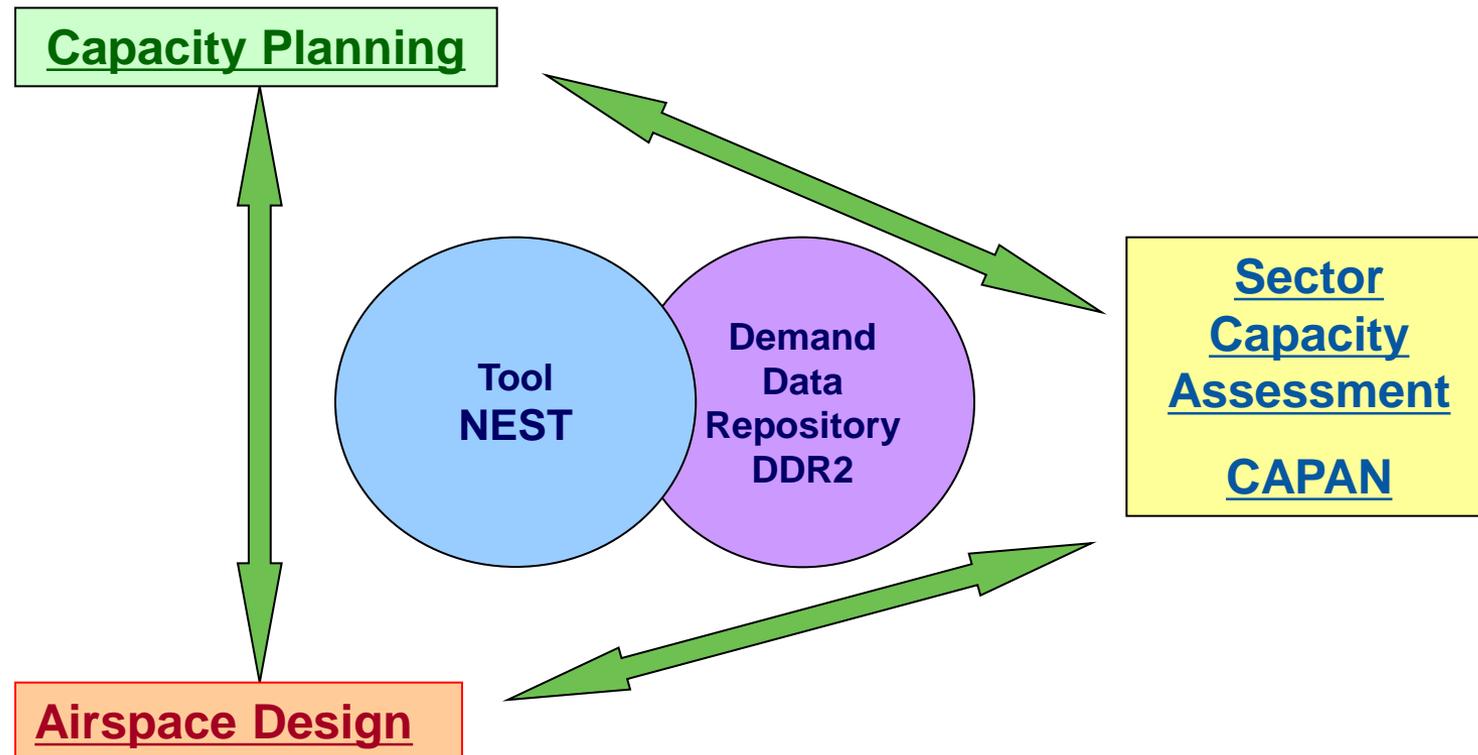# CAPAN Methodology
Sector Capacity Assessment

Air Traffic Services System Capacity Seminar/Workshop

Nairobi, Kenya, 8 – 10 June 2016

Raffaele Russo
EUROCONTROL Operations Planning
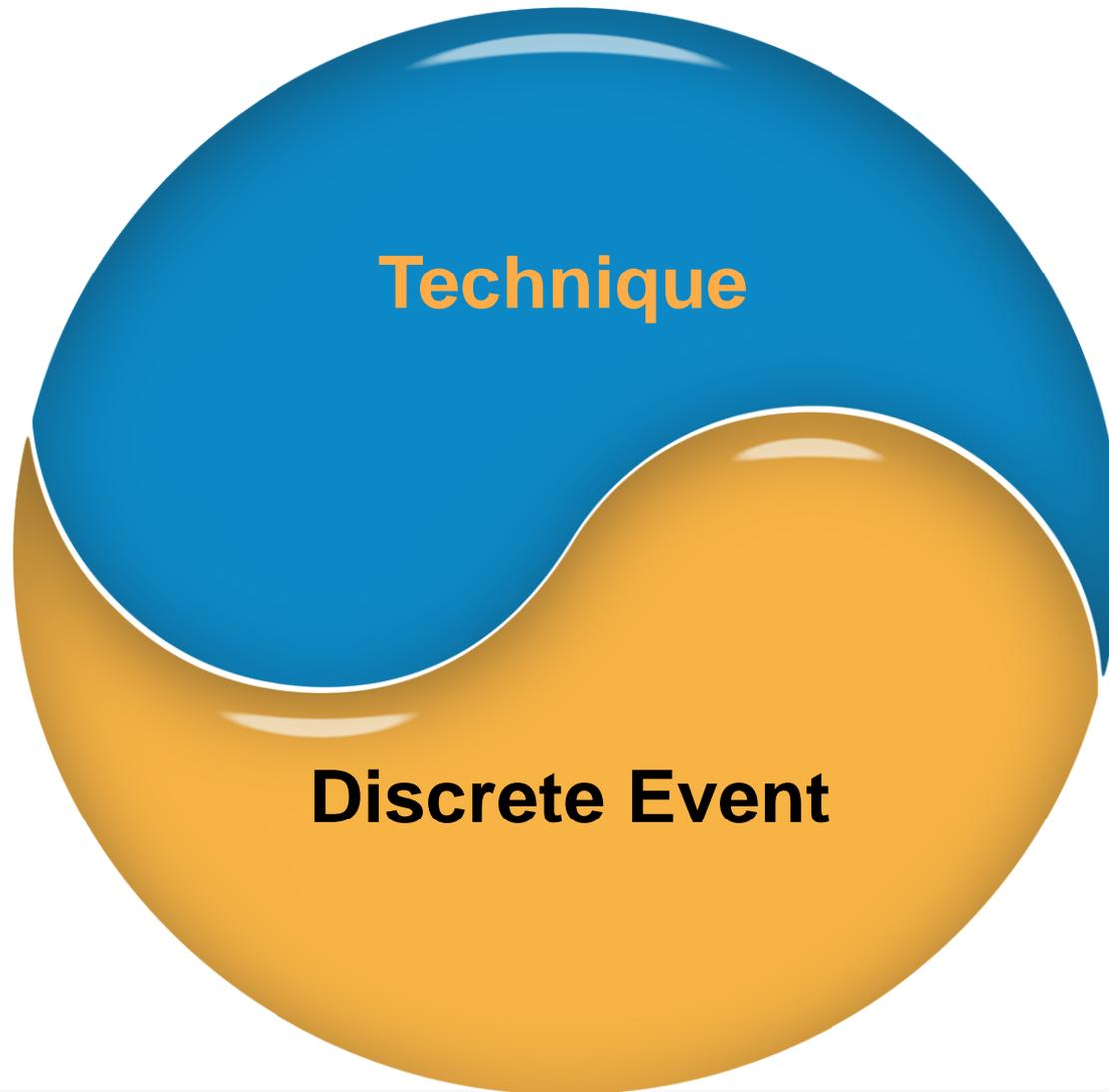
Background

Network Operations Planning

Capacity Planning

Tool
NEST

Demand
Data
Repository
DDR2

**Sector
Capacity
Assessment**

CAPAN

Airspace Design

Fast Time Simulation

Technique

Discrete Event

Fast Time Simulation in ATM

Events at Sector

Actions

Tasks

Workload
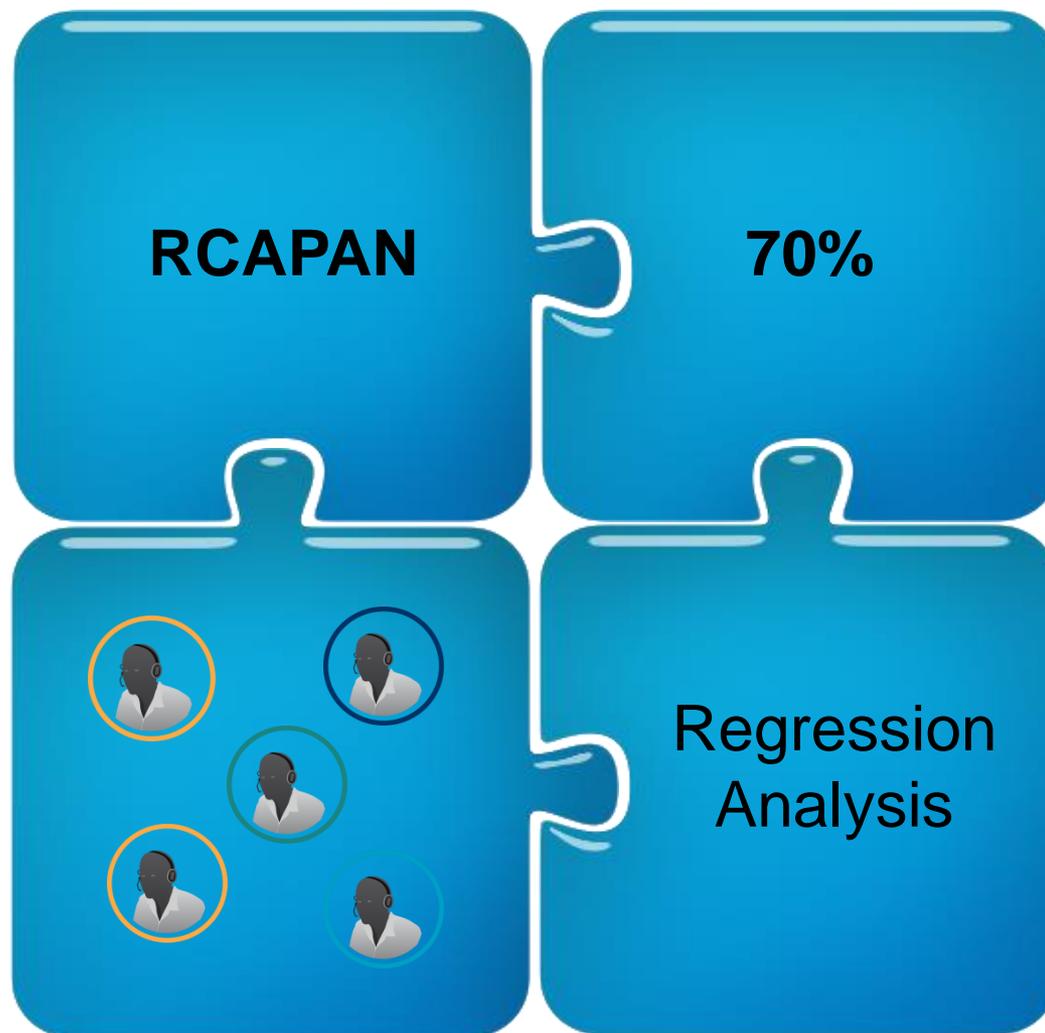
CAPAN

RAMS

RCAPAN

- CAPAN dedicated version of RAMS (Reorganised ATC Mathematical Simulator owned by ISA Software)
- Fast-time simulator as others available on the market
- It allows flexible and detailed modeling of both ACC and TMA environment

70% Workload Threshold

- Theoretical Sector Capacity is attained when controller workload reaches 70% of the absolute working time, i.e. 42 minutes in an hour

- 30% represents tasks which cannot be captured by discrete events, e.g. a general monitoring of the radar screen or recuperation time

- 70% threshold has been assessed through a process of fine-tuning of the discrete event logic when the first CAPAN studies were carried out together with several Real-Time simulations

70%
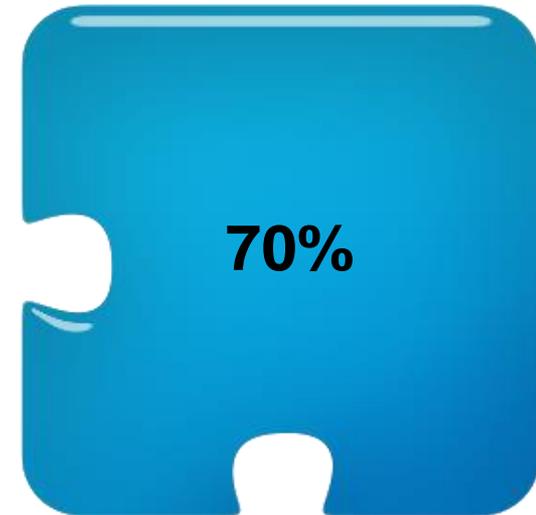
Threshold	Interpretation	Recorded Working Time during 1 hour
70 % or above	Overload	42 minutes +
54 % - 69 %	Heavy Load	32 - 41 minutes
42 % - 53 %	Medium Load	25 - 31 minutes
18 % - 41%	Light Load	11 - 24 minutes
0 % - 17 %	Very Light Load	0 - 10 minutes

Regression Analysis

- Mathematical technique for data analysis
- Type of regression specifically chosen for CAPAN purposes and based on dependency between workload and sector traffic entry rates
- Used to average sector behaviour over the simulation period, generally 24 hours
- Used to perform workload and traffic analyses based on specific periods of the day, traffic flows, etc

Regression Analysis

Controllers

- Fundamental importance for the validation of the simulation scenarios
- Provide support to define actual flight routings, procedures, tasks, conflict detection and resolution logic and other simulation parameters
- Generally working in a team throughout the study together with two CAPAN simulation experts
- At least two active controllers from every simulated unit

EUROCONTROL

CAPAN Input Data

Input Data

Environment Data
- Route network
- Airspace structure
- Sectors...

Basic traffic Data
- Flight plans (24H Traffic)
- A/C Performances...

Simulation Parameters
- Conflict Detection/Resolution
- Procedures ...
- Separation minima's
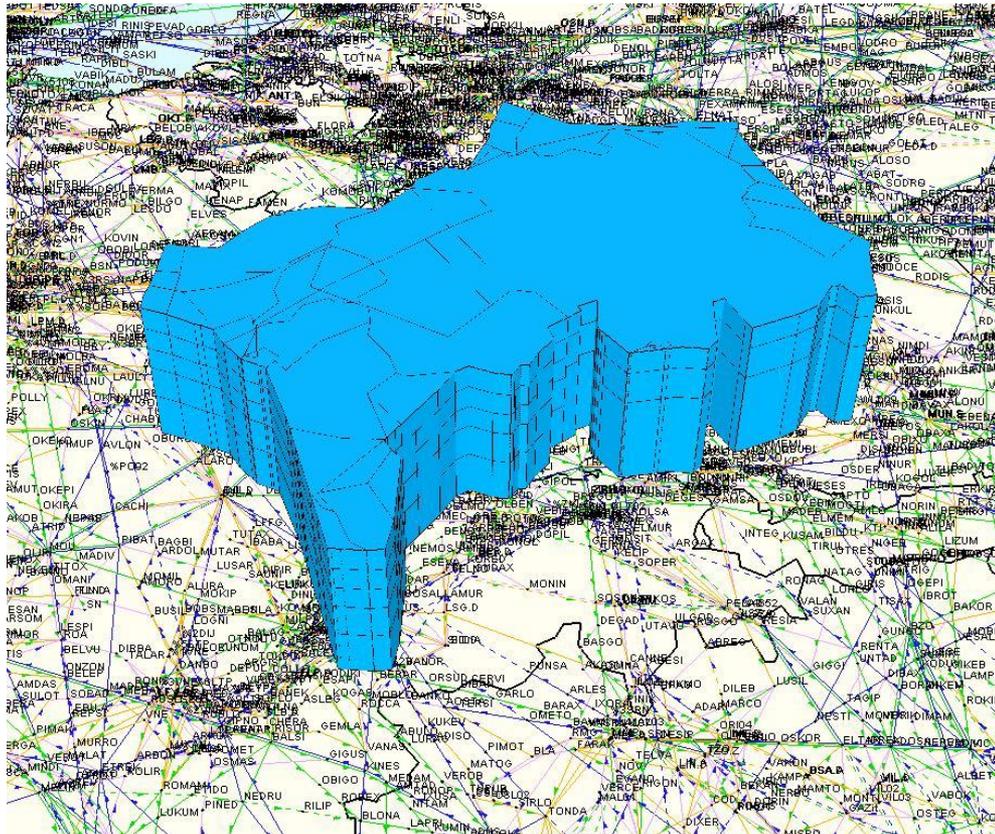
ATC Tasks
Sector manning

RCAPAN Simulation Engine
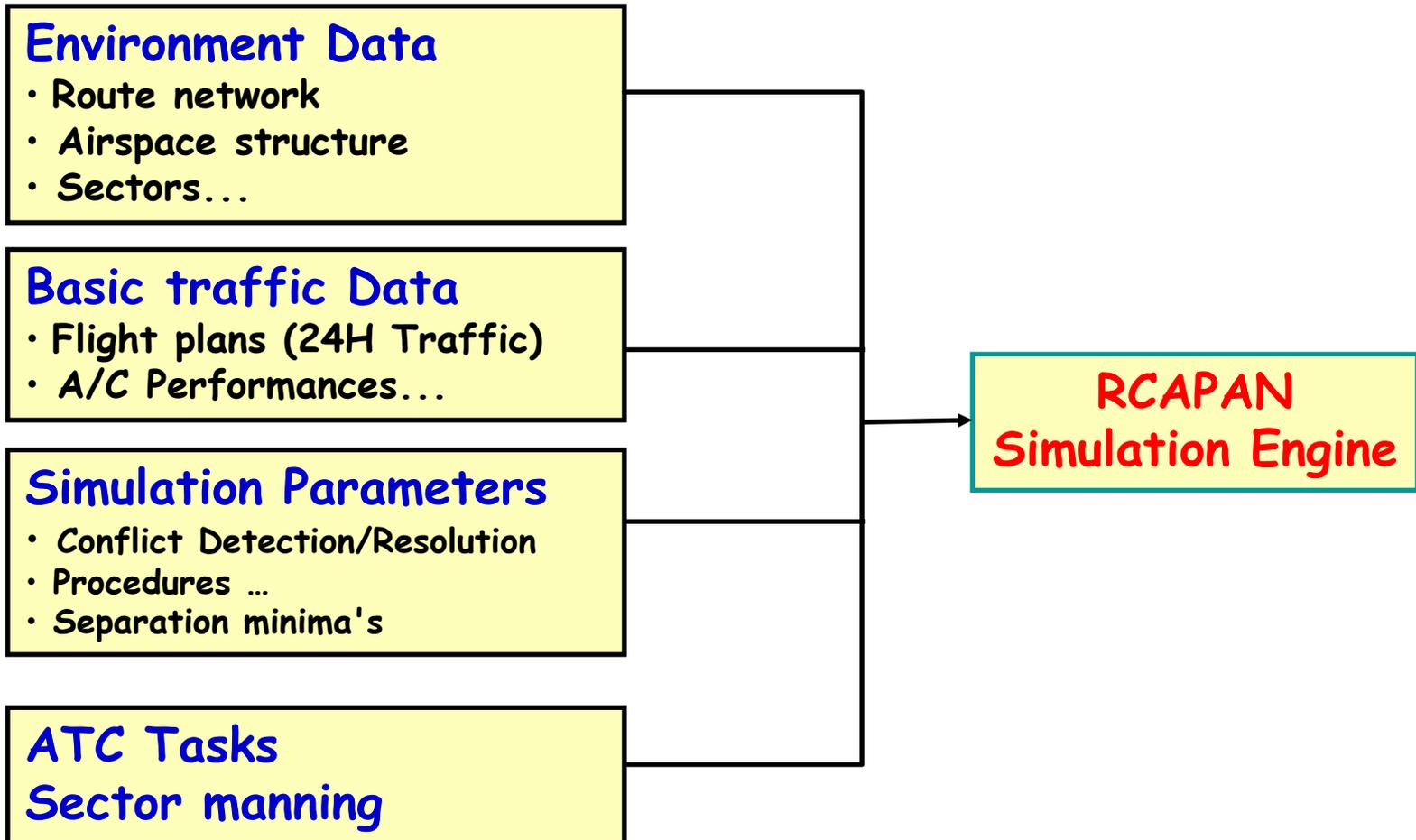
Environment Data

- Directly available in Network Manager Database

- Based on AIRAC Cycle Publication

- Complemented with AIP and tactical information

- Totally customisable

Basic Traffic Data
Flight plans (24H Traffic)

- Three different kinds of traffic data available in Eurocontrol Network Manager common archive DDR2

  1. Initial demand: last update of flight plans

  2. Regulated Demand: flight plans affected by flow restrictions

  3. Actual Demand: flight profiles based on coordinated position reports

- One or more samples are chosen to be representative of the typical flows in the area of interest

- Once ready traffic is iterated n times to reproduce random situations (e.g. entry times, performances)

Basic Traffic Data

Flight plans (24H Traffic)

Initial demand based on last update of the flight plan is used to:

- Preserve the original intentions of the flights as far as possible
- Avoid smoothing of the traffic due to the effect of regulations
- Keep original peaks of traffic
- Keep traffic complexity without the effect of controller actions

Actual demand is however used to complement flight plan information

Basic Traffic Data

Aircraft Performance

- BADA: Base of Aircraft Data

  Eurocontrol Database with nominal performances

- Fundamental for trajectory calculation

- Totally customisable to local procedures and company policies

Simulation Parameters

- Several parameters required for fast-time simulation

- CAPAN tailored parameters for ACC and TMA environment

- **Logic for conflict detection/resolution mechanisms associated to separation minima**

- Parameters to allow proper reproduction of the Procedures

Controller Tasks and Sector Manning

- Standard model for controller tasks for both ACC and TMA environment

- Totally Customisable depending on system capabilities, specific procedures, separation minima, etc

- Divided into 5 main task categories:
  1. Flight Data Management
  2. Conflict Search
  3. Coordination
  4. Standard Radio Telephony
  5. Radar

- Applicable to single/double man operations, multi-sector planner, etc.

CAPAN: the logic in practice

Events and Tasks

EZY770N A319 LGAV LIMC
EFL380 XFL340

KOFER

ROTAR

South Sector

West Sector

FL380

FL340

First Call

Descent Clearance

Last Call

Flight Level Verification

Flight Info

First Call

Last Call

Conflict Search

Flight Info

Conflict Search

| 08h21 | 08h38 | | 08h45 | 08h59 | | 09h11 | | 09h15 | 09h16 |
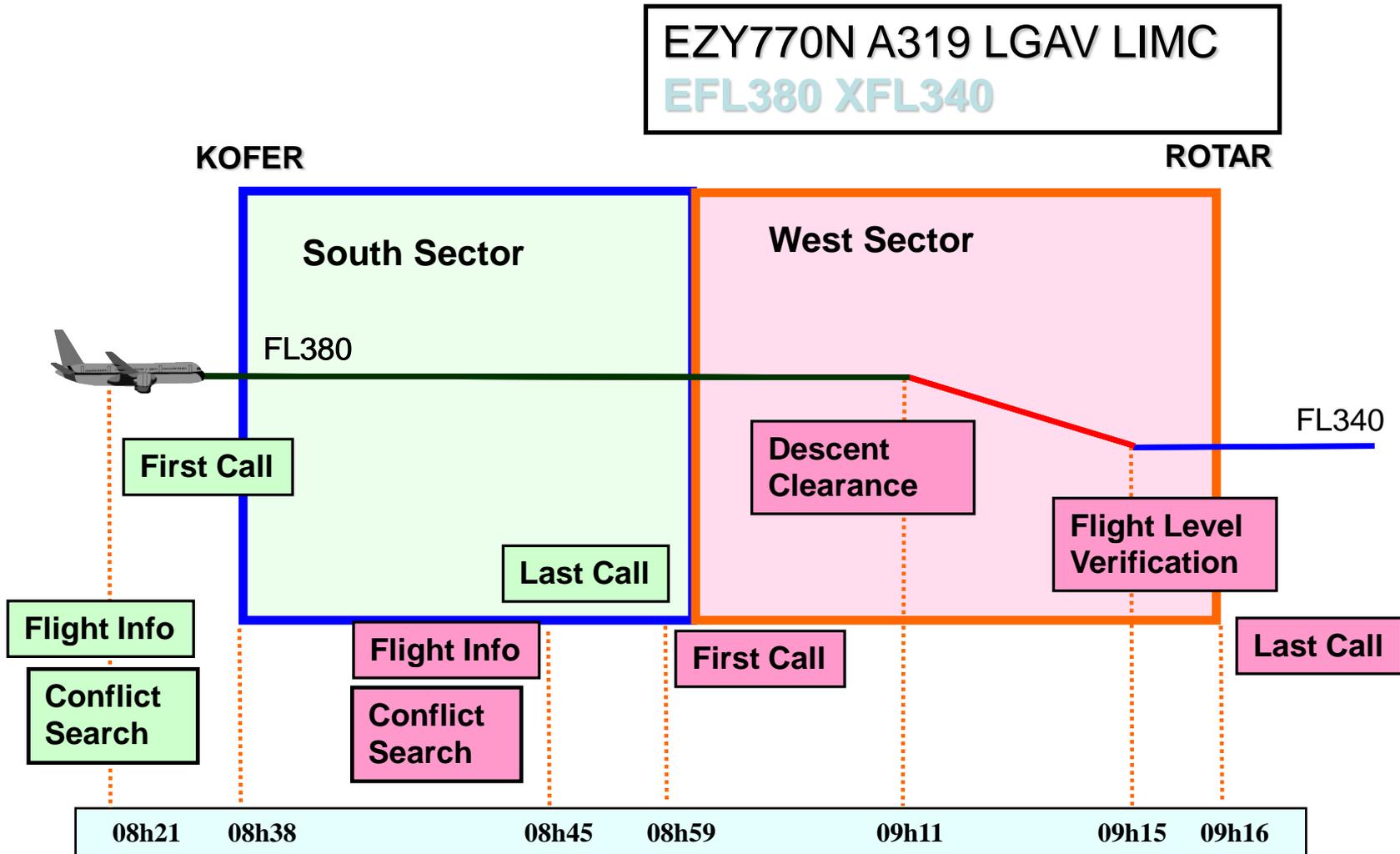
Example of ATC Tasks recorded

EC = Executive Controller
PC = Planning Controller

GAPLI sector

TIME	TASK	Definition	WORKLOADS (Seconds)	
02:47	1	Acknowledge of a new flight	PC 1	
03:03	44	Receipt of a flight progress strip	PC 7	
03:04	51	Routine conflict search to establish sector planning clearance	EC 5	PC 8
03:17	66	First call from an a/c entering the airspace of a new ACC	EC 10	PC 5
03:17	64	Additional R/T for a traffic entering from oceanic airspace	EC 18	
03:44	72	Last R/T message to an a/c leaving the sector	EC 10	PC 5
03:44	74	Propose radar transfer	EC 3	
03:44	45	Removal of the flight progress strip	PC 2	

TAKAS sector

TIME	TASK	Definition	WORKLOADS (Seconds)	
03:12	44	Receipt of a flight progress strip	PC 7	
03:33	51	Routine conflict search to establish sector planning clearance	EC 5	PC 8
03:41	18	ACT message monitoring in the last sector	PC 4	
03:43	75	Assume radar transfer from the previous sector of the same ACC	EC 3	
03:44	67	First call from an a/c entering another sector of the same ACC	EC 10	PC 4
03:50	71	R/T instruction to an a/c to comply with a new planning clearance	EC 16	PC 3
03:53	69	Report of an a/c on reaching a specified level	EC 6	PC 3
03:55	72	Last R/T message to an a/c leaving the sector	EC 10	PC 5
03:55	74	Propose radar transfer	EC 3	
03:54	45	Removal of the flight progress strip	PC 2	

Network Manager
nominated by
the European Commission

24 Hours Sector Activity

Sector Generic - Configuration X
608 Flights - 25 Iterations
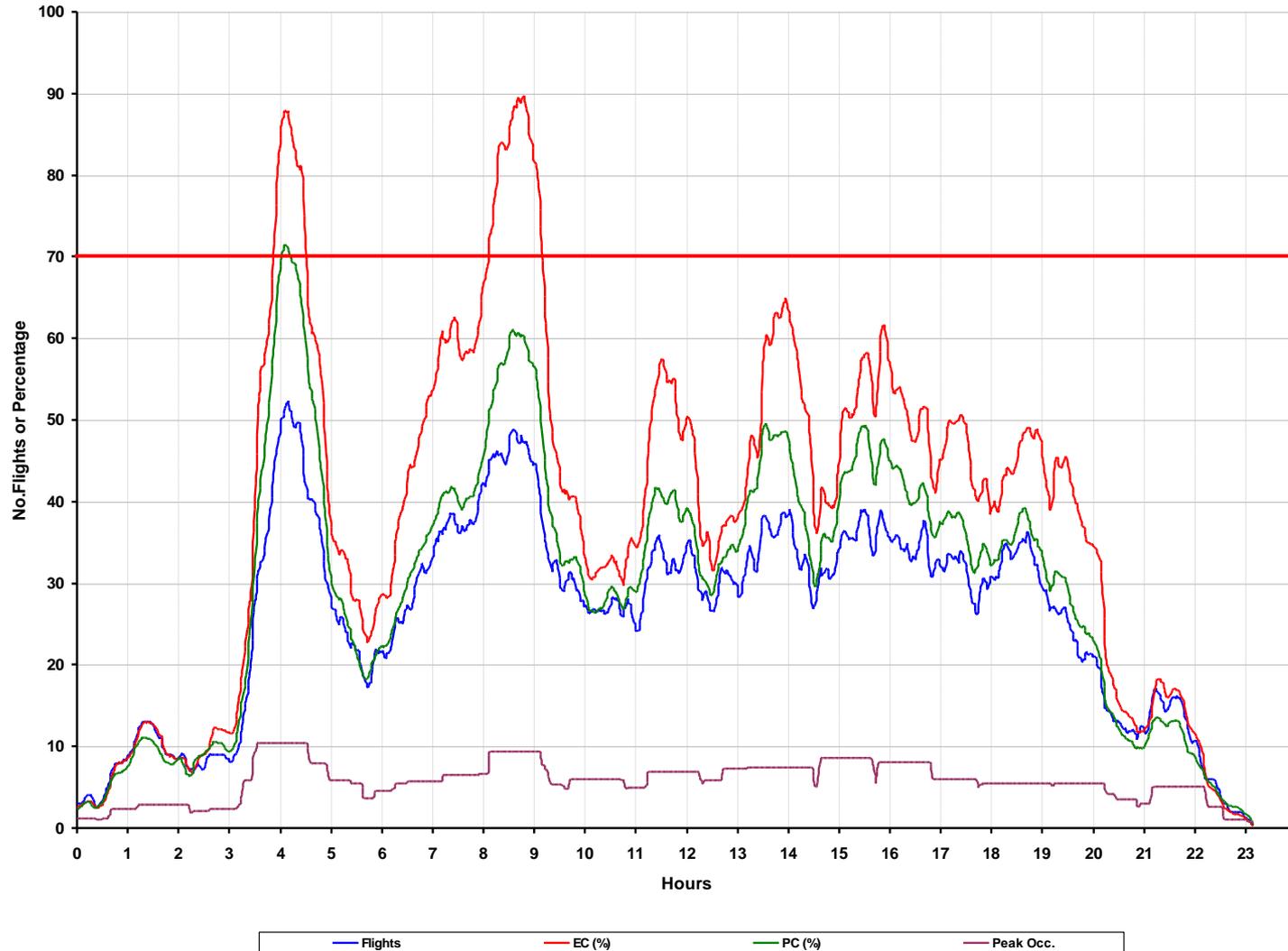
Calculation of Regression Capacity

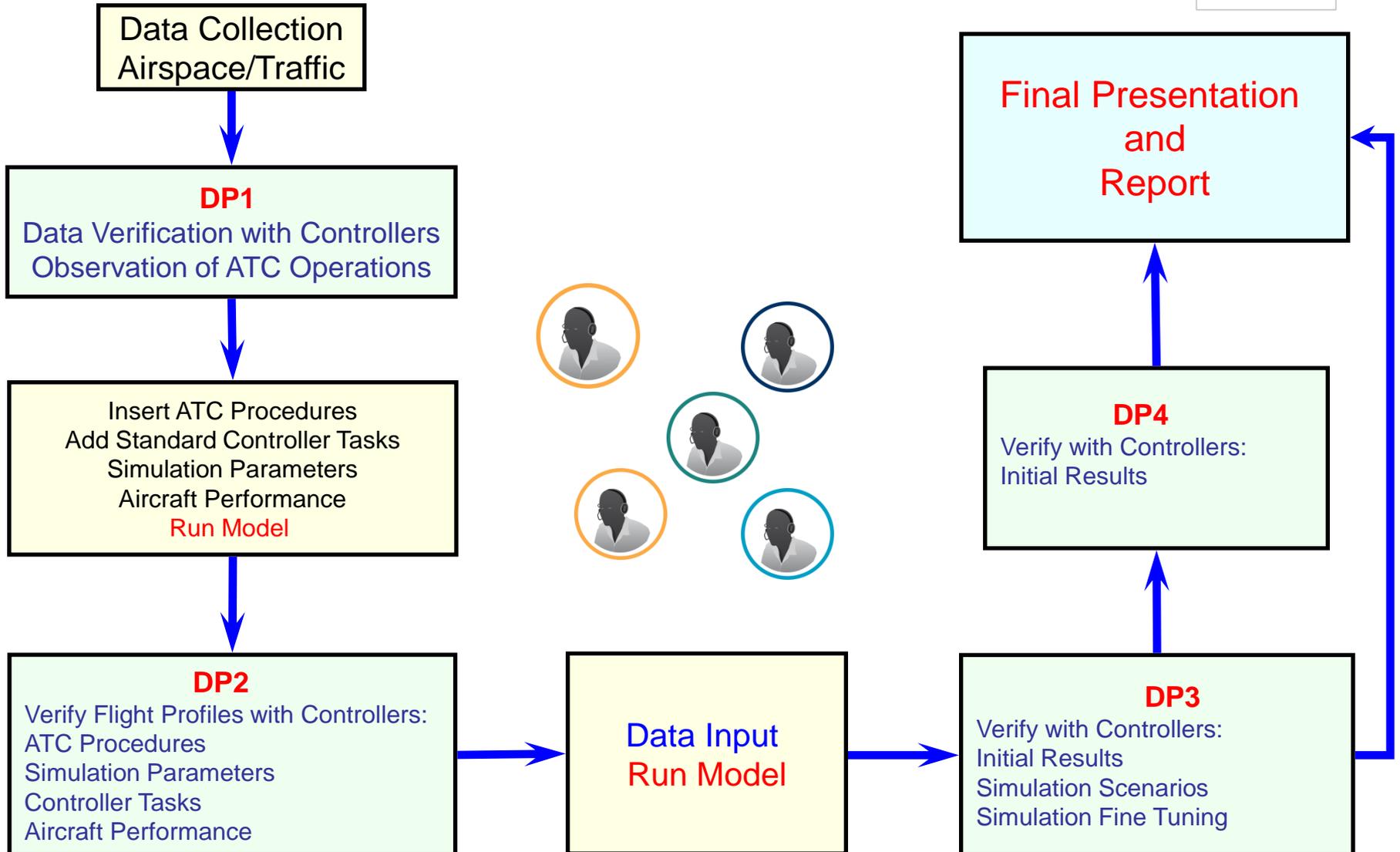Sector Generic - Organisation X
555 Flights in the 24H Traffic Sample (20 Iterations)

$y = 0.0125x^2 + 0.766x$
$R^2 = 0.9785$

Sector Capacity

50/H

Workloads (Percentage)

No.Flights

- EC (%)   - PC (%)   — Poly. (EC (%))
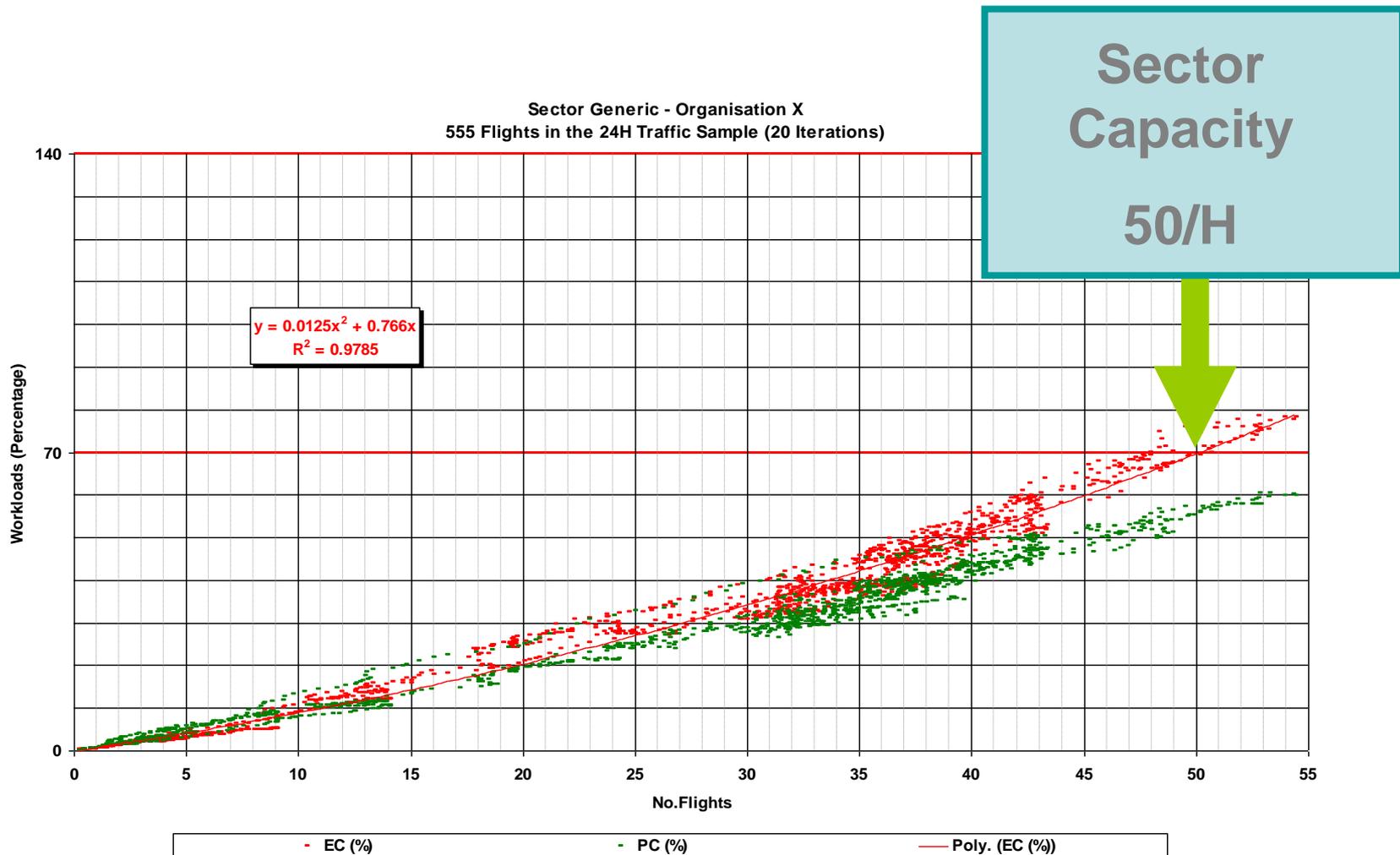
CAPAN: the workflow

CAPAN Workflow

Data Collection
Airspace/Traffic

DP1
Data Verification with Controllers
Observation of ATC Operations

Insert ATC Procedures
Add Standard Controller Tasks
Simulation Parameters
Aircraft Performance
Run Model

DP2
Verify Flight Profiles with Controllers:
ATC Procedures
Simulation Parameters
Controller Tasks
Aircraft Performance

Data Input
Run Model

DP3
Verify with Controllers:
Initial Results
Simulation Scenarios
Simulation Fine Tuning

DP4
Verify with Controllers:
Initial Results

Final Presentation
and
Report

CAPAN Workflow

Data Collection
Airspace/Traffic

**Tools
NEST
(SAAM +
NEVAC)**

**Demand
Data
Repository DDR2**

• Fast
• Reliable
• Data available for any
AIRAC cycle

**Manual
input of
traffic and
airspace**

• Time-consuming
• Traffic possibly to be built on a
day-by-day basis
• Longer time for verification
with controllers

Average Schedule
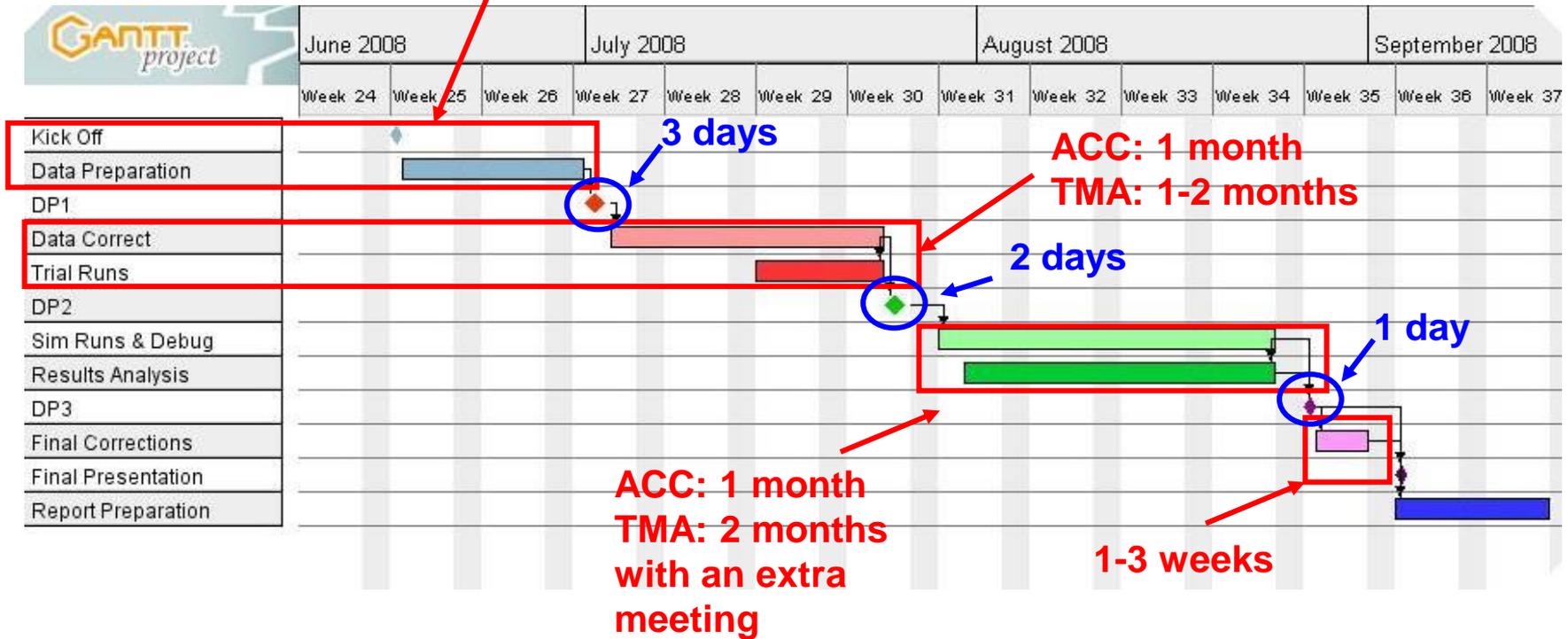
Schedule depends on complexity of study and specific requirements

Data Preparation Meeting 1 (DP1)

- Generally a 3 day meeting but variable duration depending on number of scenarios and units to be assessed
- Main objectives:
    1. Introduce the Capan Method to the Controller Team
    2. Observation of ATC Operations
    → To familiarise with local environment and working practices
    3. Verify traffic sample routes
    4. Verify traffic transfer procedures
    5. Introduction to Simulation Parameters
    6. Introduction to Controller Tasks

Data Preparation Meeting 2 (DP2)

- Generally a 2 day meeting but variable duration depending on type of unit and number of scenarios to be assessed

- Main objectives:
  1. Verification of flight profiles
  2. Aircraft performance adaptation to local conditions
  3. Controller Tasks definition
  4. Simulation parameters definition

Data Preparation Meeting 3 (DP3)

- Generally a 1 day meeting but variable duration depending on type of unit and number of scenarios to be assessed

- Main objectives:
  1. Simulation Verification
  2. Initial Results Checking

Note: for TMAs an extra meeting (DP4) is required for
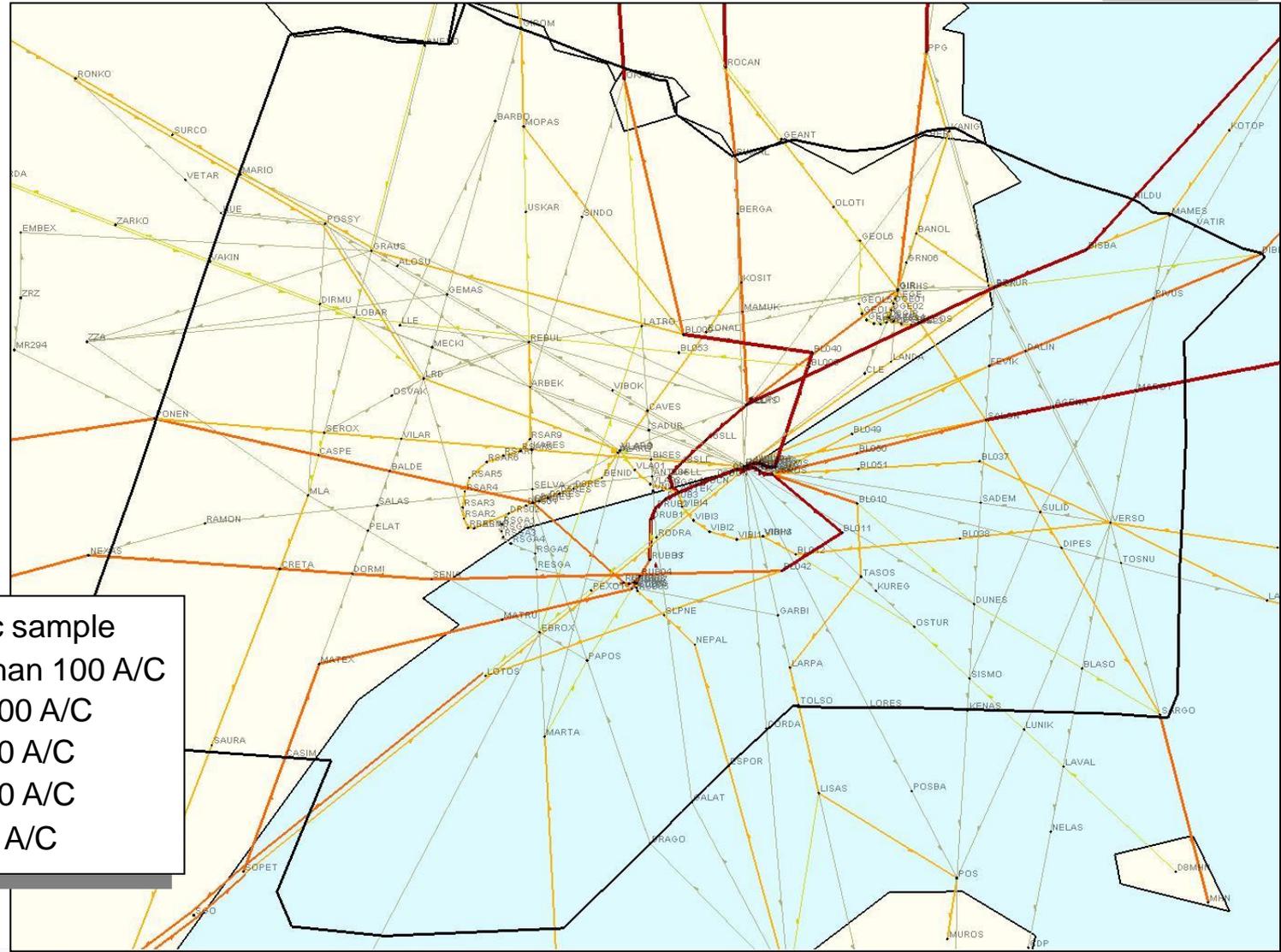 1. Verification of Simulation Scenarios
  2. Simulation fine tuning

CAPAN: Available Results

Available Results

Results Examples – Traffic Flows

24 hrs traffic sample
- ▬▬ More than 100 A/C
- ▬▬ 50 to 100 A/C
- ▬▬ 20 to 50 A/C
- ▬▬ 10 to 20 A/C
- ▬▬ 1 to 10 A/C

EUROCONTROL

Network Manager
nominated by
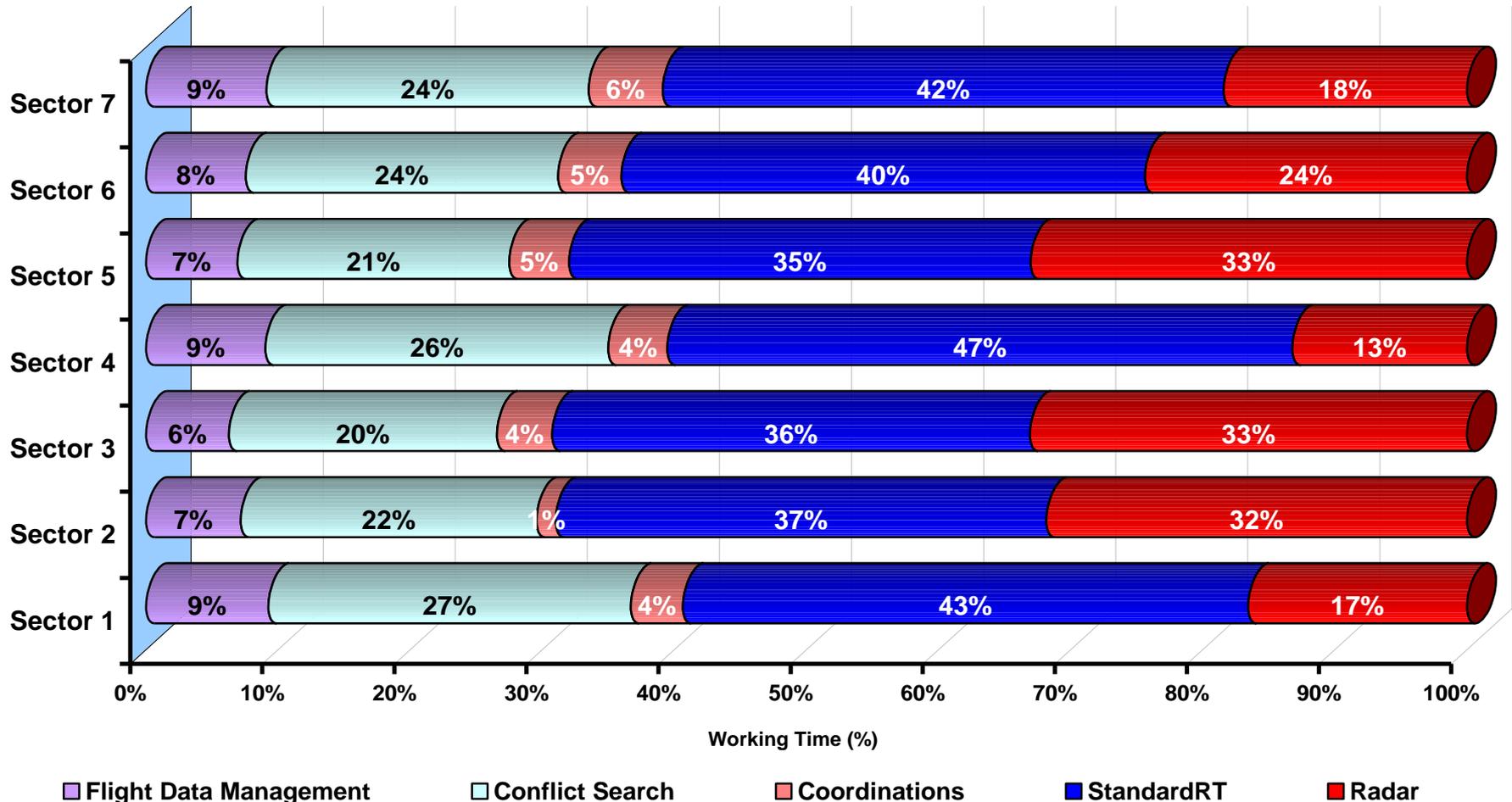the European Commission

Results Examples – Traffic distribution

Number of Flights per Sector
Configuration 7 Sectors - 15 Iterations
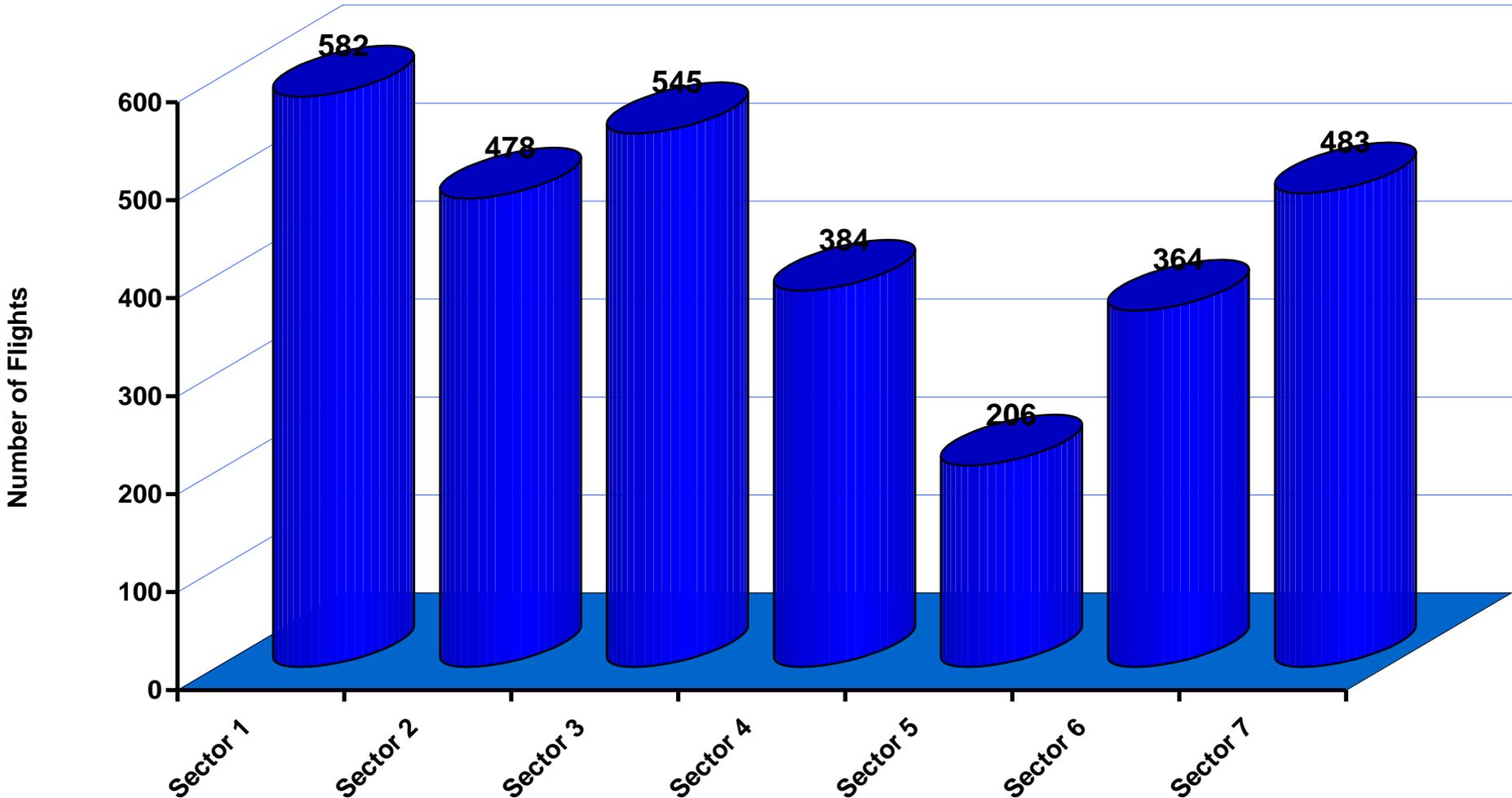
Results Examples – Working time by category

Working Time by Category
Configuration 7 Sectors - 15 Iterations

Sector	Flight Data Management	Conflict Search	Coordinations	StandardRT	Radar
Sector 7	9%	24%	6%	42%	18%
Sector 6	8%	24%	5%	40%	24%
Sector 5	7%	21%	5%	35%	33%
Sector 4	9%	26%	4%	47%	13%
Sector 3	6%	20%	4%	36%	33%
Sector 2	7%	22%	1%	37%	32%
Sector 1	9%	27%	4%	43%	17%

Working Time (%)

■ Flight Data Management   □ Conflict Search   ■ Coordinations   ■ StandardRT   ■ Radar
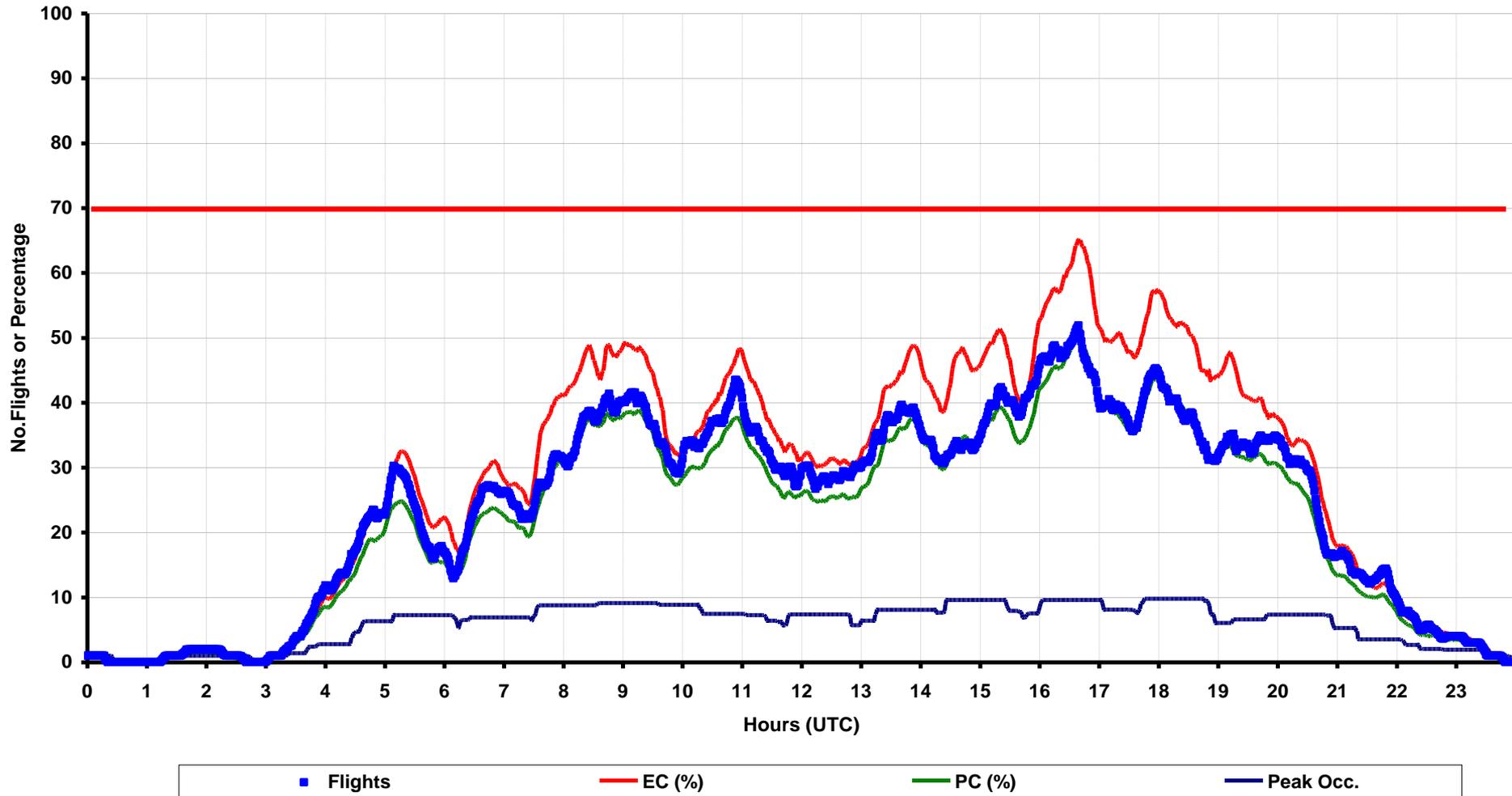
Results Examples – Peak Workload

Peak EC Workload
Configuration 7 Sectors - 15 Iterations
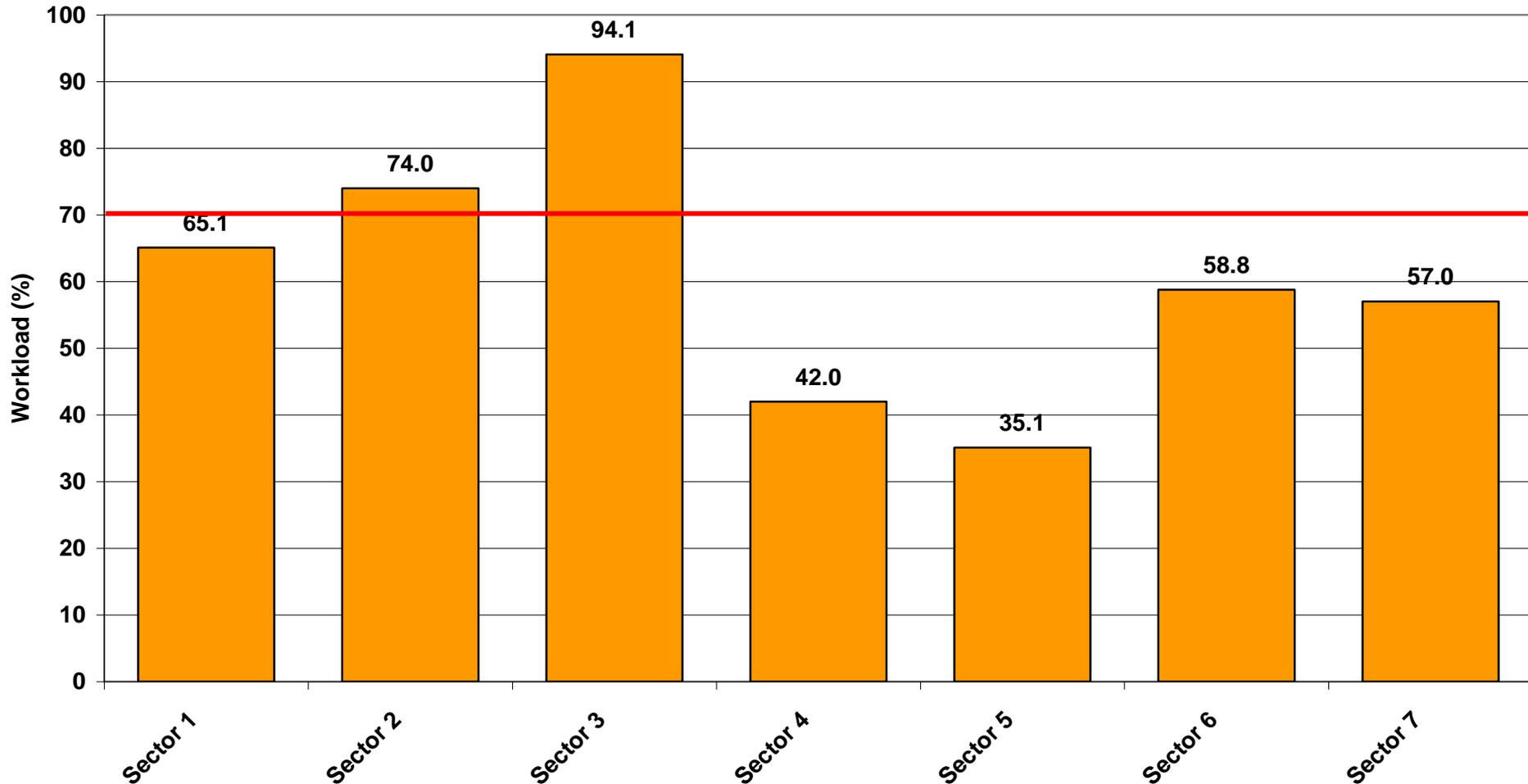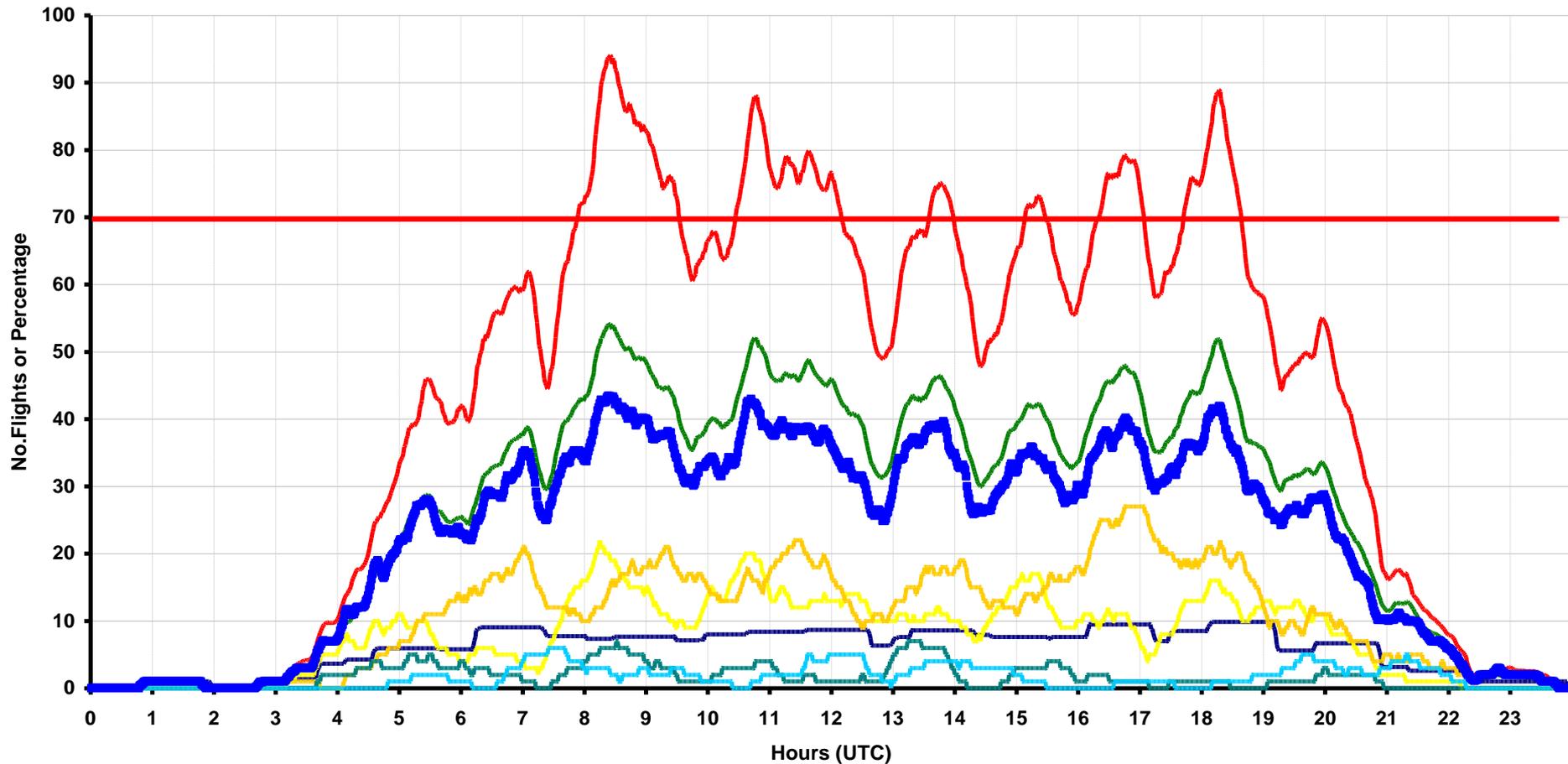
Results Examples – Sector Behaviour

24 hrs Sector Behaviour - Sector 1
582 Flights - 15 Iterations

Results Examples – Sector Behaviour

24 hrs Sector Behaviour - Sector 3
545 Flights - 15 Iterations

EUROCONTROL

Network Manager
nominated by
the European Commission

Results Examples – Conflict Areas

24 hours Traffic

Cell size is 5nm x 5nm

- More than 40 conf.
- 20 to 40 conf.
- 10 to 20 conf.
- 5 to 10 conf.
- 2 to 5 conf.
- 1 to 2 conf.

Results Examples – Capacity and Throughput

Configuration 7 Sectors						
Sector	Flights	Average Flight Time	Sector Capacity	Total Flights	Global Throughput	Average Sector Crossings
Sector 1	582	7.6	54			
Sector 2	478	5.1	37			
Sector 3	545	8.1	35			
Sector 4	384	7.0	48			
Sector 5	206	6.4	34			
Sector 6	364	4.3	41			
Sector 7	483	7.1	48			
TOTAL				**1293**	*126*	**2.4**

Where to Use CAPAN
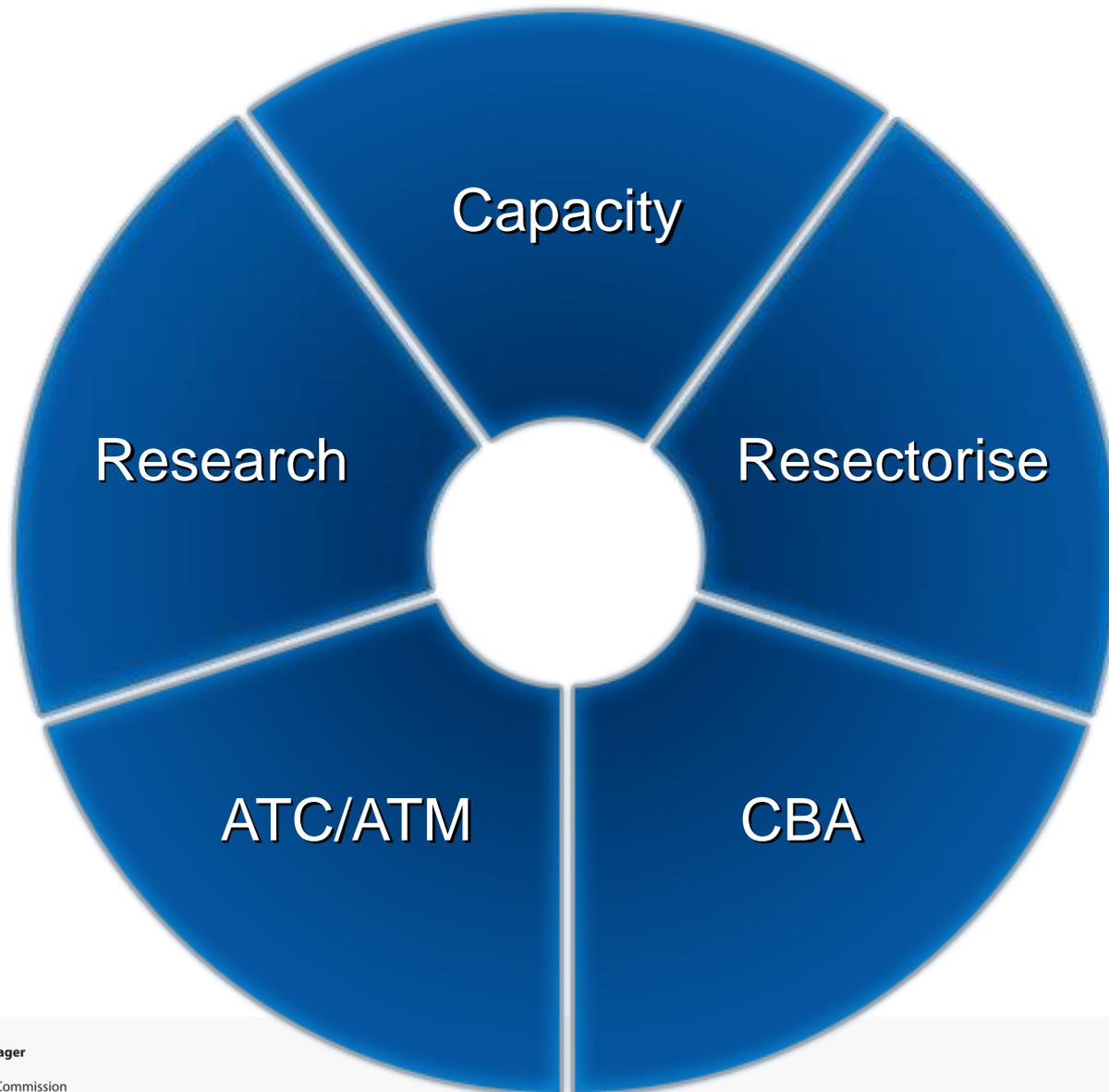
Studies

CAPAN STUDIES Up to 2015

Legend:
- At least 1 CAPAN Study performed
- CAPAN Study performed and new one requested or in progress
- CAPAN Study requested or in progress
- Expressed interest in a CAPAN Study