C/AFT
Advanced Navigation
Focus Group

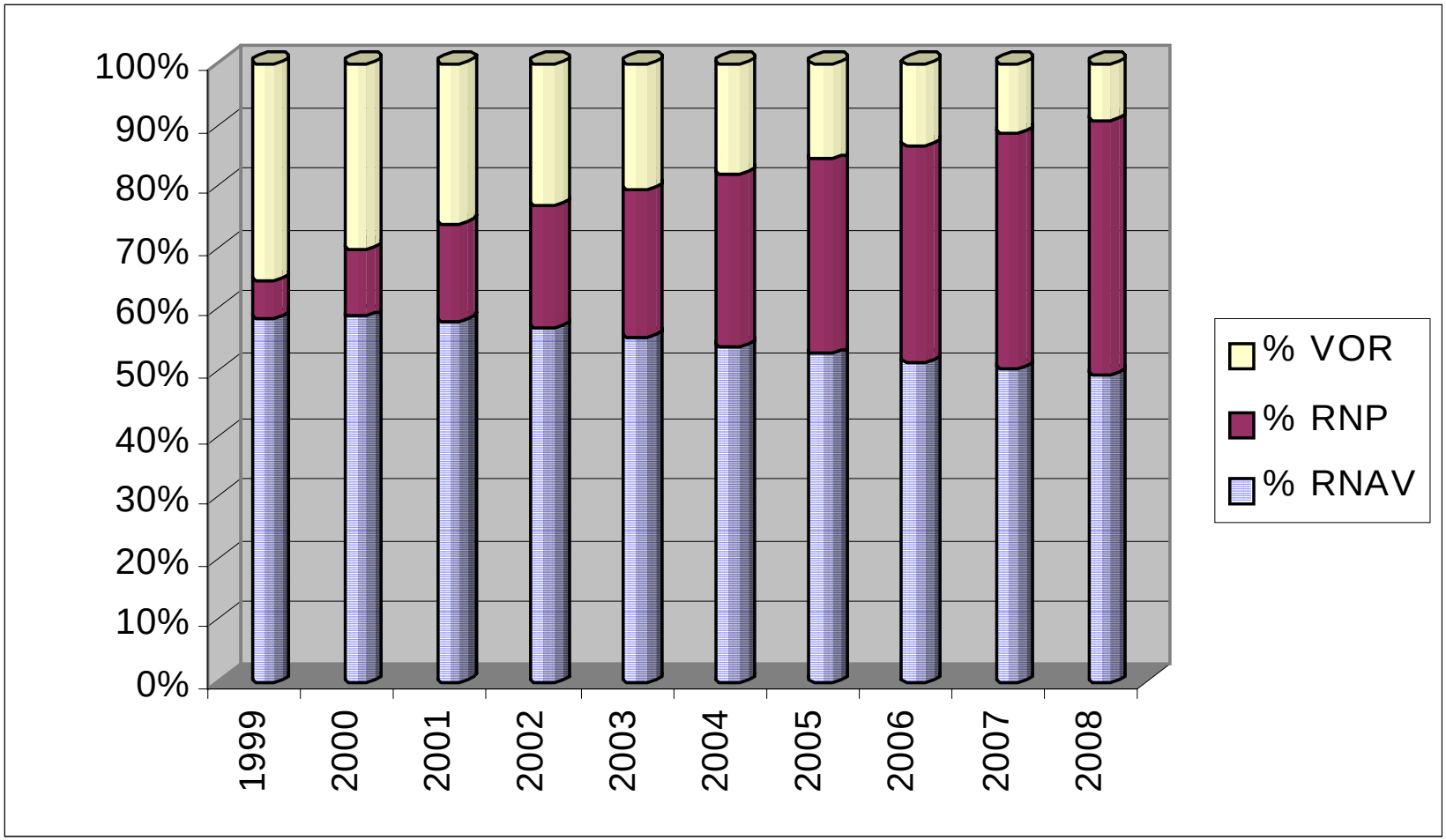
January 19, 2000
Working Session

Definition of RNP

- Example: RNAV is a method of navigation that permits aircraft operations on any desired course within the coverage of station referenced navigation signals or within the limits of a self-contained system capability or combination of these.

Need this for SFO Traffic Mix

Air Transport System Capability to Enable Capacity

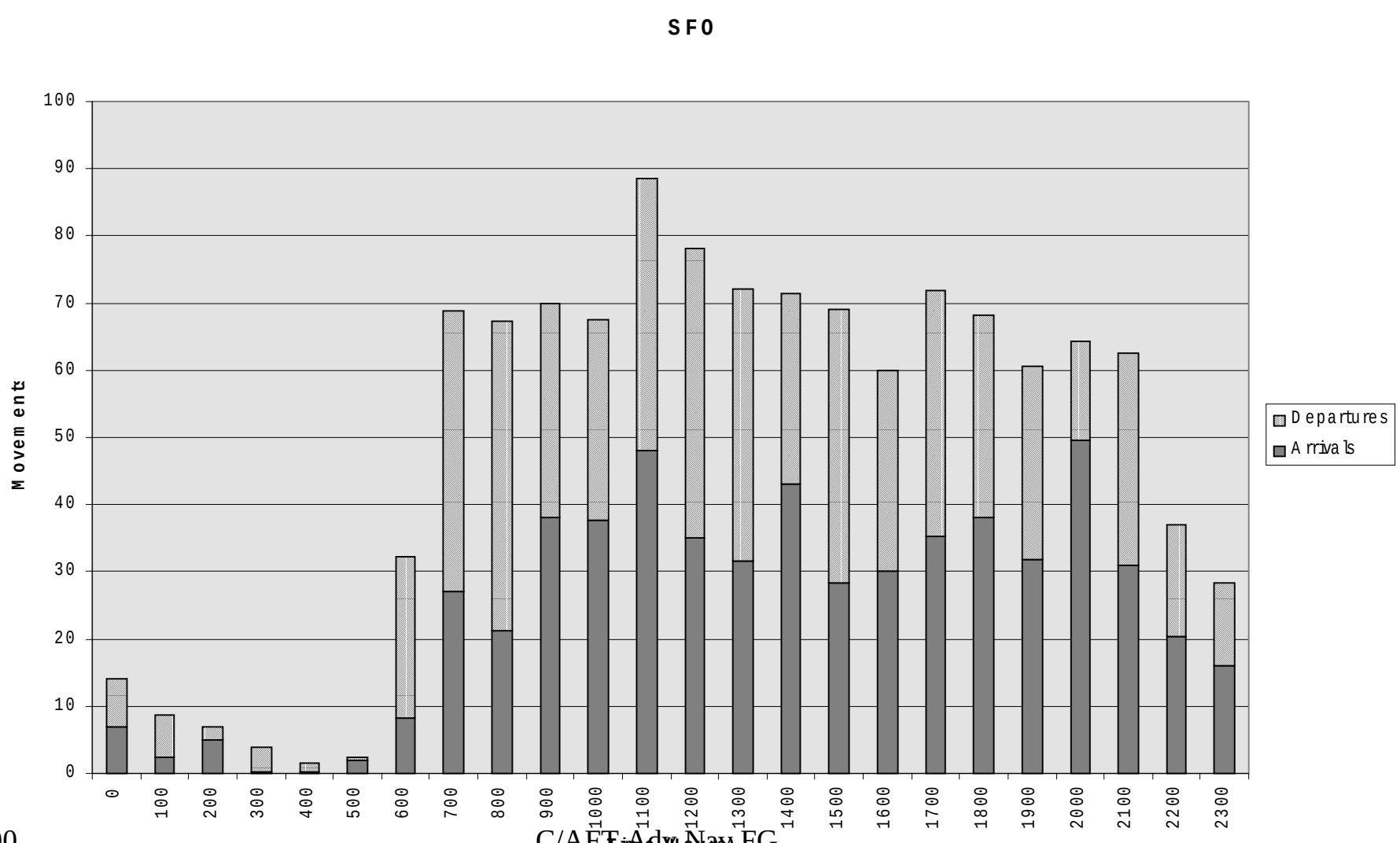


Availability of Navigation Capabilities

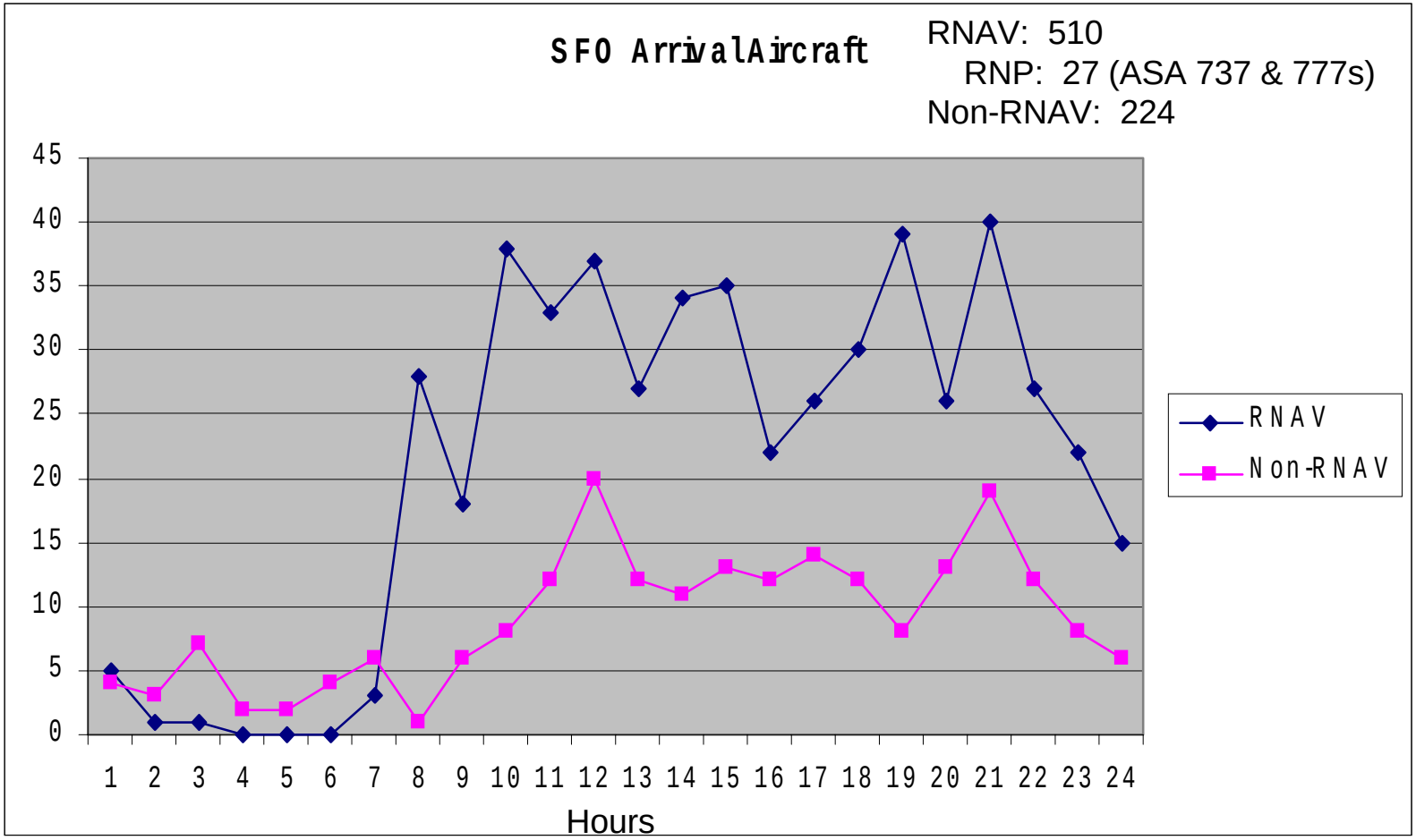
San Francisco
Current Status

- Closely spaced parallels (750’) can only be used in VFR
  - One runway (28R typically) used when ceiling <3000’
  - Greatly impacts capacity causing delays and ground holds
- PRM proposed to lower the minima for IFR (switching to 1 runway)
- RNP RNAV path is one alternative to lower minima for MVFR

Scheduled SFO Movements



SFO Aircraft Capability



Terminology

- Capability
  - Specific navigation enabler, e.g. RNP
- Operational Enhancement
  - An operational change leading to benefit.
- Benefit
  - Increased capacity, efficiency, or other cost savings (e.g. training)

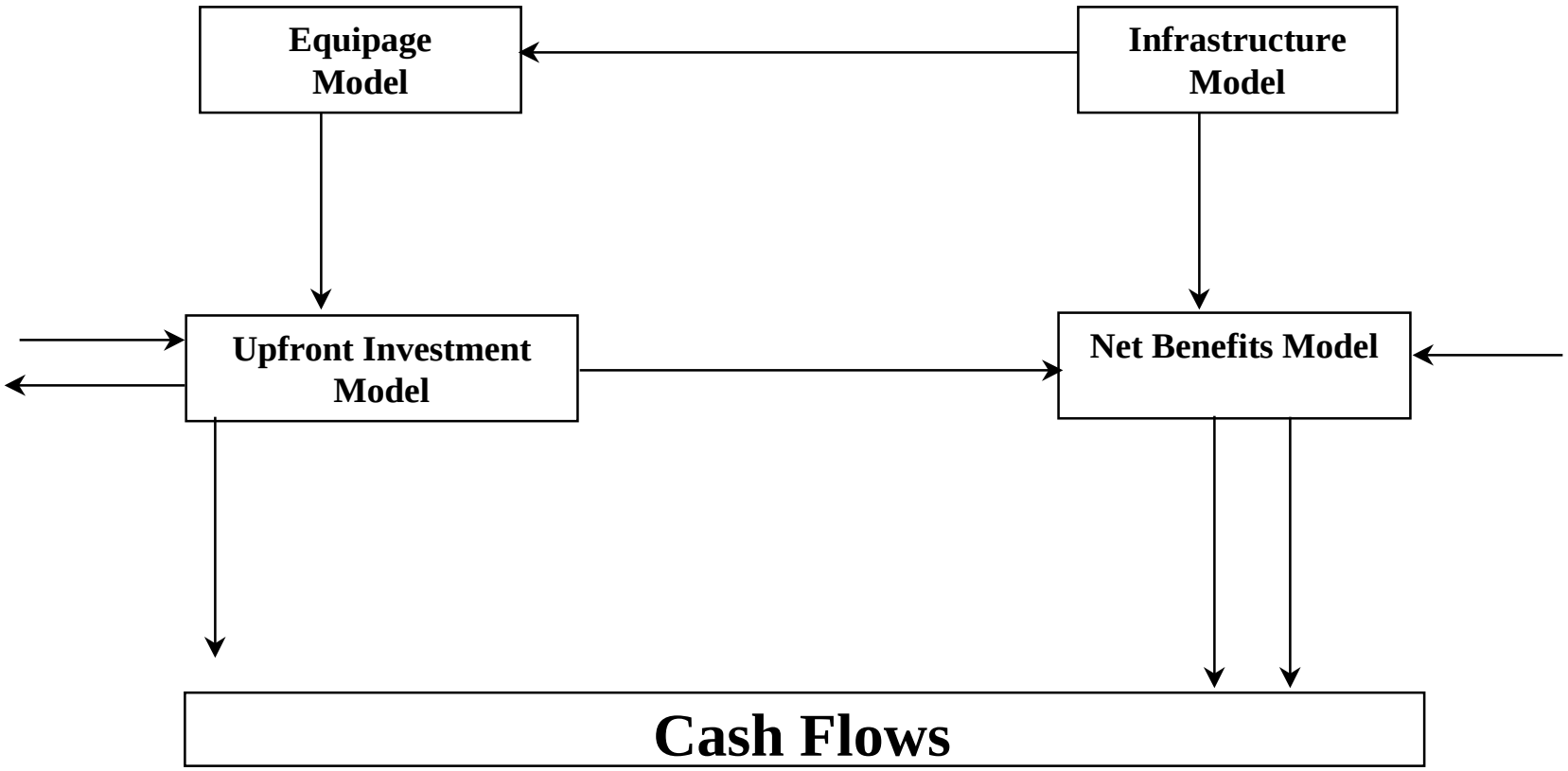
RNP at SFO
Definition of the Capability

- RNP procedure.
  - Requires Autopilot-coupled VNAV
- Ken Action: -- *Can we get benefits with greater RNP #'s using the same procedure template and the RNP 0.3 MA Procedure?*
  - *If yes, then we could get benefits for a/c greater than RNP 0.3.*
  - *What is largest RNP for procedure?*

RNP in SFO
Cost/Benefit Model Assumptions

- This is not an alternatives analysis. Not analyzing other enablers (e.g. PRM, data link, ADS)
- Baseline is do-nothing
- Analysis is from airline point of view (airline as an industry, not single airline)
- Model will be built to accommodate any airport -- first run will be for SFO.
- Analysis will be from 2000 - 2015 for equipage / procedures, and 2000 - 2020 for other costs and benefits

RNP Investment Model



RNP Benefit Model Definitions

- Capacity
  - Cancellation / Diversion Avoidance
    - used to quantify improved access to airports/runways
  - Delay Reduction
    - quantified using Direct Operating Cost (DOC) for each minute of delay saved, with higher costs assigned to higher values of predictable delay savings.
    - Revenue enhancement not modeled, although an airline could convert delay savings to increased number of flights, or avoidance of missed connections (this is airline/location dependent).
    - Efficiency
  - If unpredictable, Reduced Fuel Burned
  - If predictable, Reduced Block Fuel
    - this could be taken as increased payload
  - If predictable, Reduced Block Time
    - improved utilization

SFO RNP Benefits

- Improved usage of runway infrastructure.
  - Delay Reduction. Maintain VMC acceptance rates under MVMC conditions (e.g. converging runway procedures, parallel runway procedures)
    - this could include noise reduction
- RNP Approach Transitions
  - Reduced Block Fuel / Time. More laterally and vertically efficient paths.
- Departure benefits not quantified in this iteration.
  - Action Dave Jones -- understand departure sequencing

- *Reduced Insulation Costs. Reduced noise footprint allows more flights. May do this in next iteration.*

SFO RNP Benefits

- More precise missed approach path may result in lower landing minimums
  - IN the case of SFO the lower landing minimums benefits are taken under delay reduction.
  - Assume that the improved missed approach path **allows** the delay reduction benefits to occur
  - MA procedure developed for RNP 0.3 approach will work for any approaches developed for greater that RNP 0.3.

Capability:
RNAV --> RNP 0.3 + Vertical Navigation

- *Issue needs to be clarified - benefit and cost AI:Ken find out if VNAV is required. What happens if 28L ILS inactive?*
- Access to runways when ILS not available (e.g. construction, scheduled maintenance)
  - Cancellation Diversion. Lower minimums allow near ILS capability for landing.
  - Reduced Block Fuel / Time. More available alternates.
  - Training. Don't need to train for special conditions when ILS out.
- Improved departure procedures
  - Delay Reduction. Increase departure rate by allowing separate departure paths for different aircraft types (e.g. turboprop performance departures in Frankfurt)
  - Reduced Block Fuel / Time. Tighter containment on departure paths and path shortening.
- RNP with stabilized vertical path angle for approaches other than ILS
  - Cancellation Avoidance. Lower minimums allow increased access.
  - Increased Flights. Reduced noise footprint allows more flights
  - Reduced Fuel Burned. Due to stabilized descent.
  - Training. Only need to train one kind of approach.

RNP Infrastructure Model Assumptions

- Policy & Procedures
  - wake vortex risk.
- Ground stuff needed (cost)
  - Sequencing process (not modeling cost of CTAS)
    - don’t need anything, or
    - super sophisticated tool (e.g. special CTAS), or
    - something in-between (e.g. plain CTAS)
  - Things to think about but not modeled in first iteration
    - Ground equipment -- radar? (assume ready at beginning of each stage)
    - Ground staff (assume ready at beginning of each stage)
    - Training (assume ready at beginning of each stage)

RNP Infrastructure Model Assumptions

- Stages (dates indicate start year)
  - assume CTAS not required in this definition
    - Stage 1. 1800’ minimum, (mid 2001, end 2001, 2003)
    - Stage 2. 1200’, (end 2002, end 2002, end 2004)
    - Stage 3. 800’, (2003, mid 2004, 2006)
  - If CTAS is required add (1year, 18 months, 4 years) to start date of stages.
  - Probability that CTAS will be required: 10%

Traffic Growth / Fleet Mix

- Need existing total fleet and those RNP 0.3 capable
  - todays baseline from OAG from Ken (flights/day)
  - RNP capable range (Classic, Standard, Advanced)
    - Standard are glass cockpit without RNP
    - Advanced are GPS and RNP and RNP annunciations
- % of flights that are GA and commuter to be used on the delay vs. equipage curve (not calculating their costs/benefits)

- 0.9% per year traffic growth (additional flights per year)

Equipage Rates
Assume Standard airplane meets procedure requirements (DME/DME)

	Classic	Standard	Advanced
Retrofit (%/year)	Retrofit to standard (% of classics) (0, 1, 5)	0	0
Forward Fit	0	0	100

Equipage Rates
Assume Advanced required to meet procedure requirements
(GPS + RNP annunciation)

	Classic	Standard	Advanced
Retrofit (%/year)	Retrofit to advanced (% of classics) (0, 0, 0)	Retrofit to advanced (% of standards) (10, 20, 25)	0
Forward Fit	0	0	100

RNP Up-Front Investment Model Assumptions

- Maintenance Costs
  - need dual FMC and Autopilot for dispatch?
- Retrofit (equipment, SB, installation) cost per airplane
  - Classic to Standard (ask Emily, 49.9, 50, 500)
  - Standard to Advanced (300K, 500K, 800K)
- Out-of-service costs $/airplane (0, 75K, 125K)
  - assume airplane will be out of service for 3 days
- Forward Fit ($0 validated by Scott -- function activation fees?)
- Training costs per equipped airplane (costs to train procedures of the SFO type), 12 pilots $1000/hr* 4 hours, (50K, $100,000, 150K) per airplane
- Infrastructure
  - Procedure development: at low end it would be free, but airline could pay to accelerate the process. One-time cost $ (0,
  - Action. Ken to ask Tracy B. at USAir

Benefit Data Required

- Delay Savings
- =((VMC_Delay_Csts_per_VMC_Day-MVMC_Delay_Csts_per_MVMC_Day)*Flights_MVMC_%)*(IF(Equipage_%<Minimum_Equip_Reqd,0,(Equipage_%-Minimum_Equip_Reqd)/(1-Minimum_Equip_Reqd))^Delay_vs_Equip_Curve).

- Minumum equipage required for equipage vs delay curve
- Flights_MVMC_%
- Delay vs. Equipage Curve (include GA and commuters)

- Training????
  - recurring training costs (annual_training_$M)

Cost Data Required

- Airline_Equippage_Costs_$M+Training_Costs_$M
- Airline Equipage Costs = Retrofit Costs + Forward Fit Costs
- Training Costs = Traiing_Cost_Dev + Upfront_Training

Equipage Model

- How does equipage happen

Constants

Stuff

- To gain the benefit, ATC requires minimum equipage percentage of: (60, 80, 95) %
  - Bowser to get us in touch with someone on AILS program.
  - Joe to look into this too.
- Average cost per delay minute $25 (same as other C/AFT models)

Plans

- First iteration of model sent to group: February 1st.
- Telecon February 3.
- Continue work via e-mail. Finalize presentation in Melbourne.
- Do we need to meet with Qantas for Sydney model??
- Melbourne: Brian reviews Toulouse results, Dave Jones covers SFO