal	Key Parameter	Time	Cost			Productivity			Frequency
		Higher speed to delivery	High Load factor	Lower DOC	Lower IOC	Higher Speed	Larger Capacity	Increased Utilization	Higher Frequency of service
Ref. truck	Payload (tons) 144 tons	ref	ref	ref	Ref	Ref	Ref	ref	ref
Proposed A/C Fan Wing	Payload (tons) 10 or 20	++	++	-	-	++	-	+	+++

Table 25: Quantitative assessment - Advanced small aircraft using the fan-wing concept

15.1.16 Advanced small aircraft

The proposed aircraft would carry a payload up to 40 tons. It would be designed for medium and short distance transport. The aircraft would have a simple design, optimized for cargo transport.

The aircraft could be equipped with swivelling nozzles to shorten take-off and landing.

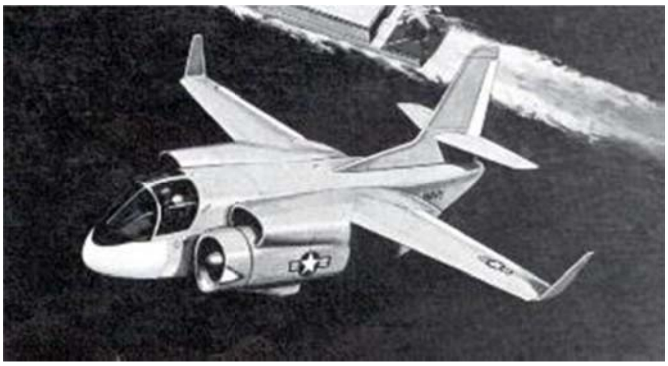


Figure 139: Advanced small aircraft

Illustrations by Airbus, TU Twente, NLR and Lockheed, Ad Cuenta

The quantitative assessment is shown in the table below.

Proposal	Key Parameter	Time	Cost			Productivity			Frequency
		Higher speed to delivery	High Load factor	Lower DOC	Lower IOC	Higher Speed	Larger Capacity	Increased Utilization	Higher Frequency of service
Ref. truck	Payload (tons) 144 tons	ref	ref	ref	Ref	Ref	Ref	ref	ref
Proposed A/C Advanced Small A/C	Payload (tons) 10 or 20	+++	+	+	-	++	-	+	+++

Table 26: Quantitative assessment - Advanced small aircraft

15.1.17 Replacement of the Cessna Caravan type of aircraft

The Cessna Caravan was developed in 1982. FEDEX was a launching customer to carry parcels over small distances. Similar aircraft like the DH Twin Otter are used to carry cargo over small distances. All these aircraft are characterized by a dated design and PT-6 engines that were developed 40 years ago. If a cost effective novel small aircraft would be developed, a substantial replacement market would exist. Besides a low cost solution could replace trucking over smaller distances. The aircraft would have a simple design but should be capable to carry standard aviation containers (LD3).

Figure 140: Cessna Caravan

It seems that the aircraft could be developed soon depending on the availability of a suitable replacement engine for the PT6. The qualitative assessment

The quantitative assessment is shown in the table below.

Proposal	Key Parameter	Time	Cost			Productivity			Frequency
		Higher speed to delivery	High Load factor	Lower DOC	Lower IOC	Higher Speed	Larger Capacity	Increased Utilization	Higher Frequency of service
Ref. truck	Payload (tons) 144 tons	ref	ref	ref	Ref	Ref	Ref	ref	ref
Proposed A/C Replacement of Cessna Caravan	Payload (4 tons)	+++	~~	+	~~	++	///	~~	+++

Table 27: Qunatitative assessment - Cessna Caravan

15.1.18 UAS systems

The idea is to develop an unmanned system that could deliver parcels and mail in urban areas. Currently small trucks are used to deliver goods. With modern technology like GPS it is possible to have small parcels delivered by UAS. This will require a high level of safety and reliability. There also needs to be a sense and avoid system to avoid collisions in urban areas.

Figure 141: UAS systems

The quantitative assessment is shown in the table below.

Proposal	Key Parameter	Time	Cost			Productivity			Frequency
		Higher speed to delivery	High Load factor	Lower DOC	Lower IOC	Higher Speed	Larger Capacity	Increased Utilization	Higher Frequency of service
Truck/ Van									
Proposed A/C Small UAS	Payload (tons)	++	+	+++	++	++	Same as ref	+	+++

Table 28: Qunatitative assessment –UAS systems

15.2 Ranking of alternative aircraft

15.2.1 Long haul cargo aircraft

As already indicated the air cargo market is influenced by GDP development (elasticity 2) as well as cost, time and frequency of delivery. Furthermore, there is the issue of environmental impact. This element is difficult to quantify as no elasticity is known. If ETS is introduced the environmental impact could be expressed in terms of cost. As already indicated previously, the elasticity for price is about -1, the elasticity of time to delivery is about 2 and no clear elasticity was found for frequency. This is supposed to be 1 as well.

Recap:

Proposal	Characteristics	Time	Cost			Productivity			Frequency
		Higher speed to delivery	High Load factor	Lower DOC	Lower IOC	Higher Speed	Larger Capacity	Increased Utilization	Higher Frequency of service
Reference B777	Payload 100 tons	ref	ref	ref	ref	ref	ref	ref	ref
Wige aircraft	Payload 680 tons	----	--	+	--	----	++++	---	----
Large cargo plane	Payload 300 tons	same	-	--	--	same.	+++	--	--
Efficient cargo plane	Payload 100 tons	+	+	+++	++	Same	+	+	same
Slower aircraft	Payload 100 tons	+/-	Same	++	same	--	same	same	same
supersonics	Payload 50 tons	+++	--	-----	--	+++	--	++	+
hypersonic	Payload 50 tons	+++	--	-----	---	+++	----	+	+

Table 29: Result of assessment - Long haul cargo aircraft

Taking the qualitative assessments into account, the ranking for the proposed long haul cargo is as follows:

1. BWB
2. Formation and coupled flight
3. Supersonic aircraft
4. Flying slower/ lower
5. Very large aircraft and WIDGE
6. Small aircraft
7. Hypersonic transport

15.2.2 Medium/ short haul cargo flights:

On the short haul the competition is from Trucks. Price is the most important issue.

Proposal	Characteristics	Time	Cost			Productivity			Frequency
		Higher speed to delivery	High Load factor	Lower DOC	Lower IOC	Higher Speed	Larger Capacity	Increased Utilization	Higher Frequency of service
Reference A320	Payload 50 tons	ref	ref	ref	ref	ref	ref	ref	ref
Cargoliner	Payload 120 + tons	same	-	+	+	same	++	-	--
HULA	Payload 500+ tons	-----	++	---	---	-----	++++	-----	------
Medium airlifter	Payload 50 ons	++	+	++	++	same	same	+	same
Tilt rotor	Payload 20 tons	++++	++	---	++	--	same	+	++
Advanced VTOL	Payload 10-20 tons	++++	++	--	--	++	-	+	++
fanwing	Payload 10tons	++	++	-	-	++	-	+	+++
Small aircraft	Payload 10tons	+++	+	+	-	++	-	+	+++
Very Small aircraft	Payload 4 tons	+++	++	+	+	++	---	++	+++

Table 30: result of assessment - Medium/ short haul cargo flights

Taking the qualitative assessments into account, the ranking for the proposed long haul cargo is as follows:

1. Replacement Cessna Caravan
2. New regional aircraft with 50 ton capacity
3. Large medium haul aircraft
4. Advanced rotorcraft including the autogyro
5. Fanwing
6. Large tiltrotor
7. Hula airship

15.3 Unmanned aircraft

The concept of fully unmanned flying should be developed by 2035, including certification. This would constitute a substantial cost reduction as no crew cost are needed.

If large cargo aircraft will be flown without pilot the fuselage might be unpressurised allowing different shapes and thus weight and fuel savings. There could be different structures proposed and substantial cost savings can be achieved. Although the issue seems not to alter the priority listing of the previous chapter the substantially lower cost due to the reduction of fuel cost (due to the light weight structure) and the reduction of crew cost will make air cargo much more attractive.

The fuel savings will also have a very positive effect on greenhouse gas emissions.

(Note: During the Cargomap workshop it was mentioned that future studies should set quantitative goals for the characteristics of novel irplanes.)

15.4 The issue of a new air cargo container.

Containers used in air cargo need to fit in the round aircraft fuselage. As a consequence these containers are very specific and do not correspond to the standard adopted in other modes of transport.

An alternative solution adopted for air cargo is pallets that can be stowed in big cargo aircraft.

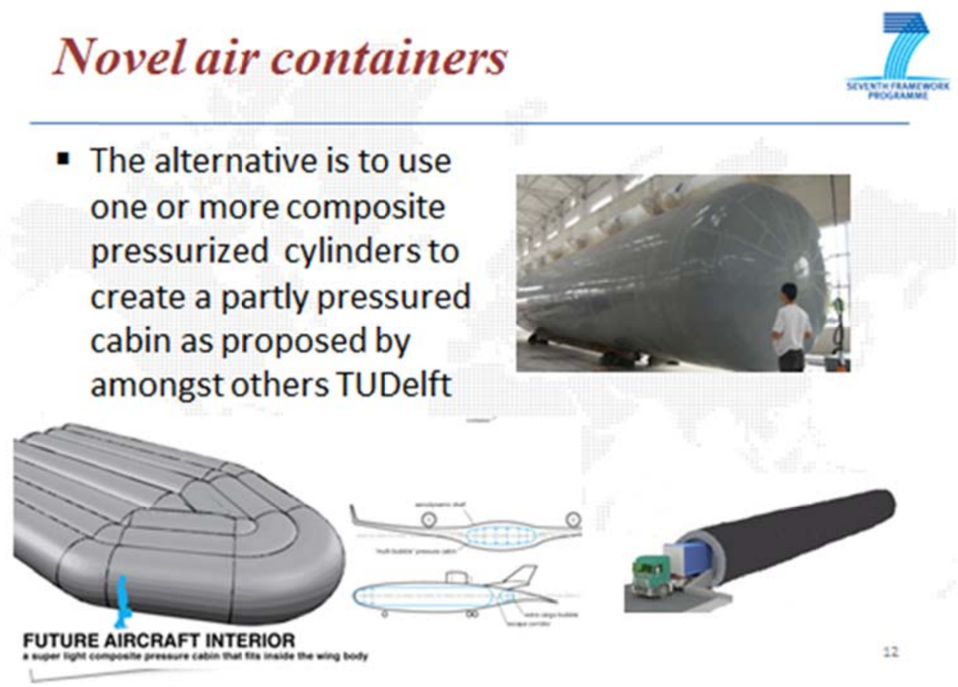
If unmanned aircraft would be designed specifically for cargo function in mind, the fuselage could have a different shape (e.g. rectangular). This unpressurized aircraft would be able to transport novel air containers that fit into standard surface transport containers. .

As some freight needs a conditioned environment, novel containers, that might fit the standard 20/40 feet containers, would need to be conditioned inside. Already pressurized containers exist. Also some containers are temperature regulated. The novel container concept that is proposed should combine several characteristics and should also be adopted to surface travel.

Figure 142: Novel air containers

Source AD Cuenta

If more than one pressurized container would be needed, the unpressuzid BWB aircraft could be fitted with large pressure vessels in which the containers vcan fit. Such barrels were already developed by amongst others Delft University. These would be made of light weight composite material.



Research into the operational benefits of such containers would be needed to see the cost benefits of the proposed solution.

(Note: The experts during the Cargomap workshop welcomed the idea of a new air container. However they also advised to keep the possibility of pallets as these can contain small packages for different customers. Containers would be interesting for big customers who need a whole container to be shipped. However the new container would need to be filled so that a high loadfactor can be realized.)

15.5 The intermodal transport chain

As has been mentioned in previous chapters, the cargo chains are characterized by many players, many transfer points and different functions that need to be coordinated. There is a customer centred approach missing. The customer has little real time information about the cargo being shipped, no single point of contact, no single bill and little information to influence pricing or time to delivery. The alternative of courier services exists but is very expensive as the time focus is the overall most important parameter. Although quick delivery is important for consumer goods or spare parts, the bulk of air transport cargo is time but also cost critical.

There is a need to foster research in the domain of intelligent cargo transport systems. Research is needed to understand business models of the different players, to understand how the whole logistic chain can be made more inter-connective efficiency, E-freight and travel information to enable seamless transport. The future transport infrastructure should enable seamless delivery of goods, transparency, reliability, greening and cost effectiveness. Clever governance and simplification of the transport chains is needed.

In view of the global character of logistic processes there is a need to redesign global logistics processes and enable co-operative intelligent transport systems that are based on advanced IT solutions and use the same standards.

15.6 The research roadmap

The CargoMap research roadmap identifies research topics that need attention in the future referring to the SRIA adopted time frames 2020, 2035, and 2050. Results should be available within those time periods. Results should be mature, integrated and validated. In most cases technology demonstration is needed.

The roadmap is organised in tables. A distinction between operations research and technology research is made. The Table indicate where specific research, technology and demonstration efforts are needed in addition to the ones already mentioned in the ACARE SRIA.

15.6.1 Operations research topics and actions

Topic	2020	2035	2050
Market			
Changes in market demand for air cargo	Develop simulation models to understand the future direction of air cargo demand	Update models	Update models
Understand customer satisfaction criteria including the elasticities for time, cost, frequency, environment and safety/ security	Develop econometric models to estimate customer demand	Update models	Update models
Planning of intermodal transport chains	Strengthen the discussion on a European scale to agree on intermodal steps in the future. Enable the transition from the current independent supply networks to open global networks.	Continue the forum	Seamless intermodal transport a fact
Create a model for fair comparison of different offers by different modes to forwarders	Modelling of price alternatives and conditions; standard lay out of websites	Unified European system available to all forwarders	
Improve a system of data exchange between the different transport modes	Uniform format developed; oversight planned	Oversight implemented	
Agree on a universal system for E freight	Develop uniform standard for E freight. Agree on ITC networks that will be used by all organisations in the transport chain	E freight implemented	
Universal system for single ticketing, tracking and indicating alternative transport opportunities in case of disruptions	Introduce a customer oriented transport chain, providing real time information, single point of contact, single ticketing and uniform tracking numbers. Shippers will have access to alternative transport opportunities during the planning and during the transport itself. This information will be provided on alternative transport cost, frequency, time to delivery and CO2 emissions.	Uniform Customer oriented decision tool is implemented	
Restructuring of the transport chain	Study to reduce the number of players in the total transport chain	Studies ready and implemented	

Table 31: Operations research topics and actions

Topic	2020	2035	2050
Airports/ landing spots			
Investigate opportunities to use regional airports and landing spots for air cargo delivery	Make a European inventory. Do not close regional airports too soon	Open up regional airports to air cargo	
Identify possibilities for VTOL/ STOL locations in Europe	Make an inventory of possible locations	Designate landing spots	
Usage of military airports	Make an inventory of military airports and barriers for air cargo services	Select military airports to be used by air cargo	
Design systems for short stay at warehouses	IT systems to speed up warehouse placement	Air cargo will stay in a warehouse no longer than one day	
Design IT systems for quick customs clearance	Airport clearance should be accomplished within one day		
Airport services to be open 24/7 if demanded by operators	Ensure 24/7 access through advanced security systems		
Aircraft need to be designed so that loading and off-loading is independent of airport facilities	Design for compatibility with envisaged airports	Develop new devices that make loading possible using robots	All robot handlin
Airports at sea or shores	Design of cost effective solutions	Implement	

Table 32: Operations research topics and actions

Topic	2020	2035	2050
Time efficiency			
Automated ATM	Implement SESAR	Design for totally automated ATM based on CNS	Totally automated ATM implemented
Develop automated separation devices and on board seek and avoid equipment	Preliminary design studies	Prototype testing	Implementation
Airports can be used without ground NAV equipment	Test WAAS, LAAS	Implement airborne RNAV	Fully independent systems implemented
Air cargo operators are linked to SWIM and CDM	Test CDM and SWIM	Implement Swim and CDM	
Automated self-separation on the ground and avoidance of runway incursions	Develop self-separation tools	Test and implement equipment	
Implement point to point flying	Implement FUA and FABs	Implement one single European sky; use of military airspace will be possible on real time basis	

Table 33:Operations research topics and actions

Topic	2020	2035	2050
Industry action			
Develop an industrial master plan to develop and manufacture novel aircraft	Set up a European interest group to develop new cargo aircraft (Subgroup in ACARE?)	European group has produced the first aircraft	Range of aircraft developed in Europe
Make a joint market analysis of the world market for novel aircraft	Start making a quantitative a market analysis and business plans	Market analysis updated	
Look for synergies with passenger / military aircraft developments	Create a forum for exchange		
Enablers			
Identify RTD capabilities in Europe and identify blind spots	RTD capabilities are upgraded to respond to the needs of the air cargo market	RTD knowledge, capabilities and facilities in place to respond to the needs of the air cargo market	Upgrades realized
Sufficient staffing is available. Education will respond to the needs of the air cargo market. Training is in line with most recent developments	Based on the market analysis make a staffing plan	Education and training fully in line with market needs	
RTD funding available to enable actions and research to be performed. Specific EU funding is available. National and industrial funding is coordinated. Development of a separate SRIA for air cargo	Separate SRIA for air cargo available. Funding at EU, MS and industry level aimed at developing the next generation of air cargo planes	Continued funding	Continued funding
Initiate another air cargo out of the box project to seek innovative ideas	EC funding available for out of the box workshop, assessment and Level 0 projects for incubation	Continued funding. Seek alignment with EDA	Fully integrated approach

Table 34: Operations research topics and actions

Topic	2020	2035	2050
Security			
Advanced screening devices to be developed	Low cost, flexible and universal screening devices to be developed	Advanced screening devices applied	Advanced screening devices constantly upgraded
Cyber war hardened IT systems, avionics and ATM	Develop anti cyber-crime methods	Continue	Continue
Full protection against manpads for air cargo aircraft	Design low cost devices against manpads	Design low cost systems against new external hazards	Continue
Safety			
Certification keeps up with technological developments and is not a barrier to innovation	A fresh look at risk based certification is started	New certification methods are implemented	
Certification cost and time is reduced by 50%	New certification methods are aimed at reducing cost and time	50% reduction of certification time and cost is achieved	Certification is based on simulation
Aircraft are simple to fly. Use of social media in aviation is fully implemented	Design for simplicity	same	same
Auto recovery systems prevents crashes	Design full proof auto recovery systems	Auto recovery systems are standard	
Aircraft data telemetry is implemented	Design effective data telemetry and avoid black boxes	Implemented	
Aircraft crashworthiness is improved	Develop methods to improve survivability	Aircraft crashes are 99% survivable	

Table 35: Operations research topics and actions

15.6.2 Aircraft related research topics

Topic	2020	2035	2050
Configurations			
Configuration studies long and medium haul aircraft	Configuration studies are performed to select the best possible future configurations based on the expected market demand. New large aircraft are expected to enter into the market in 2035	Configuration studies completed, especially on BWB aircraft	Advanced configuration studies
Technology development and demonstration for successor Cessna caravan type of aircraft	As the replacement of these small aircraft is imminent, configuration studies should lead to technology demonstration, a final design and manufacturing	Studies should lead to a joint European industry action	
Configuration studies for VTOL/STOL aircraft	VTOL/STOL solutions have not been studied for some time except for helicopters and tiltwing. New configurations need to be developed and demonstrated	Configuration studies completed as is design. Start production.	
VTOL/ STOL technology	Novel designs are needed for VTOL/STOL aircraft that are efficient and low noise. The EC promotes innovative ideas by challenging the aviation community in the same way as DARPA operates	Designs lead into production of efficient and environmentally friendly VTOL/STOL	
Studies on small UAS	Small UAS can be developed that can be used in an urban environment. Safety standards, technology and guidance and control devices need to be developed	Manufacturing of small UAS started	

Table 36: Aircraft related research topics

Topic	2020	2035	2050
Unpiloted aircraft technology	**Research is aimed at developing pilotless aircraft and their operations in 2035, with appropriate standards and complying with the civil aviation safety standards of 10-9**	**Flying urban UAS can be demonstrated**	
New aerodynamic shapes	Research should be focused on new aerodynamic shapes rather than the traditional ones. BWB, boxed wing etc. should be developed and tested to understand the potential.	New aircraft to be designed with new shapes	
Research on the fanwing concept	Research should demonstrate that the fanwing concept is a promising technology	Decide whether the fan wing concept is credible	
propulsion			
New ultra efficient engines to be developed. These could be hybrid engines powered by LNG or Hydrogen	Research into novel engine configurations	Research and demonstration of novel engine configurations	Implementation
Successor engine of the PT6 family designed in Europe	Research, demonstration and development	Implementation	
Electrical engines to be designed and the associated battery technology further developed	Research into light weight engines and batteries	Demonstration efforts	Implementation
Conformal solar panels to be developed	RTD into the feasibility of sheets of flexible highly efficient solar cells	Implementation	
APU replacement by electrical systems or fuel cells	RTD into the safe and efficient fuel cells	Implementation	

Table 37: Aircraft related research topics

Topic	2020	2035	2050
Advanced turbo prop/ diesel engines with less fuel burn, noise and emissions	**RTD into novel engines, demonstration activities**	**Implementation**	
Advanced propeller and rotor design with low noise characteristics and high efficiency	RTD and demonstration of new prop configurations	Implementation	
Advanced VSTOL/autogyro engines	RTD on novel efficient engines	Demonstration and final design	Implementation
Equipment			
Autonomous flight equipment	RTD on the concept of autonomous flight	Implementation possibly first with safety pilot on board	Full implementation
Advanced avionics, low cost, low weight, low power uptake, small volume	RTD in new avionics integrating social media	Implementation	Improvements
Low cost fly by wire	RTD to develop advanced fly by wire systems	Implementation	
Novel air cargo containers that will fit into standard 20/ 40 feet containers. Containers are developed in such a way that the contents can be conditions (temperature, humidity, pressure etc.)	RTD for the design of novel air cargo containers	Demonstration and manufacturing	
Aerodynamics			
Advanced aerodynamic solutions including laminar flow, drag reduction, BLI, advanced VTOL/STOL design	Fresh look at aerodynamics tailored for air cargo aircraft configurations	Validation, demonstration and design	

Table 38: Aircraft related research topics

Topic	2020	2035	2050
Morphing technologies for formation flight	**RTD for morphing wings**	**Application**	
RTD for coupled flight	RTD to establish the feasibility of coupled flight	Integration and demonstration	Application
Advanced rotorcraft configurations	RTD into novel concepts including stopped rotor, X wing, tilting wings etc.	Integration and demonstration	Applications
Structures			
Advanced materials and structures designed for low weight and low cost	RTD for novel ways to construct airplanes with light structures without pressure hull	Integration, demonstration and design	
Advanced nano technology	RTD for advanced nano materials for aviation	Demonstration and design	
Totally recyclable aircraft	RTD for reuse and recycling of aircraft and airport parts	Demonstration	Aircraft can be 100% recycled
Crashworthy structures	RTD for more crashworthy structures including ditching	Demonstration and implementation	
Low cost production methods	RTD for low construction cost, especially for small production runs	Demonstration and implementation	
Unscheduled maintenance avoidance	RTD for low cost maintenance by lengthening maintenance periods, avoidance of unscheduled maintenance	Demonstration and implementation	

Table 39: Aircraft related research topics

16 Recommendations for the European Commission

The development of the future Air Cargo system should get the attention of the EC considering the importance of this transport system for the European social welfare, industrial leadership.

The Cargo transport of the future has to become more and more intermodal reducing road congestion and improving the overall system. An optimal air cargo business model and efficient cargo aircraft adoption might reduce the environmental impact of the air cargo transport.

A small group should prepare a master plan soon to address relevant technologies for air cargo aircraft and Horizon 2020. The technologies to be developed include VSTOL technology, new configurations, pilotless flying, automation in ATM and the restructuring of the European airspace classification, the autogyro, new engine and fuel concepts, morphing etc.

Although no formal work program for Horizon 2020 isexisting at the moment of writing, a few suggestions can be made based on preliminary information.

Near term aircraft development and demonstration. As indicated in the roadmap, the most urgent issue may be the development of new short haul aircraft. Clean Sky 2 provides the opportunities to demonstrate the feasibility of novel short haul cargo aircraft including VTOL aircraft designs.

The incorporation of novel cargo operations should be incorporated in the **SESAR program**. The use of alternative airports, the seamless travel in the European sky, low cost air traffic management etc. are issues that SESAR needs to deal with. The restructuring of the European airspace classification is another issue for SESAR. The use of small UAS for urban transport tasks needs a new approach both in regulation and in traffic management.

Advanced production methods and novel materials for future aircraft could be part of the Commission's **materials and manufacturing program**.

The innovative aviation concepts and technologies could be addressed in the **Collaborative aeronautics research part of Horizon** 2020. Prime focus should be pilotless flying and the consequences for aircraft design. Research should also cover novel engines and aircraft control, low cost maintenance, safety issues as well as advanced configurations. New concepts for air cargo should also be addressed.

The new container idea should be given sufficient attention. After an initial research phase this could be demonstrated during the lifetime of Horizon 2020.

The availability of qualified staff is a concern that should be addressed as well. Here it will be insufficient to look only at university graduates. Other staff including pilots, maintenance staff and commercial staff needs attention to ensure that sufficient staffing levels will be available in future.

It is important to support the development of new seamless transport chains. E-freight and the associated IT systems will be only one of the many aspects to consider. A total systems approach is needed where all relevant players in the transport chain are involved. Customer orientation, greening and cost will be prime drivers. The low load factors in transport need to be improved through clever cooperation. Intermodal transport like in passenger transport (see the EC sponsored MODAIR project) needs to be implemented to this end the Commission should make sure that aviation will be part of the current transport platforms that are advising the Commission.

The Commission is encouraged to ensure that research and demonstration activities are leading to market uptake.

Close links should be established with the **EC Energy program** on the development of future aviation fuels like bio-fuels.

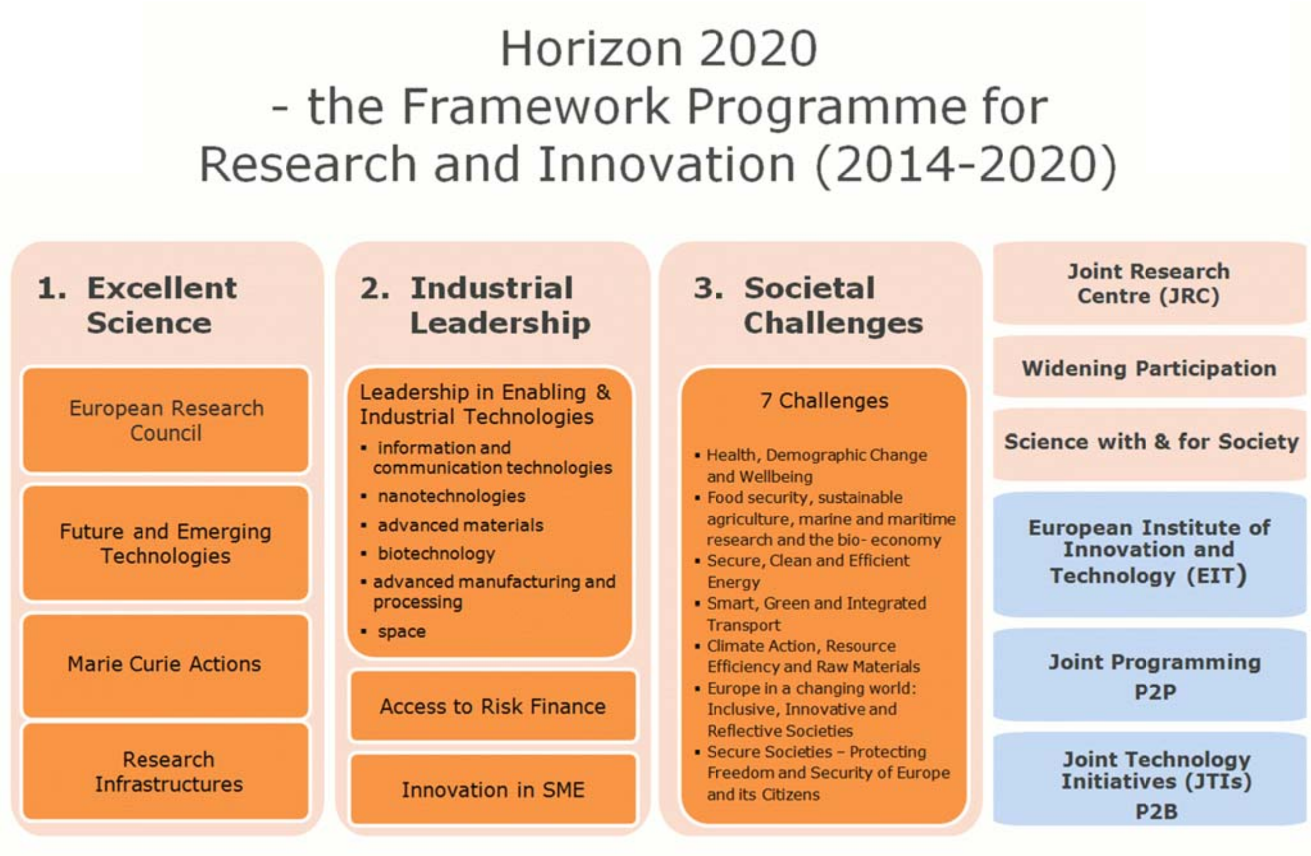


Figure 143: EC

In short in the first pillar of H2020 we see the need to take future air cargo into account in FET as well research infrastructures. We recommend that the potential of air cargo is also recognized in the ICT, nanotechnology, materials and manufacturing part of the second pillar. Innovation in SME's can benefit the Air Cargo market.

Transport research in the third pillar should enable the demonstration of new smaller cargo planes in Clean Sky as well as generic technology issues as laminar flow, novel engines and systems like fly by wire and maintenance. SESAR should take into account the new developments in air cargo. Up to now SESAR has been very much focused on scheduled passenger flights but it should include air freight and unmanned urban delivery vehicles.

The innovative aviation concepts and technologies should take into account the air cargo opportunities for 2030 as displayed in the roadmap. Safety should take into account the idea of unmanned flight, coupled flight etc. Staffing was already mentioned.

In the transport program sufficient attention should be given to a customer centred, seamless, intermodal transport chain. It should deal with concepts, governance and appropriate E-tools and ensure the implementation. The future air cargo infrastructure will not only include regular airports but local landing sites as well. Such ideas should be incorporated in future research.

Appropriate platforms should be used by the Commission to receive advice. Air Cargo should be well represented in these bodies.

Although the smart, green and integrated transport part of the third pillar will be the focus area for research and demonstration for air cargo, there is a need for attention in the security part as more cloud computing, data links and E-Systems need to be well protected. The recent experience in the harbour of Antwerp where a container was stolen through hacking of the information systems is just one example.

As stated the aviation fuel needs attention in the energy program part of the third pillar.

17 References

[1] Morrel, P. (2011). Moving Boxes by Air. Cranfield: Ashgate.

[2] Airbus, (2011). Global Market Forecast 2011-2030.

[3] CargoMap, (2012). Air Cargo Technology Road Map.

[4] Zhang, A., & Zhang, Y. (2002). Issues on liberalization of air cargo services in international aviation. Journal of Air Transport Management, 8: 275-287.

[5] Seabury Aviation & Aerospace. (2010). May 2010, The Outlook for Freight Transportation. Luxemburg: Seabury.

[6] Morrel, P. (2011). Moving Boxes by Air. Cranfield: Ashgate.

[7] Carlier, A. (2011). Air Cargo Concepts of Operation Performance Assessment Model for Future Demand Scenarios. (Master Thesis). TU Delft, ATO. Delft: TU Delft.

[8] Airbus, (2011). Global Market Forecast 2011-2030.

[9] Button, K. (2008). The Impacts of Globalisation on International Air Transportation Activity.

[10] F. Kupfer, "The airports choice for scheduled charter operations in Europe," University of Antwerp, Antwerp, 2012.

[11] "International Civil Aviation Organization," [Online]. Available: www.icao.org. [Accessed 29 May 2013].

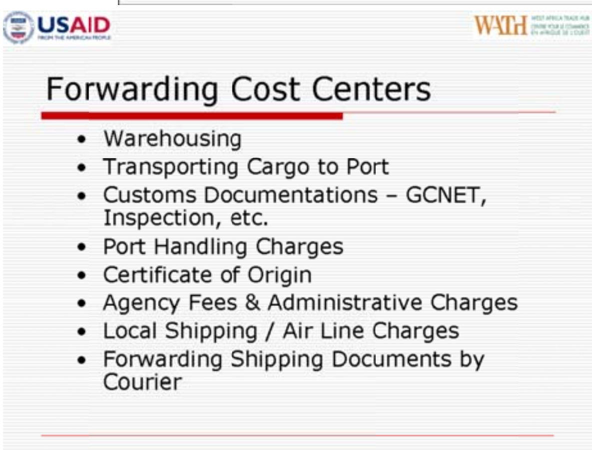
[12] F. Kupfer, "The airports choice for scheduled charter operations in Europe," University of Antwerp, Antwerp, 2012.

[13] "CAA," Civil Aviation Authority, 2012. [Online]. Available: http://www.caa.co.uk/default.aspx?catid=80&pagetype=88&sglid=21.

[14] "The geography of transport system," 2012. [Online]. Available: http://people.hofstra.edu/geotrans/eng/ch3en/conc3en/evolairtransport.html.

[15] Javier, "The blog by Javier," 16 April 2011. [Online]. Available: http://theblogbyjavier.com/2011/04/16/air-traffic-growth-vs-aircraft-orders/.

18 Appendix A – DELATA Analysis for long haul shipping costs



Shipping (Freight) Cost Centers

- Actual Sea / Air Freight
- Marine Insurance
- Port Terminal Handling
- Bunker Adjustment Factor (BAF)
- Fuel Surcharges
- Security Surcharges
- Etc.

Clearing Cost Centers

- Customs Documentations
- Broker's (Clearing Agent's) Fees
- Transporting Cargo to Importer's Warehouse

Computing Shipping Costs:

Units of Measurement:

- Sea Freight – Container Units
  - 20' Container (~33.0 cbm)
  - 40' Container (~66.0 cbm)
- Consolidation – Cubic Meters (cbm)
- Air Freight – Actual or Volume Weight
- Courier – Actual or Volume Weight
- Air Parcel – Actual Weight

Vol. Wt.= (length x width x height) cm / 6000

Volume weights are normally used for large light weight shipments

Typical Shipping Costs to USA Sea Freight

Shipping 20' Container to USA

Forwarding Costs	$520
Transport to Port	$210
Marine Insurance	$200
Freight (East Coast)	$2,800
Terminal Port Handling	$1,000
Clearing	$500
	$5,230

+ Road Transport from Mali/Burkina Faso/Niger ($...)
+Transport from East Coast to West Coast ($2700)

Air Freight

Shipping 1.0 cbm volume of Apparel

- Actual Weight = 60 kilos
- Volume Weight = 100 x 100 x 100 cm / 6000 = 166.7 kilos
- Freight Rate = $2.50 / kilo
- Freight = 2.50 x 166.7 = $417
- Airline Charges = $110
- Forwarding = $75
- Total Cost = $602

Consolidation Shipment

Shipping 1.0 cbm by Consolidation Cargo

- Freight Rate = $ 200 / 1.0 cbm
- Total Freight = $200
- Forwarding = $ 80
- Total shipping Cost = $280

Comparison with Full Container Load:
Total Cost / Total cbm = $5230 / 30 cbm = $174.34

Courier Shipment

Shipping 1.0 cbm package by DHL

- Actual Weight = 60 kilos
- Volume Weight = 167 kilos
- Rate for 150 kilos = $3,606
- Rate for 17 kilos bal. = $ 178
- Total Courier Freight = $3784
- Forwarding = $0
- Total Cost of Shipping = $3784

No Forwarding Cost because cargo could be picked from premises.

Air Parcel

Shipping 1.0 cbm Package by Air Parcel Postage

- Actual Weight = 60 kilos
- Freight Rate = $10 / kilo
- Total Freight = $600
- Forwarding = $50
- Total Shipping Cost = $650

Source US Aid Africa