CHARACTERIZING HIGH ALTITUDE AIRSPACE SECTOR CAPACITY, FLIGHT EFFICENCY, AND SAFETY RISKS(CES)

EXAMPLES OF INTERNAL CNAC RESEARCH-Based On Ongoing and Past Efforts
In Support of FAA Air Traffic Airspace Laboratory

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Observations – Basis for Research

- **The NAS consists of a complex interaction of environmental, procedural, operational, and human events. <u>The characterization of all these interactions is a major research objective.</u>**

- **Historical flight, environmental, and operational data (memory) can be used to characterize these interactions based on the behavior of the air traffic flow*. <u>All data linked by time and location in NAS</u>.**

- **The available data coupled with meaningful metrics and a valid analytical methodology can support trend analysis and prediction of changes in airspace sector capacity, flight efficiency and safety risks (CES) within the NAS. <u>Relationships between capacity, efficiency, and safety measures can be defined.</u>**

* E.g. air traffic movement, position, and movement patterns within the NAS

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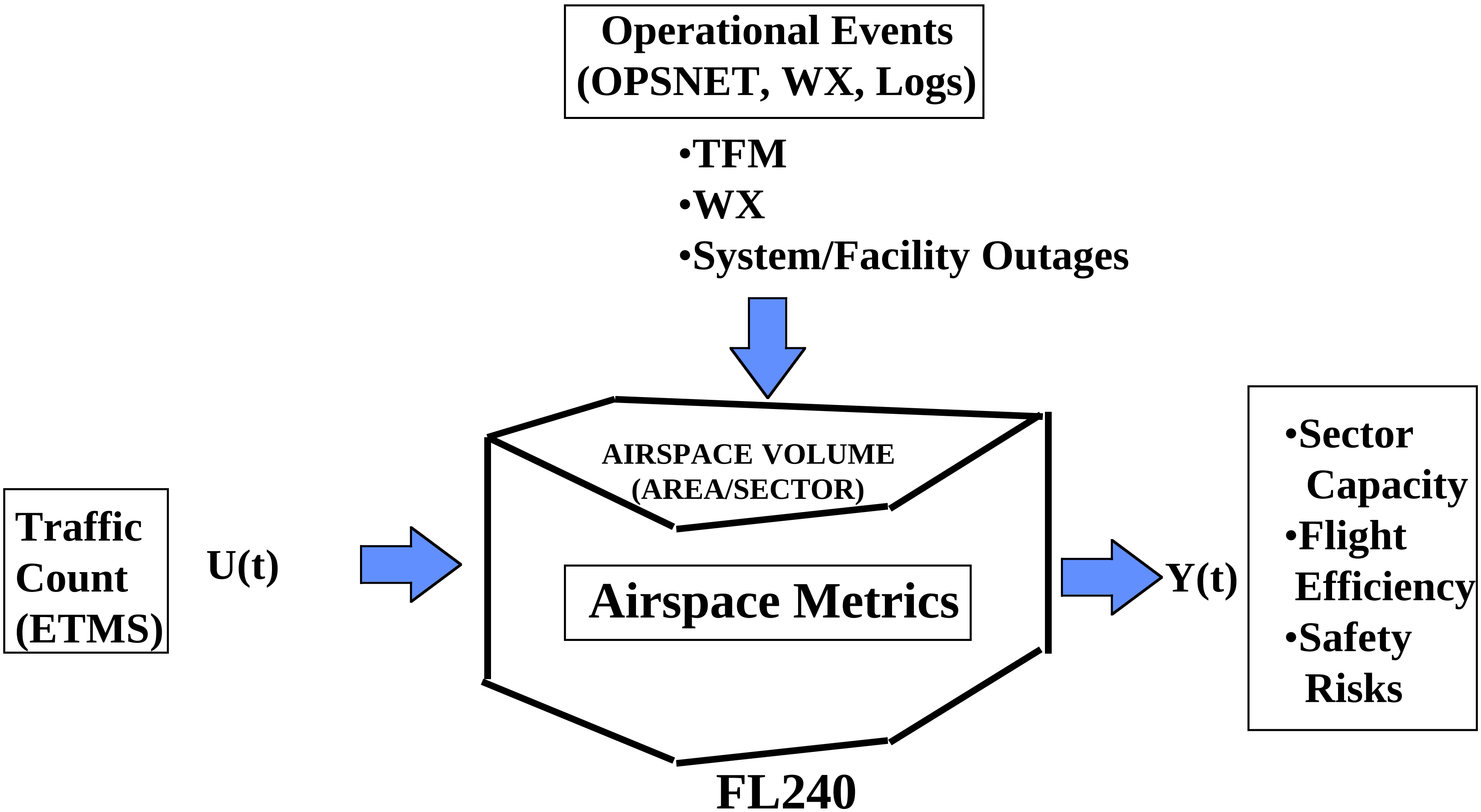
Potential Research Applications as Related to the NAS Characterization

- **Concept Evaluation of new Decision Support Tools (DSTs)**
  – Changes to current NAS characterization due to new DSTs can be quantified and used to determine CES changes.
- **Prototype evaluations of DSTs at operational sites**
  – Changes in the CES estimates can be determined for sector/area for equivalent time frames with and without utilization of DSTs.
- **Evaluation of impacts due to greater use of User Preferred Routes (UPRs) and other procedural changes**
  – Historical NAS data on NARP usage can be used to predict changes in CES with increased UPRs

Research Approach

- **Demonstrate and Validate the research application in en route airspace**
  - Assemble the event data and metrics in a relational data base and correlate metrics to events
  - Complete the CES methodology
  - Identify lessons learned from Trend Analysis (Phase #1), define relationships, and estimate CES changes (Phase #2)
- **Extend research application to full en route airspace**
- **Investigate extension to Terminal Airspace and Airport Surface**
  - Using ongoing efforts for the FAA to integrate terminal radar data and ACARS data (OOOI)with ETMS

Analytical Model



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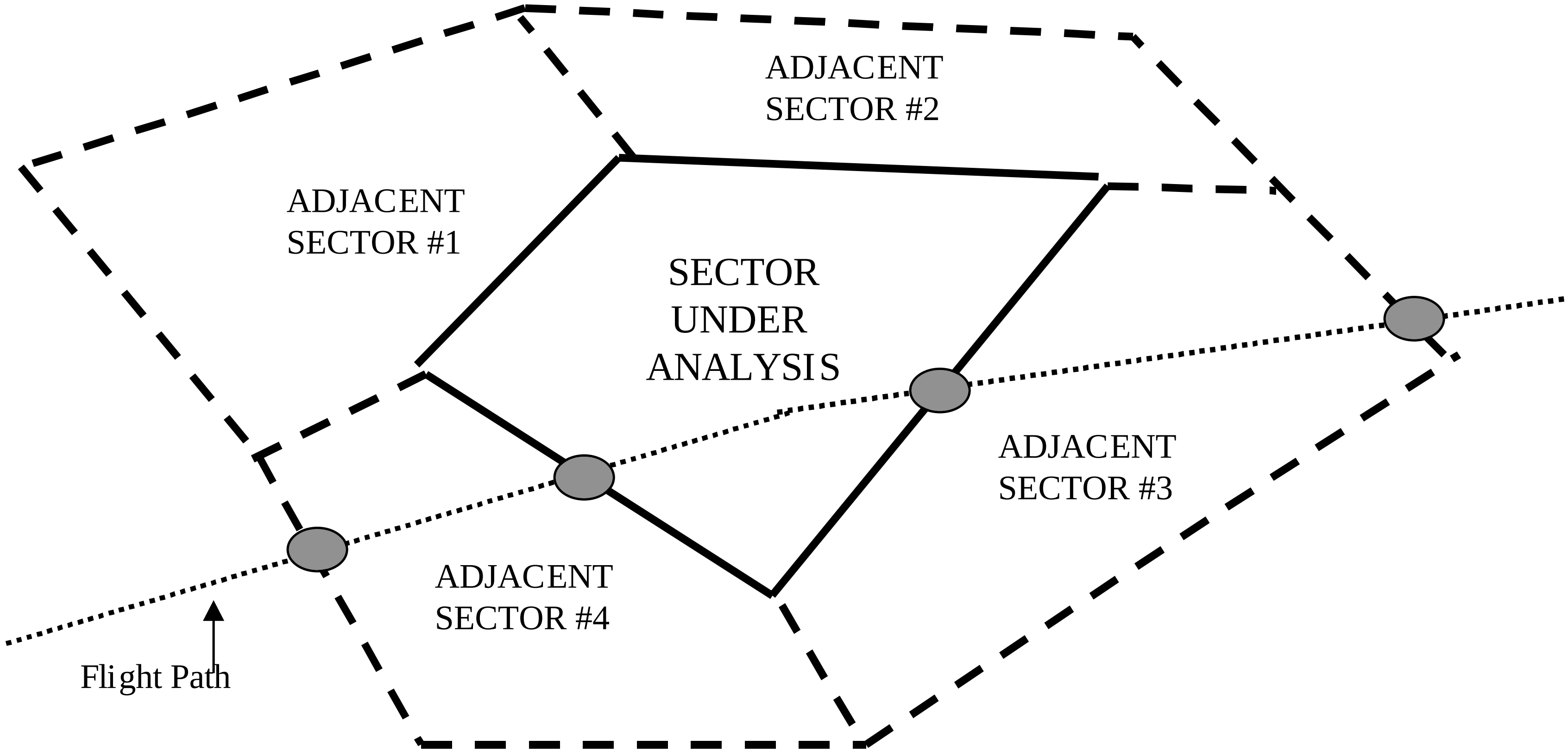
Elements of Analysis

- **Flight Object**
  - Flight ID
  - Time
  - 3-D Posit (X, Y, & Alt)
  - Arrival and Departure Airport
  - NARP use
- **Airspace Volume**
  - Single sector and adjacent sectors in area
  - FL240 and above
- **Flight Day**
  - 56 flight days used in analysis
  - Data sampled at 4 min period(2min in future)
  - Data analyzed at intervals of 1 to 24 hours for each flight day*
- **Operational Events - 3 classes**
  - Class #1: WX (within sector/adjacent sector)
  - Class #2:TFM (airport ground holds, en route restrictions)
  - Class #3: Outages (airport, within sector/adjacent sector)
  - Events identified by Class, Time, & Sector or Airport
- **Airspace Metrics**
  - Sector configuration
  - Traffic flow

*Note: Intervals divisible into 24 (1, 2, 3,4,6, 8, 12, 24)

Operational Airspace Example

(SECTOR UNDER ANALYSIS PLUS ADJACENT SECTORS IN AREA)



Flight object enters sector from adjacent sector and/or airport in sector and either exits to another adjacent sector or lands at destination airport within sector.

Note: If Flight Object enters Sector during one Flight day and exits in next Flight day, data will be collected and equated to Flight Day in which Flight object entered.

Airspace Metrics for Typical Sector/Area

SECTOR CONFIGURATION METRICS

- Total area of sector (As)- can change as area is reconfigured
- Per cent of sector area available to civil traffic (PAs) - can change as SUA Changes
- Ratio of longest distance between sector boundaries to shortest distance (L/S) - sector configuration

TRAFFIC FLOW METRICS

- For each flight object on a 24 flight day with 4 min sample period
  - –Time and posit that flight enters sector from airport or adjacent sector
  - –Time and posit that flight exits sector to airport or adjacent sector
  - –Time and posit that flight, passing through sector, enters and exits area
- For specified time interval (1 to 24 hrs) on a flight day
  - –Flight count entering or exiting adjacent sectors (Ni(n)/(No(n))
  - –Ratio of largest to smallest sector boundary flight count (Nl/Ns)
  - –Total sector flight count (Tc)
  - –Percentage of flight count filing NARP plan (Pn)
  - –Time each flight spends in sector (Ts)
  - –Distance each flight passing through sector travels in area (L)
  - –Great Circle Distance between area exit and entry points (GCD)
  - –Number of heading, speed, & altitude maneuvers in sector (M)
  - –Number of flight crossings based on horizontal and vertical separation filters in sector (Ncr)

Metric- CES Dependencies

SECTOR CAPACITY

- Maximum capacity (Cm) is computed over 56 day period as the maximum traffic count (Tcm)/interval over 56 days when there are no WX, Traffic Flow restrictions, or outage events in sector. This equals Demand over time as both traffic management and users attempt to use all available capacity. Capacity (C) is computed for all flights over 24 hour flight day as the difference between maximum capacity (Cm) and maximum traffic count (Tcm)/interval on that flight day independent of event occurrences.

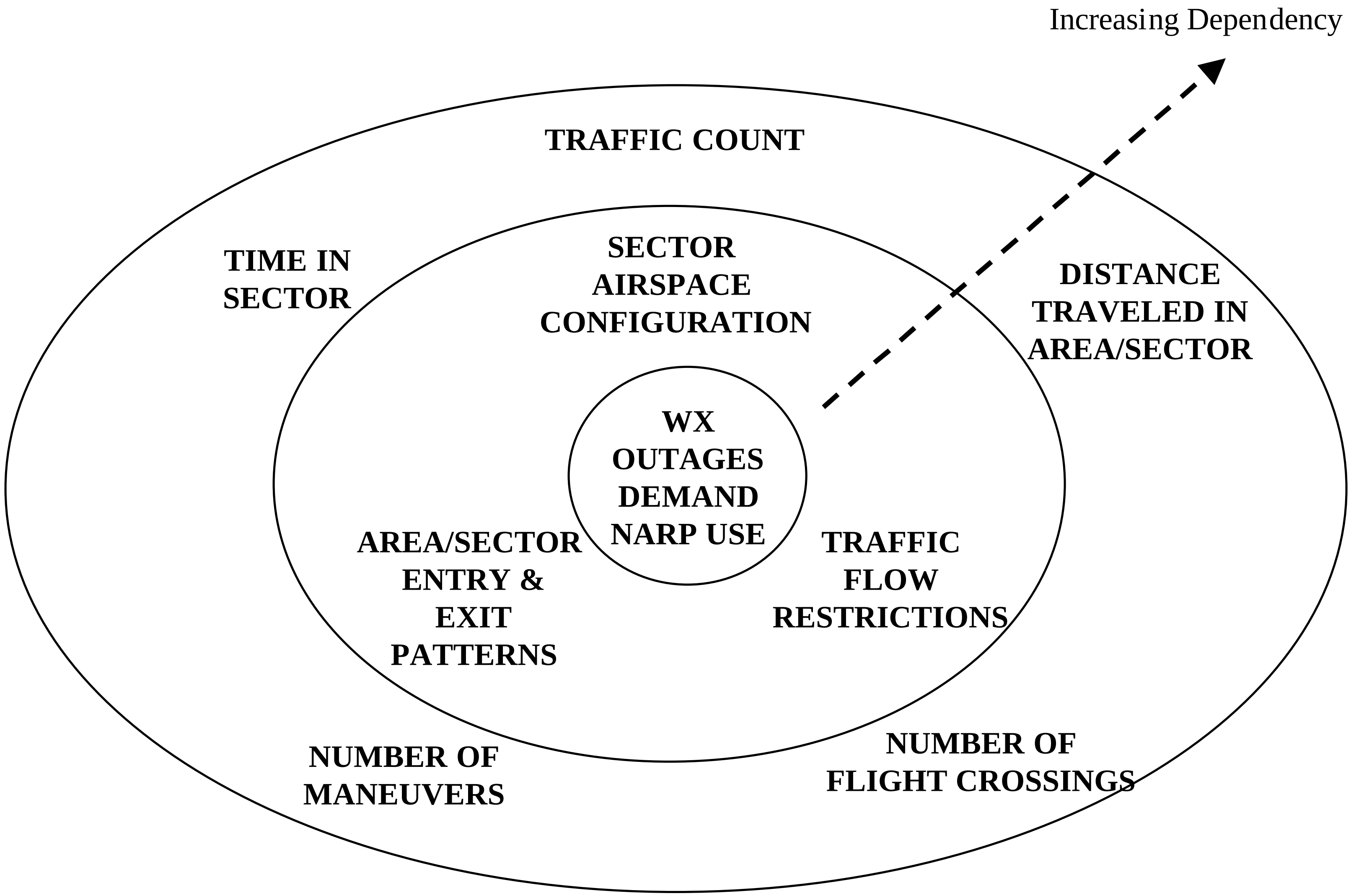
FLIGHT EFFICIENCY

- The average difference between the distance actually flown per flight in area and equivalent Great Circle Distance (L – GCD) plus average number of maneuvers per flight (M) is computed for all flights over 24 hour flight day .
- Maneuvers consist of altitude, heading, and speed changes each weighted according to relative impact to fuel consumption.

SAFETY RISKS

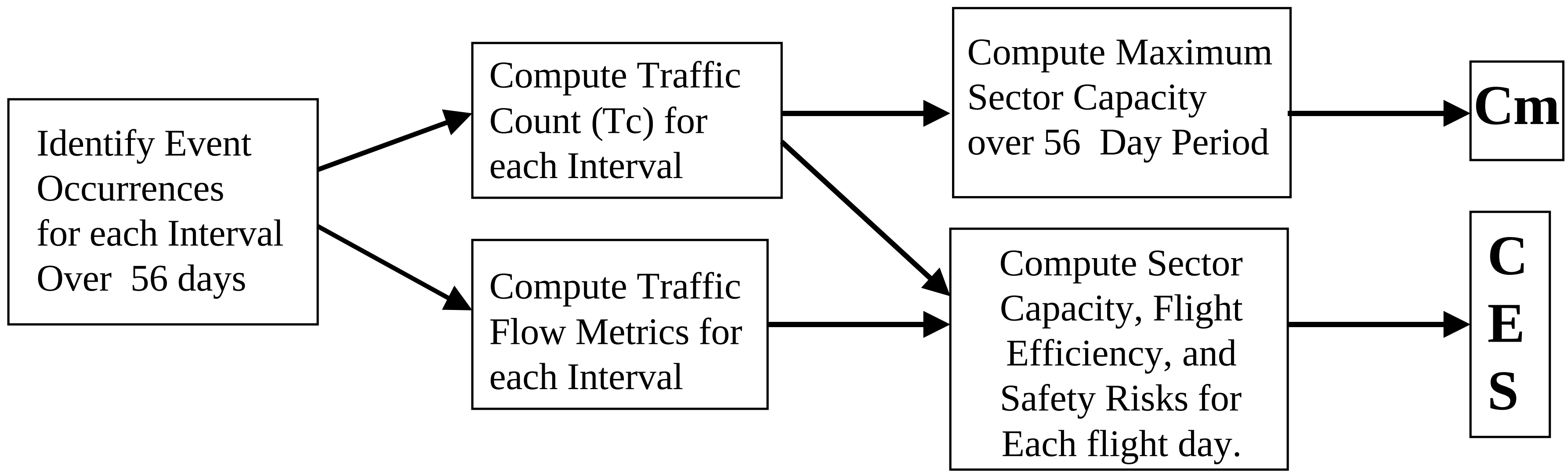
- Controller workload and separation are computed for all flights in 24 hour flight day within sector using the maximum daily traffic count (Tcm)/interval.
- Function of: (1) number of entries/exits to other sectors and terminal areas (Ni + No), (2) ratio of largest to smallest transition flight count (Nl/Ns), (3) average time of aircraft under sector control (Ts), (4) average number of maneuvers (M), and (5) average number of crossings both within and near separation standards (Ncr).

Metric - Event Dependencies

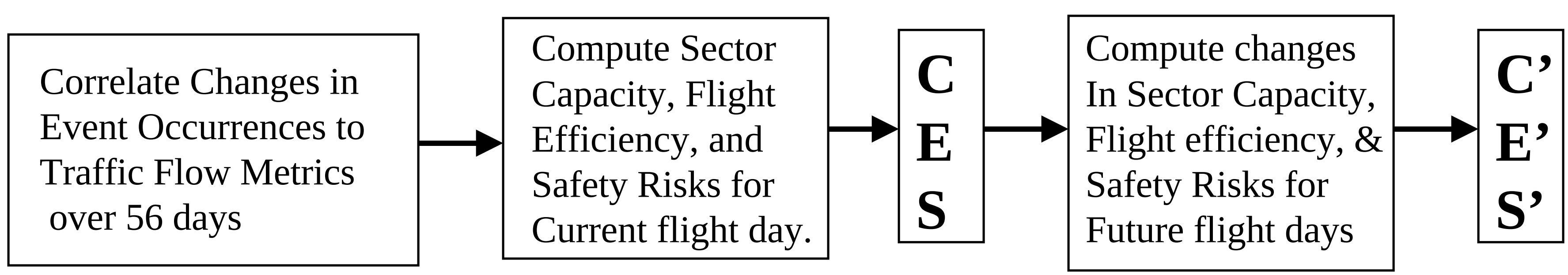


CES METHODOLOGY

Phase #1 – For sector under analysis & each flight day for 56 day history (CES Trend Analysis)



Phase #2 – For sector under analysis & 24 hour flight days



Summary Examples

CNAC Study for the FAA in 9/96: Correlating Operational Errors (574 sectors) to Dynamic and Static Sector Complexity and Supervisory Controller Experience

- Equated probability of operational errors to a subset of metrics

CNAC studies for FAA: To determine impact of National Route Program on NAS operations

- Identified potential reduction in controller workload for most high altitude sectors
- Identified greater dispersal of flights in Eastern U.S due to NRP routing

Currently investigating methods to correlate impacts of weather on sector operations and pilot decisions to fly through weather

- Metrics concerning sector boundary crossings and number of turns will be most significant.

Effort can be focused to identify CES impacts For CE 5, 6, & 7 under DAG/TM Concept

- Events and metrics address SUA, complexity, separation, WX, and TFM restrictions