JPDO NextGen Trajectory Based Operations (TBO) Conference

Aircraft Considerations

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TOPICS

- Objective
- Capabilities Available
- Perceptions/Expectations
- What's Possible
- What Differs
- Aircraft Capability
- Beyond the Aircraft
- 2D/3D Near/Mid Term Summary
- 4D/RTA Near/Mid Term Summary
- 4D/RTA Far Term Summary
- Comparison Summary
- Conclusions

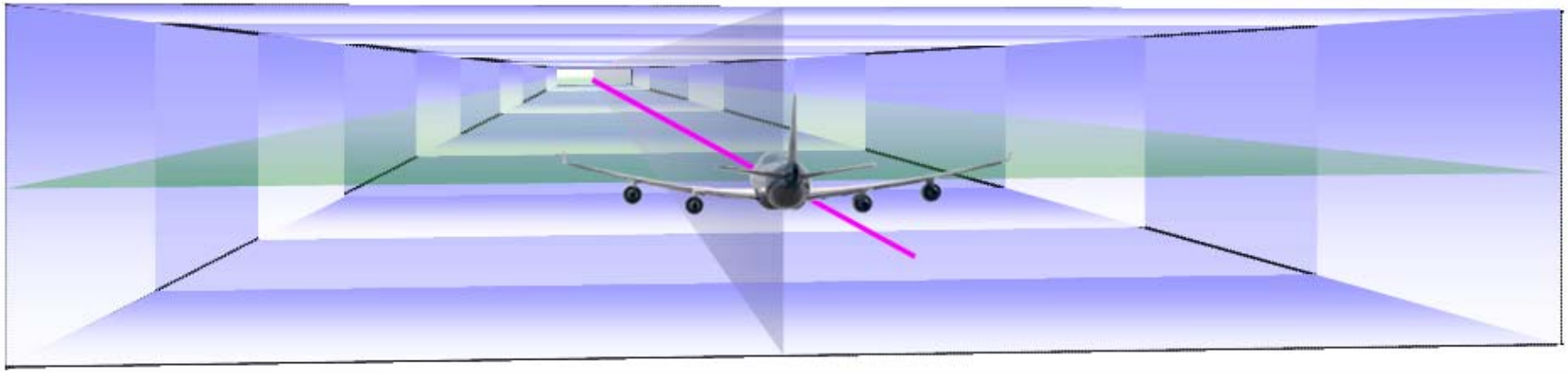
Objective:

Provide background information regarding TBO from an aircraft capability perspective

Identify areas that may be gaps and issues needing to be addressed to achieve consistent operational capabilities and to enable any advancement in TBO inside and outside the aircraft

Trajectories – Capabilities Available

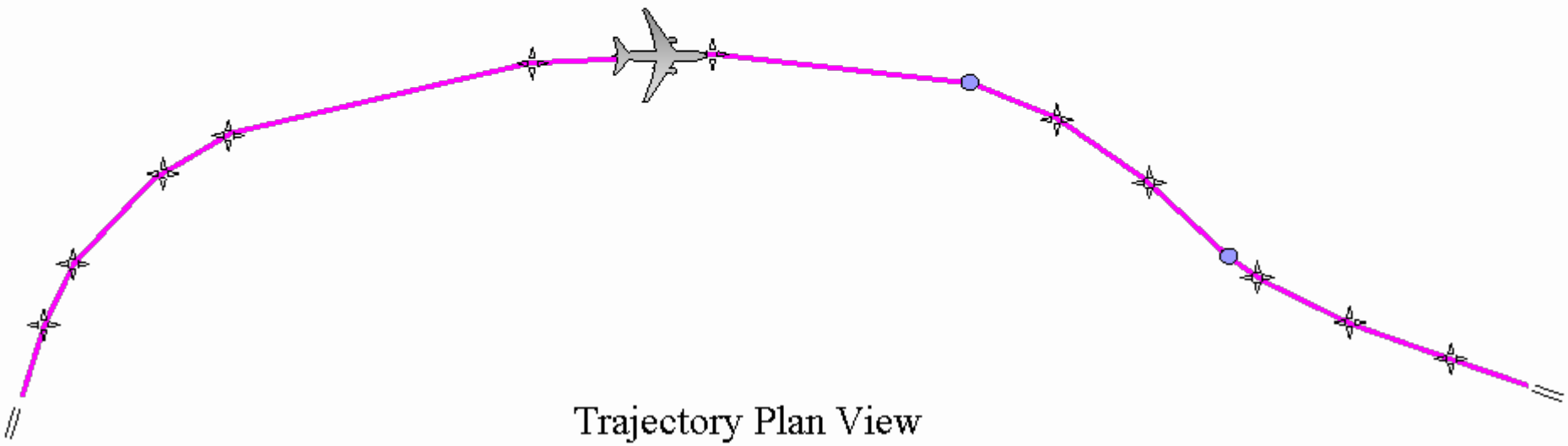
Area Navigation and Required Navigation Performance with vertical guidance via VNAV are primary capability enablers for TBO that are available in advanced aircraft/systems today.



A question that must come to mind is what does this really mean?

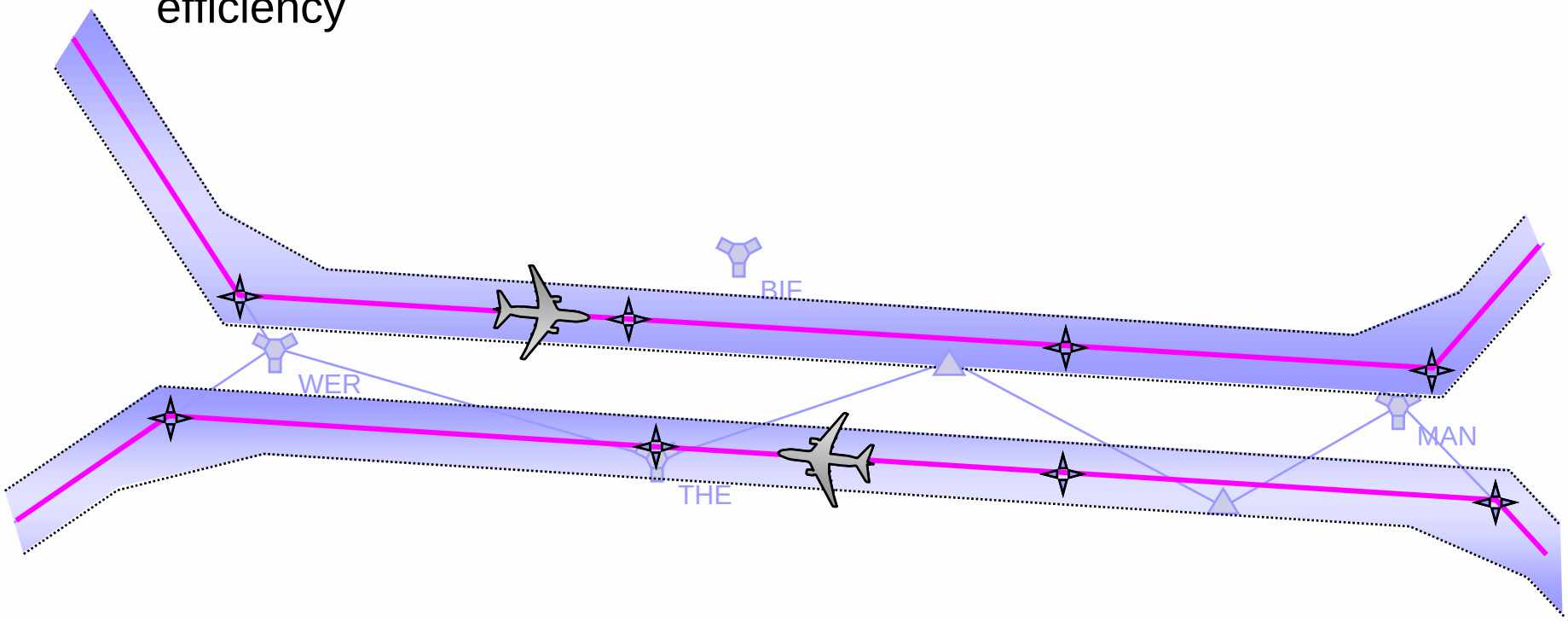
Trajectories – Perception/Expectation

The expectation is a predictable, defined flight path (trajectory), laterally & vertically for all flight phases.



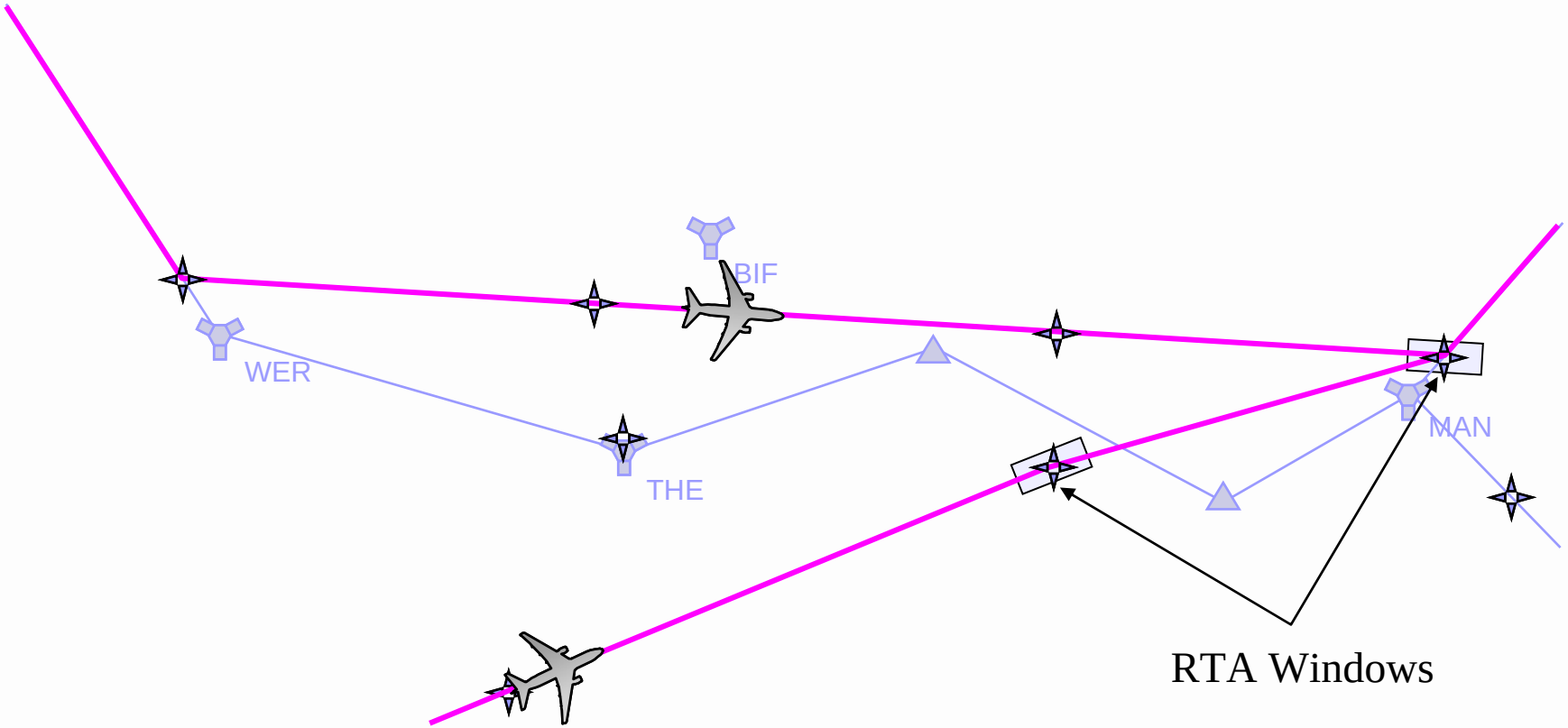
Trajectories – What's Possible

- Procedures can be developed without overflight of navigation aids
- Parallel RNAV routes to improve flow and capacity
- Reduced miles flown, reduced emissions and improved operating efficiency



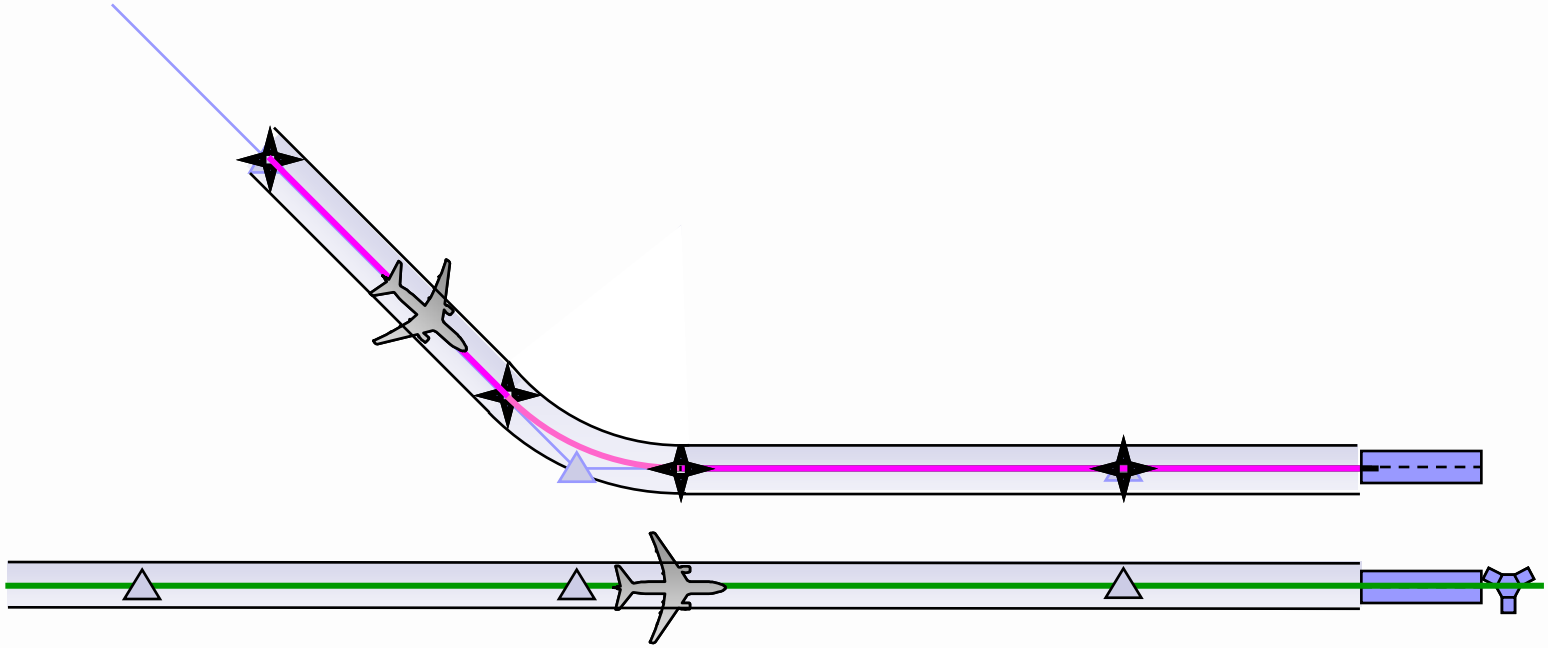
Trajectories – What's Possible

- 4DT (RTA/ETA) with further improvements in operating efficiencies
- 4DT (RTA/ETA) improvements to traffic flow and traffic management
- Some aircraft, enroute RTA only, others into the arrival procedure



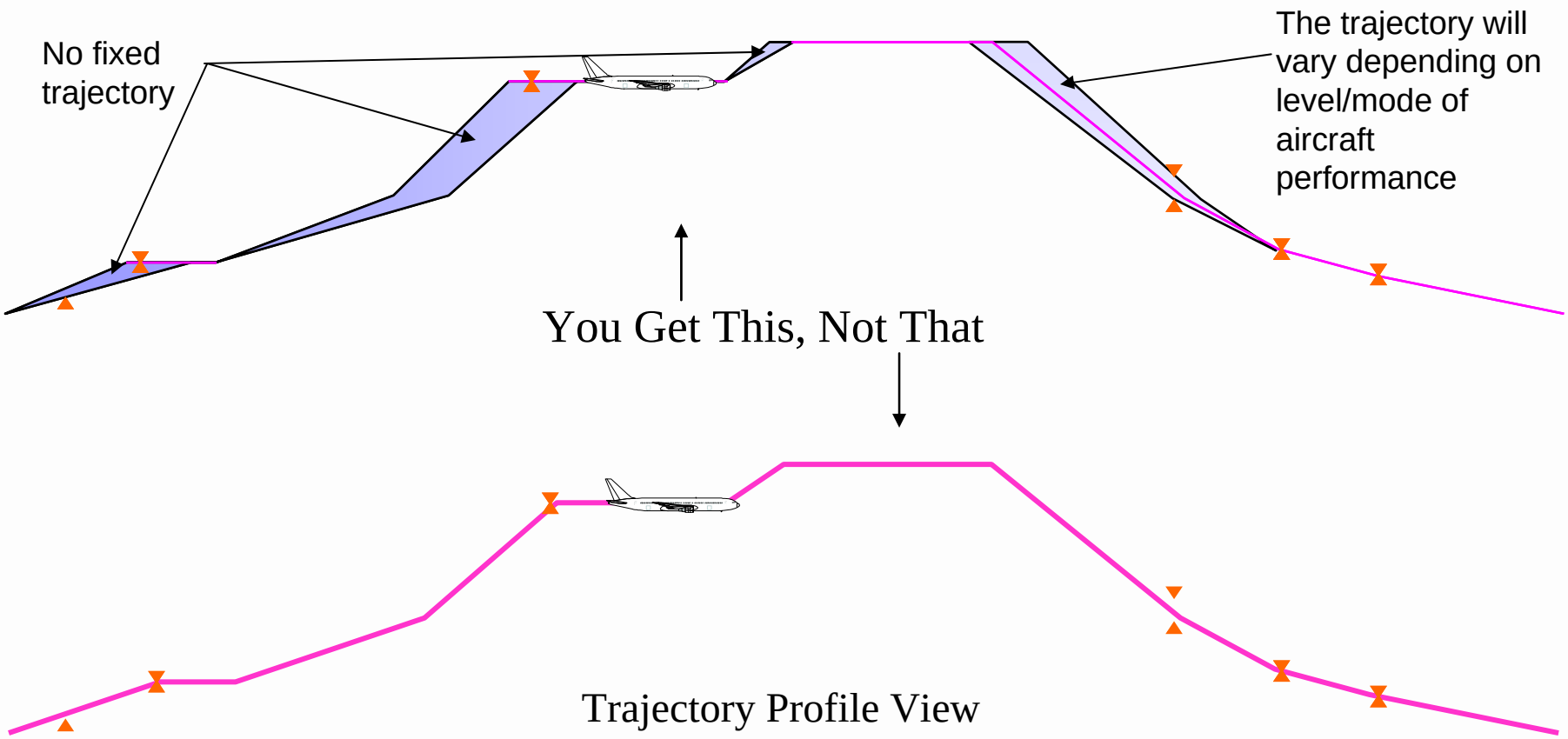
Trajectories – What's Possible

- RNP as an enabler to improved access and traffic flow
- RNP as an enhancement to operational safety
- RNP performance integrity, along with monitoring and alerting, is the basis



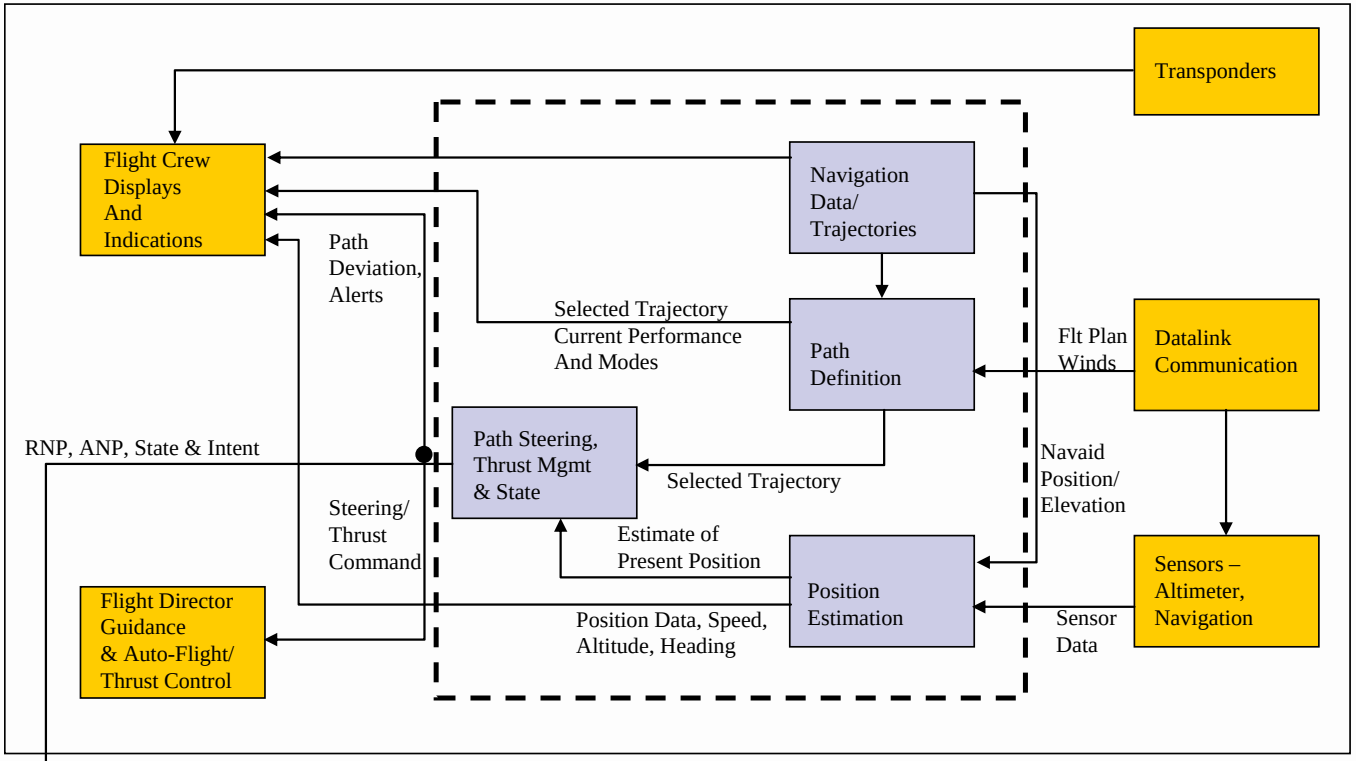
Trajectories – What Differs

Lateral trajectories can exist end to end, but vertically there are some parts of the flight profile where a defined path (trajectory) does not exist.



Trajectories – Aircraft Capability

Thousands* of aircraft systems contain a capability for calculating the aircraft trajectory considering performance, winds, requirements, etc.



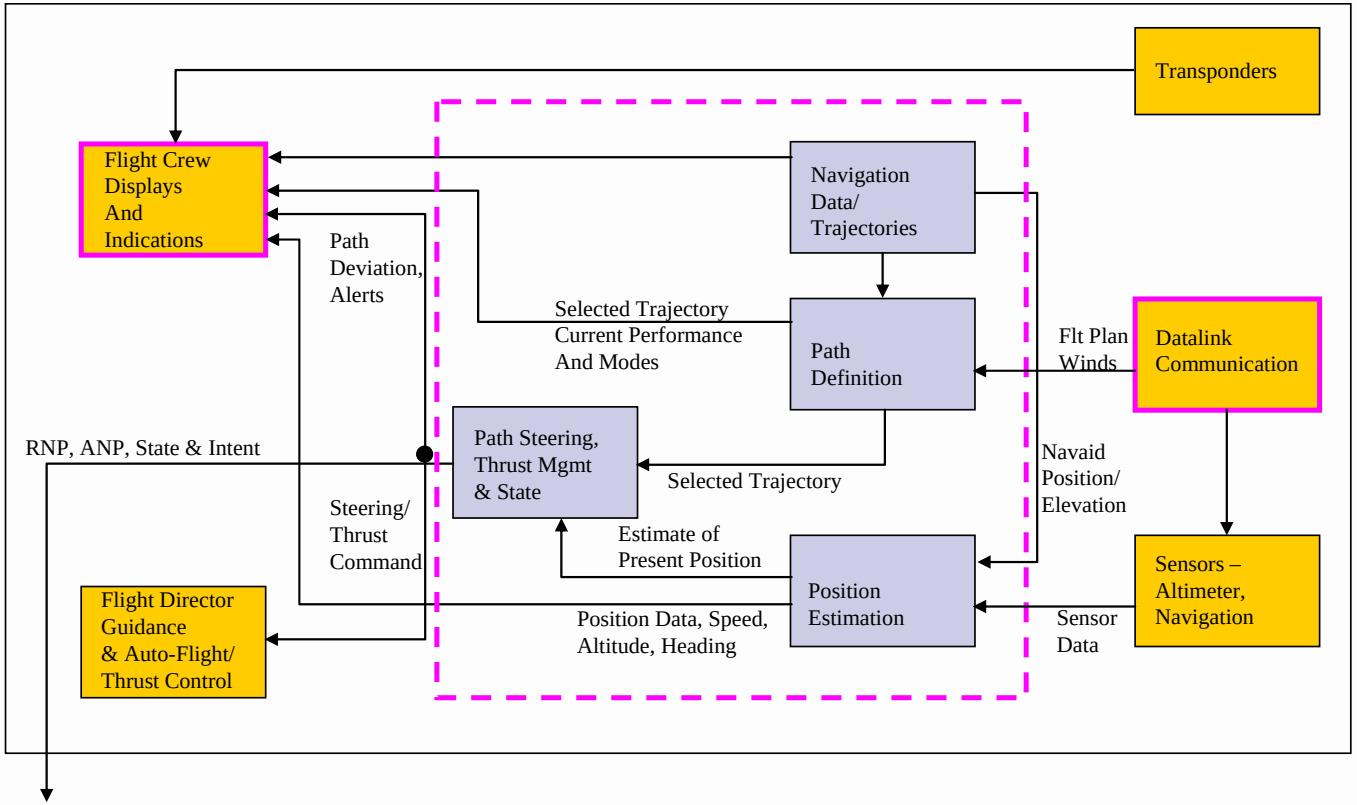
Example of Aviation System Capabilities

Systems functions and performance relatively fixed, and somewhat different.

*Mitre est 2600 of 7200 Part 121 aircraft

Trajectories – Aircraft Capability

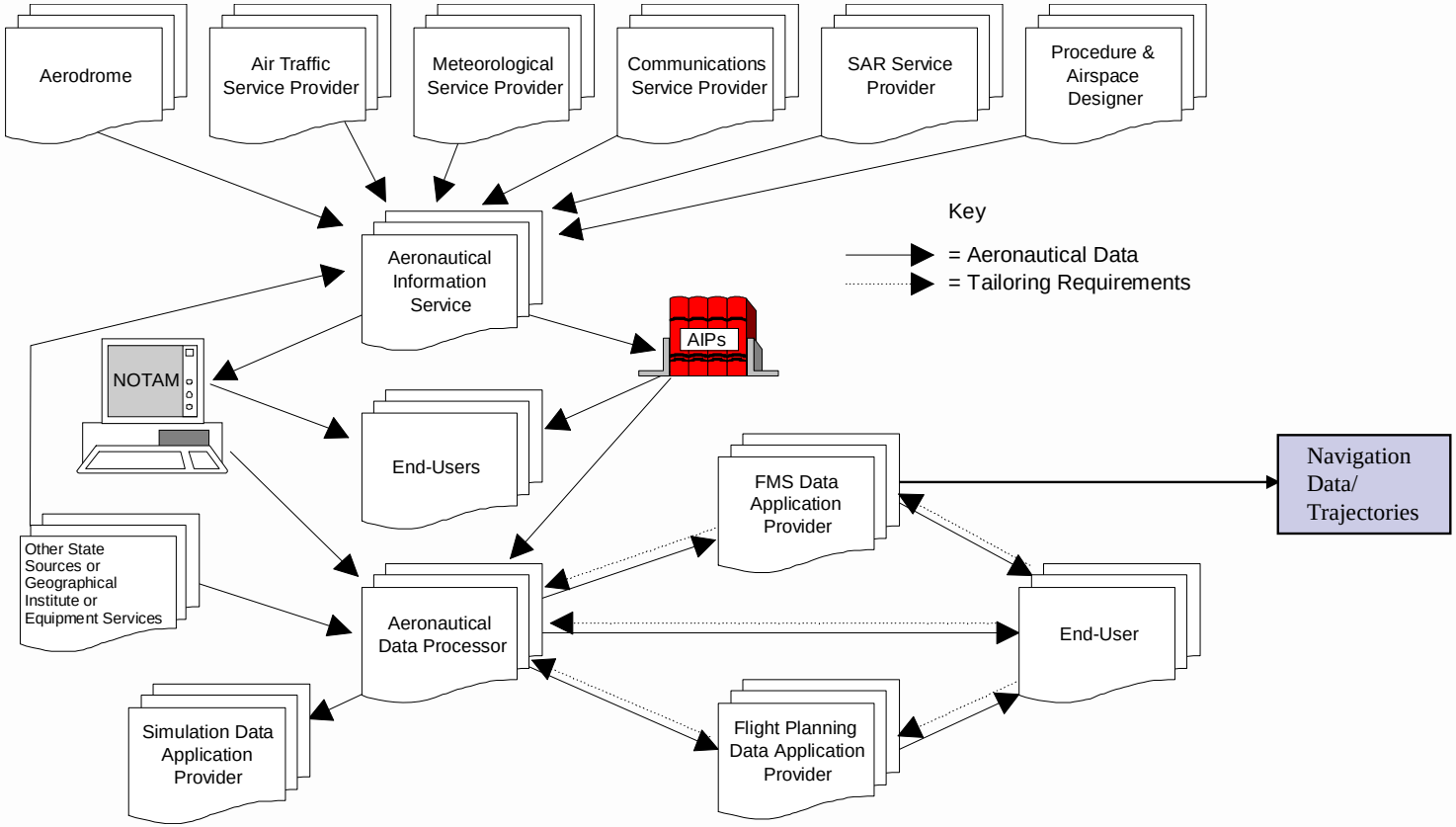
Changes in discussion for TBO while affecting "one capability" really cross boundaries of many systems, systems that must be changed/replaced.



Value only in beneficial <u>bundling of functionality, which is more than TBO</u>

Trajectories – Beyond the Aircraft

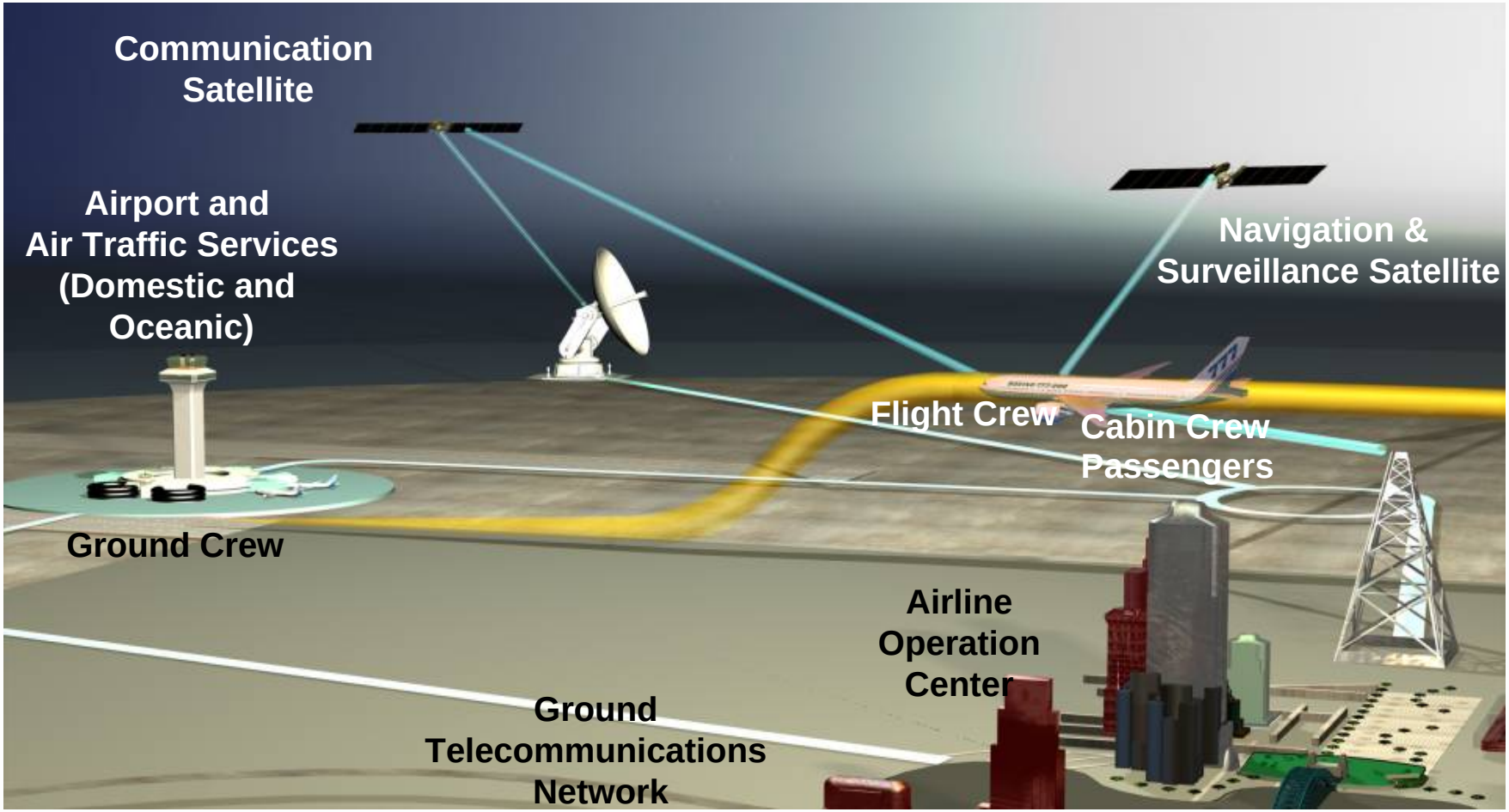
TBO has a ripple effect, a reliance on aeronautical data outside the aircraft



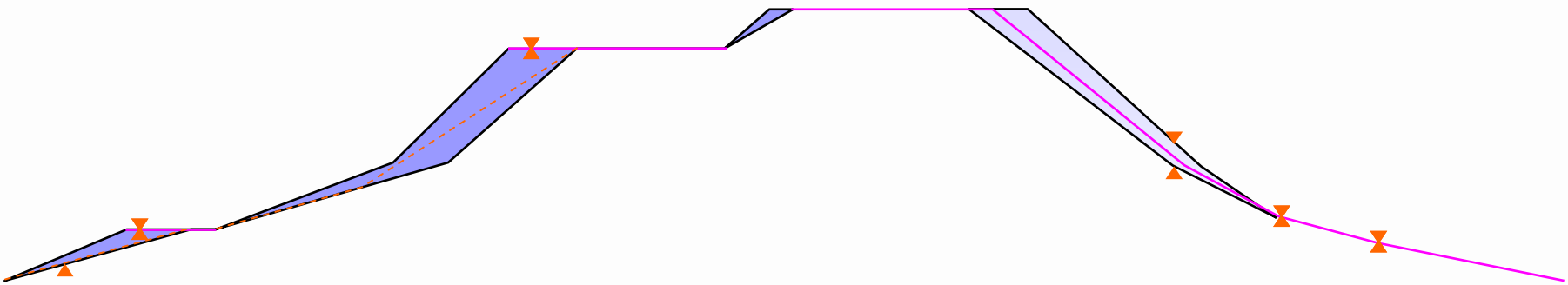
Trajectory data only supports what exists today, TBO desired changes not defined

Trajectories – Beyond the Aircraft

TBO also affects information and data in ground & communication systems

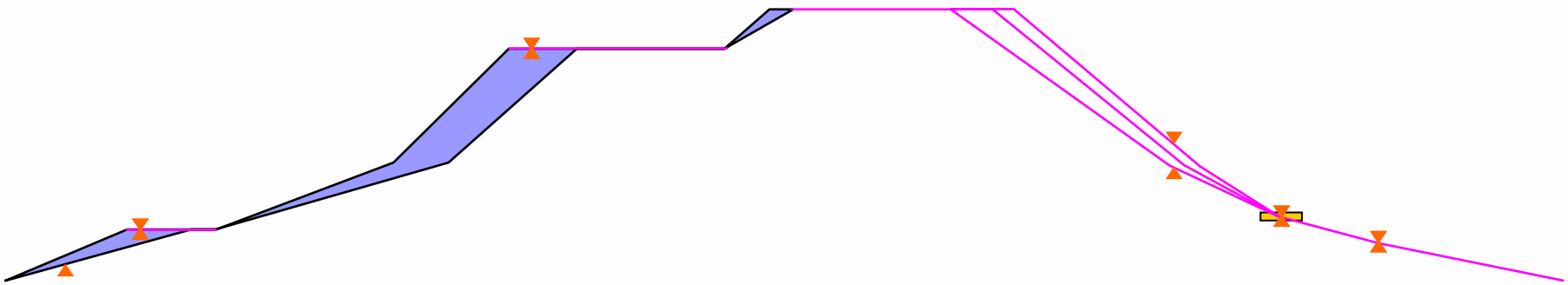


Trajectories – 2D/3D Near/Mid Term



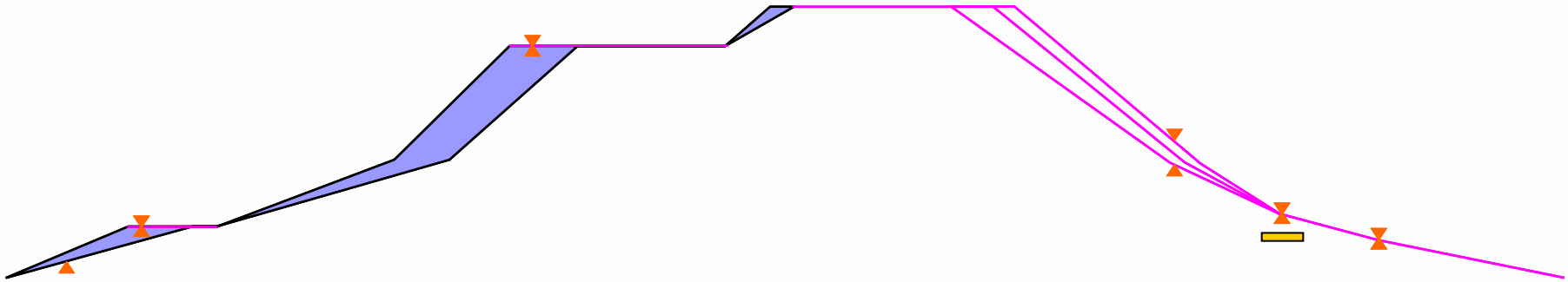
- Through the Mid Term, the Aircraft 2D/3D Trajectory is Characterized by:
  - No defined climb path, instead climb gradient depends on weight, thrust, configuration, lift, selected rate, etc.
  - Although Departure and enroute transition paths can be specified by fixes laterally and altitude constraints vertically (Window/AA/AB/AT), they are primarily a 2D path, with fix specific vertical requirements reflecting clearance, separation, resulting in enveloped airspace where the aircraft will be. Specification of a vertical requirement does not mean an aircraft can meet it.
  - The only certain paths that can be specified are level segments and descent. These paths are based on level off altitude constraints, cruise altitude selection, Window/AA/AB/AT constraints for descent paths & A/C Performance Mode
  - There is no means for full flight path vertical performance integrity e.g. VRNP.

Trajectories – 4D/RTA Near/Mid Term



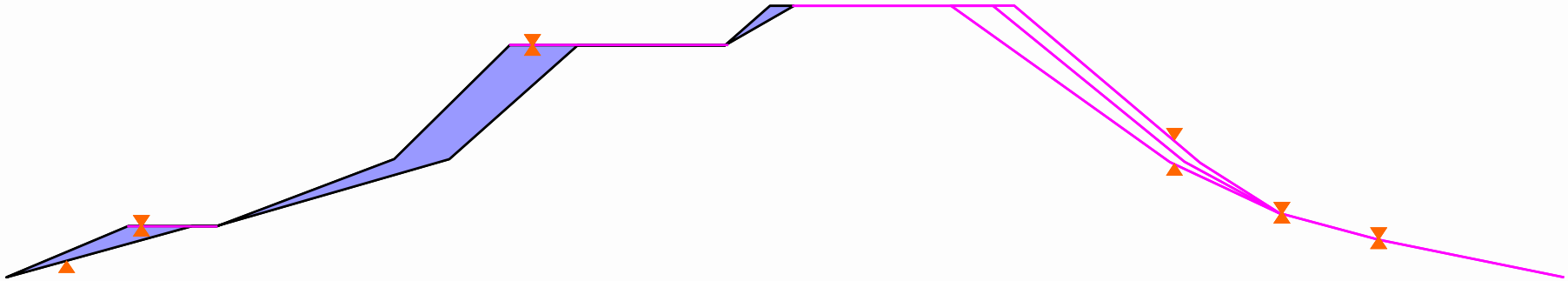
- Through the Mid Term, the Aircraft 4D/RTA Characterized by:
  - Builds on 3D but is it sufficient to implement?
  - An ability to estimate prior to departure, and only single RTA
  - Limited adjustment on aircraft speed, and less as flight progresses
  - Some flight profile adjustments depending on path requirements. Earlier top of descent possible depending on path requirements. Delayed top of descent depends on flyability. Path shortening/stretching
  - Wind models in aircraft impact calculation and time estimates. Wind models vary in number of wind/levels per fix, wind integration/interpolation, and means to update by manual entry or datalink.
  - 4D unique requirements only notional, nothing specific for path definition, 4D windows/tolerances, airspace tubes vs aircraft path,

Trajectories – 4D/RTA Far Term



- For the Far Term, the Aircraft Trajectory functional changes are unknowns:
  - 4D unique requirements only notional
  - nothing specific for path definition, what is different about the way a path is specified? Hard points defined by fix and altitude, fix and speed, fix only?
  - Is there a path, especially vertically or is it just selection of flight level? How does the aircraft know what space is allocated.
  - What changes between air/ground from what is done with FANS? Assume AOC/FOC plan coordinated with ANSP, changes negotiated by either aircraft or ground after wards?
  - 4D windows/tolerances, what are they? 5 seconds for terminal merging/spacing applications?
  - Where are the standards e.g. MASPS for this?
  - CNS functional bundling, what is required e.g. FANS?

Trajectories – Comparison



What Is Desired

Lateral/Vertical/Temporal Path
- 4DT Generation + Datalink
- 4D Performance, Windows, & constraints
- Modify trajectory
- Intended trajectory, & actual
- Legs w/ speed/altitudes, TOAC auto/manual
- Multiple TOA fixes?
- Trajectory adjustment, orig to dest
- Negotiated trajectory changes
- Lateral windows
- Additional vertical paths
- Continuous trajectory

Trajectory Ops Enablers
- Precise management of current & future position
- Monitor compliance & alert, far term
- Vertical RNP
- Voice & Data Com

What's Available or Planned

Lateral/Vertical/Temporal Path
- 4DT Generation + Datalink
- 4D Performance, Windows, & constraints
- Modify trajectory, level/descent only
- Intended trajectory & actual, level/descent only
- Legs w/ speed/altitudes, TOAC auto/manual
- Single TOA fixes
- Negotiated trajectory changes

Trajectory Ops Enablers
- Precise management of current & future position
- Optimized Baro VNAV
- Voice & Data Com
- Expanded 4DT datalink message set

Gaps

Lateral/Vertical/Temporal Path
- Windows/large windows vs aircraft computed, fixed trajectory
- Wind model changes
- Actual wind integration
- No climb path, now or in future
- Wxr, airspace, traffic, environment info in cockpit vs lack ops/technical standards
- Consistency from system to system
- Aeronautical Information

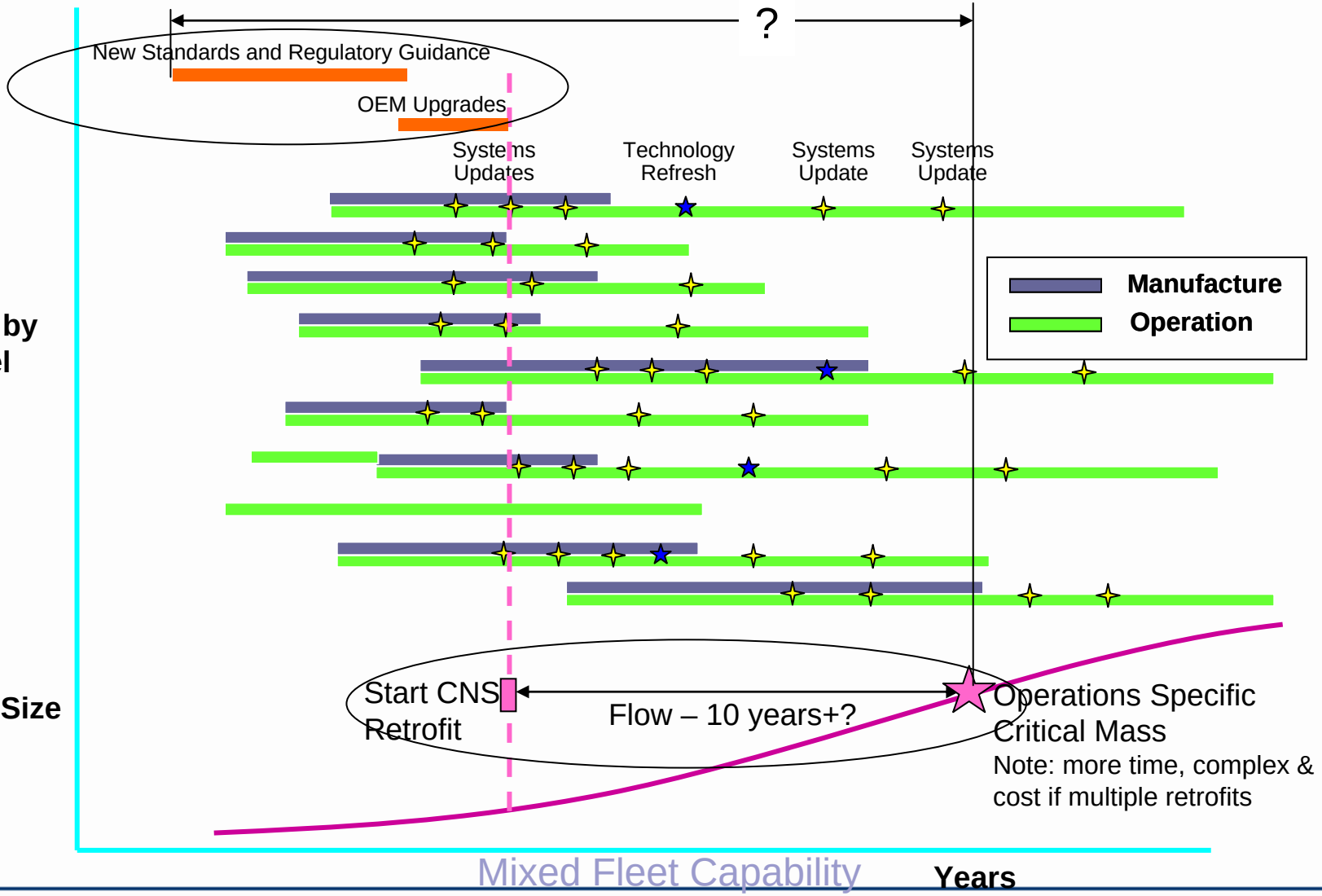
Trajectory Ops Enablers
- Ops requirements & standards to enable determination that where desired and existing capabilities appear the same that they are the same; if not, why not.
- Air/Ground Integration, Aircraft/AOC
- Regulatory Guidance Material is TBD

Conclusions

- What TBO can be depends on how many issues and actions are tackled:
- Operational scenarios are needed to enable modeling, simulation and research into 4D unique requirements
- 4D windows/tolerances and authority, what are they, e.g. 5 seconds for terminal merging/spacing applications?
- Any new aspects of path definition (trajectory) functionality and capability need to be specified.
- Aircraft climb gradient must be factored into the thinking of TBO negotiated trajectories and separation e.g. departures/arrivals.
- The only ATS datalink with any operational experience is FANS. How can FANS be used as a transitional building block for DataCom?
- Where are the system performance standards e.g. MASPS for TBO? DO-236B/ED-75B contain the current state but will require changes.
- Any changes in regulatory guidance material and actions need to be identified. PARC TBO activity is currently on hold.
- Aircraft changes will only be justified through business cases that are based on CNS functional bundling, e.g. FANS.

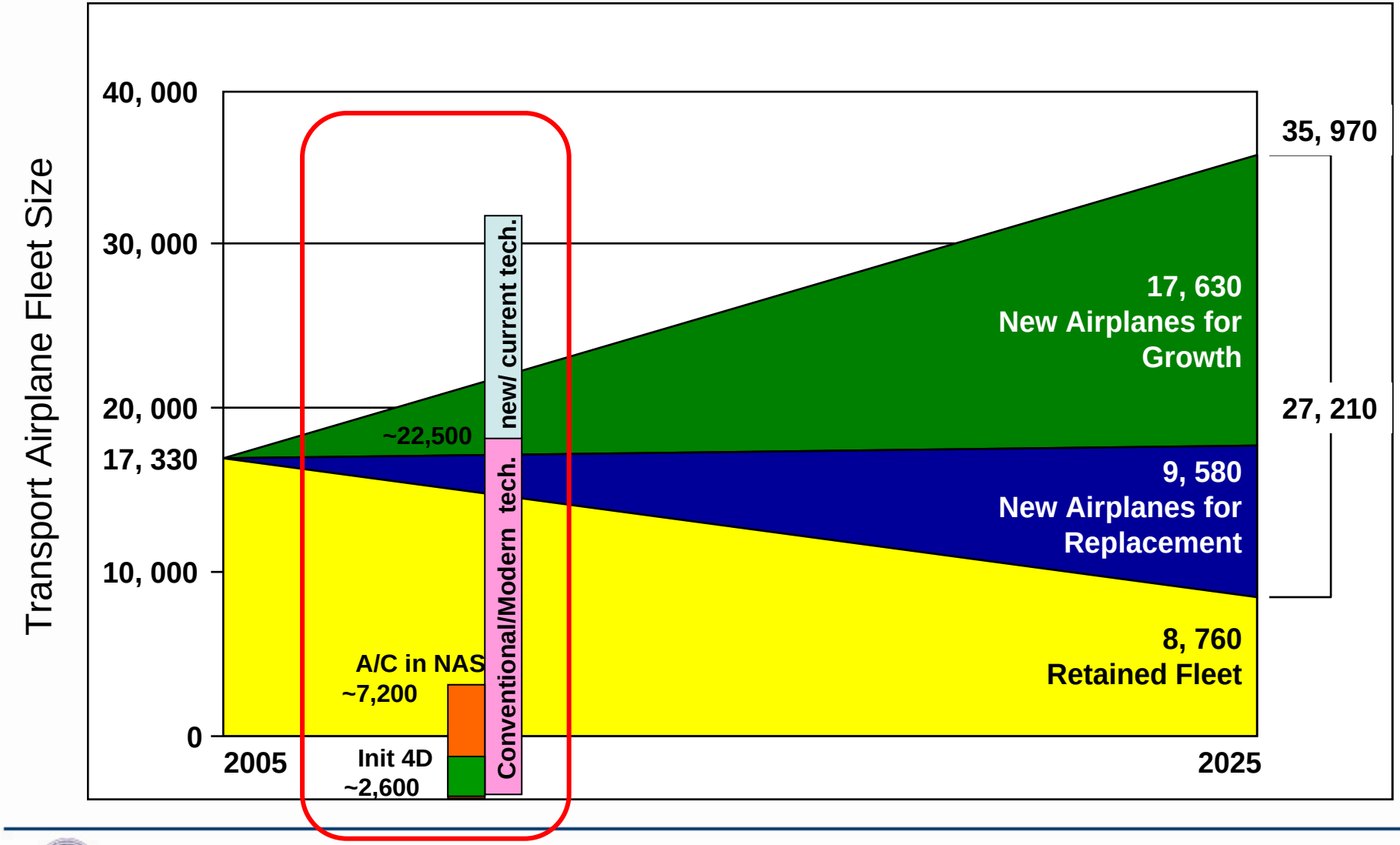
Conclusions

A Perspective and the Challenge, Forward Fit and Retrofit



Conclusions

A Perspective and the Challenge, Forward Fit and Retrofit



Data Source --- Boeing forecast
(note: Airbus forecasts vary by 5-15% on individual estimates)

Comments