TACEC

Terminal Area Capacity Enhancement Concept

Advanced ATM Concept for 2020

prepared for
VAMS Technical Interchange Meeting #1
NASA Ames Research Center
21-23 May 2002

Terminal Area
Operating Domain

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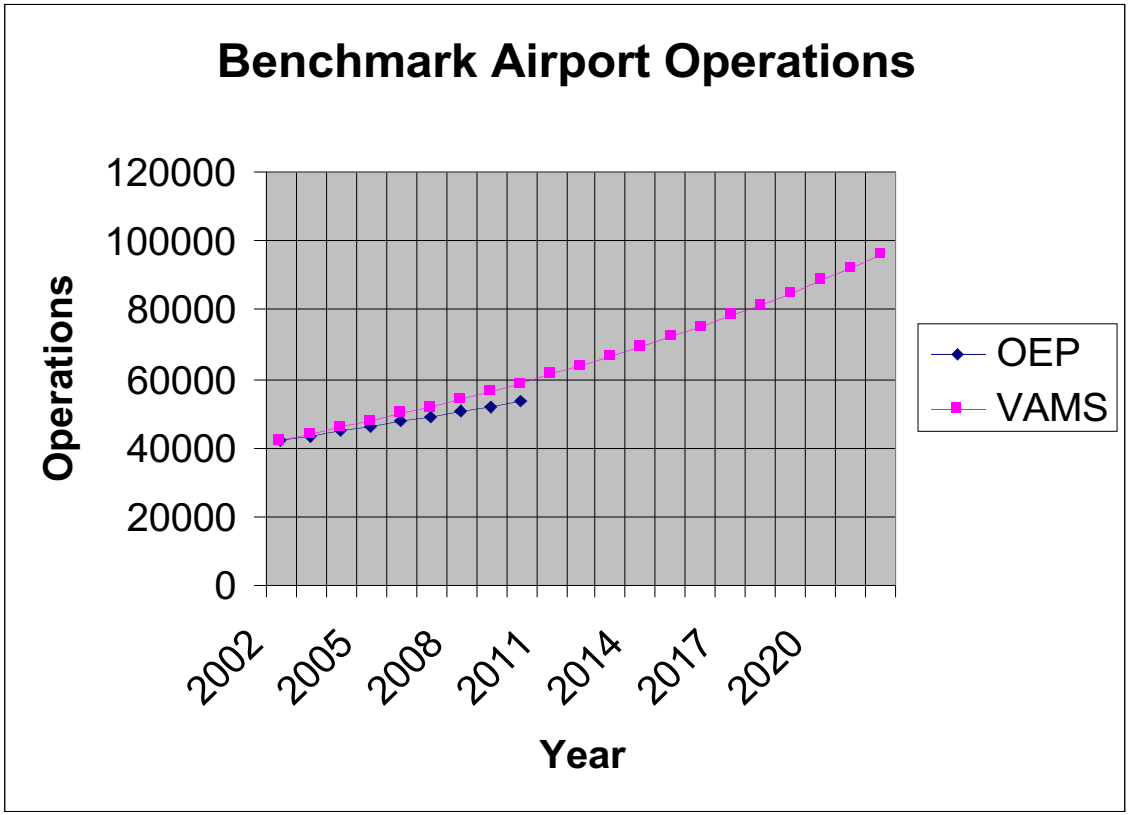
- The Terminal Area is defined as airspace surrounding an airport or airport group (similar to today's TRACON) as well as the airport surface (runway, taxiway and ramp). In addition the Terminal Area includes gate and street side operations.

- For comparison purposes the Terminal Area is similar to the environment addressed in the FAA's Operational Evolution Plan for Arrival and Departure Rate

Problem

Dramatically increase operational capacity

- **Today's NAS is operating at or near capacity**
- **FAA OEP predicts a 24% total growth in air traffic by 2010**
- **VAMS predicts a 4.5% growth per year through 2020**



	2010	2022
OEP	54,000	-
VAMS	59,000	96,000

Challenges

Increase capacity using new technology and operations

- **Majority of FAA's OEP envisioned capacity growth comes from building new runways.**
- **Continued construction beyond 2010 is not envisioned**
- **Assuming similar regional operations in the future the 13 busiest airports today will see the majority of growth in 2020.**

	OPS per HR		
AIRPORT	TODAY	OEP/2010	VAMS/2020
ATL	185	237	426
ORD	200	236	460
DFW	261	316	600
LAX	148	185	340
DTW	143	187	329
PHX	101	132	232
MSP	115	152	265
LAS	84	109	193
MIA	124	153	285
DEN	204	251	469
CVG	123	172	283
BOS	118	125	271
STL	104	135	239

Increased capacity and operational requirements

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Doubling OPS/Hr means twice as many aircraft in the airspace, on the runway, and at the gates….

- Separation requirements between aircraft within the terminal airspace must be reduced by up to a factor of 2.
- Final approach and departures must be conducted at twice the rate achieved by any OEP improvements envisioned.
- Surface traffic must be increased by a factor of two and runway occupancy time reduced.
- Gate operations must double, either by increasing their number or halving their occupancy.

TACEC is an Evolutionary Approach

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- **Technology exists today to significantly reduce separation**
  - **Train, demonstrate, validate and instill confidence necessary over the next 20 years**
    - » **Integrate "intent" with current position to reduce uncertainty**
    - » **Distribute the separation responsibility between air and ground**

- **Operational algorithms using today's computational power can plan, schedule, and communicate ATC operations today**
  - **Over the next 20 years more sophisticated algorithms and "super" processors can deal with the large number of ATC OPS factors required…….but confidence in these results must be developed.**
    - » **Establish proper parameters via research**
      - **Wake Vortex**
      - **Weather**
      - **Runway Occupancy Time**
      - **etc**
    - » **Optimize the human elements role and responsibility**
    - » **Provide NAS wide fault monitoring of all system elements**

But the evolution will be difficult

- **Issues to deal with**
  - Aircraft equipage
  - Ground side constraints
    - » road access
    - » noise
    - » emissions
    - » parking
    - » security
  - Human factors
  - Confidence in technology
  - Safety
  - Culture/folklore
- **Stakeholder Issues**
  - National Policy (DOT, FAA, Government)
  - Funding authority
  - Airlines, aircraft owners
  - Aircraft manufacturers
  - DOD/USAF
  - Pilots & controllers
  - Operations and Maintenance
  - Gate/Ramp management
  - Airport management

Increasing capacity in the Terminal Area relies on following key elements:

- **Accurate 4D Trajectory Calculation**
- **Aircraft execution of required trajectories**
- **Highly reliable and secure data link**
- **Reduced separation standards**
- **Improved surveillance**
  - **WAAS enhanced GPS**
  - **Multi-sensor surface surveillance fusion**
  - **Mode S MSSR**
- **Airborne self separation**
- **Complex finals - curvilinear, multi-aircraft formations landings**
- **Optimized taxi routing**
- **Integrated Terminal Area information network (all stakeholders)**

TACEC Overview

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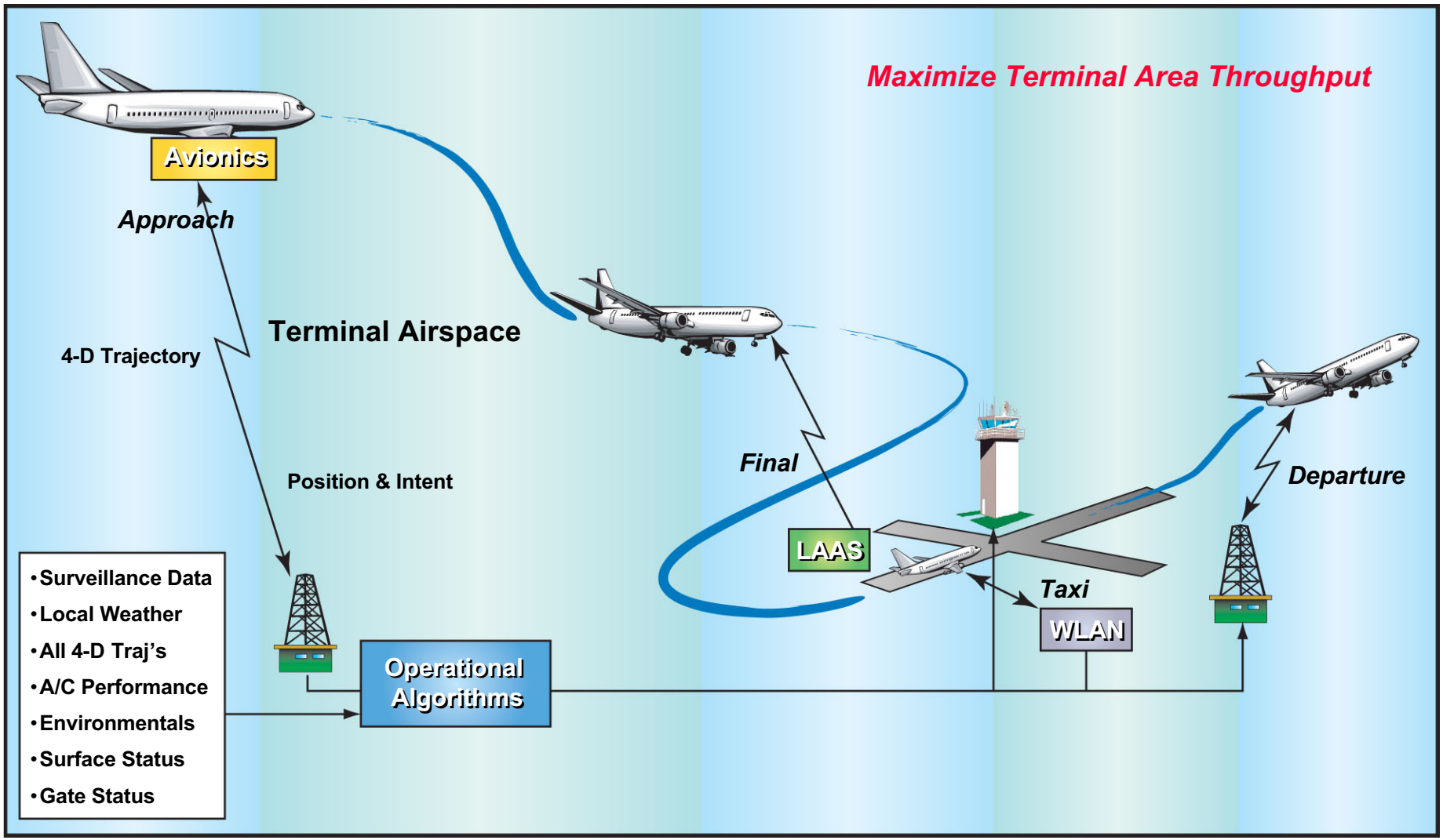

Separation Assurance Components

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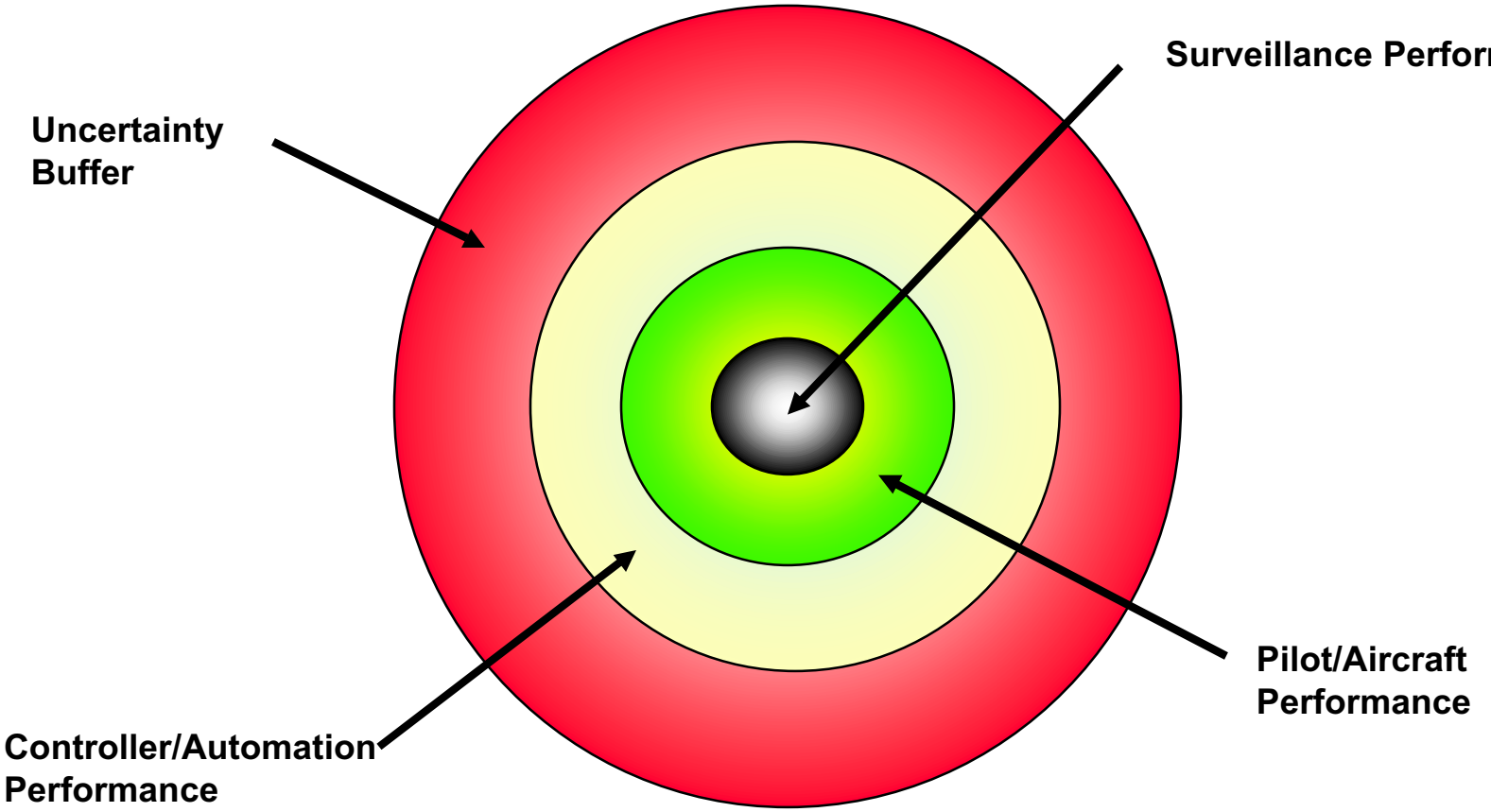

Human-Centered Systems (HCS)

- **The most effective solutions will come from the proper blend of automation and human decision making.**

- **Human involvement is critical because:**
  - **Humans are better than automation at higher-order tasks such as complex pattern recognition, avoiding false alarms, generating imaginative solutions to difficult problems, and handling unique/exceptional situations**
  - **Humans must ensure proper response to non-normal situations**

- **Automation will augment human abilities**
  - **Automation can compensate for human limitations of attention and memory capacity (e.g., humans can only monitor and interact with a very limited number of aircraft simultaneously)**
  - **Cognitive-based visualizations can enhance situation awareness and management in a fusion with automation and what-if tools.**

Human Centered Operations

- **Re-define the role of the Human in the system**
  - **Identify proper roles for all human activities in TACEC**
  - **Identify tools required to support and conduct role**
- **Primary objective of system solution is to maintain controller and flight crew situational awareness and responsiveness, in an automation environment.**
- **Establish pilot/controller commitment to the "situation" established by the 4D Trajectory calculation.**
- **First principle includes shared separation responsibility, appropriately between ground manager and flight crew.**

Re-defined Roles
Control vs Management

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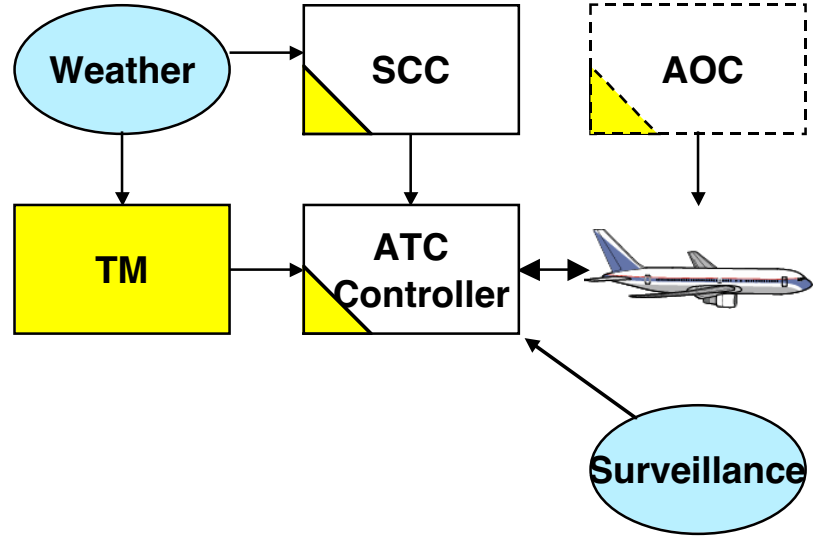
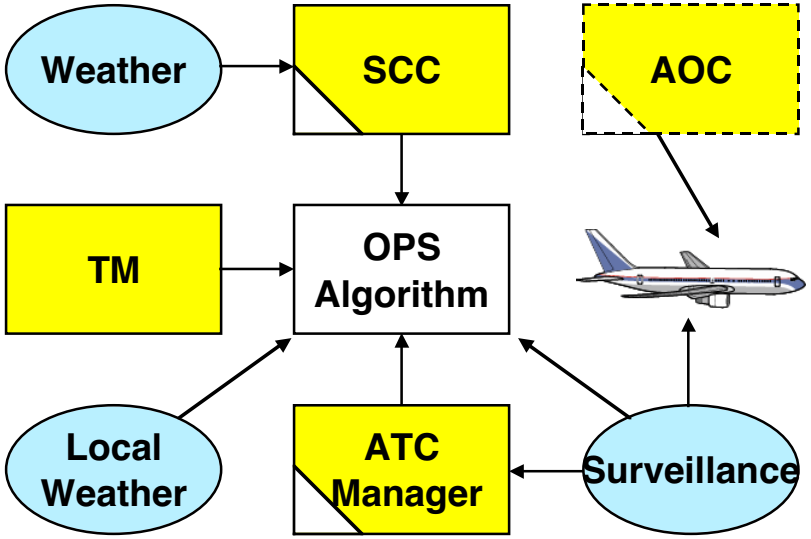
Today's Division



Management Control Information

TACEC Division



Management Control Information

Improving Situational Awareness (SA)

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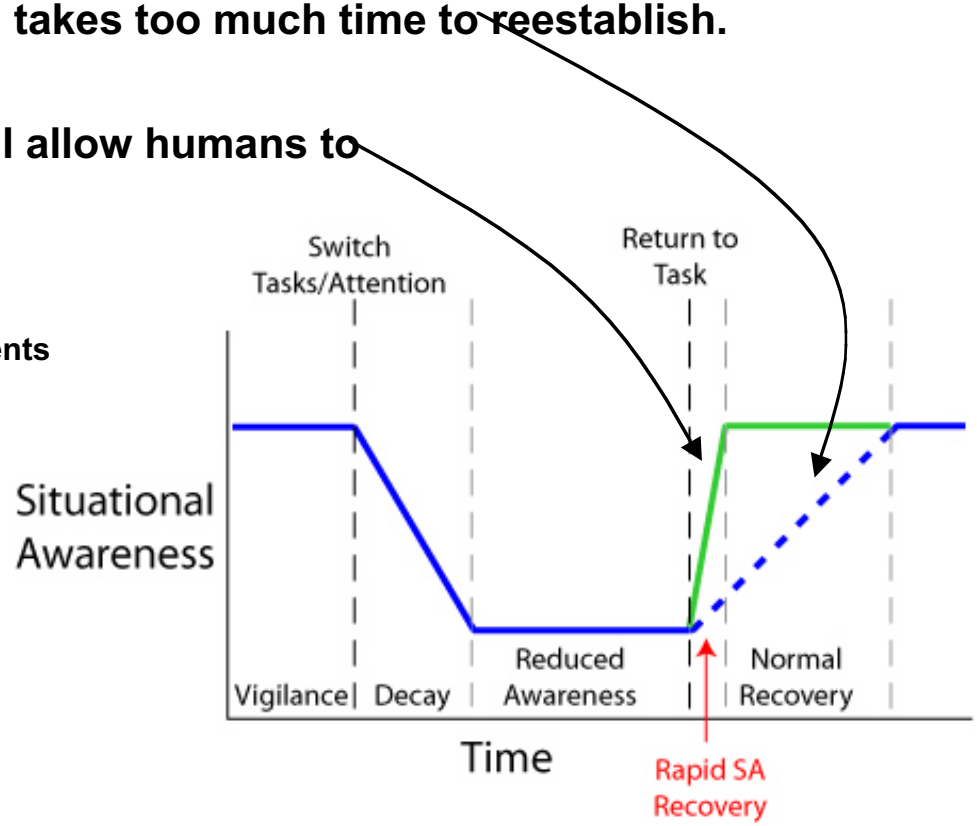
- Rapid reacquisition of situational awareness will be a key problem in future ATM. **While automation frees up humans to perform multiple tasks, there is a cost of switching between tasks.**

- **Situational awareness is disrupted by many factors (e.g., relying on automation or task switching) and takes too much time to reestablish.**

- **Cognitive-based visualizations will allow humans to rapidly acquire SA when:**
  - **Maximizing TRACON throughput**
  - **Responding to unexpected situations**
  - **Preserving safety during non-normal events**



One Example of a Specific Visualization Concept for SA

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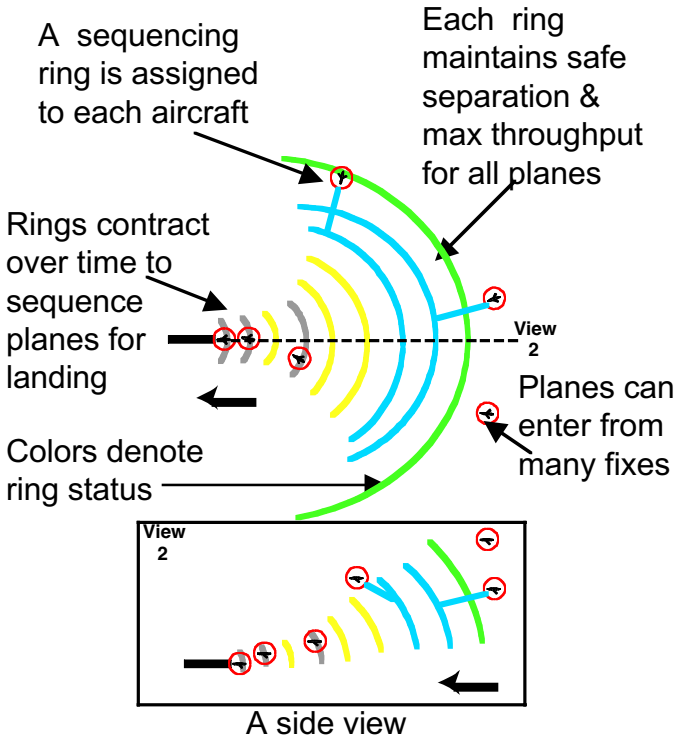
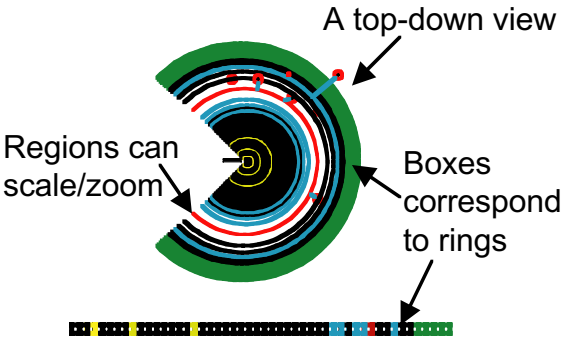
Enhanced visual displays for sequencing approach (or departure) aircraft

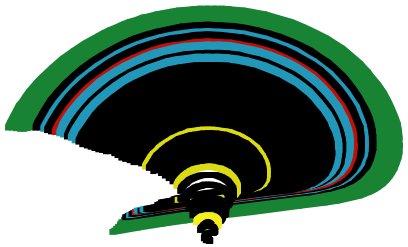
Sequencing Schematic
for approach sequencing



Concept Display
for 50 incoming planes



A linear representation of the same display



A 3D representation of the same rings (looking up at it)

Benefits

- **Planes can be sequenced from multiple fixes, allowing for more throughput**
- **Allows managers to collectively monitor more planes; they track spatial patterns instead of each plane**
- **Increases the long-range info about time & space, so manager does not have to control individual aircraft**
- **Important areas can be isolated using scalable/zoomable displays**
- **Similar displays can also be developed as a tactical display for pilots**

A Second Example of a Visualization Concept for SA

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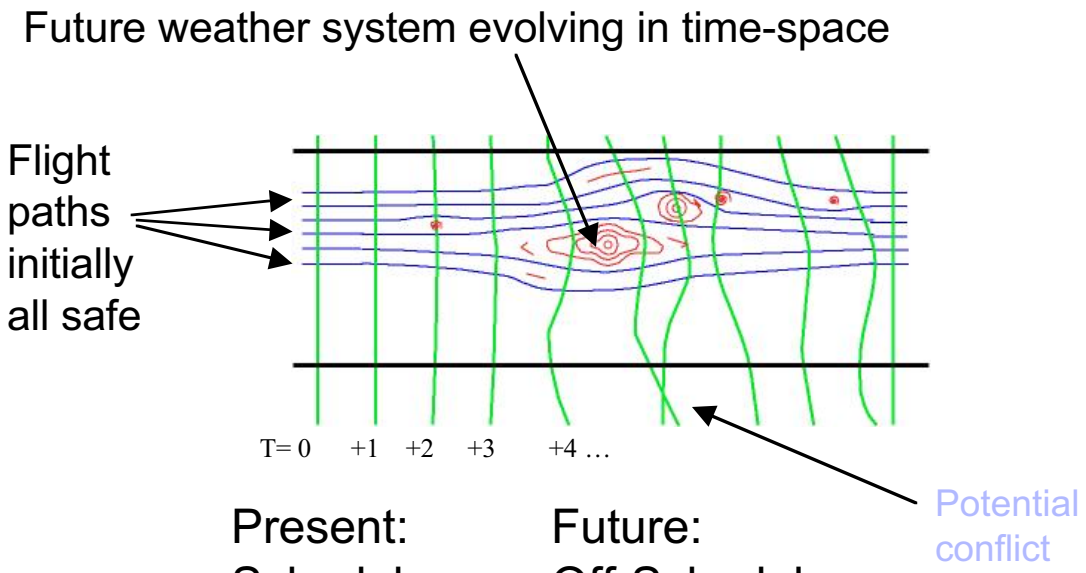
A visualization concept that using visual metaphors to manage flight schedules in time-space



Benefits

- **Provides quick detection of deviations from normal operation**
- **Flow abnormalities "pop-out" as crooked lines**
- **Makes obvious a potentially dangerous schedule (crossing lines are visually salient)**
- **Allow operators to see and manage complex evolving situations and explore what-if solutions.**

GFI Top Level Architecture
Modified for TACEC

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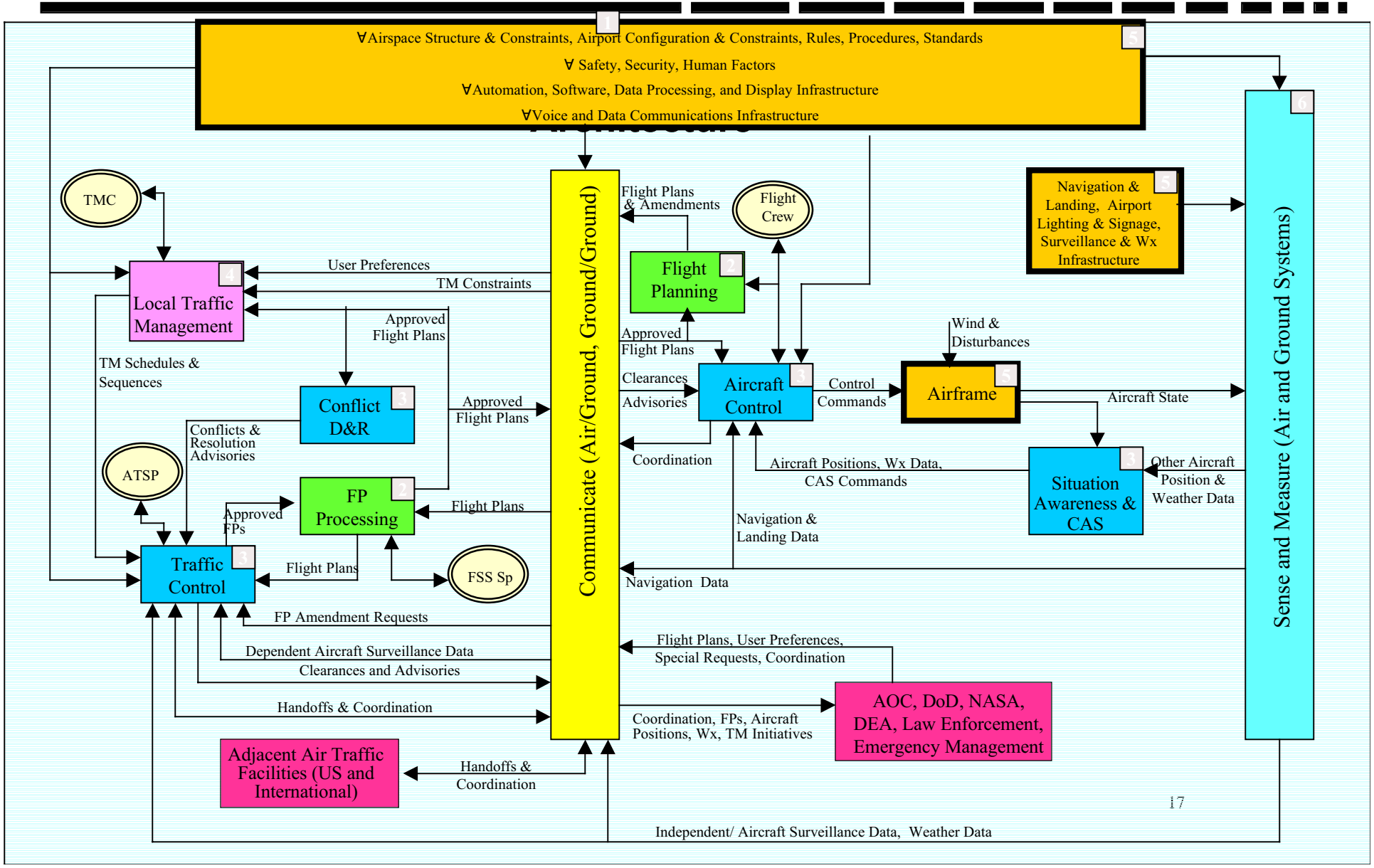

TACEC and the GFI Model

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ATM Function (From the GFI Top Level Model)	Function per Concept Description
Local Traffic Mgmnt	Participate in optimized flight planning using situational awareness and assessment tools. Specialized focus provided by “drill down” capability within automation.
Adjacen tAir Traffic Facilities (US and International)	Share in situational awareness via linked displays.
Traffic Control	Terminal & Ground controllers provide primarily monitoring activities utilizing new Situational Awareness tools. Concur on Trajectroy updates, participate in real time awareness activities to insure rapid response to abnormal conditions.
FP Processing	Now 4-D Trajectories - Automated for optimal routing, updates in real time, datalinked to a/c.
Flight Planning	Now 4-D Trajectories - Automated for optimal routing, collaborative process with all parties.
Conflict D&R	Integral with 4-D Trajectory determination utilizing high accuracy surveillance and onboard (FMS) intent capability.

TACEC and the GFI Model

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ATM Function (From the GFI Top Level Model)	Function per Concept Description
Aircraft Control	FMS driven auto-flight, all phases of operation within the terminal area.
Airframe	Accommodate operational realities, flight path control meets required intent precision.
Situation Awareness & CAS	Revised designs focus on current and future airspace situation. Embedded training provides minimal response time to abnormal situations….both Ground and Cockpit capabilities.
Sense & Measmnt Air & Grnd Systems	ADS-B using WAAS corrected position reporting primary surveillance tool. Mode S SSR is back-up source. Surface surveillance uses Multisensor Fusion (ASDE, ADS-B, et al)
AOC, DoD, NASA, DEA, Law Enforcement,, Emergency Management	Collaborative Decision Making framework. Interchange of situation data based on a “need to know” criteria. Specific authorizations required when flight planning changes are issued, priorities communicated, and emergency procedures addressed.
Navigation & Landing, Airport Lighting & Signage, Surveillance & Wx Infrastructure	Integrated via Terminal Area Operations network with Operational algorithms and inter-facility linkage.

Safety

- **Failsafe Operational capabilities**
  - **All major elements of the TACEC solution must be redundant**
    - » **Dual data link**
    - » **Dual Surveillance systems**
    - » **Dual Automation systems**
  - **Dual, independent trajectory calculations**
    - » **Approach, departure, landing and taxi trajectories use both current position and future intent data.**
    - » **Independent truth data (sensors), processors, and algorithms.**

- **Robust Separation Assurance**
  - **WAAS/LAAS accuracy, integrity, and reliability insures current and future position knowledge**
  - **Reaction times can be reduced based on improved intent information, automated control loops (aircraft/ground) and optimized information flow**

Benefits Assessment

- **Primary benefits derived from increased Terminal Area capacity**
  - **Increased revenues**
  - **Safer operation**
  - **Passenger comfort**

- **Secondary benefits include;**
  - **reduced operations costs**
  - **increased schedule reliability**
  - **enhanced ATM system reliability**
  - **excess capacity to absorb uncontrollable disruptions**