

CNS/ATM Enhancement Comparison

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Boeing Air Traffic Management Services

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Background

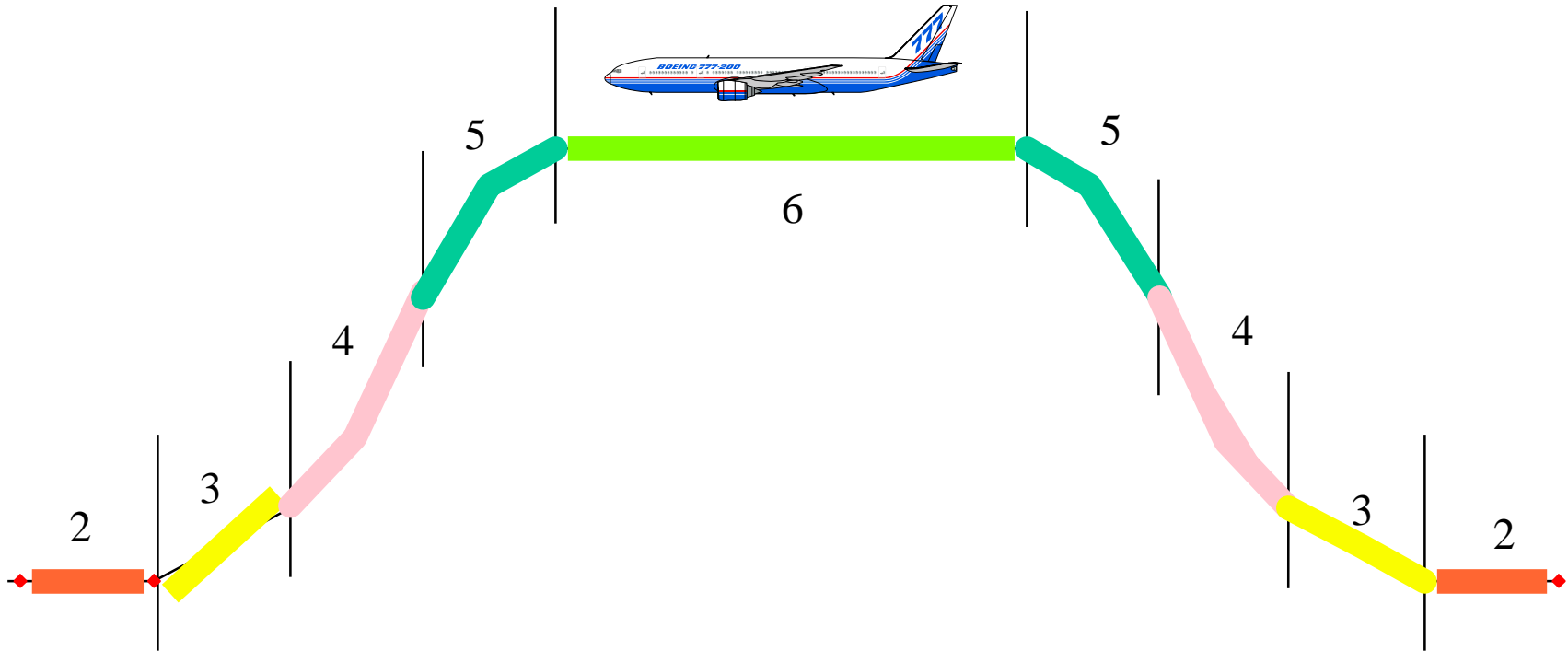
- Boeing performed alternatives analysis after C/AFT Data Link business case was published:
 - Data Link business case convinced airlines to equip with VDL-2
 - Boeing had to determine the most likely evolutionary path for data link implementation in order to design HMI interface in cockpit.
- Goal: Develop a process by which operational enhancement alternatives could be evaluated.
- Based the work on C/AFT models
 - Constraints Analysis
 - Transition Logic Diagrams
 - Operational Enhancement Data Base




C/AFT Tools

Constraints Analysis

- Breaks down airspace system by phase of flight
- Identifies factors that constrain operations in each phase
- Factors are unique to each condition/location
- Constraining factors point to operational enhancements in the Transition Logic Diagrams

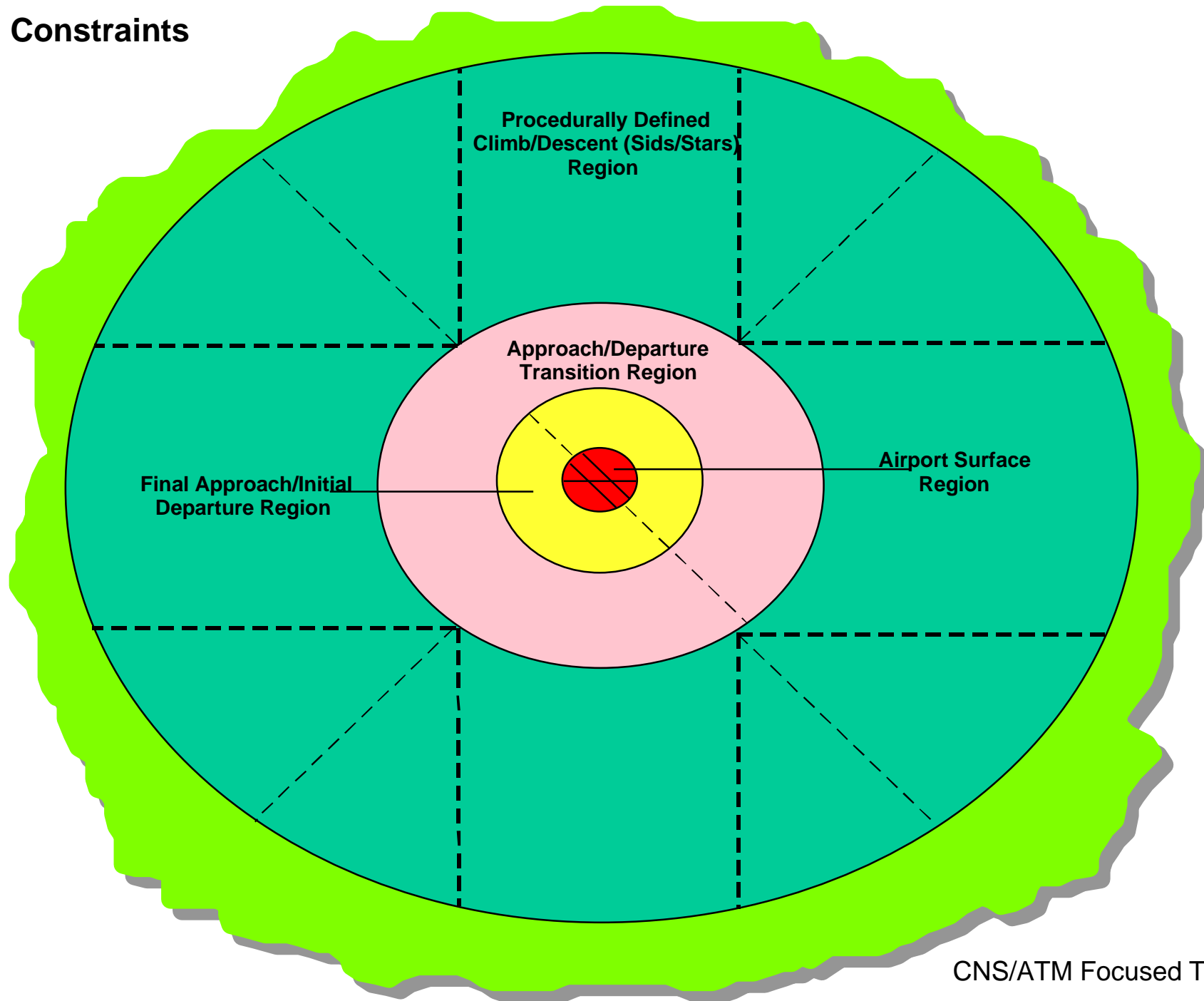
AIRSPACE CONTROL REGIONS



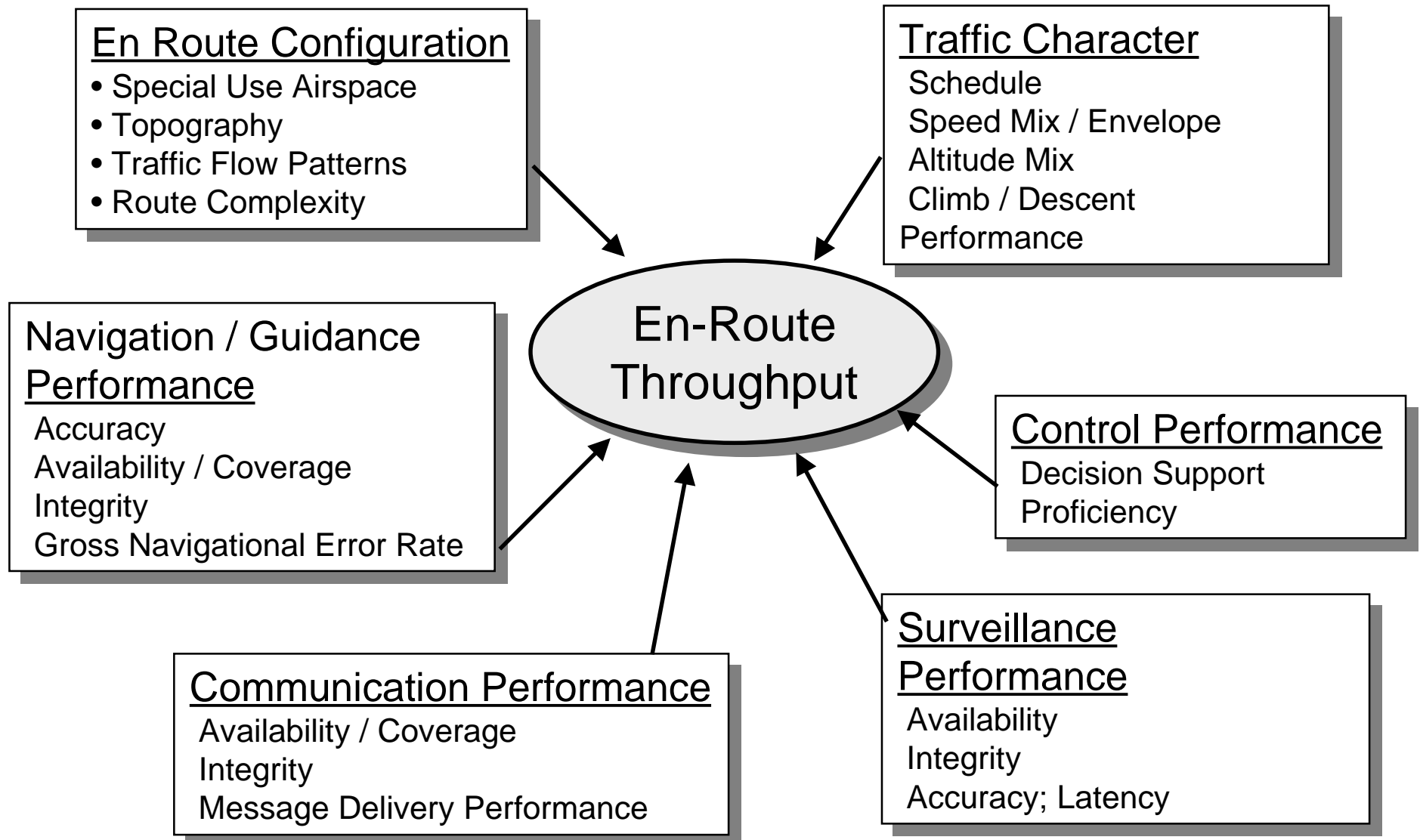
- 2  Airport Surface
- 3  Final Approach / Initial Departure
- 4  Approach/Departure Transition

- 5  TMA Arrival / Departure
- 6  En Route

Constraints



Factors Affecting En Route Throughput

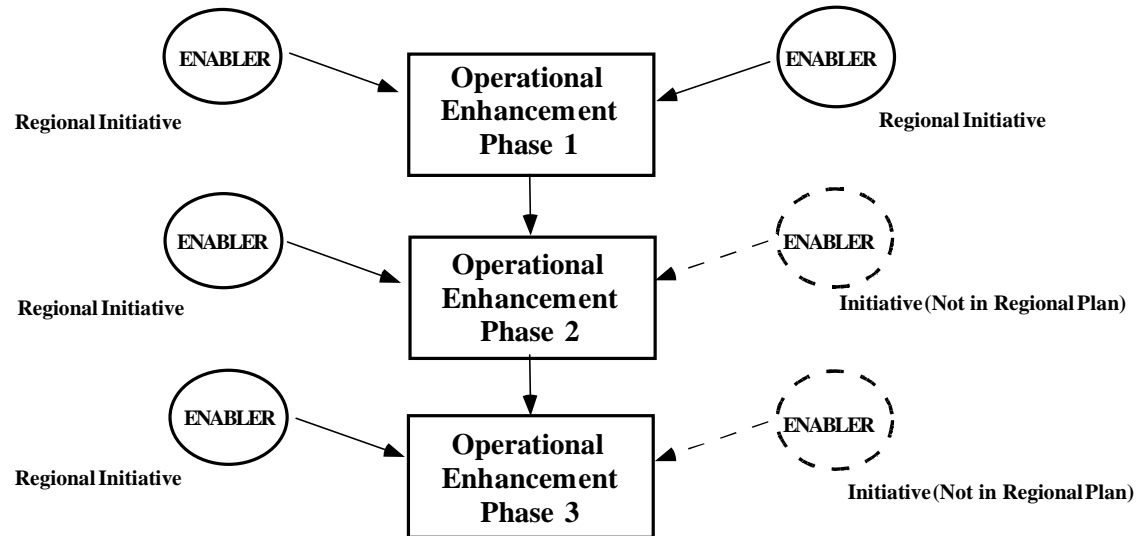


CONDITION: _____

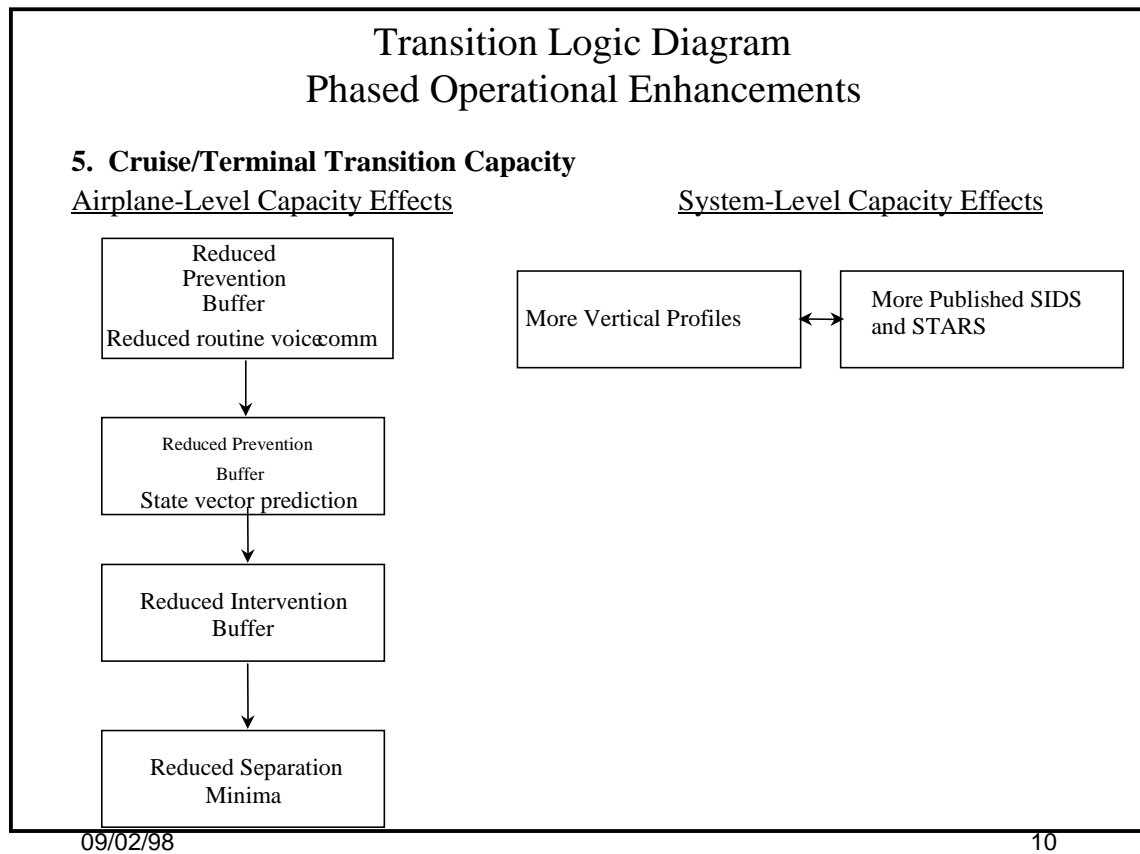
LOCATION: _____

Transition Logic Diagram Legend

CNS/ATM Transition Logic Diagram **REGIONAL PLAN**
Operational Phase **Benefit Mechanism** **Capacity (Efficiency)**

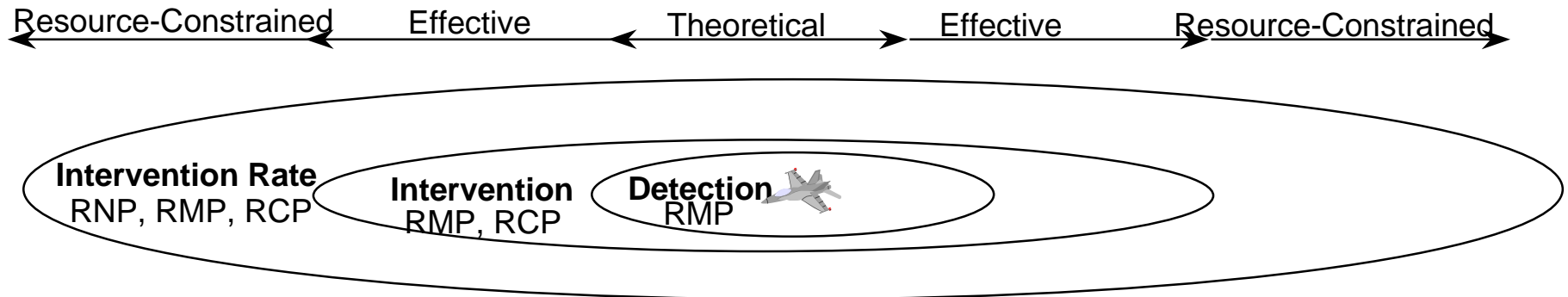


Transition Logic Diagram



Basis for Transition Logic Diagrams

Separation Buffers



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

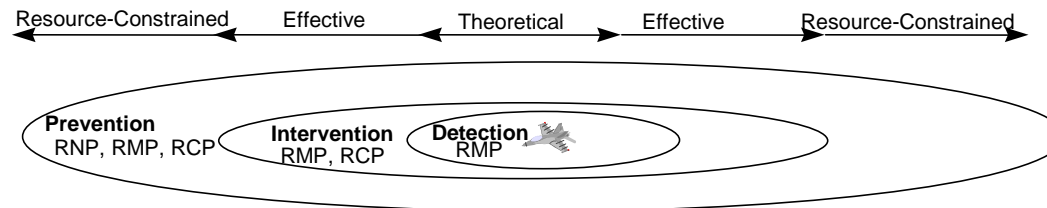
$RxP = f(\text{sensors, decision support, human})$

Required System Performance sets Separation Standard

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

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Constraints Analysis and Transition Logic Diagrams

- See paper on C/AFT web site: “The Economic Evaluation of CNS/ATM Transition” for a description of Constraints Analysis and Transition Logic Diagrams and other tools.
- www.boeing.com/caft, go to Documents link.

Boeing Alternatives Analysis Process

Operational Enhancement Comparison Process Using Data Link Example

- Create database of proposed CNS/ATM operational enhancements, structured by the Transition Logic Diagrams
- Rate each enhancement (high, medium, low) in each applicable phase of flight:
 - Benefit: how well the enhancement will improve final approach throughput
 - C/AFT OEIA will need to develop prioritized operational enhancement goals
 - Cost: considering ground systems and airplane fleet
 - Risk: e.g. unknown requirements, uncertain benefits and/or cost, acceptance by unions
 - Likelihood: is enhancement being implemented, planned, thwarted?
- When there are multiple potential enabler solutions with differing cost-benefit-risk, multiple enhancement entries created

Example Operational Enhancement

61 Medium term trajectory prediction without datalink

Medium term trajectory prediction is enhanced through improved radar tracking and flight plan information. May need better wind data.

The predicted trajectory, up to 20 minutes, is shown on the controller's radar display.

This will reduce the false alarm rate and allow controller team to reduce the prevention buffer.

5) Cruise / Terminal Transition

C Benefit	med		C5-1
E Benefit	med	possible shorter paths	S
Likely	unlikely	no current program, may encounter ATC union resistance	
Risk	med	unsure cost of enablers, more enablers may be needed.	
Cost	med	no a/c cost, pieces of CTAS may provide needed functions	
Favor	yellow		

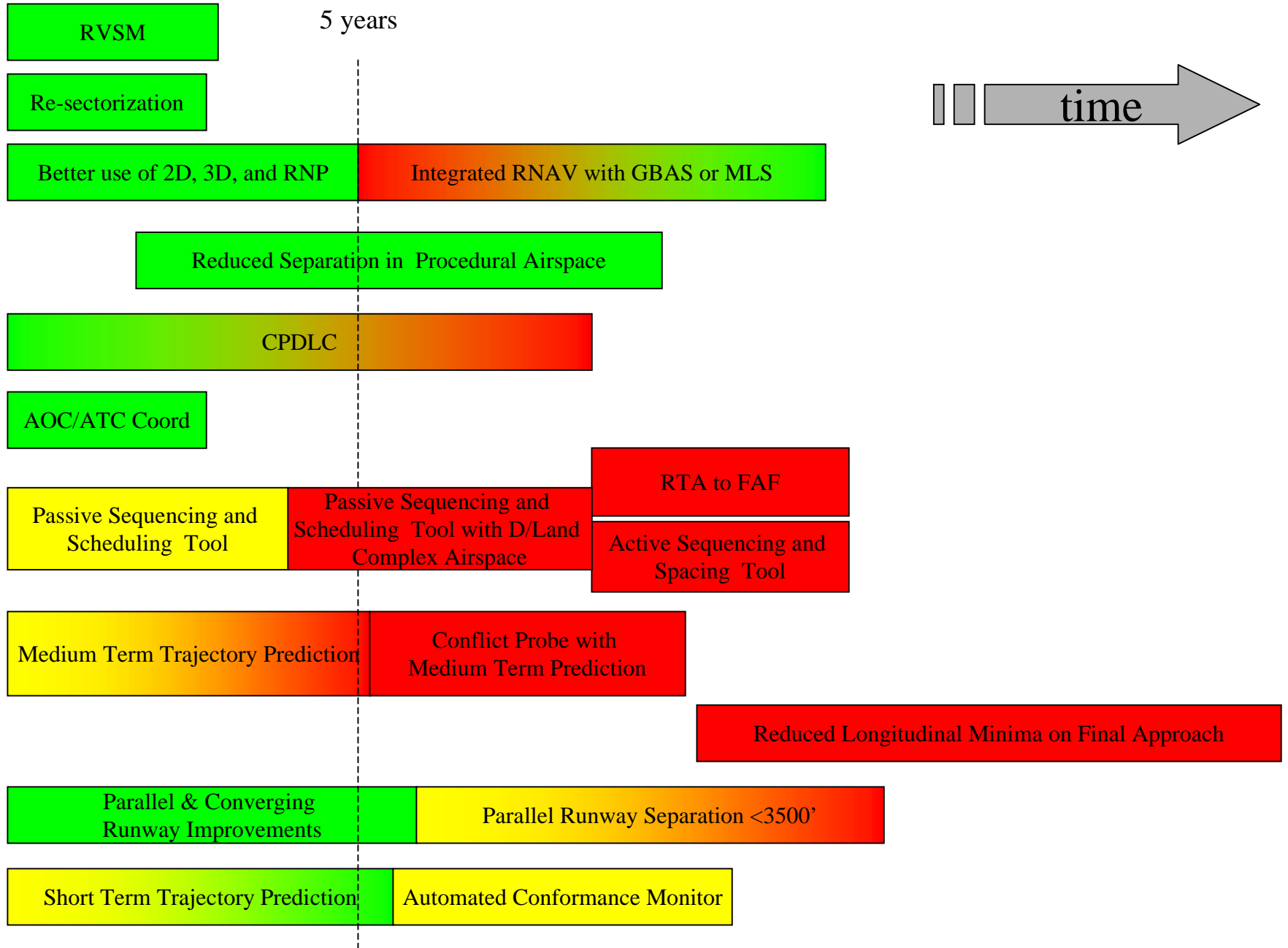
6) En-Route Cruise

C Benefit	very low	capacity not a problem in this region	C6R-1
E Benefit	high	better predictions may enable more user preferred trajectories, may reduce costs	
Likely	unlikely	no current program, may encounter ATC union resistance	
Risk	med	unsure cost of enablers, more enablers may be needed.	
Cost	med	no a/c cost	
Favor	red-red	low benefits	

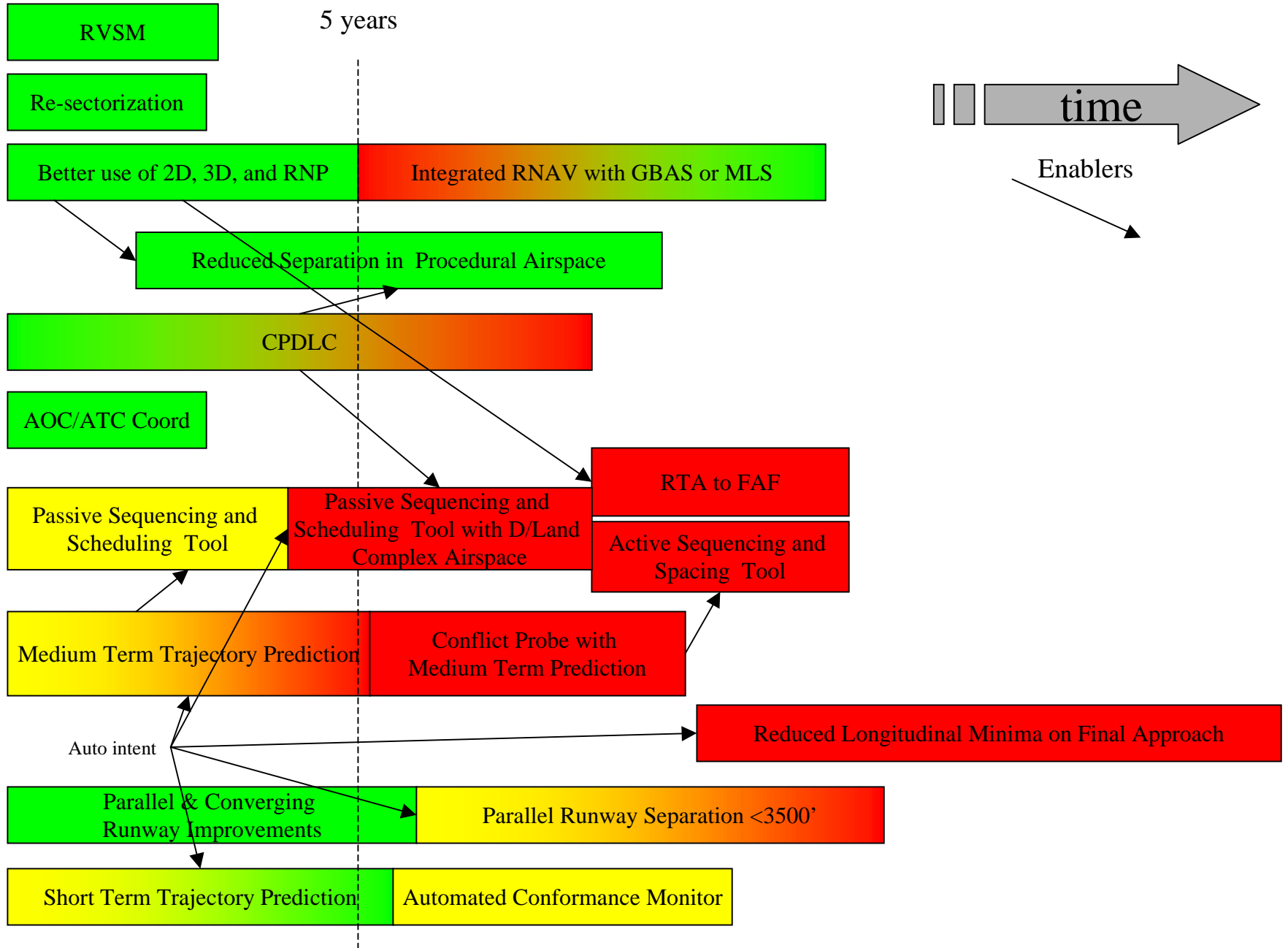
Determining Overall “Favorability” Using Data Link Example

- Green:
 - Benefit greater than cost, and risk low or medium
 - Some things which are not datalink related appear “green” simply because they are “low-hanging fruit” (e.g. RVSM)
- Yellow:
 - Benefit equal to cost, and risk low or medium
 - Some enhancements were upgraded from red to yellow if they were required to transition to a “green” enhancement
 - gives value to an enhancement’s potential to aid in migrating to the next step
- Red
 - Benefit less than cost, or risk was high
 - Research/ studies could be performed to reduce risk

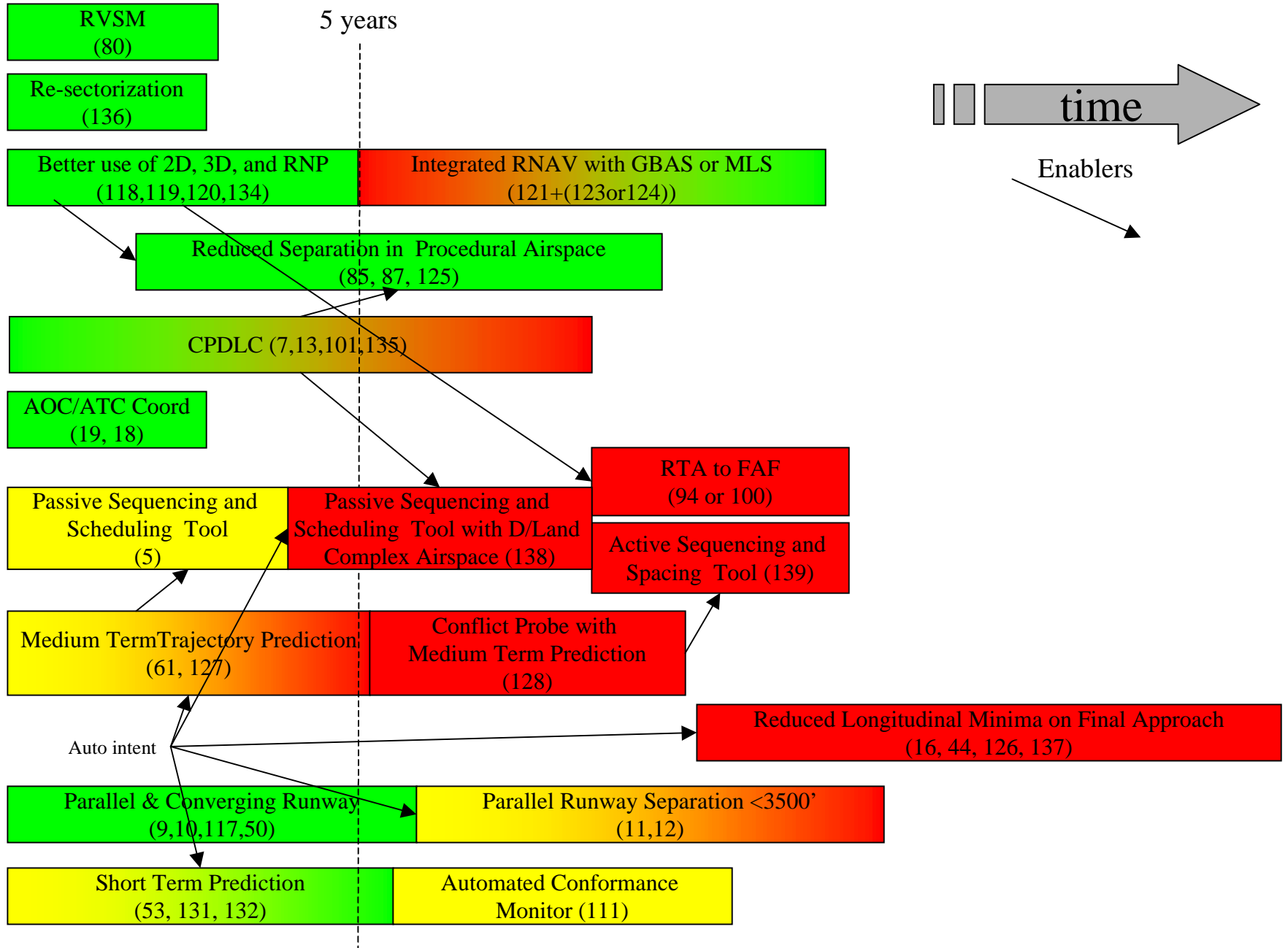
Recommended Enhancements for Increased FAF Throughput



Recommended Enhancements for Increased FAF Throughput



Recommended Enhancements for Increased FAF Throughput



Closer Look at 'CPDLC' Components

Flight Phase

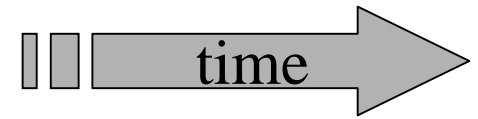
Planning

Passive Sequencing and Scheduling Tool (5)	Passive Sequencing and Scheduling Tool with D/L and Complex Airspace (TBD)	Active Sequencing and Spacing Tool (TBD)
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Surface

Digital Taxi Clearances (7)

Lower benefit,
Lower cost, Lower risk



Enablers

Final

Higher benefit,
Higher cost, Higher risk

Vectoring



Higher (questionable) benefit,
Higher cost, Higher risk

SIDS &
STARS

Lower benefit,
Lower cost, Lower risk

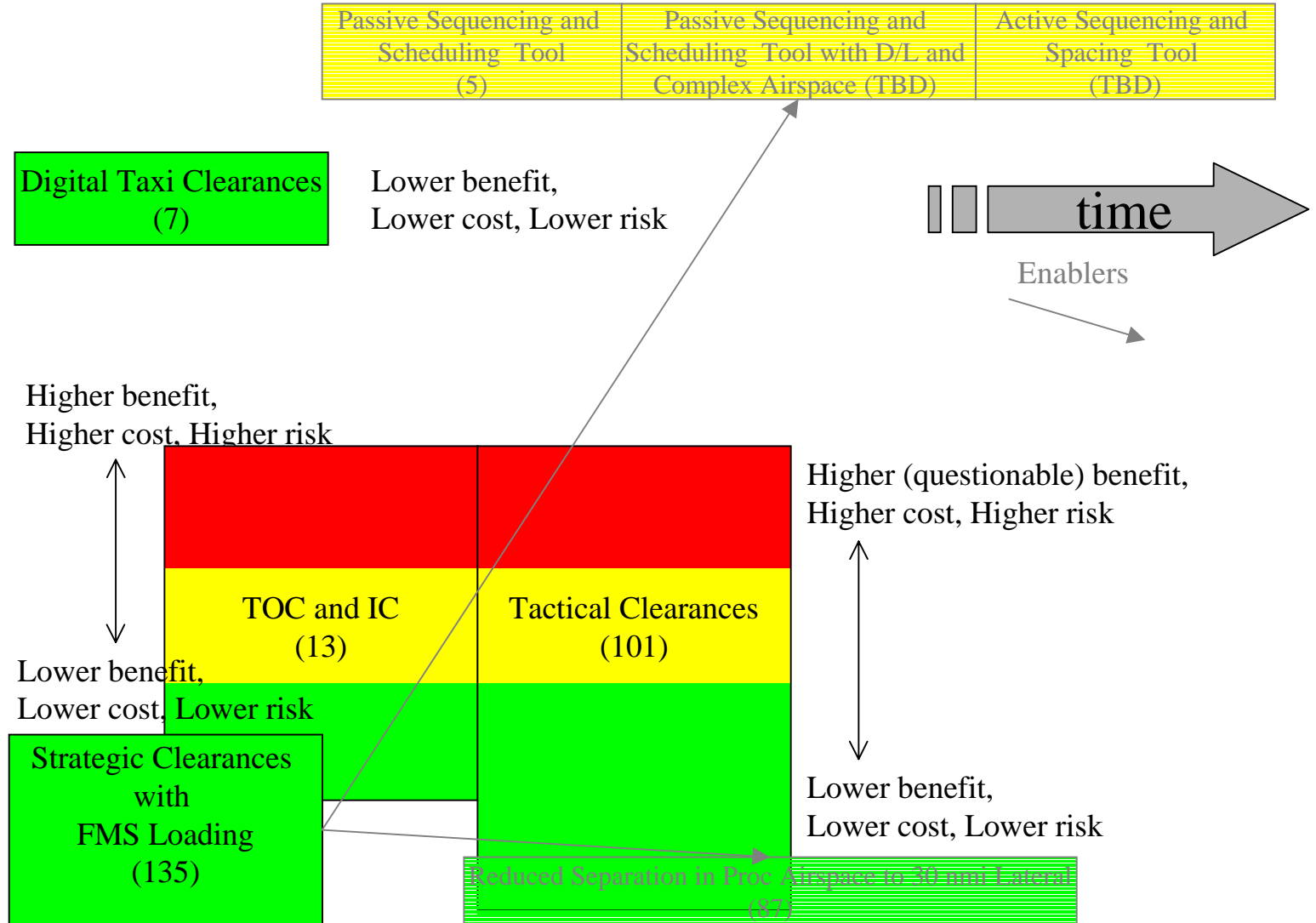
Enroute

Strategic Clearances with FMS Loading (135)

Lower benefit,
Lower cost, Lower risk

Remote

Reduced Separation in Proc Airspace by 30 min Lateral (87)



Conclusions

- The process developed met the goals of Boeing in the data link example
- Process needs to be refined, but can be applied to other constraints/operational enhancements