



CENTER FOR ADVANCED AVIATION SYSTEM DEVELOPMENT (CAASD)

Improving Flight Efficiency Through Terminal RNAV

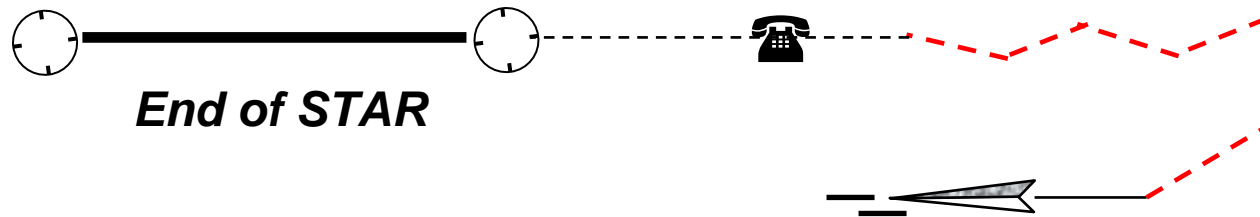
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Advanced Aviation System Development*

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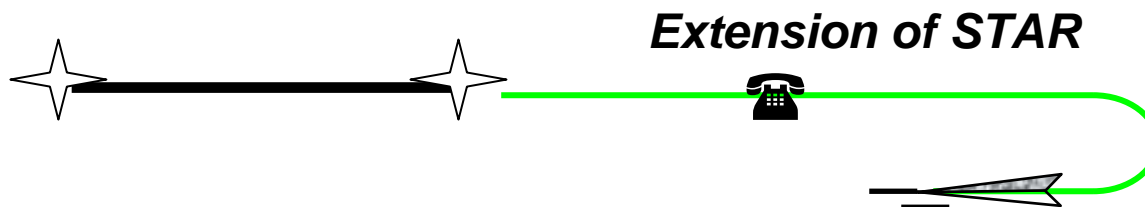


What is 'RNAV'?



End of STAR

Pre-RNAV: Aircraft Navigate Via Ground Based Navigation Aids (VOR, DME) or ATC Heading Vectors



Extension of STAR

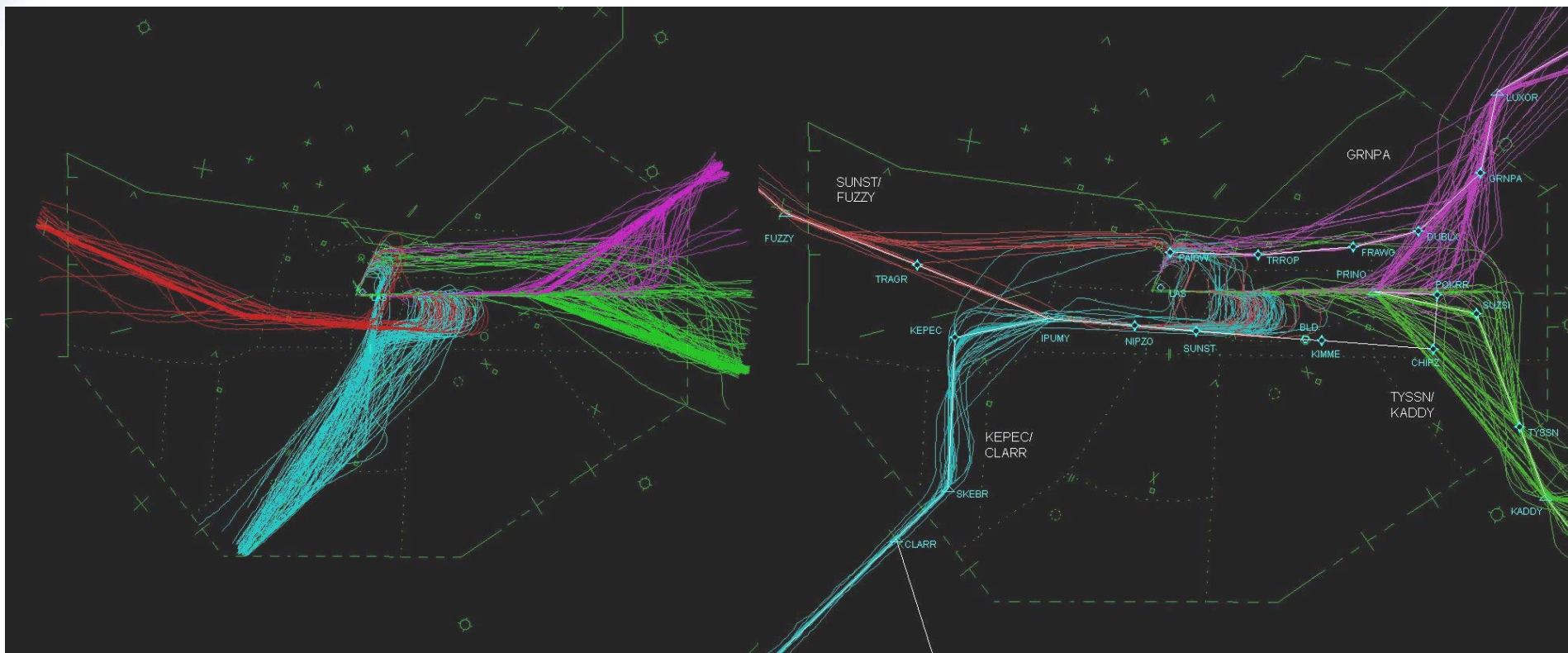
RNAV Procedure: Aircraft Self-Navigate Via Waypoints, Resulting in More Predictable Flight Path and Improved Situational Awareness



LAS Arrival Flows

2000

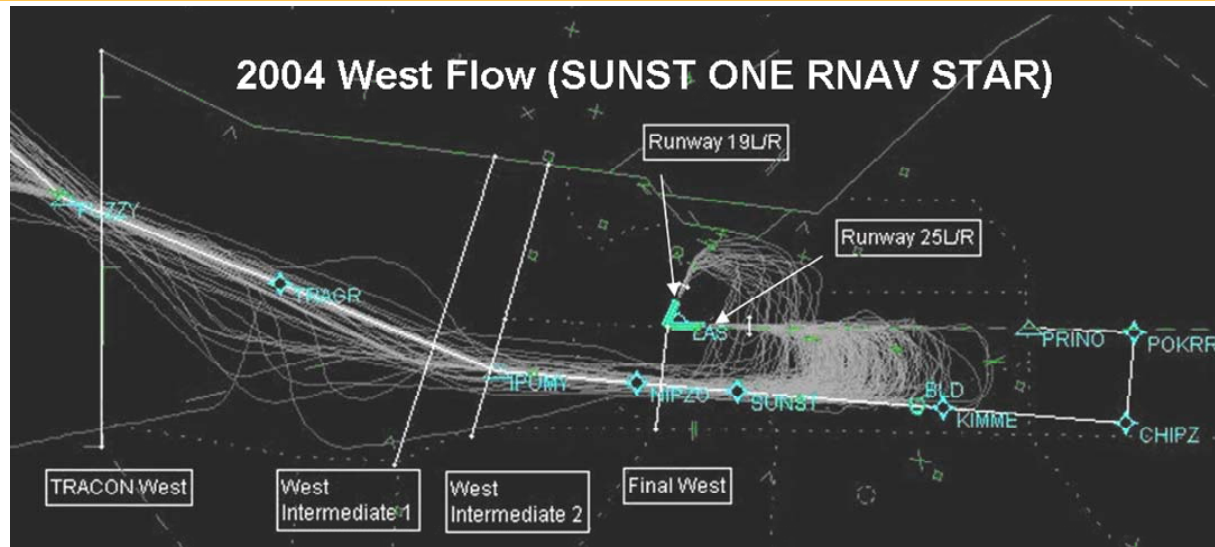
2004



Current RNAV arrival procedures were turned on Nov 12, 2003 at LAS



Operational Analysis



- **Compared flights from 2000 and 2004 along the west flow and gathered key metrics**
 - West flow tracks used due to overlay nature of ground track
- **Other flows had modified ground tracks, making direct comparison across years impossible**
- **Measured Time and Distance from Terminal area entry point to final controller handoff point, collected other metrics at intermediate points**



Results of Case Study: Operational Findings

Metric	Measuring Point	2000	2004	p-value
Flight Distance	TRACON -> Final W	35.01 nmi	34.99 nmi	0.713
Flight Time	TRACON -> Final W	379 sec	410 sec	< 0.0001
Groundspeed	TRACON West	302 kts	283 kts	< 0.0001
	Final W	248 kts	238 kts	< 0.0001
Lateral Track Dispersion	West Intermediate 1	0.36 nmi	0.27 nmi	0.037
	West Intermediate 2	0.24 nmi	0.12 nmi	< 0.0001
Altitude	West Intermediate 1	10,846 ft	11,622 ft	< 0.0001
	West Intermediate 2	10,273 ft	10,949 ft	< 0.0001
Inter-Arrival Time Variance*	Final E	51 sec	46 sec	< 0.0001

* - measured using east flow data

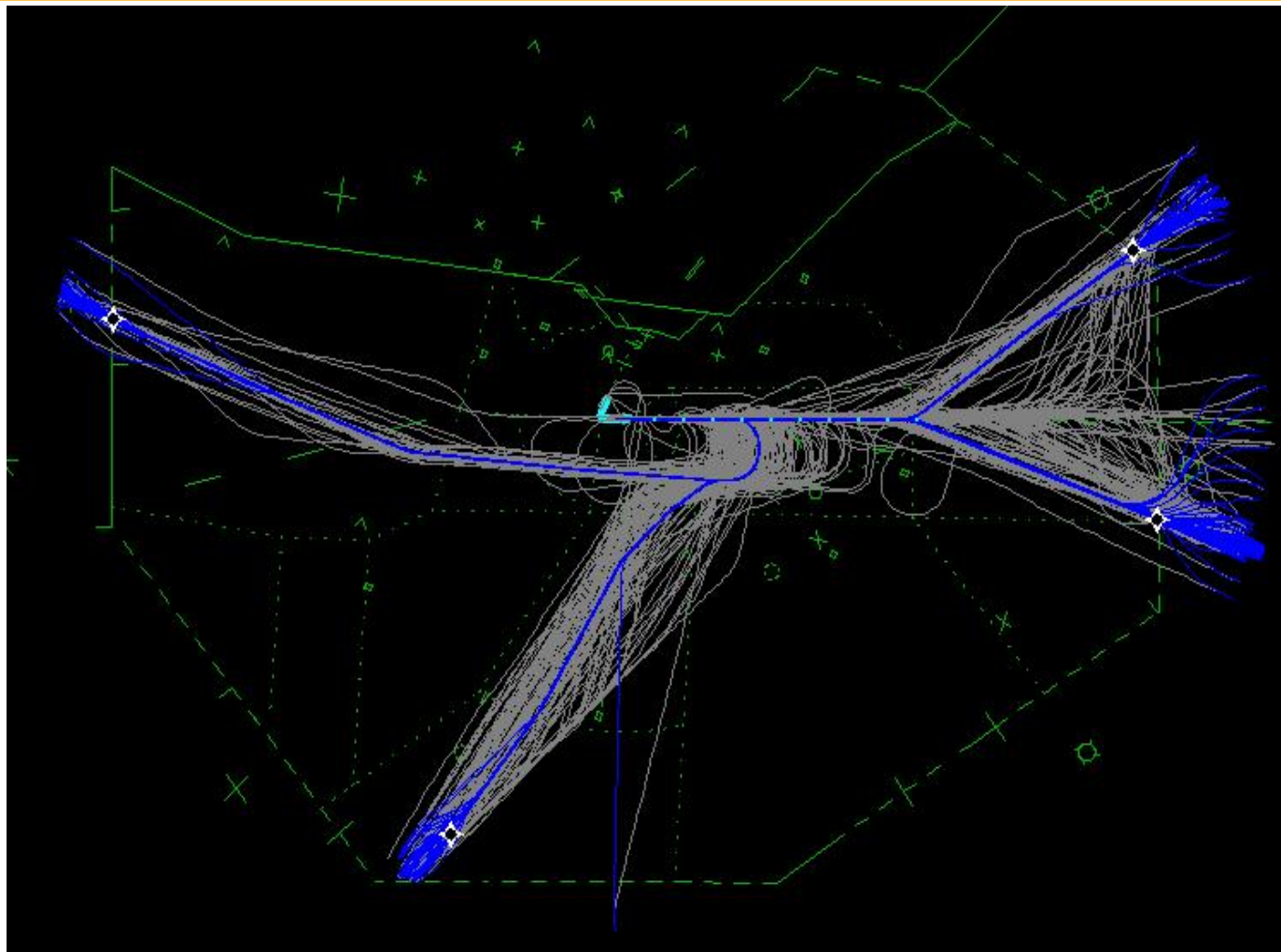


Simulation Modeling

- **Motivation**
 - Routes redesigned for RNAV implementation
 - Environmental reasons, interaction with departures
 - Impact of 9/11
 - Continuing growth of Las Vegas air traffic
- **Steps undertaken**
 - Collect metrics from vectored traffic
 - Create overlay RNAV routes
 - Produce a new track set with traffic on RNAV route
 - De-conflict RNAV traffic with speed or lateral adjustments when necessary
 - Collect metrics from de-conflicted RNAV traffic
 - Analyze data



Baseline + Simulated Tracks





Analysis Results; Overall Time and Distance Savings

- Overall time and distance savings from TRACON to threshold approximately 38 seconds and 0.8 nautical miles per flight
- Both the time and distance savings are statistically significant

	<i>RNAV</i>	<i>Vectored</i>
<i>Time* (sec)</i>	615	653
<i>Distance* (nm)</i>	43.6	44.4

Average flight statistics for actual versus simulated flights; Least Squares Means

*P < .0001



2004 Operational Analysis

- **Compare RNAV-equipped flights in October 2004 with non-equipped flights from the same data set**
- **Use flight plan data to determine who filed for RNAV procedures**
 - **This will lead to some flights being listed as RNAV although they received radar vectors to the runway**
- **Analyze tracks for time and distance**
 - **This does not accomplish the original goal of comparing the pre-RNAV environment to the post-RNAV environment, but should still provide some insight into the benefit of RNAV**



Other RNAV Sites

- **Dulles – 4 RNAV STAR procedures implemented in January 2005**
- **Atlanta - 13 SID procedures implemented in April 2005, 4 STARS implemented May 2005**
- **PHL – 2 RNAV STAR procedures implemented in March 2005**
- **DFW – 16 RNAV SID procedures to be implemented in September 2005**
- **200 more RNAV procedures planned at OEP 35 Airports within the next several years**



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Questions? Comments?



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Backup Slides



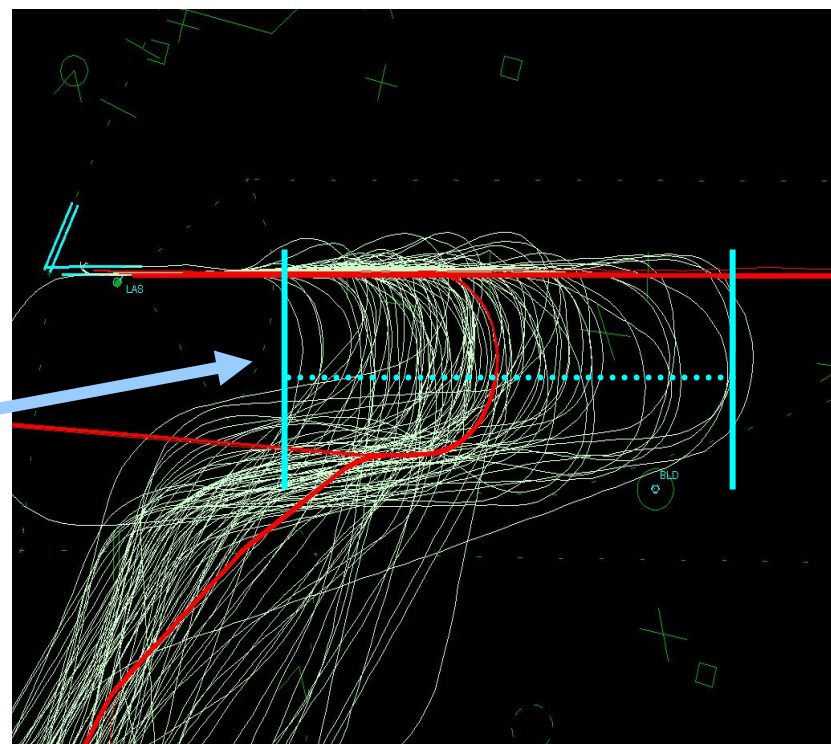
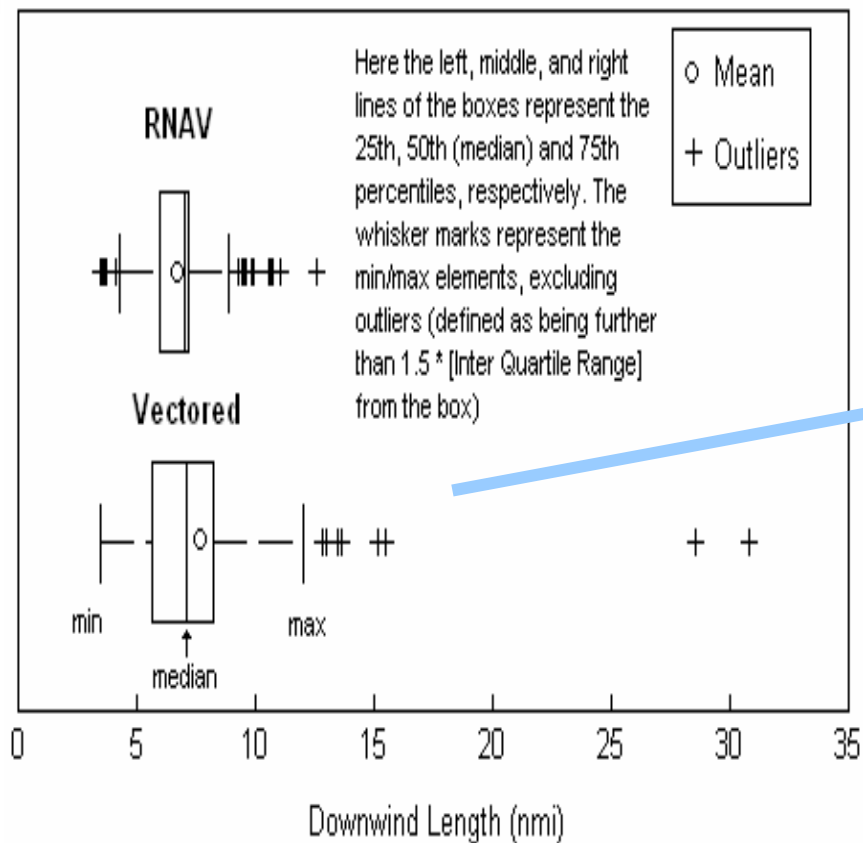
Operational Data Analysis: Time and Distance

- Environmental issues required path modification
- Flights from northeast (GRNPA) not analyzed, procedure largely unused
- Results vary depending on overlay vs. non-overlay RNAV procedures
 - Distance/time does not improve (much, if at all) for overlays
 - Non-overlays increase distance/time if longer route than vectored path

	2000		2004	
Flow (RNAV route)	Time (avg)	Distance (avg)	Time (avg)	Distance (avg)
<i>Southwest (KEPEC)</i>	336 sec	28 nmi	450 sec	35 nmi
<i>West (SUNST)</i>	379 sec	35 nmi	410 sec	35 nmi
<i>East (TYSSN)</i>	230 sec	18 nmi	330 sec	24 nmi



Simulation Benefit: Shorter Downwind





RNAV vs. Conventional Flights During Peak Time

<i>RNAV Procedure</i>	<i>Average Flight Time (sec)</i>	<i>Conventional Procedure</i>	<i>Average Flight Time (sec)</i>
TYSSN	294	KADDY	330
KEPEC	312	CLARR	323
SUNST	267	FUZZY	308

Time Savings

TYSSN: 36 seconds/flight

KEPEC: 11 seconds/flight

SUNST: 41 seconds/flight



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