C/AFT
European
Datalink Investment Analysis

Working Meeting

September 1, 1999

Overview

- Introduction & Assumptions
- AOC Situation
- ATC Situation
- C/AFT Modeling Process
- Model Inputs
- Results
- Potential benefit of future datalink enhancements
- 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
- Datalink is primary candidate enabler for delay reduction

Assumptions

- This is not an alternatives analysis, datalink 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)
- AOC frequency congestion drives equipage
- Air traffic growth drives ATC infrastructure readiness, which drives equipage
- 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 AOC and ATC benefits considered

U.S. Airline Operations Control
Why the Need for Change?

- **ACARS Demand is Increasing**
  - New aircraft being delivered
  - New airline users entering service
  - New applications and non-airline users
- **ACARS is a Shared-Access System**
  - Based on non-discriminatory system of FCC frequencies
- **Spectrum Availability and Congestion**
  - Limited number of VHF frequencies
  - Interim ACARS expansion is short-lived and expensive

U.S. Airline Operations Control
Increasing U.S. Demand for Service

- **Growing number of ACARS aircraft in U.S.**
  - Today: Approx. 5600 U.S. + 1500 Non-U.S. = 7100
  - Future: Up to 1200 more over next 3 to 5 years
- **Potential new demand from new participants**
  - Civil: Large Scheduled (Regional), Cargo, & Business
  - Military: Non-Tactical Aircraft, Air National Guard
  - Estimated potential at more than 4500 additional a/c
- **Increasing number of data link applications**
  - Aircraft Performance
  - Crew Management
  - In-flight Operations

European AOC Issues

- X% of airlines 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, 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 (to be confirmed by SITA)
- Relying on AOC more than before, AOC is becoming backbone of Operational Control organization. Airlines will be relying more on ACARS data. Impact to passengers -- flight information on board.

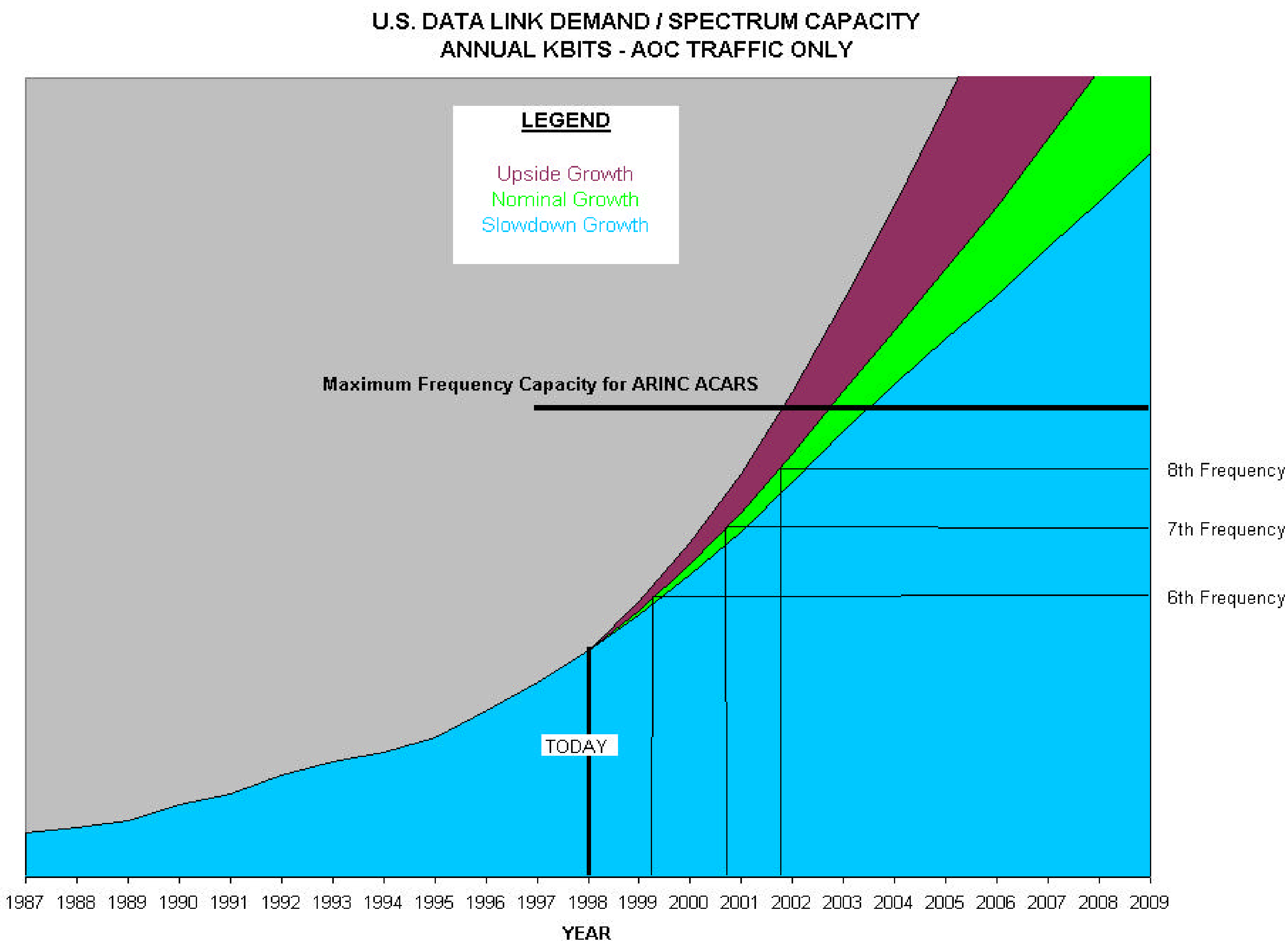
European Spectrum Issues
Congestion and Availability

- New applications is the primary reason for increasing demand for ACARS
- New data link users entering service is the secondary reason for increasing demand for ACARS
- Many areas of US already already experiencing congestion on en route frequencies
- Other industries are looking and petitioning for available spectrum (use it or lose it)

Managing spectrum congestion and availability will be a growing and continuing concern for the airline industry.

The Digital Solution (VDL-2)

- Migration of ACARS traffic to VDL-2 will effectively address projected frequency congestion
- ACARS capacity cannot be expanded
- ATC Data Link is a common element in most new applications related to ATC modernization and airspace management
- Network Service Providers transitioning to VDL Mode 2 to provide more ACARS capacity
- ATC data link services will be available on ATN VDL Mode 2



U.S. DATA LINK DEMAND / SPECTRUM CAPACITY
ANNUAL KBITS - AOC TRAFFIC ONLY
LEGEND
Upside Growth
Nominal Growth
Slowdown Growth
Maximum Frequency Capacity for ARINC ACARS
8th Frequency
7th Frequency
6th Frequency
TODAY
1987 1988 1989 1990 1991 1992 1993 1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009
YEAR

U.S. ATC Situation

- American Airlines performed study of impact of delay on airline schedule
  - Without capacity improvements airline flight schedule critically impacted by year 2005
  - By reducing separations airline schedules can be maintained
- FAA study of Cruise/Terminal Transition area datalink indicates significant delay reduction possibilities
  - Reduce voice frequency congestion
  - Redistribute controller workload, allowing improved ATC services for increased sector productivity and efficiency
- FAA has funding approval for Builds 1 and 1a VDL Mode 2 CPDLC.
- PETAL-II trials in Europe underway to evaluate datalink operational issues

European ATC Situation

- Current delay situation is very bad, need to do something immediately
  - airlines are willing to invest in reducing the amount of delay that exists today
  - need to maintain acceptable levels of delay (see performance target document)
  - FAP document has 5 year forecast -- use those numbers -- update will be ready in October
- European study of impact of delay on airline schedule?
  - Henk/Ben will provide delay growth numbers
- Eurocontrol doing data link simulation (L2KBC)
  - studying potential capacity gains by implementing ATS data link
  - preliminary results in October
- Link 2000+ using business case to justify ATS data link implementation
- PETAL-II trials in Europe underway to evaluate datalink operational issues

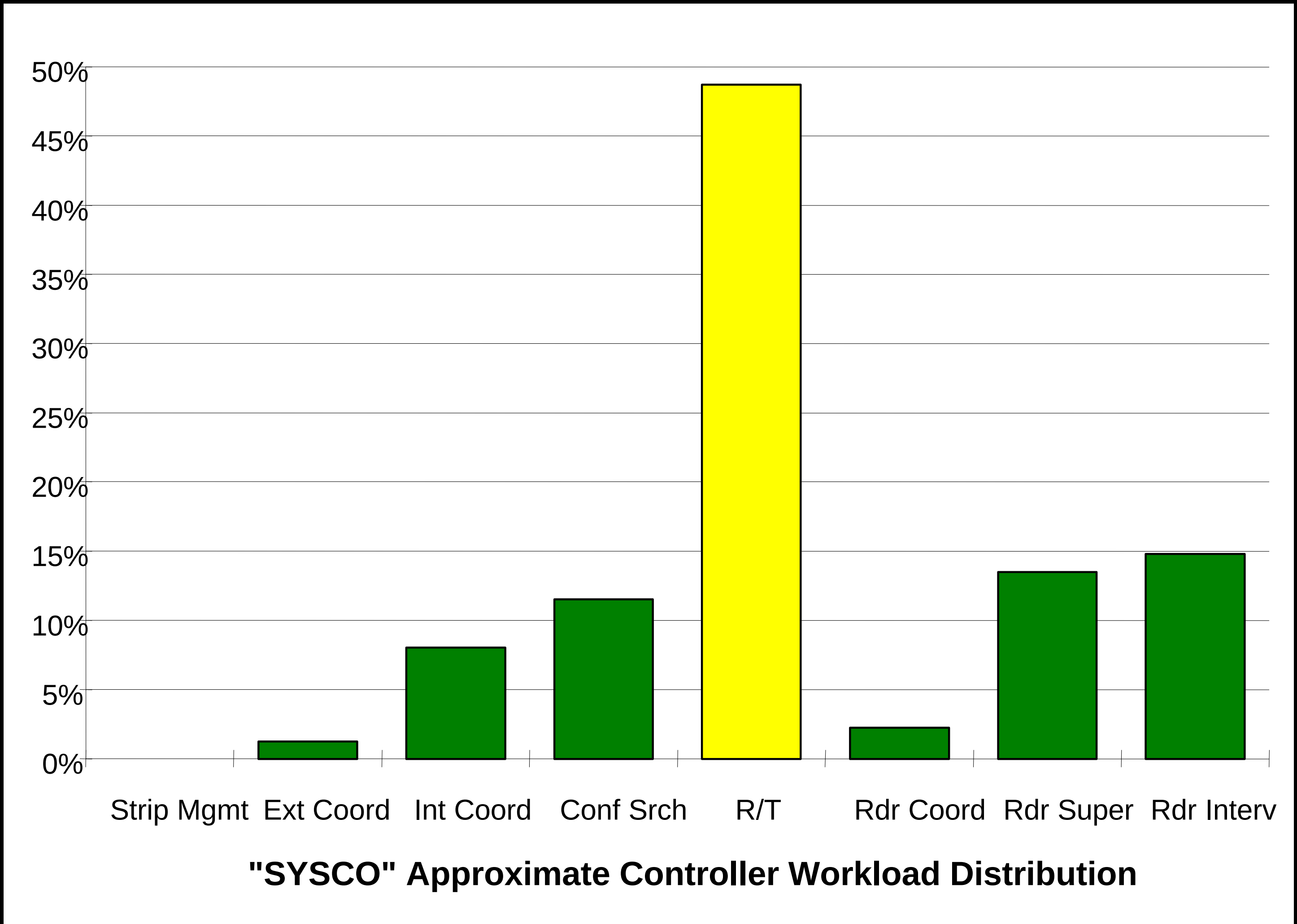
European ATC Situation, continued

- Voice frequency congestion looming, it will not be possible to increase capacity by opening new sectors and therefore a different approach (e.g. controller tools) will be needed.
- ATC unit costs must not increase, capacity growth has to be affordable
- Infrastructure improvements must be sustainable (provide evolutionary path)
- Assume dual-stack (FANS/ATN) not supported in the areas of Europe represented in this analysis

FAA's Data Link Program
Based on ATN over VDL-2

- Builds 1 and 1A are subset of PETAL-2
- Build 2 includes initial oceanic message support
- Build 2 has international scope
  - Eurocontrol and European States requesting joint FAA collaboration to define follow-on data link implementation project.
- Build 2 follow-on activity expected to be key in setting the international standard for ATC data link in congested, highly developed airspace.
- Build 2 will define the beginning of the transition from FANS-1 to ATN.

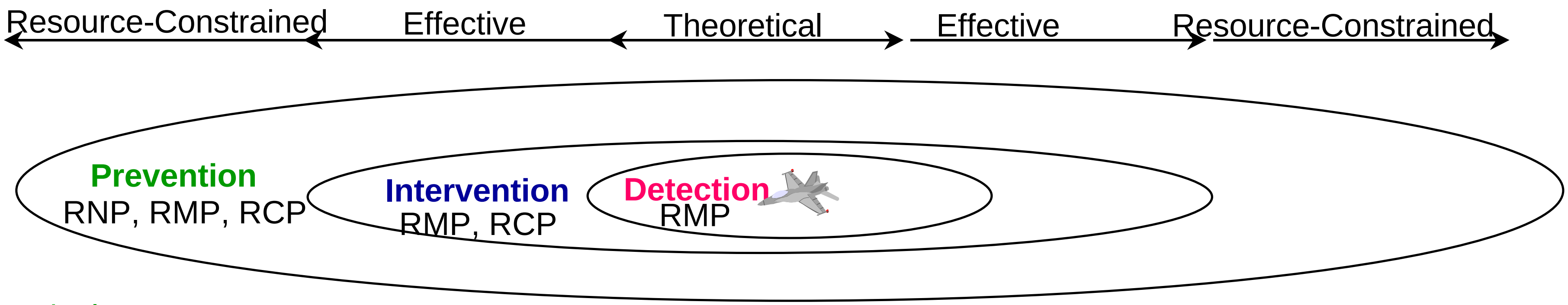
The First Step:
Controller Communications Workload
document source



C/AFT Modeling Process
Transition Logic Diagrams

- C/AFT is proponent of incremental operational enhancements
- Transition Logic Diagrams
  - separate diagram for each phase of operation
  - developed for both capacity and efficiency
  - operational enhancements “enabled” by technology or procedural improvements
- C/AFT analysis focuses on capacity-related improvements
  - Reduced separations
  - Additional routes

Separation Rings



Display
Weather
Medium-Term Intent
Data Controller
Comm: g/g
Pilot
Flow Rates
Airspace Complexity

Sensor
Display
Short-Term Intent
Controller
Comm: a/g
Pilot
Closure Rate

Sensor
Display
Controller
Pilot

Required Element Performance

RxP = **f** (sensors, decision support, human)

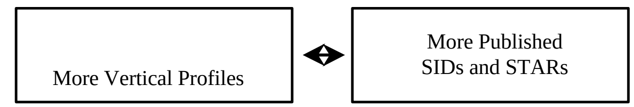
Required System Performance sets Separation Standard

RSP = **g** (RCP, RMP, RNP)

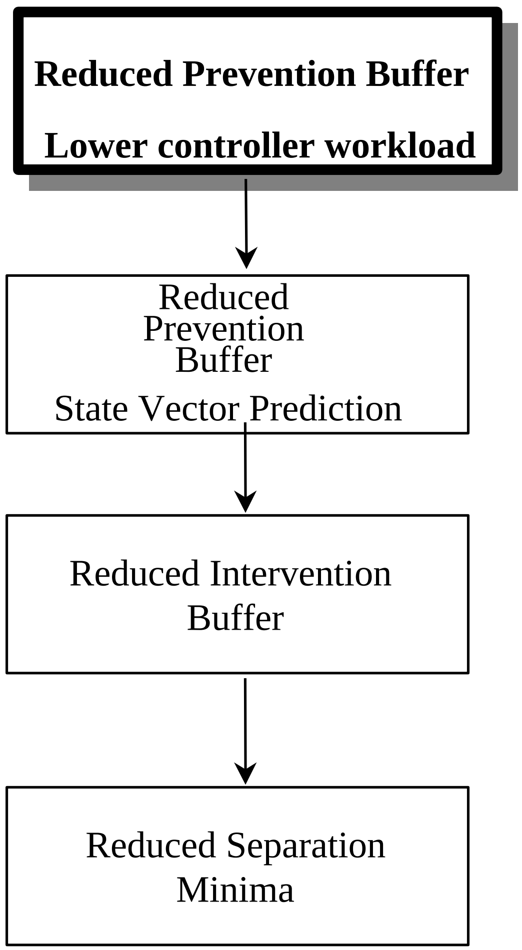
CNS/ATM Focus Team

5. Cruise/Terminal Transition Area Transitions

System-Level Capacity Effects



Airplane-Level Capacity Effects



Atlanta study baseline.
Datalink used for Clearances and Transfer of Comm

FAA Atlanta Study

- **Cruise/Terminal Transition Sector handles arrival sequencing, overflight traffic, and departures**
- **Restrictions are enforced due to communication volume saturation**
- **Problem: During peak periods 20 Miles in Trail (MIT) for departures entering sector, resulting in ground delays**
- **Result: Using datalink for routine voice communications allowed reduction from 20 MIT to 5 MIT (62% delay reduction)**

European ATC Benefits

- Will be looking at multiple services affecting multiple phases of flight
- First stage will be local services at airports
  - Departure Clearance
  - D-ATIS
  - Assume that transition from old way to new way will occur between now and some date (e.g. 2005), more airports will provide the infrastructure, and more airports provide service, and that airlines will transition to VDL-2.
  - For those currently using these services they will see benefit because of more airports offering the service, and lower cost of service (assuming that service over VDL-2 is cheaper than over VHF ACARS)
  - For those not doing it now, but that equip with VDL-2 they will see the benefit of the service
    - airport infrastructure readiness will drive equipage

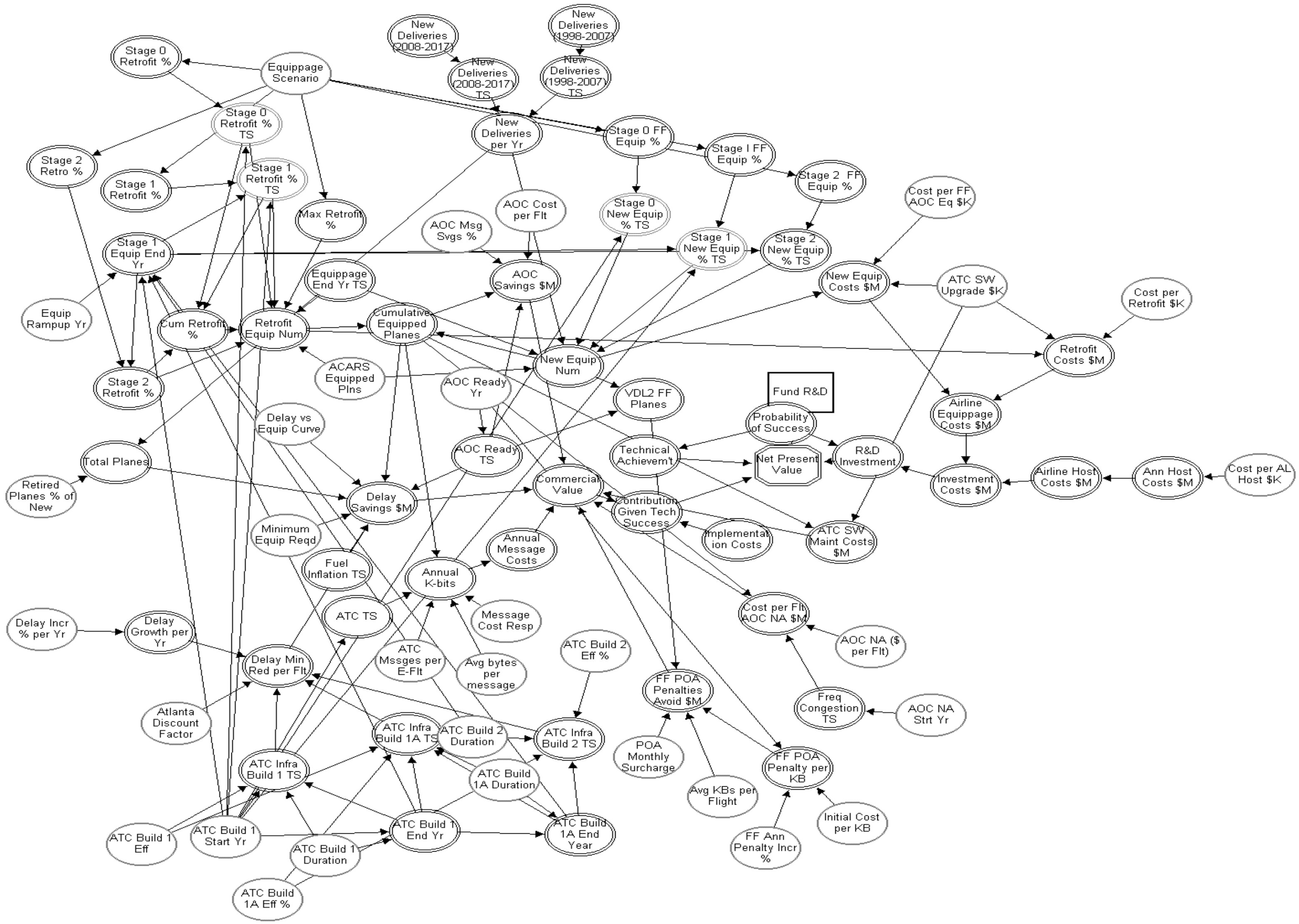
European ATC Benefits, continued

- Second and third stage will be area-wide services in en-route
  - C/AFT concludes that grouping of the functions in Appendix B of the LINK 2000+ Operational Scope Document in the L2KBC simulation does not identify the benefit contribution of every element. The C/AFT approach is to evaluate the value of incremental operational enhancements. Itemizing the functions would be consistent with the C/AFT approach.
  - Link 2000+ Drafting Group to make a decision on how to adapt the L2KBC simulation by Monday September 6, 1999. Ben Berends to inform C/AFT of the decision.
  - If any elements are excluded from the simulation they will also be excluded from the costs in the C/AFT model.

C/AFT Modeling Process
Economic Model

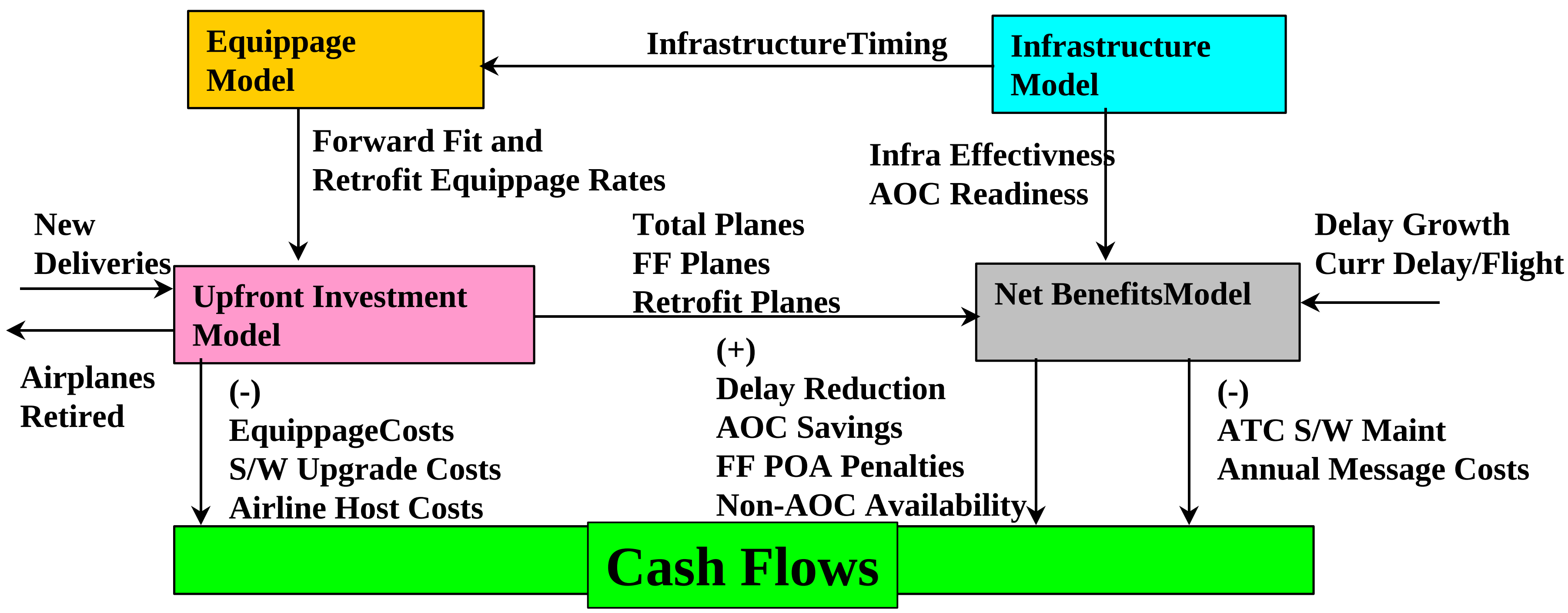
- **Determines**
  - Costs
  - Benefits (converted to dollars)
  - Risk
  - Rules
- **Builds Deterministic Sensitivity Analysis**
  - Identifies influence of each uncertainty on NPV
  - Used to calculate overall risk and return

Datalink Influence Diagram



CNS/ATM Focus Team

Datalink Investment Model



U.S. Model Inputs
Constants

- ✷ Start Year of Model 2000
- ✷ Final Year for Equippage = 2015
- ✷ Final Year for Benefit = 2020
- ✷ Discount Rate = 12%
- ✷ Inflation Rate = 3.5%
- ✷ Direct Operating Cost (DOC) per minute = $25
  - Does not include amortization of costs for ownership
- ✷ Percentage of Fuel-related DOC = 30%
- ✷ Fuel inflation rate = 5%

European Model Inputs constants

- Similar to US constants
  - see spreadsheet for details
- Will also include number of “other” airplanes for equipage vs. benefits curve
  - Proposal: Include costs and benefits of passenger jetliners. Include equipage levels of commuter and business aircraft, but do not factor in their costs/benefits.
  - The model will be structured so that it can be run for any population of airplanes. If airlines wish to determine costs and benefits for their commuter fleet they can have the spreadsheet and simply change the input data.

Airplane Types

- **Passenger Jetliner**
  - **This category includes all commercial aircraft with more than 100 certified seats. These aircraft are typically operated by scheduled airlines and charter airlines. The main manufacturers of aircraft of that category are Airbus and Boeing. The most frequent aircraft types are B737, MD80, B757, B747, B767, A300, A320, and A310.**
- **Commuter**
  - **This category includes all commercial aircraft, either jet or turbine-powered, with more than 15 (but less than 100) certified seats. These aircraft are typically operated by scheduled airlines, regional carriers and charter airlines. The main manufacturers of aircraft of that category are ATR, BAE, Embraer, Dornier, Saab, Canadair and de Havilland. The most frequent aircraft types are AT42, BA46, F50, DHC8, SF34, and SB20.**

Airplane Types

- Business Aircraft
  - This category includes all executive/corporate aircraft with more than 5 certified seats. These aircraft are typically operated by private enterprises and air taxi operators. The main manufacturers of aircraft of that category are Dassault, Gulfstream, Beechcraft, Canadair and Cessna.
- Private Aircraft
  - This category includes all remaining aircraft not considered in the previous categories but equipped for IFR operation.

U.S. Model Inputs
Delay Growth

- Derived from Free Flight, Preserving Airline Opportunity, by Captain Russell Chew, Fig. 4
- Large range of this variable due to:
  - Russ' study was using conservative good weather day estimate
  - This represents delay over optimum (not schedule)
  - This takes into account unmet traffic growth due to capacity constraints

Variables	10	50	90
Delay Growth Per Year	2.5%	7%	11%

European Model Inputs
Delay Growth

- Need similar data for Europe

U.S. Model Inputs
Traffic Growth

- Start with current number of airplanes, add new deliveries and subtract retiring planes each year
  - 1997 Total Number of Airplanes 5194 (ATA)
  - New Deliveries per Yr (1998 to 2007) 233 (Boeing CMO)
  - New Deliveries per Yr (2008 to 2017) 326 (Boeing CMO)

Variable	10	50	90
Retired Planes as % of New	15%	22%	40%

European Model Inputs
Traffic Growth

- Need similar numbers for Europe

U.S. Model Inputs
Traffic Growth

- Number of planes at start of model: 5194 (from ATA)
- Number of planes in 2015:
  - Low estimate: 8054
  - Medium estimate: 8943
  - High Estimate: 9289

European Model Inputs
Traffic Growth

- Need similar numbers for Europe

U.S. Model Inputs
Infrastructure

- Model includes both AOC and ATC Infrastructure
- CPDLC Builds have an associated "Delay Reduction Effectiveness" which represents the percentage of datalink-related delay that is affected with each build.

U.S. Model Inputs
Infrastructure

Variables	10	50	90
ARINC VDL-2 Infrastructure Readiness Year	2000	2001	2002
ATC Infrastrucutre			
Build 1 Start Yr	2002	2003	2004
Duration of Build 1 (years)	1	2	3
Duration of Build 1a (years)	2	3	4
Duration of Build 2	2	4	8
Build 1 Delay Reduction Effectiveness	0%	0%	0%
Build 1a Delay Reduction Effectiveness	50%	70%	85%
Build 2 Delay Reduction Effectiveness	70%	90%	95%

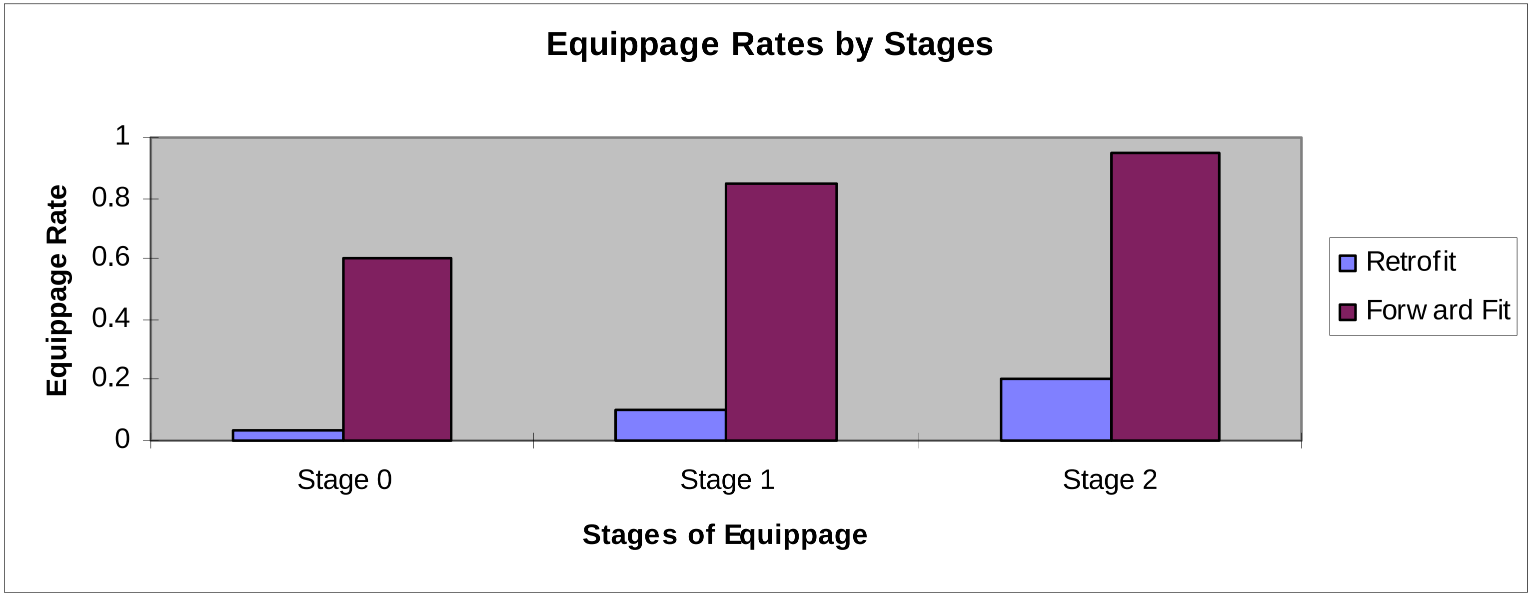
European Model Inputs
Infrastructure

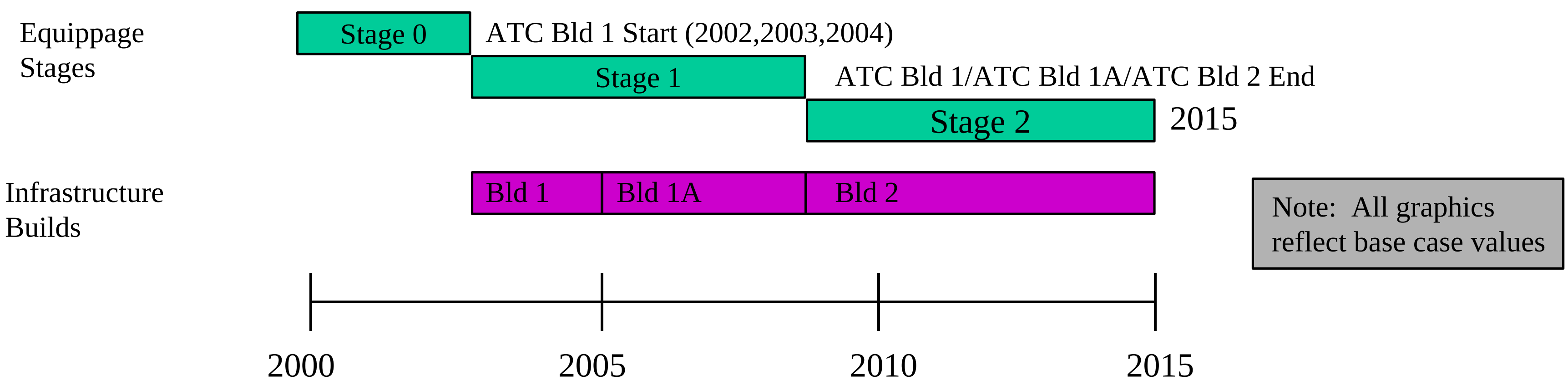
- **Model includes both AOC and ATC Infrastructure**
  - **VDL Mode 2 AOC infrastructure assumed to be ready at start of model**
- **ATC Infrastructure has 3 stages:**
- **CPDLC Builds have an associated "Delay Reduction Effectiveness" which represents the percentage of datalink-related delay that is affected with each build.**

U.S. Model Inputs
Three Stages of Equipage

- **Stage 0**
  - tied to AOC infrastructure readiness
  - AOC benefits biggest driver (message cost reduction and penalty avoidance)
  - no ATC delay reduction benefits
  - high forward fit of VDL-2 equipment, low retrofit
- **Stage 1**
  - tied to ATC infrastructure readiness
  - both ATC delay reduction and AOC benefits
  - increased forward fit, low retrofit
  - ends when airlines equip more aggressively due to infrastructure maturity and realized benefits
- **Stage 2**
  - tied to ATC infrastructure maturity
  - both ATC delay delay reduction and AOC benefits
  - low change in forward fit, high retrofit

U.S. Model Inputs
Equipage





Model Inputs
Equipage Timing Variables

Variables	10	50	90
Stage 0			
Stage 0 Start Yr		2000	
Stage 0 End Yr	Build 1 Start	Build 1 Start	Build 1 Start
Stage 1			
Stage 1 End Yr	Build 1a Start	Build 2 Start	Build 2 End
Stage 2			
Stage 2 End Yr		2015	

Model Inputs
Equipage Percentages

Variables	10	50	90
ACARS-equipped airplanes %	85%	90%	95%
Equipage Scenarios	**Low**	**Med**	**High**
Max Retrofit Total (over life of model)	50%	75%	90%
Stage 0 Forward Fit % per yr	25%	60%	75%
Stage 0 Retrofit % per yr	2%	3%	4%
Stage 1 Forward Fit % per yr	50%	85%	90%
Stage 1 Retrofit % per yr	7%	10%	13%
Stage 2 Forward Fit % per yr	75%	95%	100%
Stage 2 Retrofit % per yr	15%	20%	25%

European Model Inputs
Costs

- ATM Infrastructure costs are included
- Equipment costs assumes minimal avionics/flight deck impact: CMU, VDR, wiring, and dedicated display

AOA vs. GACS

- Step 1. Hardware (CMU/VDR) + AOA SW
- Step 2. GACS + ATC + rest of ATN

- OR

- Step 1. Hardware (CMU/VDR) + GACS + ATN
- Step 2. ATC

- DECISION: for first run of the model to put an adequate range on the cost of equipage and ATC benefit timing to represent either configuration.

Model Inputs
Costs

Variables	10	50	90
Equipment Costs			
Retrofit	$ 50,000	$ 80,000	$120,000
Retrofit Installation costs	$100,000	$160,000	$240,000
Forward Fit	$ 30,000	$ 60,000	$100,000
ATC Upgrade	$ 10,000	$ 30,000	$100,000
Average host upgrade, all airlines	$100,000	$200,000	$300,000
Message Costs			
ATC Messages per equipped flight	200	229	260
Average bytes per message	40	56	75
Multiplying Factor on Message costs	0.0	0.5	1.0

Model Inputs
Costs

- ✷ Maintenance costs: 10% per year of ATC upgrade cost
- ✷ Message costs:
  - $.18 0-1Million Kbits;
  - $.14 1-4Million Kbits;
  - $.10 4-8;
  - $.06 8-15;
  - $.05 > 1

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 (discount factor 0.67, 0.8, 0.86)
- **AOC Penalty Avoidance for VDL-2 equipage**
  - per-Kilobit penalty (3%, 5%, 10% increase per year)
  - Monthly surcharge ($900, $1000, $1100 per month)

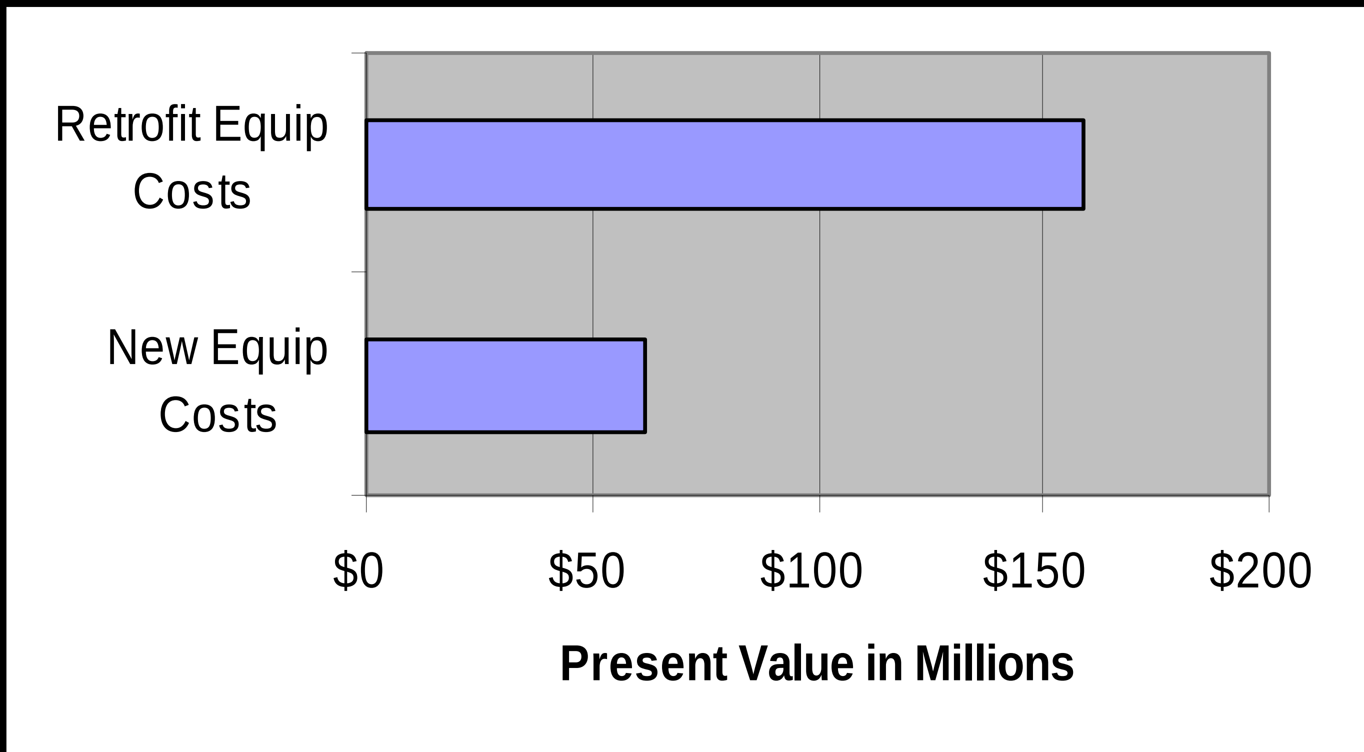
Model Inputs
AOC Benefits

Variables	10	50	90
AOC Benefits (Penalty and Non-Availability Avoidance)			
Forward Fit POA Penalty Avoidance			
Forward Fit POA Penalty Start Year	ARINC I/F start	ARINC I/F start	ARINC I/F start
Average cost per kilobit at start of model	$ 0.10	$ 0.12	$ 0.15
Forward Fit POA Per Kilobit Penalty per yr	3%	5%	10%
Forward Fit POA Monthly Surcharge	$ 900	$ 1,000	$ 1,100
Average Kilobits per flight	30	37	50
Lower messages costs for AOC	0.67	0.8	0.86
Average AOC cost per flight segment ($)	$ 5	$ 10	$ 15
AOC Non-Availability Avoidance			
Start Yr of AOC Non-Availability Problems	2002	2006	2010
Cost per flight of AOC Non-Availability	$ 16	$ 32	$ 48

Model Outputs
AOC Only

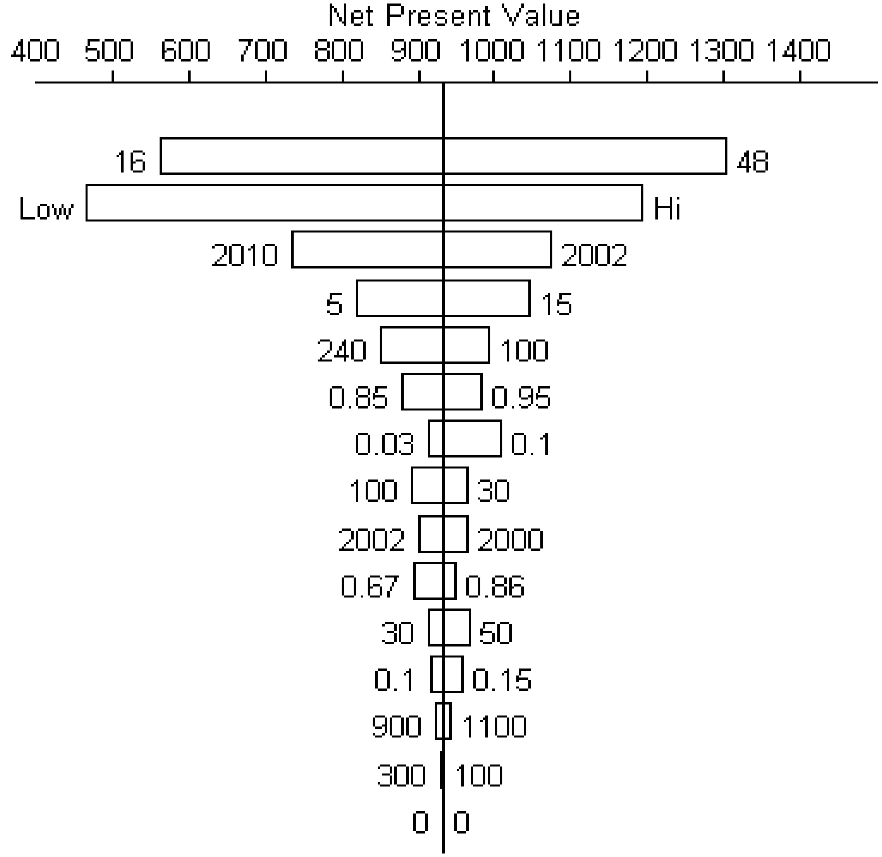
- Let's look at AOC only scenario
- AOC-only scenario uses Stage 0 equipage rates only:
  - Forward Fit per Year 25%, 60%, 75%
  - Retrofit per Year 2%, 3%, 4%

AOC Only
(Stage 0 Equipage Rates)
Cost by Category



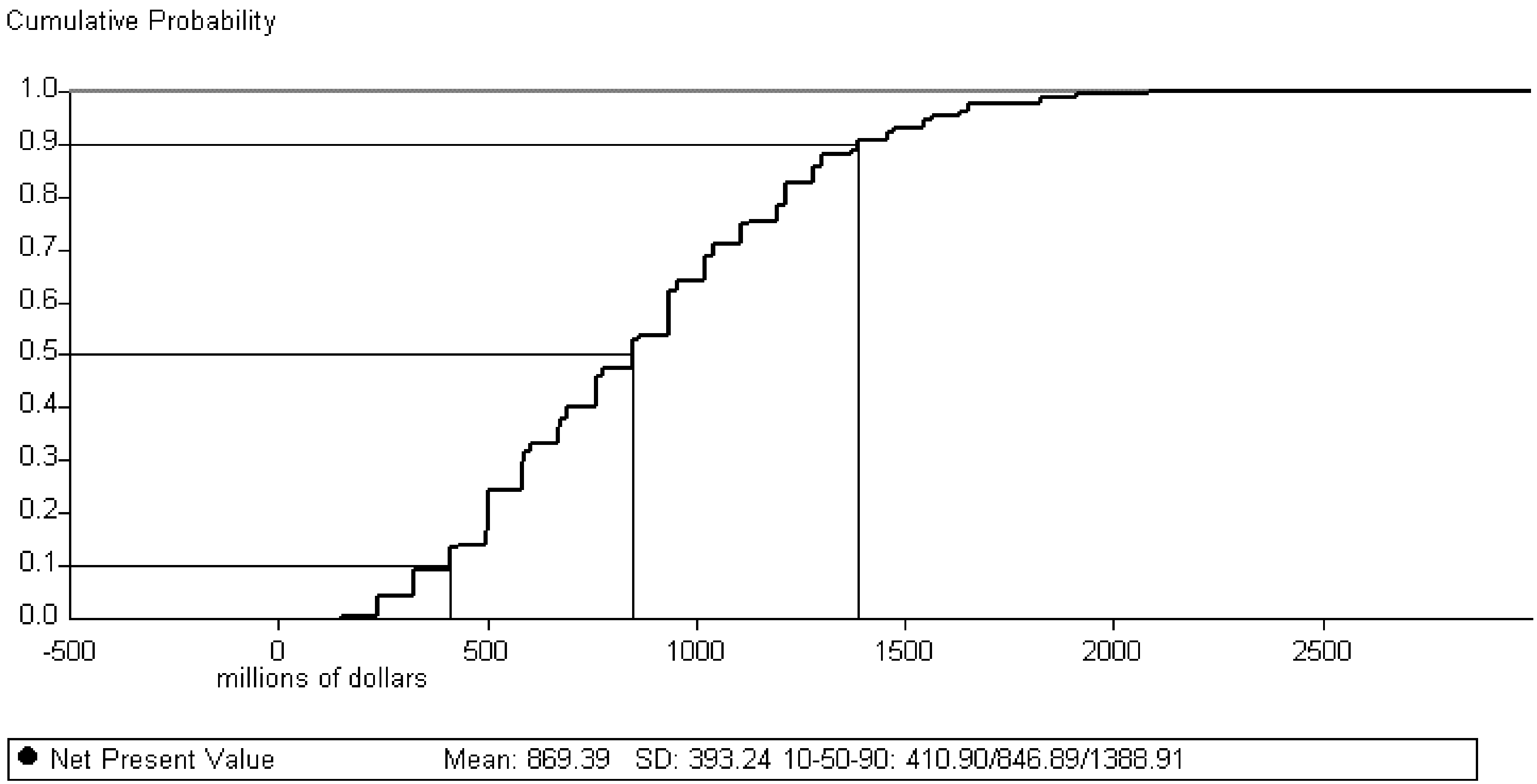
AOC Only
(Stage 0 Equipage Rates)
Deterministic Sensitivity

Variable	Base Case	Variance Contribution(%)
AOC NA ($ per Flt)	32	42.1
Equippage Scenario	Med	40.8
AOC NA Strt Yr	2006	8.8
AOC Cost per Flt	10	3.8
Cost per Retrofit $K	160	1.4
ACARS Equipped Plns	0.9	0.8
FF Ann Penalty Incr %	0.05	0.6
Cost per FF AOC Eq $K	60	0.3
AOC Ready Yr	2001	0.2
AOC Msg Svgs %	0.8	0.2
Avg KBs per Flight	37	0.2
Initial Cost per KB	0.12	0.1
POA Monthly Surcharge	1000	0.0
Cost per AL Host $K	200	0.0
ATC SW Upgrade $K	0	0.0



Base Case Value: 932.21

AOC Only
(Stage 0 Equipage Rates)
Cumulative Probability Distribution



AOC Only
(Stage 0 Equipage Rates)
Value of Perfect Information and Control

Selected Chance Variables	VOPI	VOPC
Equippage Scenario	0.0	$301M
AOC NA Strt Yr	0.0	148
AOC NA ($ per Flt)	0.0	349
AOC Cost per Flt	0.0	98

Value of Perfect Information: The value you should be willing to pay to know the outcome of an uncertainty before you make the investment decision.

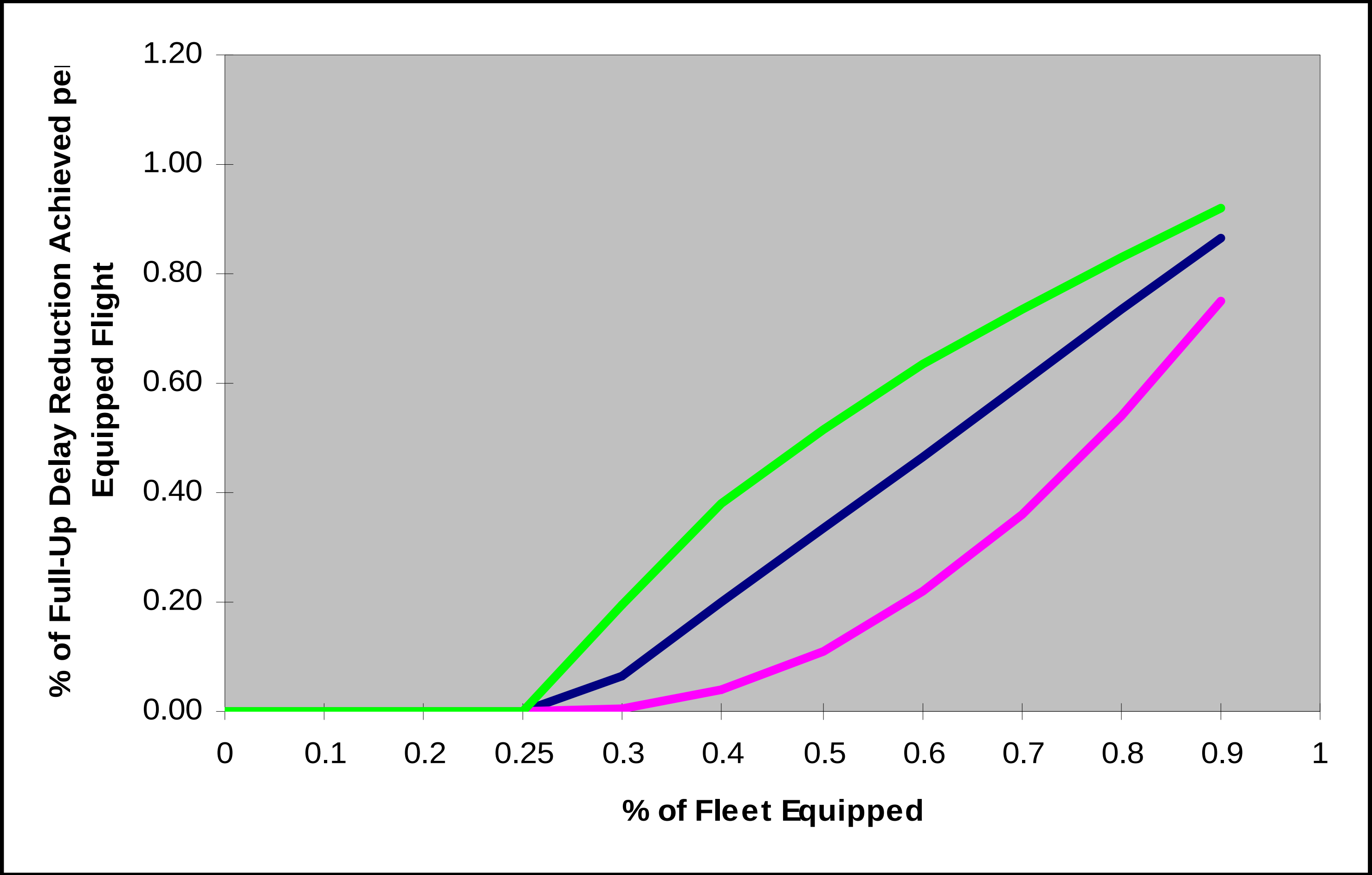
Value of Perfect Control: The value you should be willing to pay to ensure that the outcome of an uncertainty comes out to the most favorable outcome for your decision.

Note: These calculations assume a 25% chance of the 10th percentile event occuring, a 50% chance of the 50th percentile event occuring, and a 25% chance of the 90th percentile event occuring.

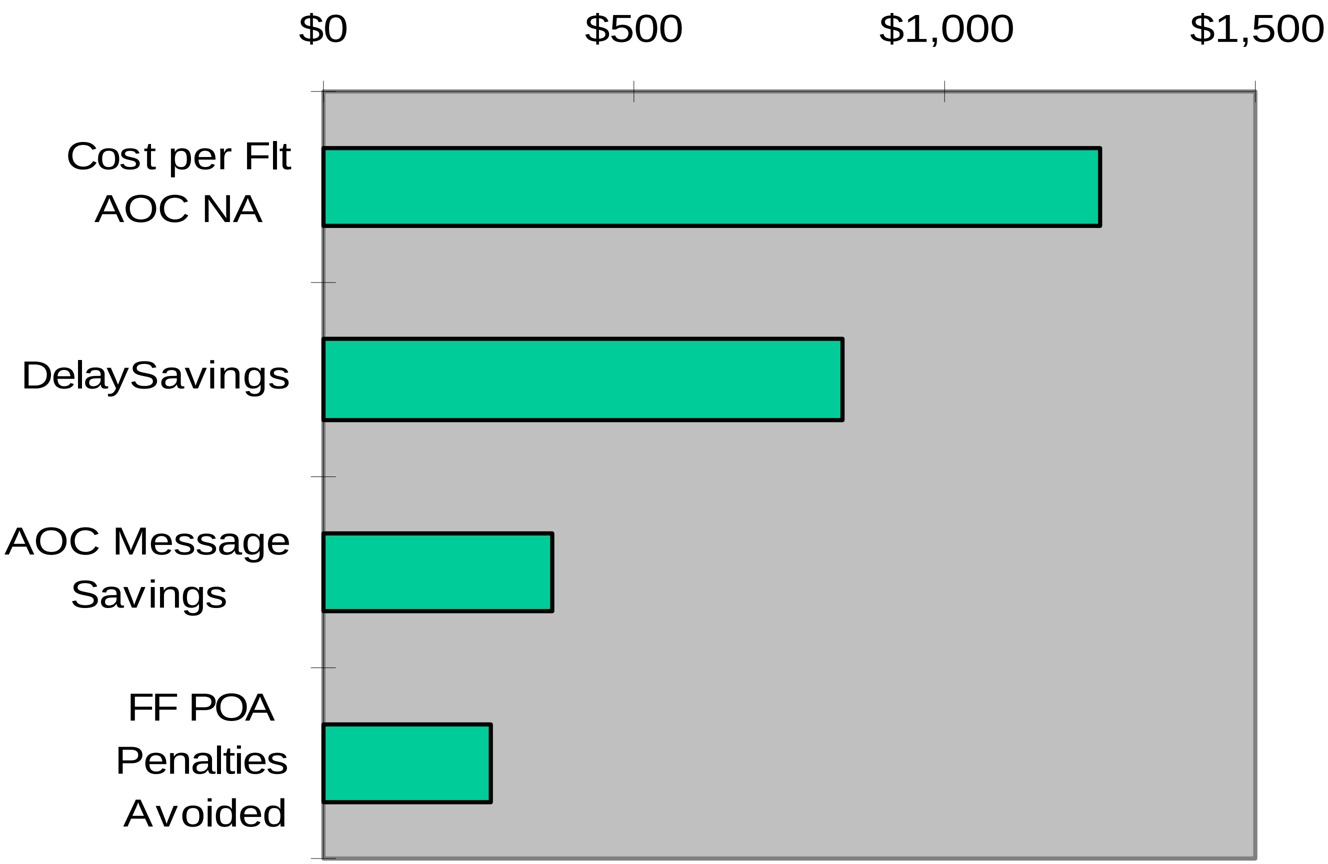
Datalink Model
ATC Benefits

- ✷ Delay reduction benefits applied to <u>all</u> airplanes, not just those equipped
- ✷ ATC Delay Reduction Benefit
  - Based on Atlanta study; scaled study benefits
  - Assigned delay reduction % to each FAA Build
- ✷ Uses the following formula:
  - Atlanta NAS-wide benefits * discount factor * annual delay growth
    - Atlanta NAS-wide benefits = 11,491,387 minutes saved in Cruise/Terminal Transition phase of flight
    - Discount Factor = 30%, 50%, or 80% of Atlanta-study benefits
    - Annual Delay Growth = 2.5%, 7%, 11% per year

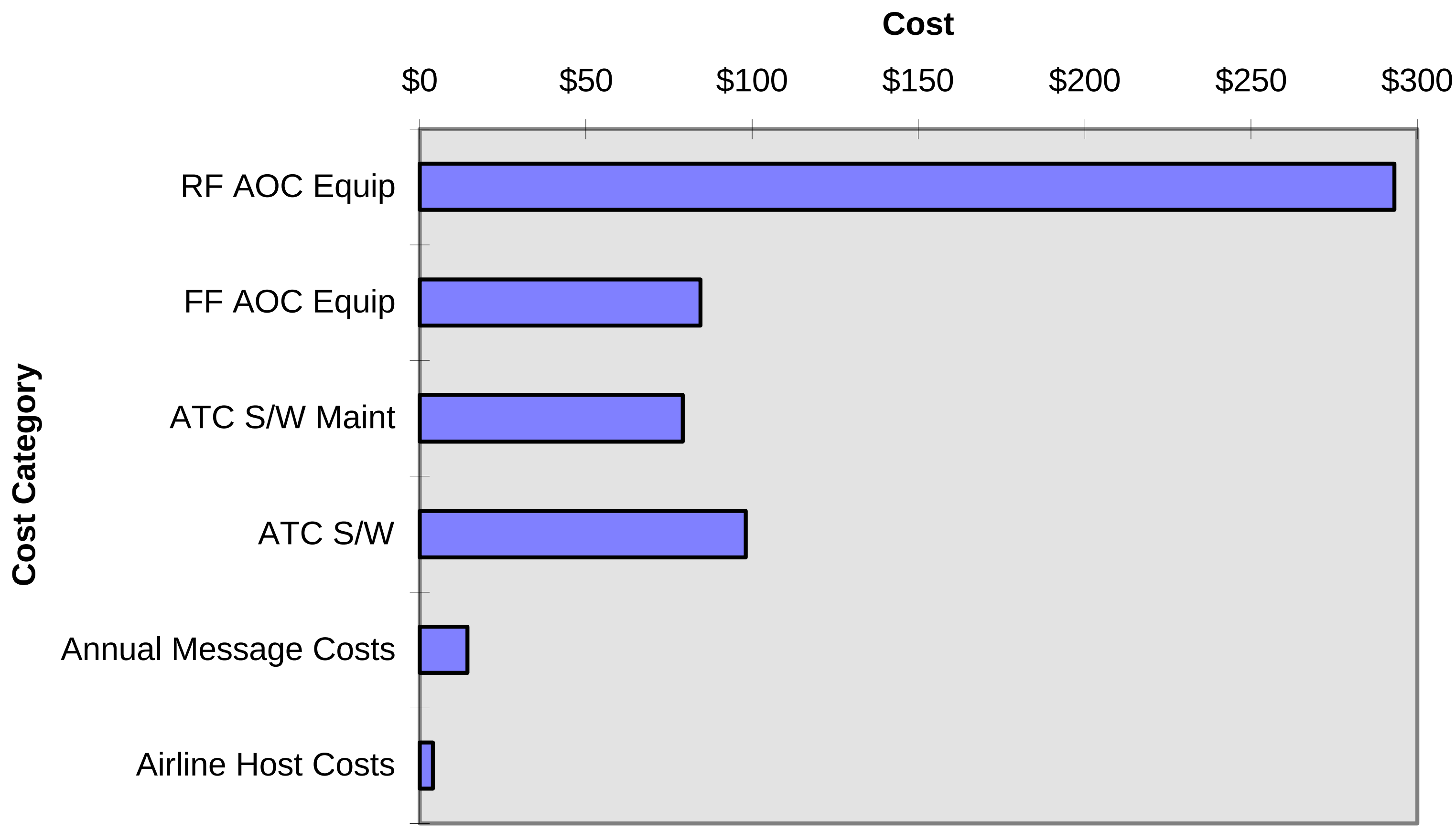
Model Inputs
Delay vs. Equippage Curve



Full Datalink Benefits by Category



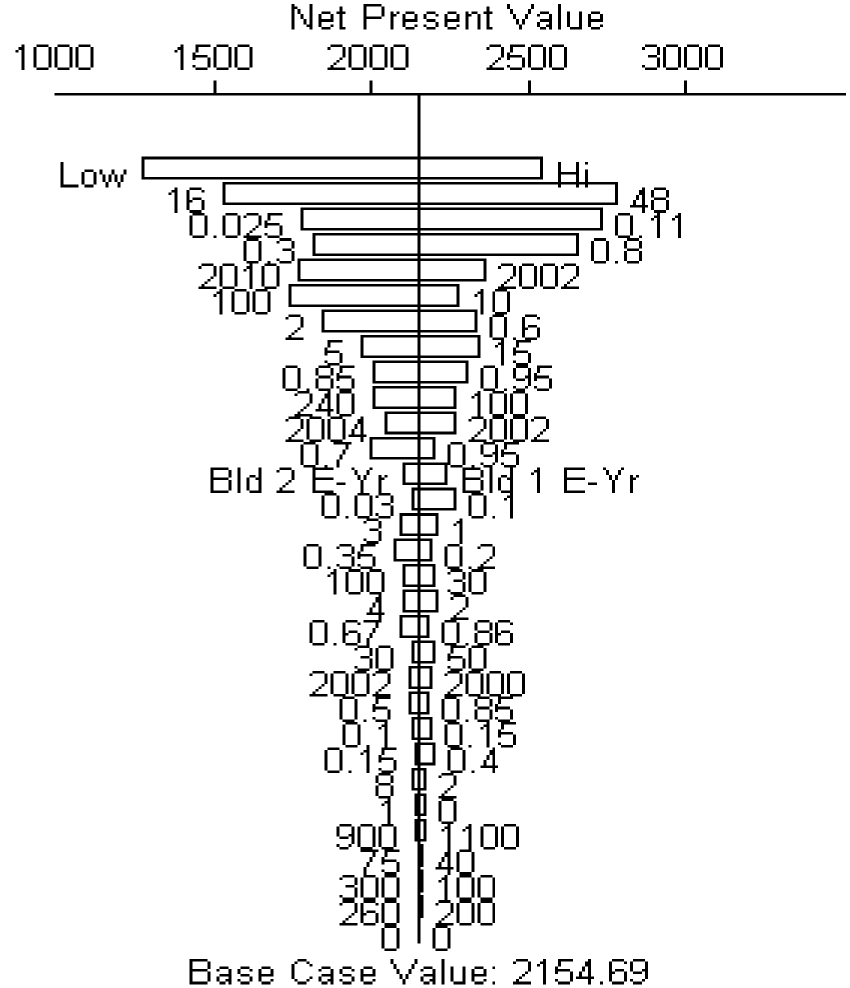
Full Datalink Cost by Category



Full Datalink

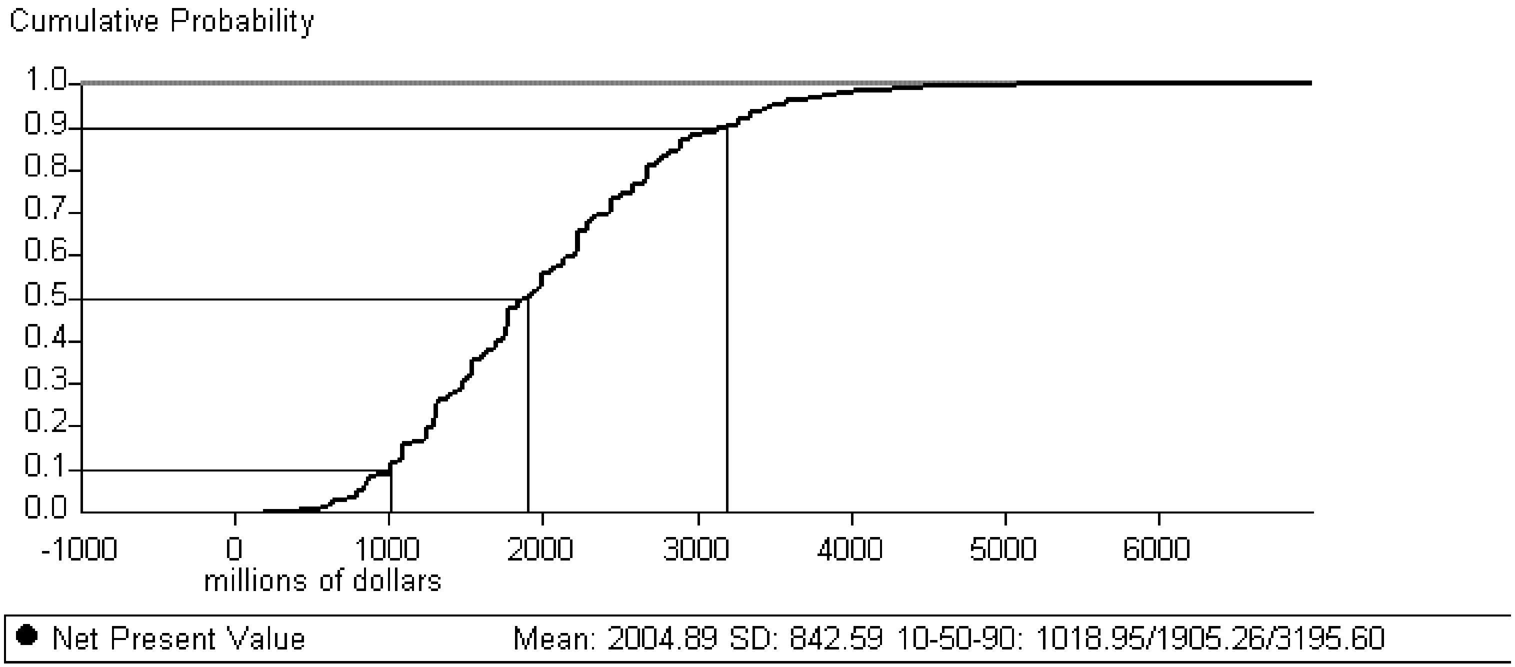
Deterministic Sensitivity

Variable	Base Case	Variance Contribution(%)
Equippage Scenario	Med	25.9
AOC NA ($ per Flt)	32	25.7
Delay Incr % per Yr	0.07	14.8
Atlanta Discount Fa...	0.5	11.4
AOC NA Strt Yr	2006	5.6
ATC SW Upgrade $K	30	4.5
Delay vs Equip Curve	1	3.7
AOC Cost per Flt	10	2.2
ACARS Equipped...	0.9	1.3
Cost per Retrofit $K	160	1.0
ATC Build 1 Start Yr	2003	0.7
ATC Build 2 Eff %	0.9	0.6
Equip Rampup Yr	Bld 1A ...	0.3
FE Ann Penalty In...	0.05	0.2
ATC Build 1 Duration	2	0.2
Minimum Equip Reqd	0.25	0.1
Cost per FF AOC E...	60	0.1
ATC Build 1A Dura...	3	0.1
AOC Msg Svgs %	0.8	0.1
Avg KBs per Flight	37	0.0
AOC Ready Yr	2001	0.0
ATC Build 1A Eff %	0.7	0.0
Initial Cost per KB	0.12	0.0
Retired Planes % of...	0.22	0.0
ATC Build 2 Duration	4	0.0
Message Cost Resp	0.5	0.0
POA Monthly Surch...	1000	0.0
Avg bytes per mes...	56	0.0
Cost per AL Host $K	200	0.0
ATC Mssges per E-Flt	229	0.0
ATC Build 1 Eff	0	0.0



CNS/ATM Focus Team

Full Datalink
Cumulative Probability Distribution



Full Datalink

Value of Perfect Information and Control

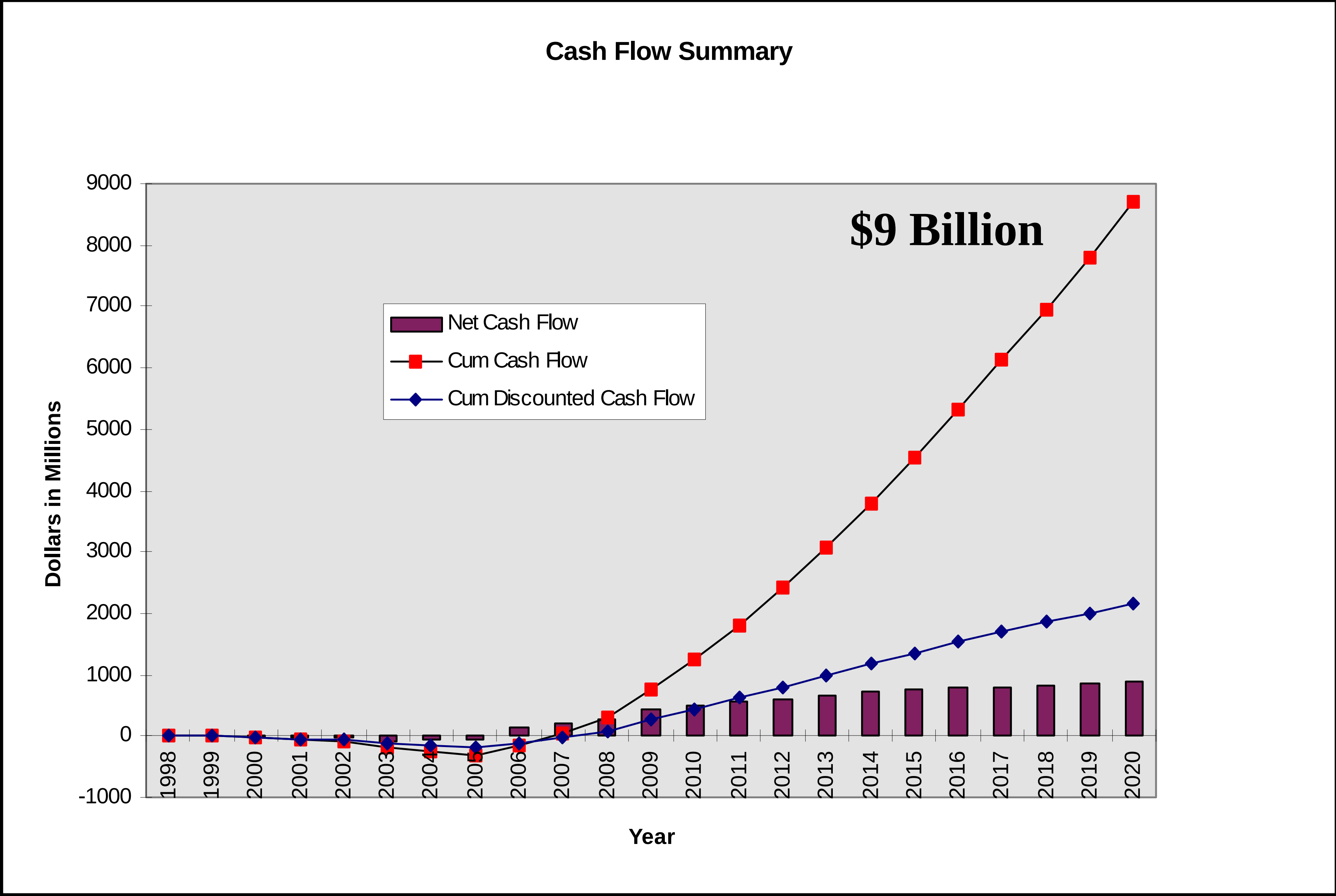
Selected Chance Variables	VOPI	VOPC
Equippage Scenario	0.0	$520M
Delay Incr % per Yr	0.0	512
ATC Build 1A Eff %	0.0	25
Atlanta Discount Factor	0.0	452
AOC NA Strt Yr	0.0	242
ATC SW Upgrade $K	0.0	177
AOC NA ($ per Flt)	0.0	575

Value of Perfect Information: The value of knowing the outcome of an uncertainty before you make the investment decision.

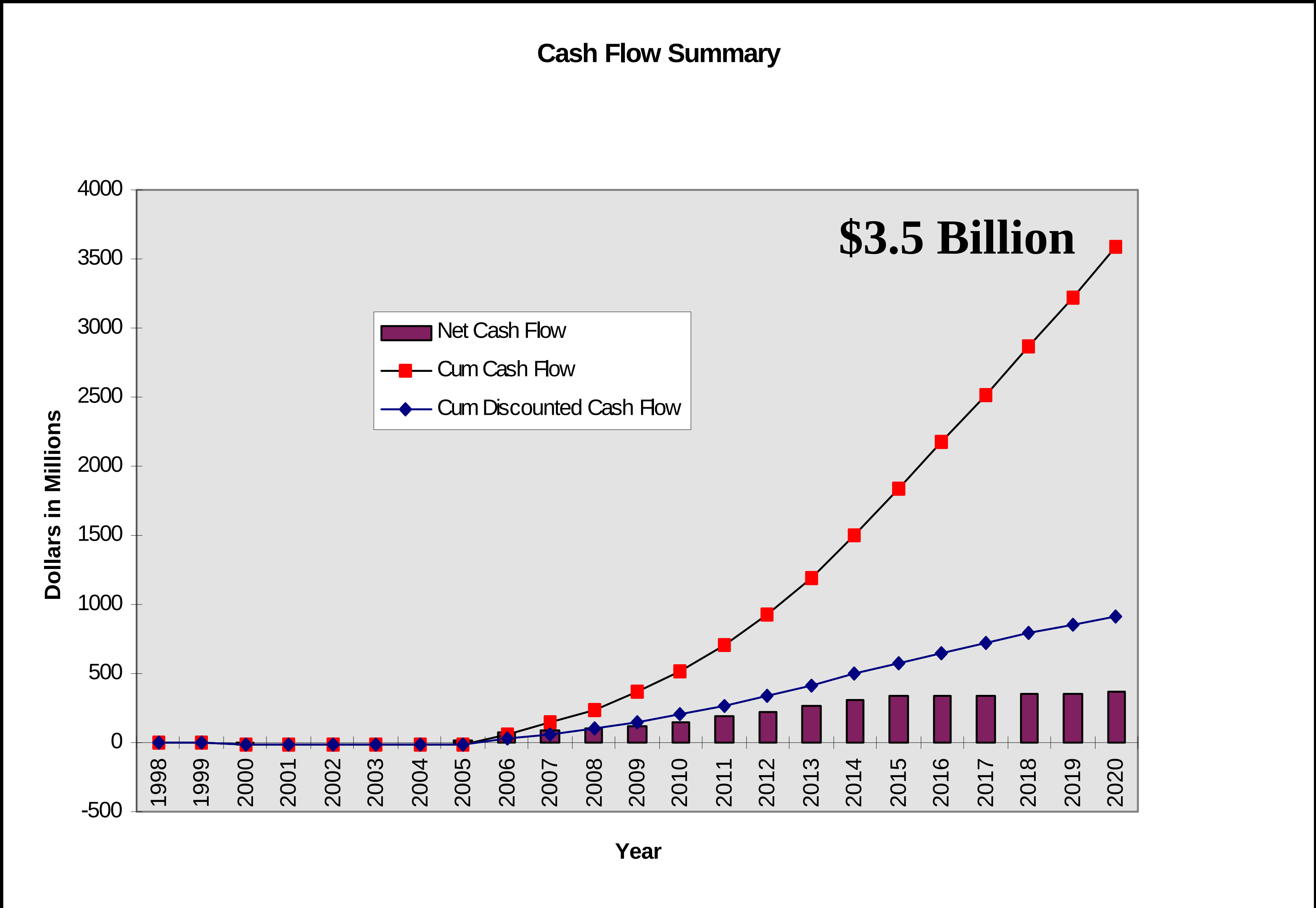
Value of Perfect Control: The value you of ensuring that the outcome of an uncertainty comes out to the most favorable outcome for your decision.

Note: These calculations assume a 25% chance of the 10th percentile event occurring, a 50% chance of the 50th percentile event occurring, and a 25% chance of the 90th percentile event occurring.

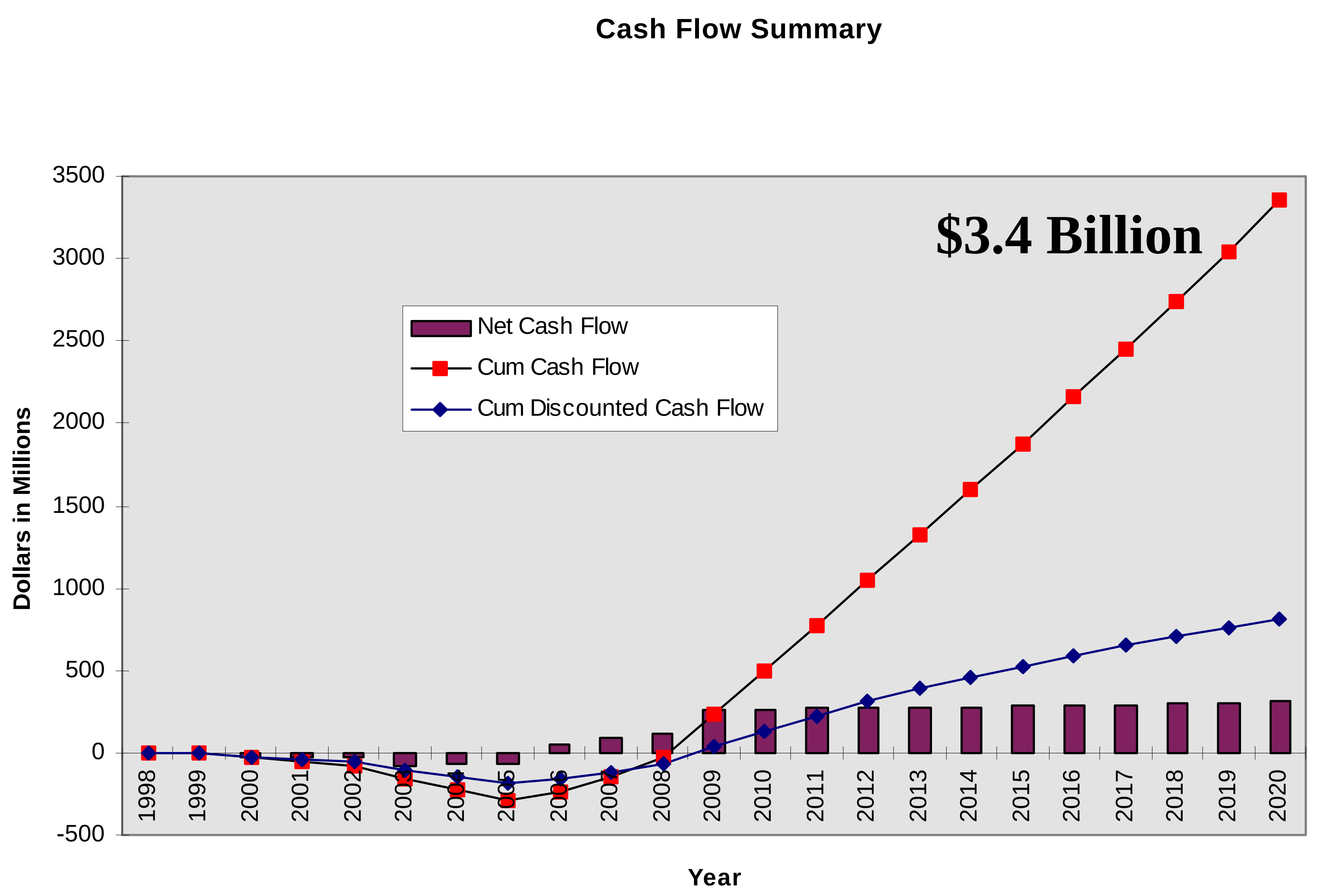
Full Datalink--Cash Flow Summary



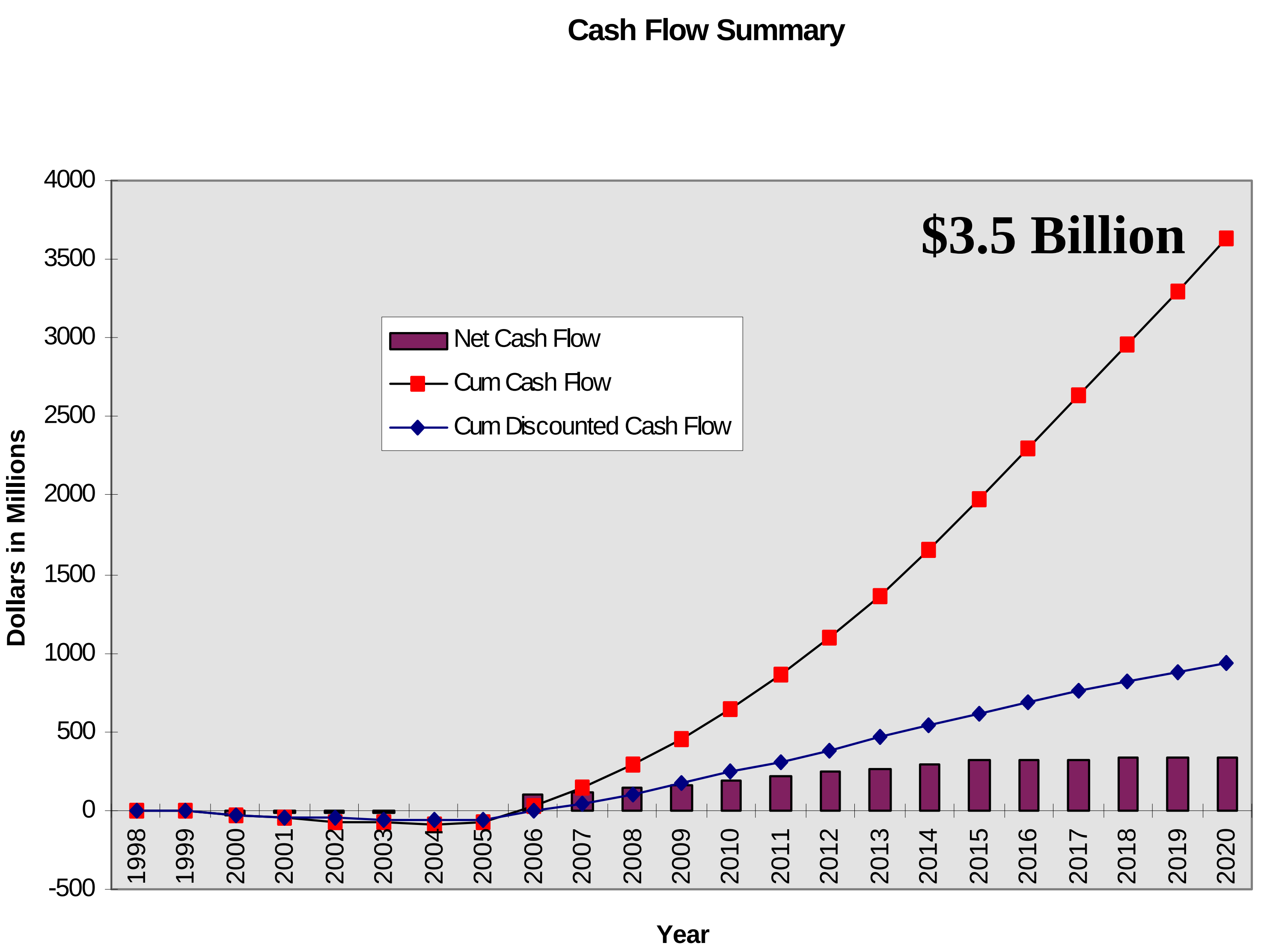
Full Datalink FF--Cash Flow Summary



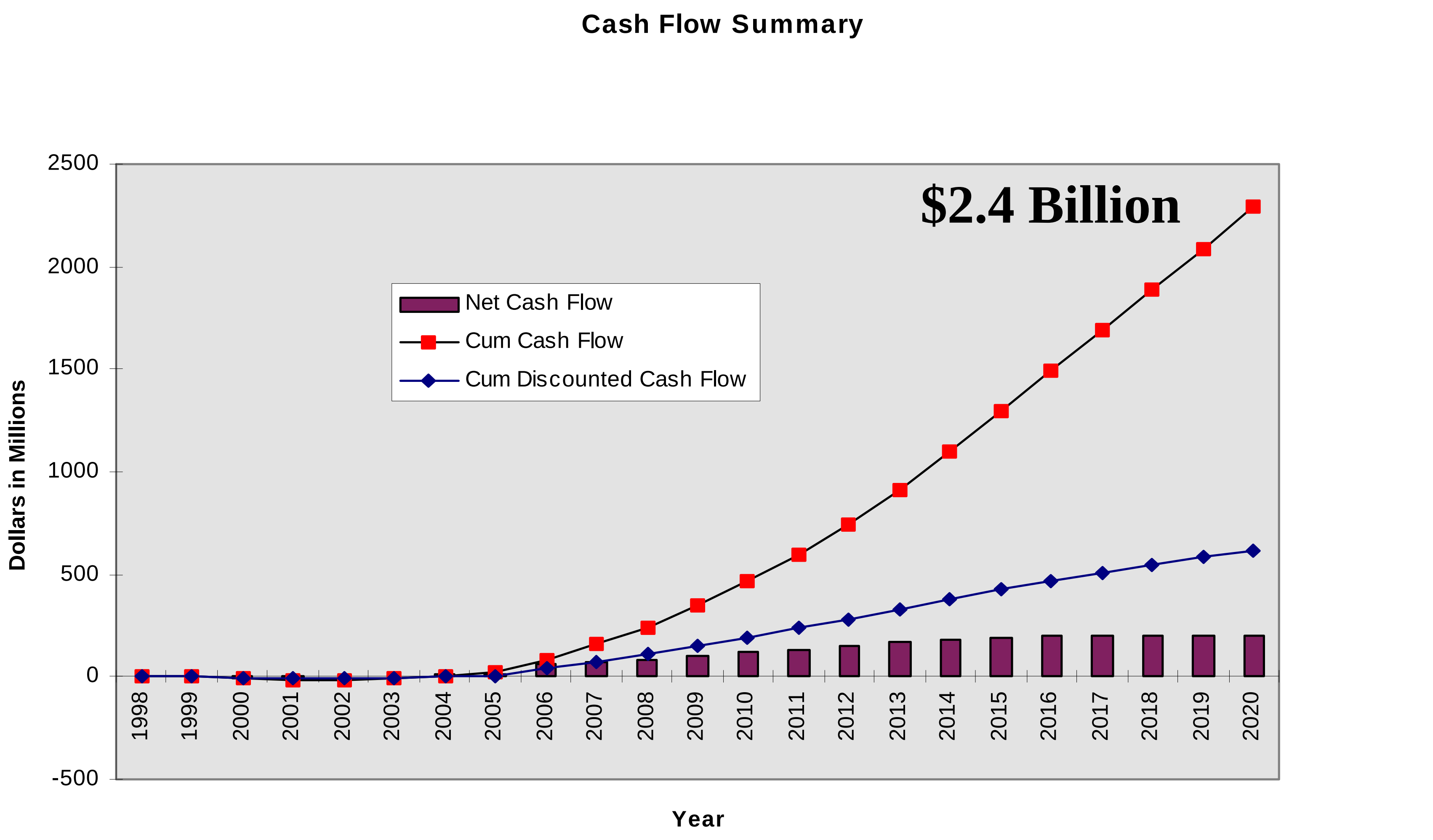
Full Datalink Retrofit
Cash Flow Summary



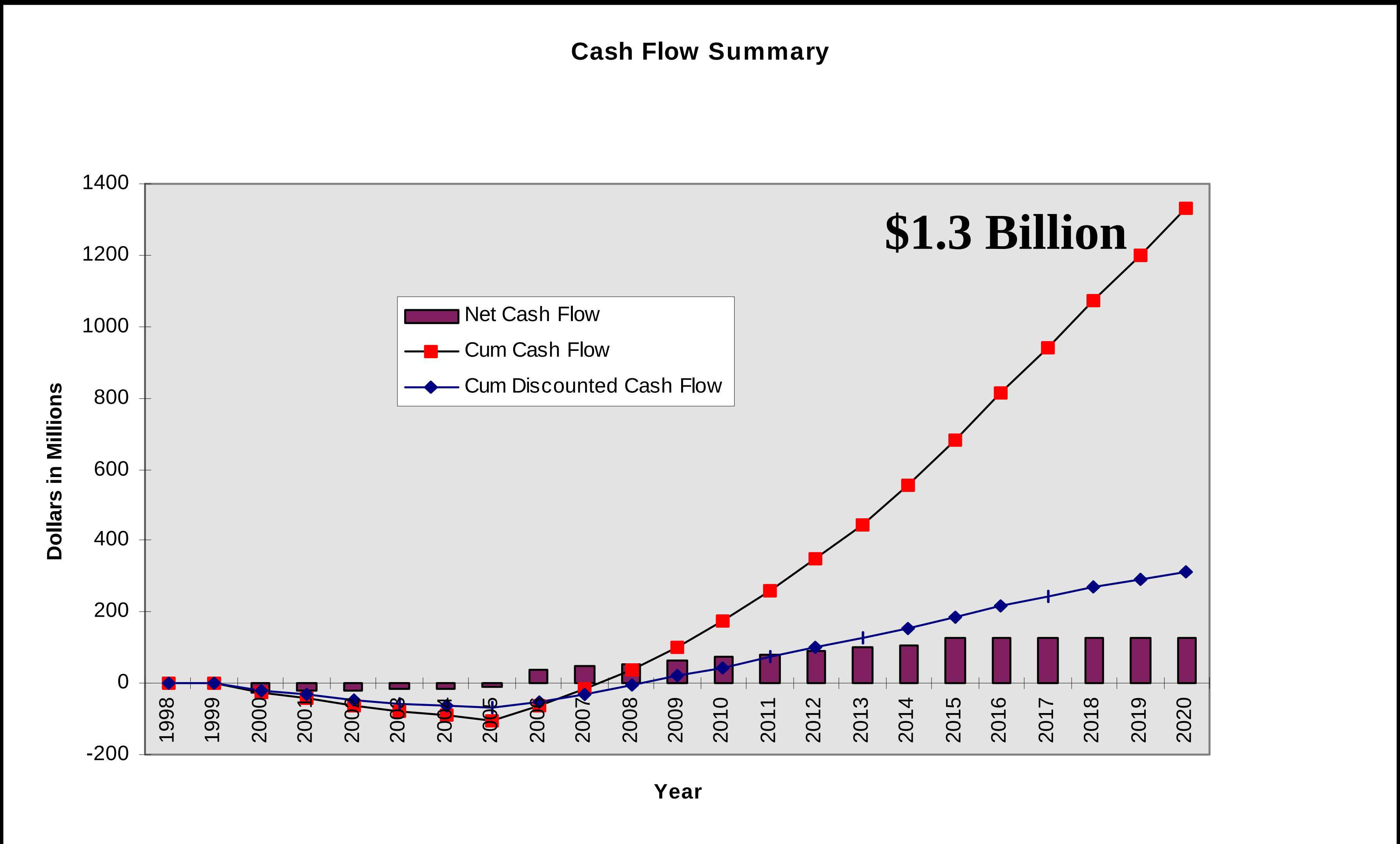
AOC Only--Cash Flow Summary



AOC Only FF
Cash Flow Summary



AOC Only Retrofit
Cash Flow Summary



ROI's for Datalink Scenarios

Scenario	End Equippage %	NPV	Expected Productivity Net Expected Benefit / Net Expected Inv.	IRR	Breakeven Year (Cum Disounted Cash Flow)
Full Datalink	72%	$2004M	5.0	45%	2007
AOC Only	47%	$869M	5.0	46%	2006
Full Datalink for FF	35%	$793M	6.7	61%	2006
Full Datalink for RF	37%	$716M	3.0	31%	2009
AOC Only for FF	24%	$567M	10.0	72%	2006
AOC Only for RF	22%	$302M	2.8	28%	2009

Conclusions

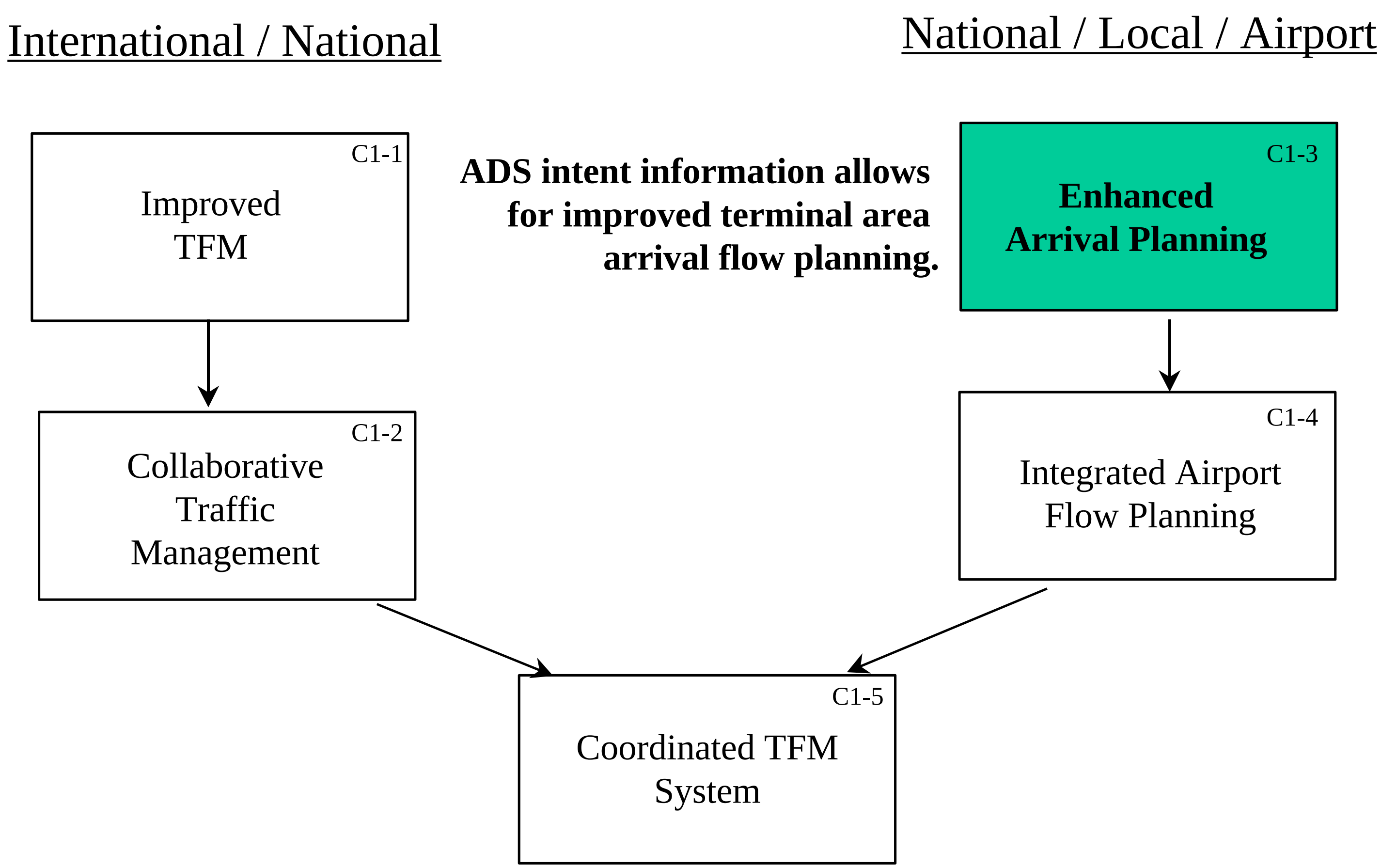
- AOC drives forward fit, ATC drives retrofit
- Benefits of AOC enable equipage
- In all cases datalink shows a reasonable return on investment
- Cumulative cash flows exhibit long-term infrastructure investments (longer term ROI)
- The value of maintaining AOC datalink capability is one of the primary cost-avoidance drivers
- Forward Fit equipage should start ASAP to avoid high retrofit costs

Conclusions, cont'd

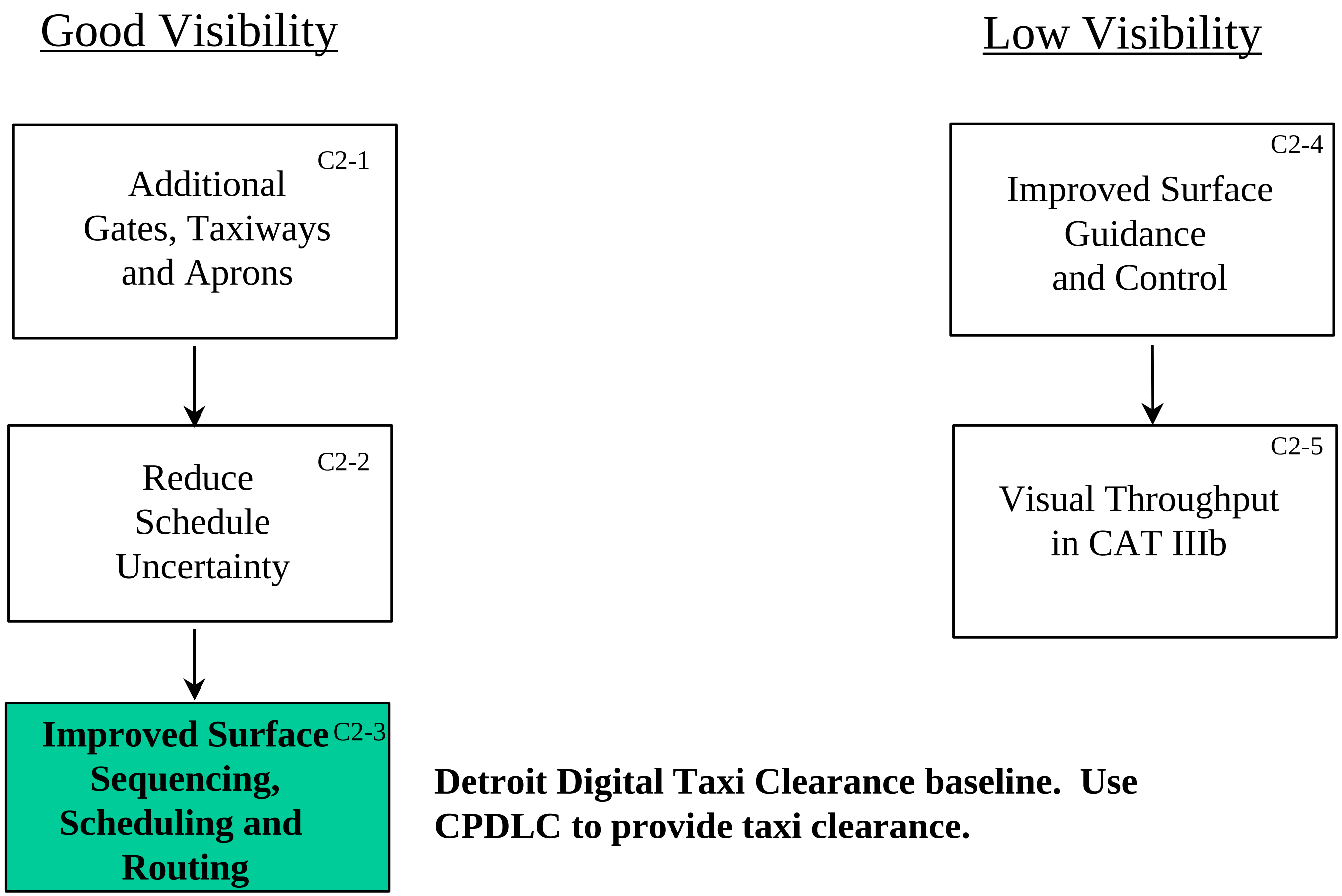
- Risks associated with going to ATC datalink are mitigated by the need to preserve AOC
- ATC delay reduction benefits apply to the Cruise/Terminal Transition phase of flight only
- Variables that need the most attention influence ATC benefits

Potential Benefit of Future Datalink Enhancements

1. Planning Capacity Transitions



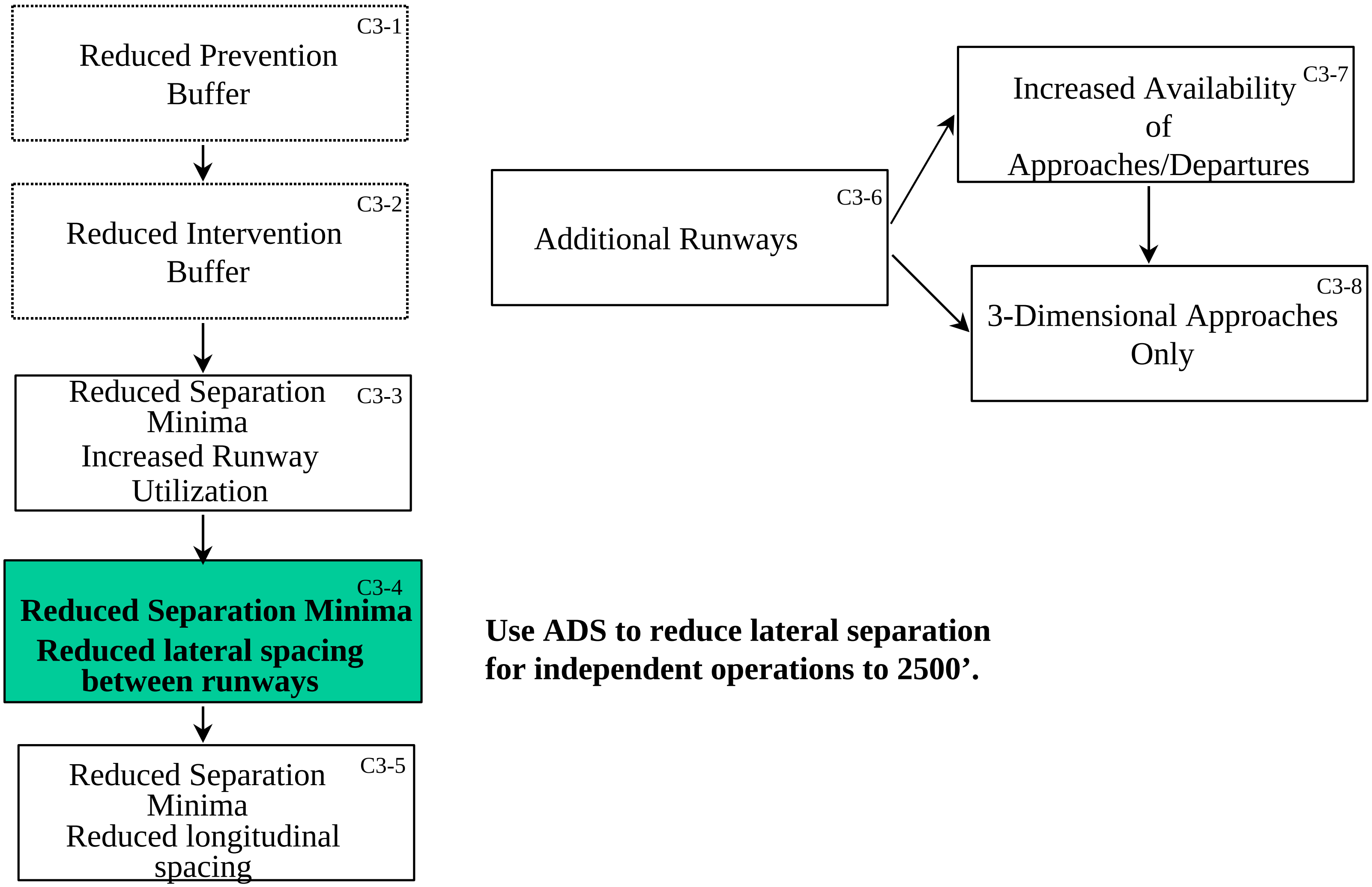
2. Surface Capacity Transitions



3. Final Approach / Initial Departure Capacity Transitions

Airplane-Level Capacity Effects

System-Level Capacity Effects

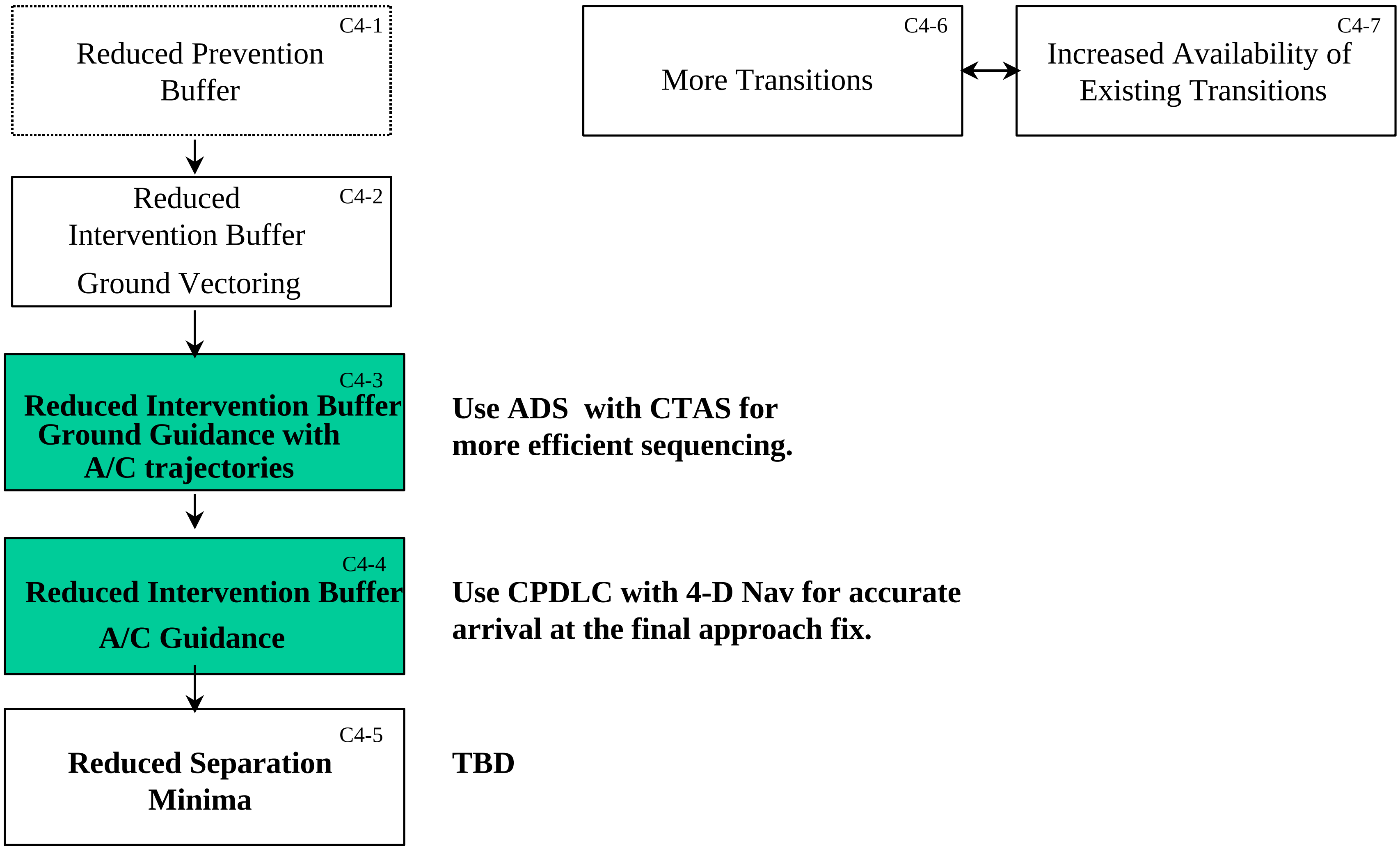


Use ADS to reduce lateral separation for independent operations to 2500'.

4. Approach / Departure Transition Capacity Transitions

Airplane-Level Capacity Effects

System-Level Capacity Effects



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5. TMA Arrival/Departure Capacity Transitions

System-Level Capacity Effects

C5-5 More Vertical Profiles ⟷ C5-6 More Published SIDs and STARs

Airplane-Level Capacity Effects

C5-1 Reduced Prevention Buffer — Lower controller workload

Newark study baseline. Data Link used for Clearances and Transfer of Comm

↓

C5-2 Reduced Prevention Buffer — State vector prediction

ADS used to provide med-term state vector information to CTAS for improved sequencing and spacing.

↓

C5-3 Reduced Intervention Buffer

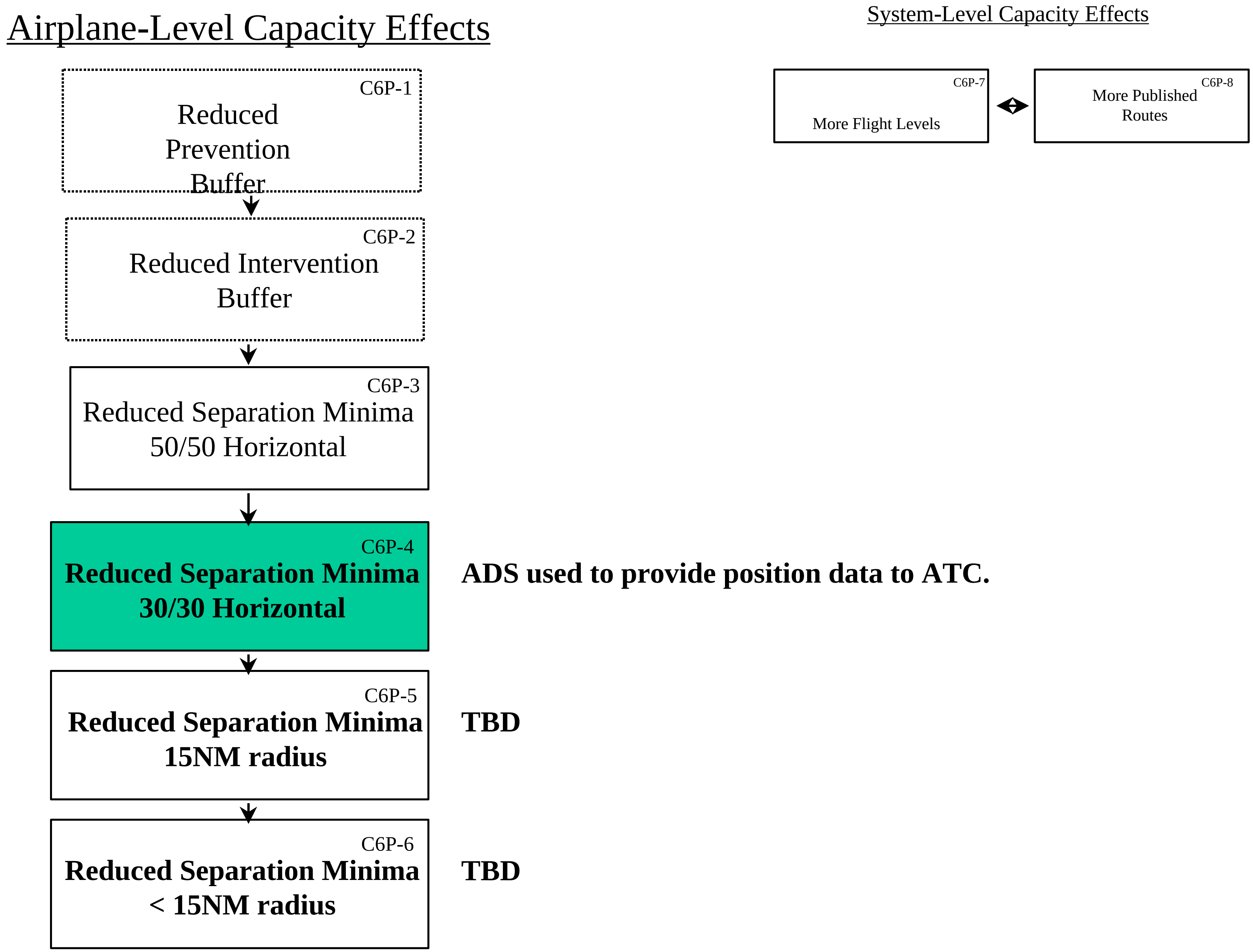
4-D contract: ADS for intent, and CPDLC for trajectory coordination.
OR
Improved performance of CPDLC allows for reduced controller intervention.

↓

C5-4 Reduced Separation Minima

TBD

6. En-Route Capacity Transitions (Procedural Separations)



6. En-Route Capacity Transitions (Radar Separations)

System-Level Capacity Effects

C6R-5 More Flight Levels	↔	C6R-6 More Published Routes

Airplane-Level Capacity Effects

C6R-1 **Reduced Prevention Buffer (Lower Controller Comm Workload)**	**Atlanta study baseline. Data Link used for Clearances and Transfer of Comm**
C6R-2 **Reduced Prevention Buffer State vector prediction**	**ADS used to provide state vector information for medium-term trajectory prediction.**
C6R-3 **Reduced Intervention Buffer**	**4-D contract: ADS for intent, and CPDLC for trajectory coordination. OR Improved performance of CPDLC allows for reduced controller intervention.**
C6R-4 **Reduced Separation Minima**	**TBD**

Future Datalink Model Assumptions (1 of 2)

This analysis is a very quick and dirty one to provide a rough-order-of-magnitude regarding the benefits of future datalink capabilities. With that in mind, these are the assumptions we made:

- 12% discount rate and 3.5% inflation
- Cash flows start in 1998 and end in 2015
- Assumed no revenue enhancement
- No costs are included
- The following model assumptions are the same as the baseline datalink analysis, including:
  - Equippage and infrastructure timing
  - Relationship between equippage and delay reduction
  - Airplane deliveries and airplanes removed
  - Growth in delay
- Assessed an 11% full-up delay reduction (vs. 5% for baseline datalink) [See next page]

Future Datalink Model Assumptions (2 of 2)

Source of Delay:

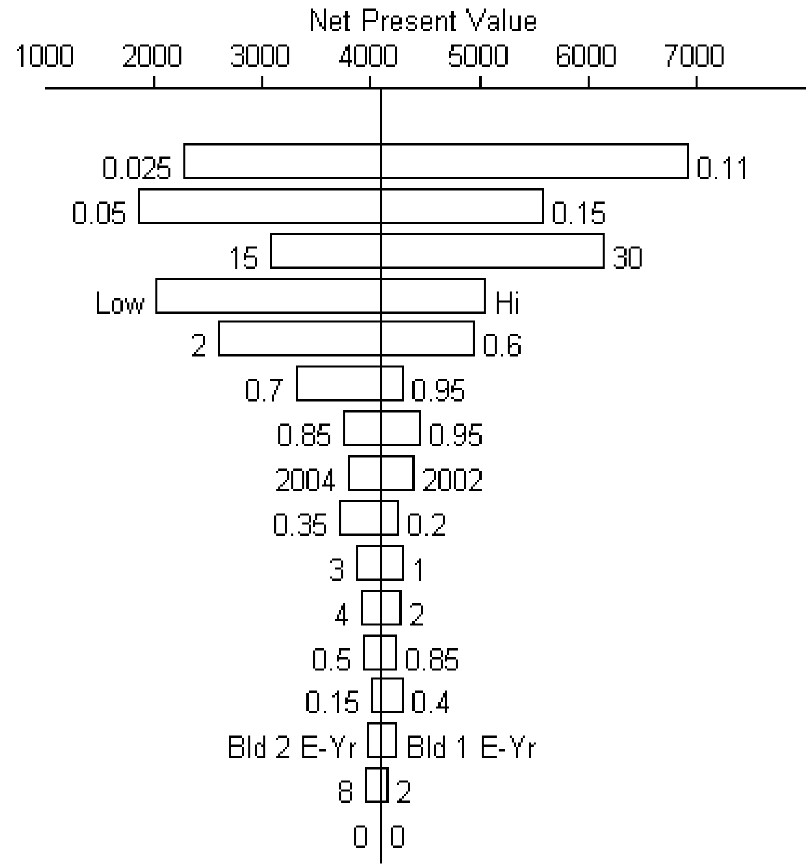
- % of Delay Surface = 5.75%
- % of Delay Final App/Init Dep = 41.85%
- % of Delay App/Dep Transition = 19.8%
- % of Delay TMA Arrival/Departure = 20.5%

Delay Reduction %:

- Surface Delay Red = 69.5%
- Final App/Init Dep Delay Red = 19.3%
- App/Dep Transition Delay Red = NA
- TMA Arrival/Departure Dealy Red = 13.1%

Future Datalink
Deterministic Sensitivity

Variable	Base Case	Variance Contribution(%)
Delay Incr % per Yr	0.07	34.8
Delay Red per Flt	0.11	22.1
ATC Delay per Flt (Yr 2000)	20	15.0
Equippage Scenario	Med	14.7
Delay vs Equip Curve	1	8.8
ATC Build 2 Eff %	0.9	1.5
ACARS Equipped Plns	0.9	0.7
ATC Build 1 Start Yr	2003	0.5
Minimum Equip Reqd	0.25	0.4
ATC Build 1 Duration	2	0.2
ATC Build 1A Duration	3	0.1
ATC Build 1A Eff %	0.7	0.1
Retired Planes % of New	0.22	0.1
Equip Rampup Yr	Bld 1A E-Yr	0.1
ATC Build 2 Duration	4	0.0
ATC Build 1 Eff	0	0.0



Base Case Value: 4095.41

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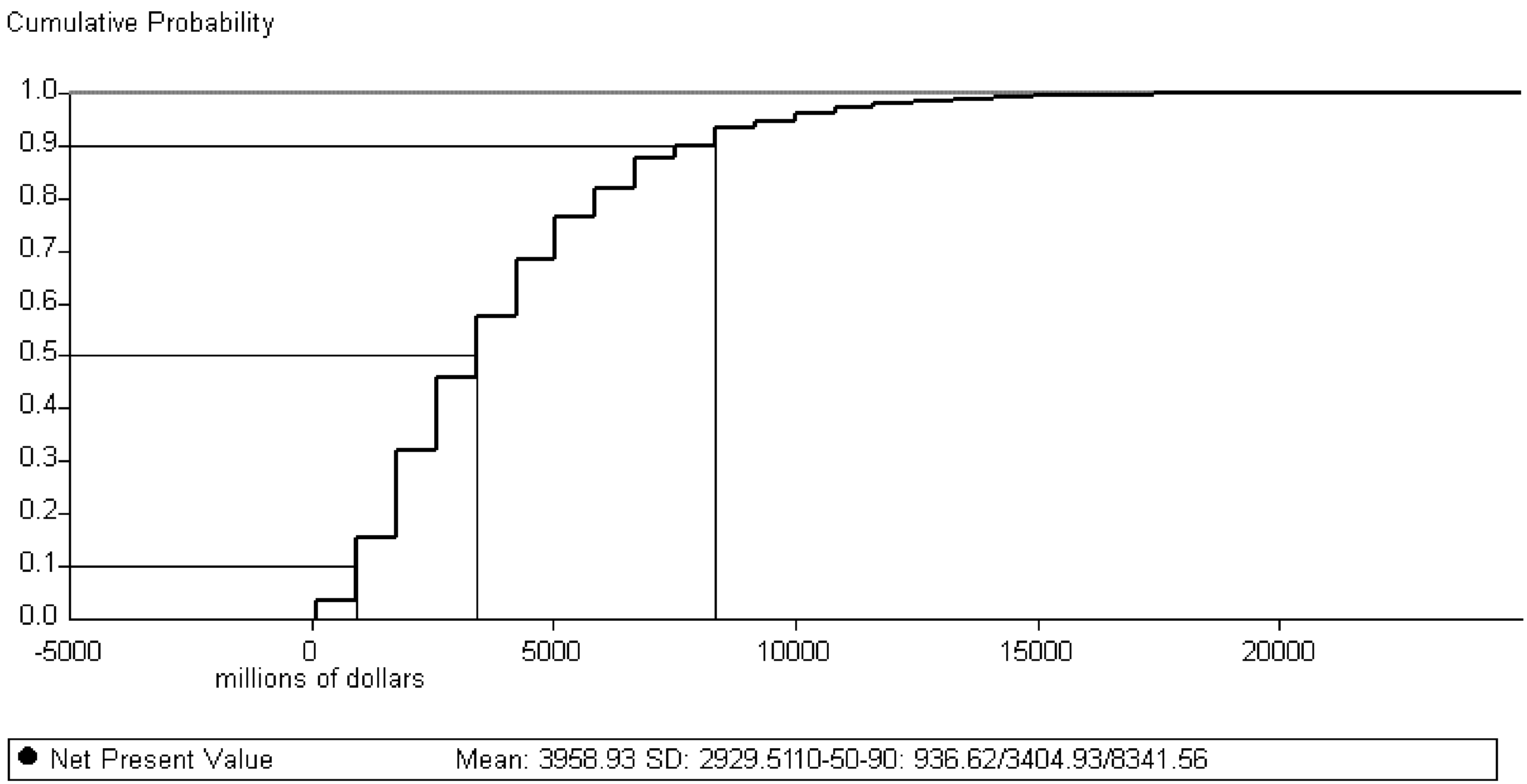
Future Datalink
Cumulative Probability Distribution



C/AFT
Datalink Investment Analysis

Results

November 18, 1998