

Agenda

- * Welcome and Introductions, Kathleen
- * 8:15 Status of Euro DL CBA in Europe, Bernard
- * 8:45 L2KBC+ Results, Catalin
- * 10:00 Break
- * 10:15 Detailed Model Review, Kathleen
 - Key Issues
 - Delay reduction discount factor, equipage curves
 - AOC vs. non-AOC baselines
 - Delay Growth capped in 2010
- * 12:00 Lunch
- * 1:00 Continued Model Review
- * 2:45 Break
- * 3:00 Agree on All Assumptions and Conclusions
- * 3:30 Next Steps for Euro DL model
- * 4:00 Adjourn

**C/AFT
European
Datalink Investment Analysis**

**Final Review
April 27, 2000**

Overview

- * Introduction & Assumptions
- * AOC Situation
- * ATC Situation
- * Model Inputs
- * Results
- * Conclusions

Introduction

- * C/AFT airlines agree that future system capacity is a primary driver for global airspace system changes**
- * C/AFT proposes incremental operational enhancements that can be enabled by CNS technologies**
- * Data Link is primary candidate enabler for delay reduction**

Assumptions

- ✦ C/AFT EURO is not an alternatives analysis, Data Link is the only technology enabler considered.
- ✦ Analysis is performed for High Traffic Level Areas of Europe.
- ✦ Based on airline point of view (airlines as an industry, not a single airline).
- ✦ Air traffic growth drives ATC infrastructure readiness, which drives air and ground equipage.
- ✦ AOC frequency congestion drives equipage (Stage 1)
- ✦ Evaluates transition from character-based ACARS AOC to ATN-based AOC and ATC operations.
- ✦ Evaluates transition from non-datalink AOC operations to ATN-based AOC and ATC operations.
- ✦ Both ATC and AOC benefits considered.

European AOC Situation

- * **Approx. 50% of airplanes use data link AOC**
 - frequency congestion problems
- * **Those not using AOC data link may equip for VDL-2 for both AOC and ATC benefits**
- * **No more frequencies available for ACARS**
 - there is political pressure by European Frequency Management group to make better utilization of frequencies
 - much more serious situation than in US
 - ATC will be using up channels freed by 8.33, no chance for growth for ACARS
- * **Two frequencies that were designated ACARS freq's will have to go to VDL-2 2003-2005**
 - More congestion for ACARS, bad for bandwidth

European AOC Issues, continued

- * Number of airplanes equipped with AOC is growing (SITA)
- * More applications, AOC traffic is growing per airplane
- * Potential for very high growth in AOC traffic as more airlines equip
 - between 20-25% annual growth
 - Airlines rely on AOC more than before, AOC is becoming backbone of Operational Control organization. Airlines will be relying more on ACARS data. Punctual operation is driver.
- * “SITA is convinced VDL is required to avert ACARS service breakdown in 2003/4 timeframe.”

European ATC Situation

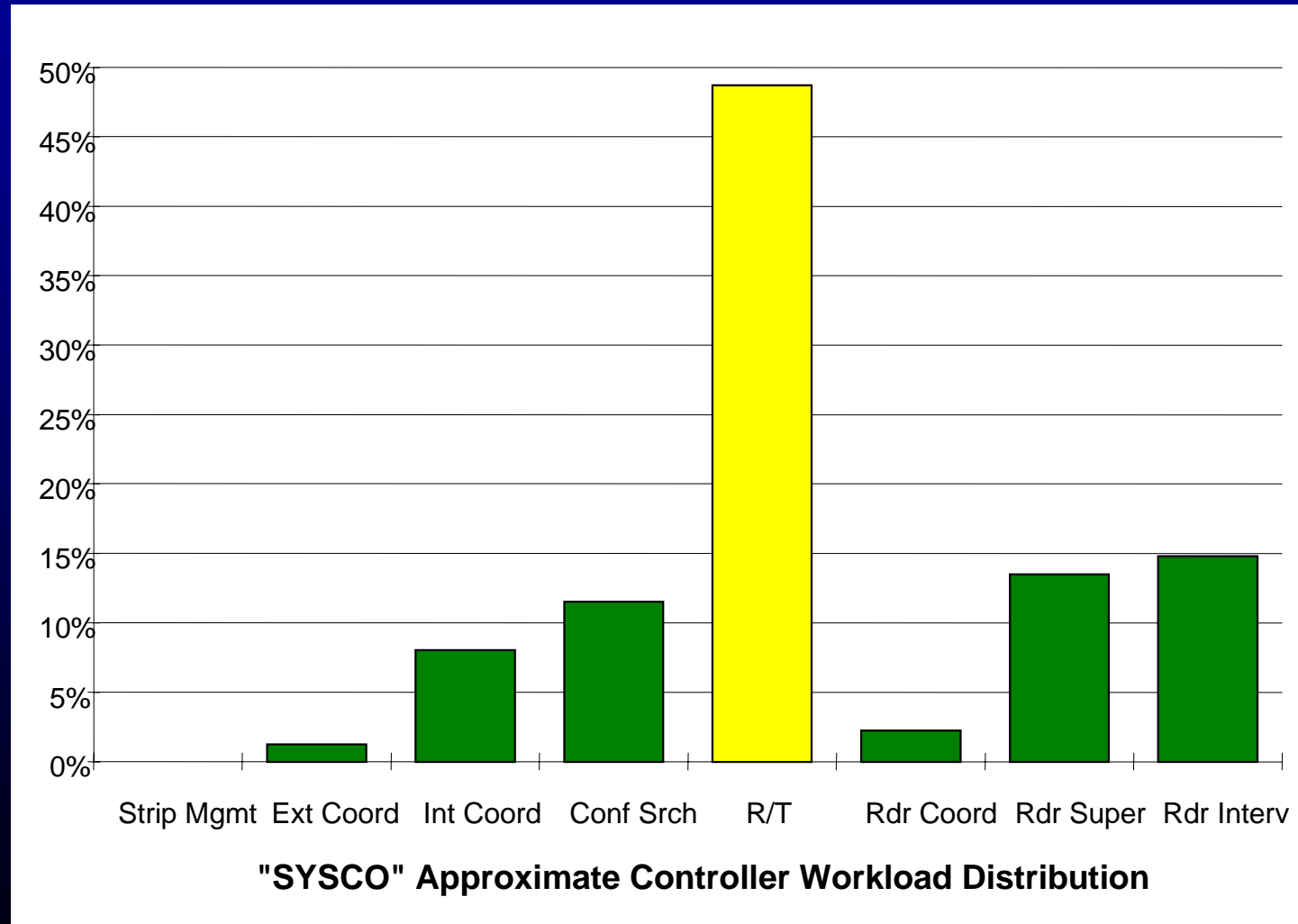
- ★ **Current delay situation is very serious, need to do something immediately**
 - airlines want to reduce the amount of delay that exists today
 - need to maintain acceptable levels of delay (see performance target document)
 - FAP document has 5 year forecast, update will be ready in October
 - Current estimate for 2005 is 33.5 minutes average delay per flight (FAP prediction -- verify that this is still the right number)

- ★ **Link 2000+ using business case to quantify benefits of ATS data link.**

- ★ **PETAL-II trials in Europe evaluating data link operational issues**

- ★ **Eurocontrol performed data link simulation (L2KBC)**
 - capacity gains and delay reduction by implementing ATS data link
 - results published.

The First Step: Controller Communications Workload



C/AFT Modeling Process

Economic Model

*** Determines**

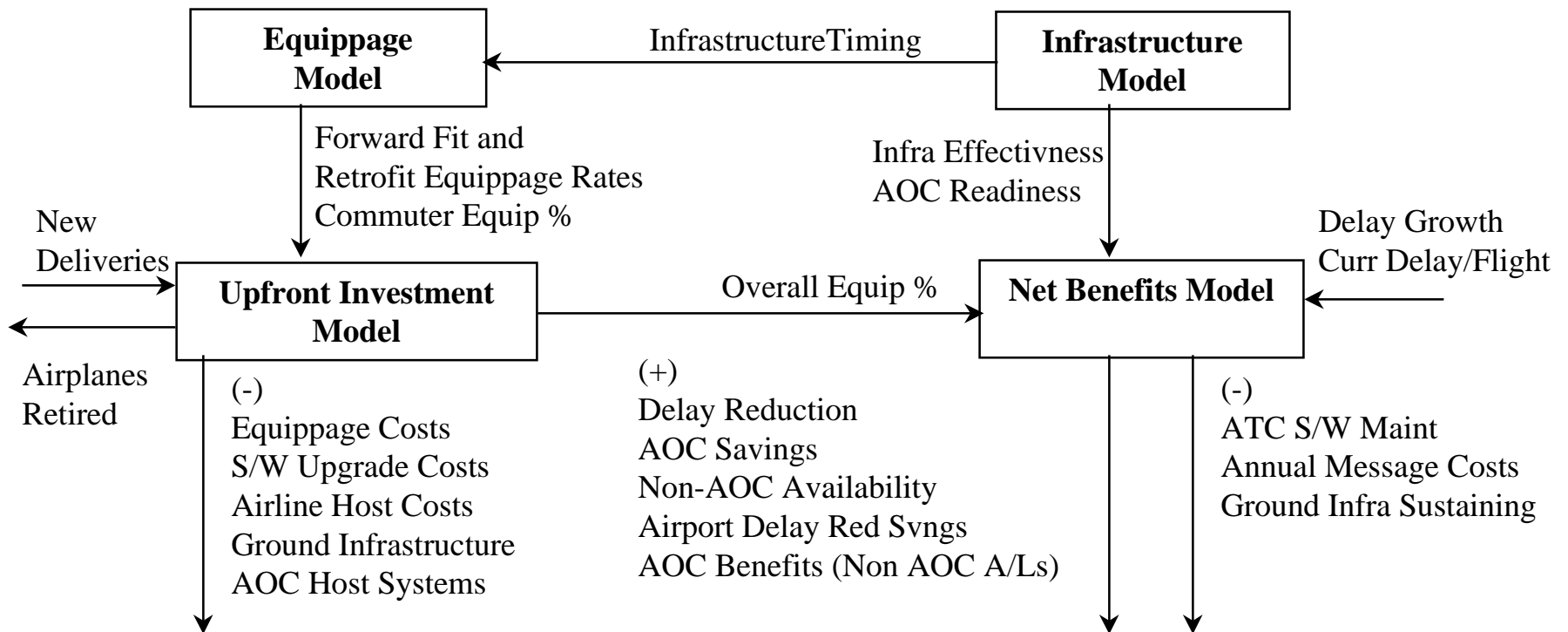
- **Costs**
- **Benefits (converted to euros)**
- **Risk**
- **Rules**

*** Builds Deterministic Sensitivity Analysis**

- **Identifies influence of each uncertainty on NPV**
- **Used to calculate overall risk and return**

Datalink Investment Model

Cash Flows



European Model Inputs

Delay Growth Assumptions

- ✦ Different growth rates at different times
- ✦ Until 2005
 - High Delay Growth per Year (20%, 25%, 35%)
 - Based on Eurocontrol ATFM Delay variation 1997/1998
- ✦ 2005 - 2010
 - Delay growth slows down due to planned operational improvements
 - Delay Growth per Year 5%, 10%, 15%
- ✦ 2010 - 2020
 - Assume delay remains constant at 2010 levels

European Model Inputs

Traffic Growth

- * **Costs and benefits calculated for 70+ seat airplanes**
- * **Commuter airplanes are included in the model, but costs and benefits are not calculated for them.**
- * **New deliveries are added and retiring planes are subtracted each model year**
- * **After 2010 number of retiring planes equals new deliveries.**

Traffic Growth Inputs

Constants	Value	Analysis Source	Notes
Stage 1 Number of 70+ seats Airplanes (jetliners) - European-registered (ECAC) in 1999. (Aircraft types falling into this category: Avro RJ and BAe 146 series, BAC 1-11, Fokker jet series, Airbus A319, 320, 321, Boeing 727, 737, 757, MD80, Airbus A300, 310, 330, 340, Boeing 747, 767, 777, DC10, MD11, Lockheed L-1011 Tristar.)	4443	EUROCONTROL	70+seats represents 52% of the total annual flights. Includes US aircraft flying in Europe. Assume that equipage is based on passenger and commuter airlines but that benefits are calculated for passenger airlines only.
Commuter Equipage Percent	5%	SITA	Current level of equipage for European commuters, relative to commercial
New Deliveries Passenger Airplanes through 2008 core Europe	210/year		Boeing CMO http://www.boeing.com/commercial/cmo/5apc1.html multiplied by 75% to represent OSD definition of core europe. (bernard lacroix)
New Deliveries Passenger Airplanes after 2008 core Europe	240		Boeing CMO http://www.boeing.com/commercial/cmo/5apc1.html multiplied by 75% to represent OSD definition of core europe. (bernard lacroix)
After 2010 new deliveries equals retirements			

Variables	10	50	90	Source
Number of commuter airplanes as percent of commercial	3%	5%	7%	Calculated as Stage 1 European 70+ divided by Stage 1 commuter airplanes. (183/3864)
Retired Passenger Airplanes as % of New until 2010	15%	22%	40%	from US analysis. Note: After 2010 will equal new deliveries.

Issue

Traffic & Delay Growth Cap 2010

- * After 2010 delay and number of airplanes remain constant.
 - After 2010 delay is capped at 30 minutes/flight
 - Total Planes after 2010 is capped at 6104 (not including commuter airplanes)

Issue

Traffic & Delay Growth Cap 2010

* Alternative 1

- Include delay growth and increase in traffic
- Add benefit of being able to continue to operate due to data link's delay reduction benefits. (analogous to AOC N/A Avoidance)

* Alternative 2

- Loss of revenue as passengers seek alternative forms of transportation.
- When delay time exceeds certain amount (flight time?) give higher cost of delay to account for this loss of revenue.

* Alternative 3

- use 2005-2010 values for traffic and delay growth out to 2020 (5/10/15%)

* Alternative 4

- cap delay/traffic growth when traffic doubles from start of model.
- Note: this rationale is misleading. Rationale for this is that at 200% traffic in L2KBC+ it was found that controllers could handle 200% traffic with data link services modeled (ISA). See Section 3.2

Issue

Traffic & Delay Growth Cap 2010

- ✦ **Decision:** leave traffic and delay growth cap as is
 - To account for saturation of controller workload
 - assumed linear growth of traffic

European Model Inputs

Constants

- * Start Year of Model 2000
- * Final Year for Equipage = 2015
- * Final Year for Benefit = 2020
- * Discount Rate = 12%
- * Inflation Rate = 2%
- * Percentage of Fuel-related DOC = 15%
 - Issue -- is this too low? (Issue # 32)
- * Fuel inflation rate = 5%
- * Direct Operating Cost (DOC) per minute is range of 11, 22, 33 Euros
 - includes crew, passenger services, ticketing & sales, general & administration, fuel/oil, aircraft costs, maintenance, en-route charges, aeronautical charges, station and ground handling

Benefits not captured in model

- * **Loss of revenue**
 - alternative forms of transportation
- * **non-linearity of delay value**
- * **Option value of incremental future functionality**

Constants

Constants	Value	Analysis Source	Notes
Start Year of Model	2000	C/AFT consensus	
Final Year for Equippage	2015	C/AFT consensus	
Final Year for Benefits	2020	C/AFT consensus	
Discount Rate	12%	Airline consensus	IATA
Inflation Rate	2.0%	Airline consensus	EUROCONTROL
Fuel percent of DOC	15%	Airline consensus	IATA, 1997 AETF
Fuel inflation rate	5%	Airline consensus	Received data from IATA, but don't understand.
Number of flights/year of commuter (up to 70 jetliners) airplanes	2207		Eurocontrol. IATA and other airlines have validated this data.
Average Flights per year per airplane for 70+ seat airplanes	1560		Eurocontrol. IATA and other airlines have validated this data.
VDL-2 Infrastructure Readiness Year	2001	ARINC/SITA	
Average cost per ATC kilobit (annual)			
up to 1 Million Kbits per year	\$0.28	C/AFT Consensus	SITA/ARINC
1 - 4 Million Kbits per year	\$0.24		
4 -8 Million kbits per year	\$0.16		
8 - 15 Million Kbits per year	\$0.08		
Current number of datalink AOC airlines whose host computers are based in European airspace	32	SITA	IATA

European Infrastructure Stages

- ★ **AOC benefits applied to all equipped airplanes at all stages**
 - Some benefits differ due to baseline (AOC vs. non-AOC)
- ★ **ATC benefits will be achieved by multiple services affecting multiple phases of flight**
 - **First stage is local services at airports**
 - Departure Clearance and Digital-ATIS
 - VDL-2 is cheaper than VHF
 - Benefit will also apply to new users
 - **Second and third stages will be area-wide services in en-route**
 - ATC Communications Management
 - ATC Clearance
 - ATC Microphone Check
 - Controller Access Parameters
 - Note: Downstream Clearance is not included in the model.

European Infrastructure Assumptions

- ★ VDL Mode 2 AOC infrastructure assumed to be ready at start of model
- ★ Stage 1 Airport Services ready at start of model.
 - High Forward Fit rate for AOC and ATC benefits
 - Low Retrofit Rate
- ★ Stage 2 start year range : 2004 - 2007
 - Continued Forward Fit
 - Increased Retrofit Rate
- ★ Stage 3 from end of Stage 2 to end of model.
- ★ Infrastructure readiness in each stage is a ramp function (not a step function)
- ★ Issues:
 - 16, 18, & 27. How should stages be defined in model.

Infrastructure

Constants	Value	Analysis Source	Notes
Stage 1 start	2000		
Stage 3 end	2015		

Defintion of Stages and Stage Dates				
Stage 1	DCL and ATIS Messages in HTLA's of Core Europe + airline AOC			
Stage 2	Area-Wide Messages in HTLA's of Europe			
Stage 3	Area-Wide Messages in additional HTLA's of Europe			
Variable	10	50	90	Notes
Stage 1 duration	4	6	8	
Stage 2 duration	4	6	8	

Infrastructure Effectiveness				
Variable	10	50	90	Notes
Stage 1 Percent of 70+ seat Flights Covered by Airport Services	30	35	50	Eurocontrol. (CFMU 1997).
Stage 2 Percent of 70+ seat Flights Covered by Airport Services	50	60	65	Eurocontrol. Medium=application of ATNI % to the current A/Ps classification in MAAP, LAAP and MEAP. Low=100%MAAP+25%LAAP+0%MEAP. High=100%MAAP+75%LAAP+50%MEAP.
Stage 3 Percent of 70+ seat Flights Covered by Airport Services	65	70	75	Eurocontrol
Stage 2 Percent of 70+ seat Flights Covered by EnRoute Services	Stage 2 Airport Services + 15%	Stage 2 Airport Services + 15%	Stage 2 Airport Services + 15%	Eurocontrol. Based on STATFOR (Statistics and Forecasts).
Stage 3 Percent of 70+ seat Flights Covered by EnRoute Services	Stage 3 Airport Services + 15%	Stage 3 Airport Services + 15%	Stage 3 Airport Services + 15%	Eurocontrol

European Equipage Assumptions

- ✦ Includes 3 different types of airplanes
 - 70+ seat ACARS AOC baseline
 - 70+ seat non-AOC baseline
 - Commuter Equipage
- ✦ ACARS-equipped airplanes and Commuter Equipage numbers are expressed as a percentage of the 70+ airplane population.
- ✦ Retrofit rates for non-AOC and commuters are also expressed as a percentage of 70+ airplane retrofit rates
- ✦ Assuming that all new forward fit airplanes are ACARS based.
- ✦ Issue #8. Bernard would like to discuss equipage rates and incentives.

Equipage

	ACM/ACL Equipage Scenario			
Variables	10	50	90	Notes
ACARS-equipped airplanes	40%	50%	60%	Note: 1752 airplanes using SITA network right now.
Commuter Equipage Percent	1%	5%	10%	SITA. Current level of equipage for European commuters, relative to commercial.
Max Retrofit Total (over life of model)	50%	75%	90%	
Forward Fit % per yr	50%	60%	75%	Forward Fit with VDL-2 percentages are high because of the need to increase AOC capacity. This number is a guess.
Retrofit % per yr of ACARS baseline	10%	15%	25%	Retrofit with VDL-2 is also driven by AOC congestion. Other reasons are non-related retrofit (e.g. 8.33). Expressed as a percentage of ACARS_equipped airplanes %
Non ACARS/ACARS Retrofit Ratio	0%	20%	100%	Conversion factor used to determine non-AOC baseline retrofit rates, based on AOC baseline retrofit rates.

European Model Inputs

Non-Recurring Costs

* Costs include:

- Equipment: hardware and software
- AOC host costs
- Training

* Equipment cost assumes avionics/flight deck impact: CMU, VDR, wiring, and dedicated display

Airborne Equipment Costs (ACARS Baseline)				
Variable	10	50	90	Notes
Retrofit (AOC VDL-2, including Service Bulletin)	\$ 50,000	\$ 150,000	\$ 400,000	Airline consensus
Forward Fit (AOC VDL-2, including Master Chart)	\$ 30,000	\$ 90,000	\$ 150,000	Airline consensus
ATC Software Upgrade	\$ 30,000	\$ 70,000	\$ 120,000	Airline consensus

Airborne Equipment Costs (no-AOC Baseline)				
Variable	10	50	90	Notes
Retrofit (AOC VDL-2, including Service Bulletin)	\$ 90,000	\$ 190,000	\$ 600,000	

CAP Upgrade (both baselines)				
CAP Upgrade	\$ 10,000	\$ 30,000	\$ 75,000	Assume VDL-2 equipped airplane <u>with</u> FMS connection, and that this is required in Europe only. Assume that non-FMS airplanes are those that will not equip with VDL-2.

Airline Host Costs (ACARS Baseline)				
Variable	10	50	90	Notes
Average host/router upgrade, per airline	\$ 100,000	\$ 200,000	\$ 300,000	Airline & ARINC/SITA consensus

Airline Host Costs (no-AOC Baseline)				
Variable	10	50	90	Notes
Average AOC infrastructure costs	\$.5M	\$1.5M	\$2.5M	SITA, reflects costs of: host system, applications, training, etc on ground.
Number of airlines implementing AOC host systems per year	2	3	4	SITA.

Training (both baselines)				
Variable	10	50	90	Notes
Average Cost of simulator upgrade	\$ 100,000	\$ 240,000	\$ 400,000	KLM
Number of simulators to be upgraded as percentage of total number of airplanes	2	3	5	

Issues 1, 2, 6, 9

AOC vs. non-AOC Baseline

- * Minor differences between benefits (\$\$)
- * Benefit of AOC for No_AOC baseline has range of 4-9 Euro (equal to the average AOC cost per flight segment) -- should this benefit have wider range?
 - Alternative? Calculate benefit based on implementation cost + operating cost
- * Russ, please explain how you came up with average AOC cost per flight segment
 - actual cost based on airline input.

Benefits

AOC, ATC, and Recurring Costs

Benefits	VDL-2 Equipage Baseline		AOC or non-AOC Baseline			
	VDL-2 Equipped	Non VDL-2 Equipped	AOC Baseline Equipped	AOC Baseline Non-Equipped	Non-AOC Baseline Equipped	Non-AOC Baseline Non-Equipped
Delay Reduction	X	X	X	X	X	X
ATC Message Costs	X		X		X	
ATC SW Maint Costs	X		X		X	
Infrastructure Costs	X	X	X	X	X	X
AOC N/A Avoidance	X		X		X	
AOC Msg Savings			X			
AOC benefits for non-AOC airlines					X	

The purpose of this matrix is to map the benefits to the population of airplanes that receive them. In the US analysis we had simply VDL-2 equipped and non-VDL-2-equipped airplanes in the total population. In the European analysis this is further complicated because we have included airlines that do not currently use ACARS AOC as well as those who do. The "AOC Message Savings" and "AOC benefits for non-AOC airlines" benefits are dependent on the baseline, either AOC or non-AOC. All other benefits can be applied based on VDL Mode 2 equipage because they are obtained independently of the AOC baseline.

Model Inputs

AOC Benefits

* AOC Non-Availability

- Cost to an airline of not having full ACARS capability (\$16, \$32, \$48 per flight)

* AOC message cost reduction

- per-bit savings and message length reduction

* Benefit of AOC applications to non-AOC baseline airplanes

AOC Benefits

AOC Non-Availability Avoidance (Both Baselines)				
Benefits	10	50	90	Notes
Cost per flight of AOC Non-Availability	\$ 16	\$ 32	\$ 48	Airline consensus. This variable is an industry estimate. This data is highly competition sensitive and will be unique for each airline.
Start Yr of AOC Non-Availability Problems		2003		SITA

AOC Lower Message Costs (AOC Baseline)				
Benefits	10	50	90	Notes
Current average AOC cost per flight segment	\$ 4	\$ 6	\$ 9	SITA/ARINC. Kathleen ask Russ to explain this.
Lower messages costs for AOC	50%	75%	83%	Airline consensus. Percentages correspond to 2:1, 4:1, 6:1 savings due to message length reduction, and are applied to the average AOC cost per flight segment each year. These rates would apply to incremental traffic on higher speed data link. There i

AOC Applications to Airlines Not Currently Using Datalink AOC				
Benefits	10	50	90	Notes
Per flight AOC benefit	4	6	9	This is for non-AOC airplanes. Assume for now that the benefit is equal to the AOC cost per flight segment.

Datalink Model

ATC Delay Reduction Benefits

- * Stage 1 is airport delay reduction**
- * Stages 2 & 3 are en-route delay reduction**
- * Based on data from Eurocontrol L2KBC+ simulation**
- * Applied to all airplanes, not just those equipped**
- * Benefits are dependent on equipage levels**

Delay Reduction Changes

Issue #28

- * Originally had % Delay Savings per Flight of 10/40/66%
- * Changed to a constant 66%, based on L2KBC+ results for 100% equipage
- * Used European Scaling Factor (30/50/80%) to express uncertainty in delay reduction
- * Use new Delay vs. Equipage curve to account for varying equipage levels (see next slide)

Proposed Delay Reduction Model Benefits (2)

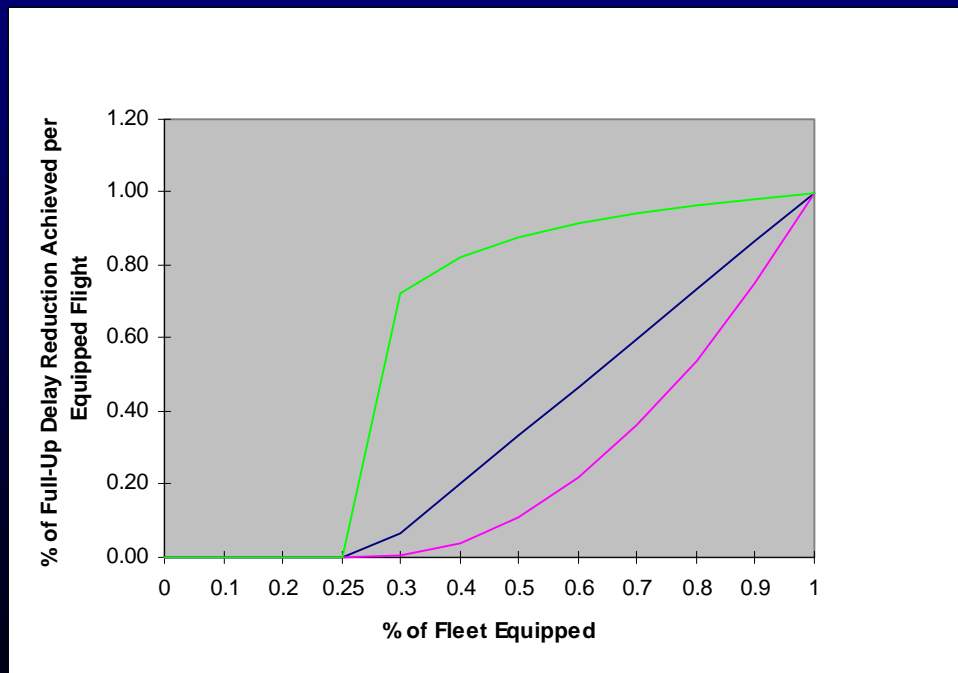
- * We will use 66% delay reduction discounted with European scaling factor (30/50/80%) because we don't have calculated results for 150% and 200% traffic density situations.

Issue #30

Delay vs. Equipage Curve Proposed

Upper Curve Based on L2KBC+ (without discount factor)
Other Curves same as in US analysis

Decision: Use only the top (green) curve, as it represents actual simulation results



ATC Benefits

Cost of Delay per Minute				
Cost of Delay per Minute	\$ 11	\$ 22	\$ 33	IATA and Eurocontrol

Airport Delay Reduction				
Benefits	10	50	90	Notes
Cost Avoidance of late flight or missed connection (\$/equipped and airport covered flight)	\$2	\$4	\$6	KLM. Reduced turn-around time.

Enroute Delay Reduction				
Benefits	10	50	90	Notes
% Delay savings per flight (assume 100% equipage).		66%		Based on preliminary results from L2KBC simulation.
European Scaling Factor	30%	50%	80%	Discounts the delay savings per flight because of uncertainty in the relationship between controller workload reduction and delay reduction.
Delay minutes per flight (1999)		6.6		Eurocontrol -- Medium-term Capacity Shortfalls 2003-2005 -- EEC Note No. 16/99
Minimum Equipage Required	20%	25%	35%	ATC benefits don't start until this percent equipage is achieved. Estimate based on NASSIM and DPAT results
Delay Reduction vs. Equipage Curve				Using 3 curves.

Model Inputs

Recurring Costs

- * Ground Infrastructure Sustaining Costs (route charges)**
- * ATC Message Costs**
 - It is very likely that the ATC Message Costs will be reduced significantly, thereby increasing the benefit/cost ratio**
- * ATC Software Maintenance**

Recurring Costs

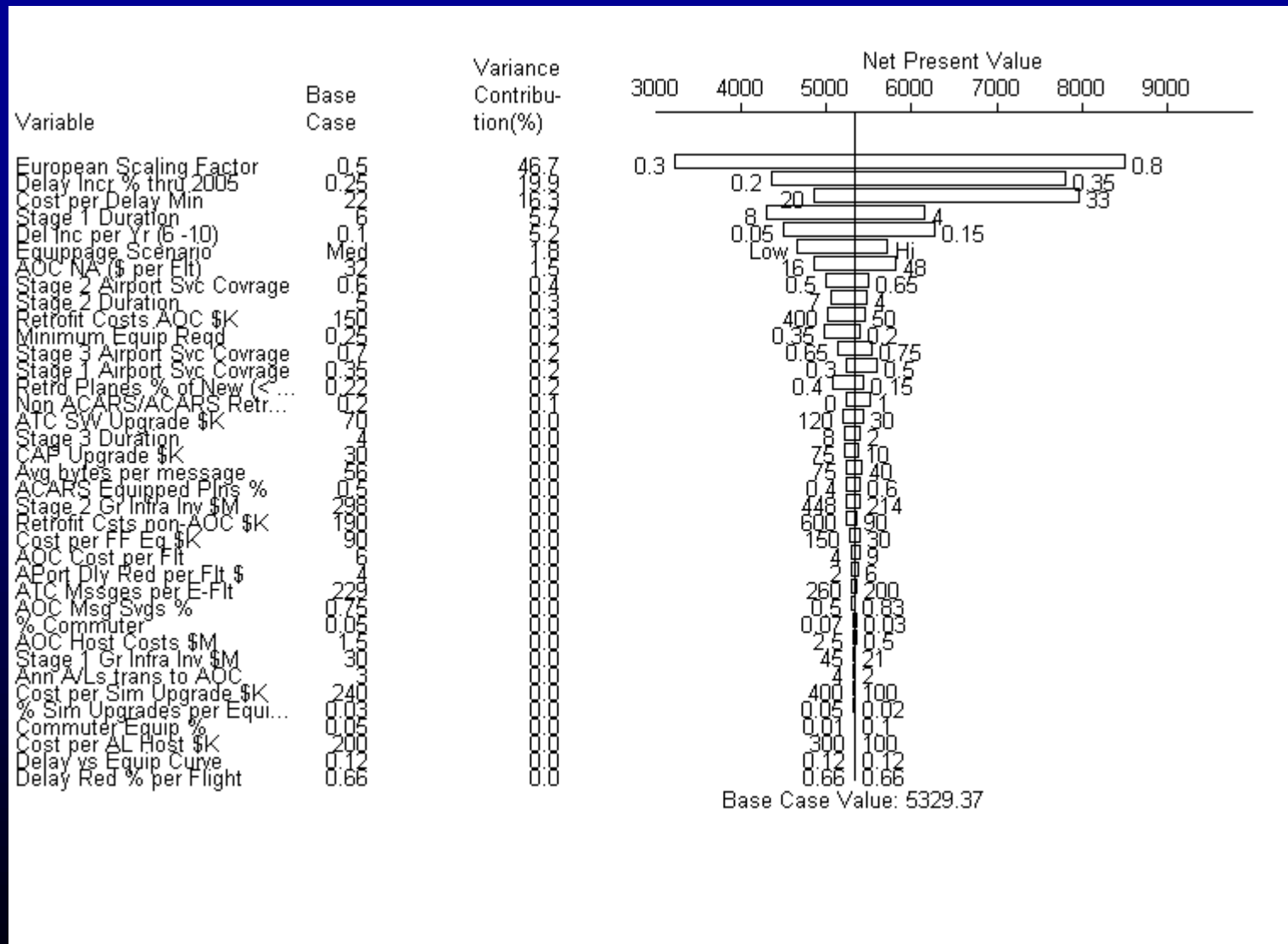
Ground Infrastructure Sustaining Costs (route charges)				
Benefits	10	50	90	Notes
Stage 1. Total implementation cost of ground infrastructure	21	30	45	Eurocontrol. L2K+ OSD area
Stage 2. Total implementation cost of ground infrastructure	214	298	448	Eurocontrol. L2K+ OSD area
Total annual recurring cost of ground infrastructure (Annual Datalink Sustaining) includes communication costs. This is applied to ALL flights (not just those equipped) in a "covered" area.	10% of total implementation cost	10% of total implementation cost	10% of total implementation cost	Eurocontrol. Starts at beginning of Stage and implementation is spread over Stage duration. Sustaining costs from stage end and beyond.

ATC Message Costs				
Variable	10	50	90	Notes
ATC Messages per equipped flight	200	229	260	FAA JRC charts
Average bytes per message	40	56	75	FAA JRC charts

ATC S/W Maintenance Costs		
ATC SW Maintenance	10%/year of ATC Software Upgrade Cost, starting 2nd year	Airline consensus

European Datalink--Overall Case

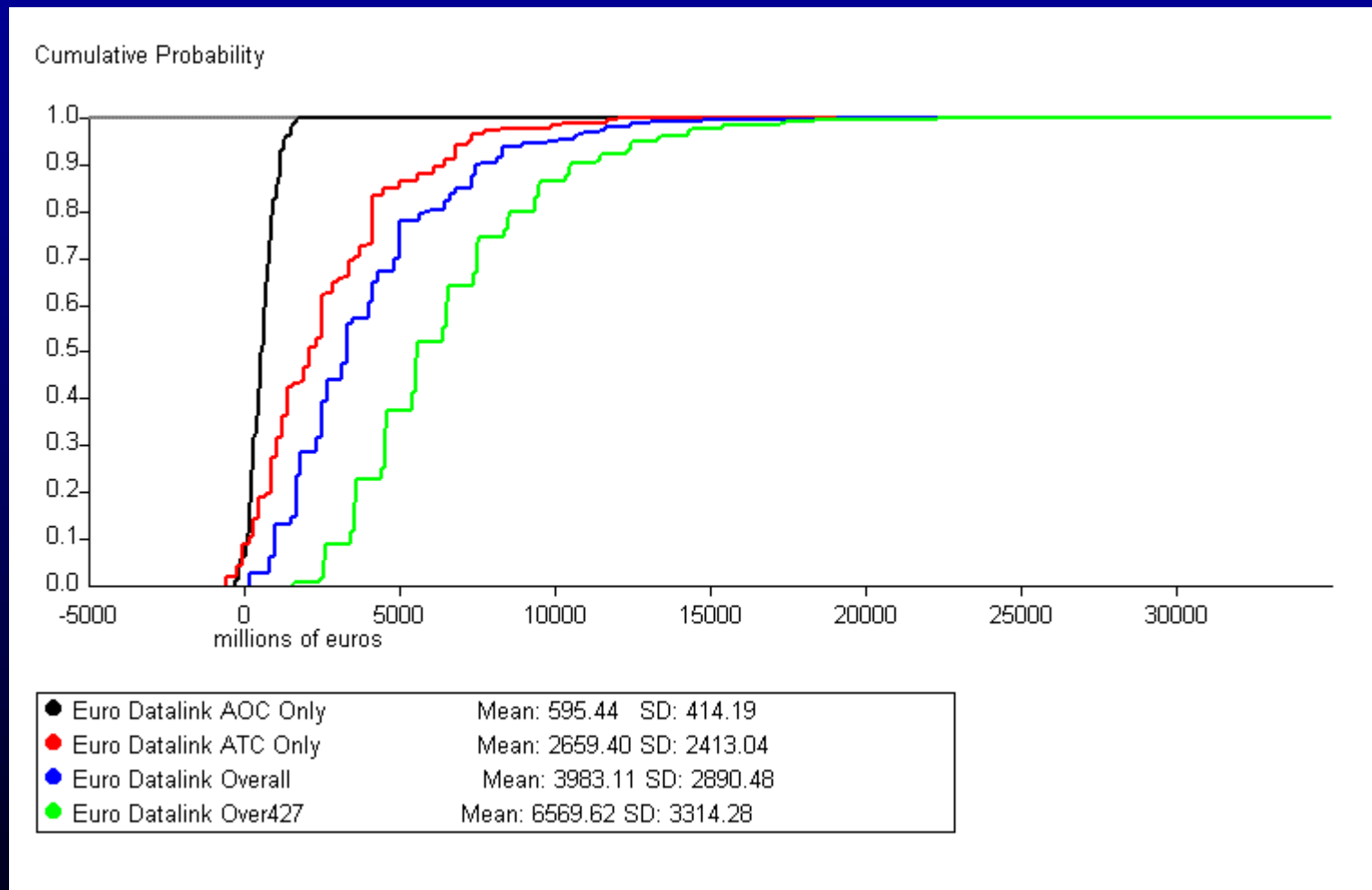
Tornado Diagram



European Datalink--Preliminary Results

Cumulative Probability Distribution

Note: Green line represents latest results



European Datalink--Preliminary Results

Summary of Values

Scenario	NPV \$M	Benefits (NPV) \$M	Costs (NPV) \$M	Benefit/ Cost Ratio	Breakeven Yr	IRR
Overall (4/27)	\$6569	\$7346	\$777	9.4	2006	64%
Overall 90%tile Delay Red vs. Equipage Curve	\$5329	\$6721	\$777	8.6	2006	64%
ATC Only	\$2659	\$3434	\$775	4.4	2011	34%
AOC Only	\$595	\$1114	\$519	2.1	2008	35%

Conclusions

- * Reiterate NPV, IRR, Break-even year etc.
- * There is a strong business case for airlines to equip with ATS datalink for future delay reduction
- * There is minimal investment risk for ATS data link (probability of negative NPV is negligible)
- * Delays in infrastructure cost TBD NPV (~\$1/2 billion per year)
 - There is huge amount of NPV that an airline would lose by delay in ground infrastructure and airplane equipage
 - The NPV can be significantly increased by accelerating equipage rate and infrastructure implementation.
 - The break-even year is constrained by infrastructure implementation (stage 1 duration)
- * The real-time simulations and fast-time validation performed last year provide solid basis for estimating relationship between delay reduction and capacity
- * The maximum benefit is derived from combining AOC and ATC
- * Results of European model are different from US mainly because delay growth in Europe is x% higher than US