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HOURLY ENTRY COUNT VERSUS OCCUPANCY COUNT RELATIONSHIP DEFINITIONS AND INDICATORS (I)

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TITLE:

HOURLY ENTRY COUNT VERSUS OCCUPANCY COUNT – DEFINITIONS AND INDICATORS (I)

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Abstract :

The document presents relevant indicators within the operational ATFCM context and within the study of the global system performance evaluation. They are issued from the Hourly Entry Count versus Occupancy Count Relationship abacuses.

For each given sector, they could be extracted during the strategic phase and used during the tactical phase as current Tactical Monitoring indicators as, mainly:

- The Standard, Warning and Risk Occupancy values related to given thresholds and related to each Hourly Entry Count value (Sector Work Rate Profile).
- The Traffic Monitoring Value Hourly Rate, the Maximum Value Rate (Warning Density Area).
- The Peak Value Occupancy and the Sustain Value Occupancy (Warning Density Area).

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FOREWORD

Some first investigations have been made concerning:

- The models, the calculation modes and the variability of the Instant Load indicator and the Maximal Instant Load indicator as well. First, high-level recommendations have emerged from the study of the Instant Load indicator in order to be applied in the current operational tactical context. The relevance of the Instant Load indicator depends on the look ahead. Indeed, higher the look ahead is, more uncertain the flights information are. And whichever the used model, the reliability of the Instant Load depends on the accuracy of the available flights informations. More flights informations the model needs, more sensitive it is related to their accuracy. According to the uncertainties of the flights informations, more sensitive the Instant Load model is, more it has to be used with a short look ahead. Then, the relation between Hourly Entry Count and Occupancy Count as Instant Load has been proposed as a method to extract the Maximal Instant Load value as Instant Capacity related to the Hourly Regulation Capacity. Its promising exploitation has initiated the current *Hourly Entry Count versus Occupancy Count Relationship* study. The first technical note amongst three, named *Hourly Entry Count versus Occupancy Count Relationship – Definitions and Indicators* is presented here.

- The Instant Work Load using COCA Workload concepts based on some specific complexity indicators. The first results showed that the Instant Work Load concept has to be matured and that it seems difficult to base the regulation only on an only WorkLoad Indicator. In a first time, it seems to be more relevant to focus the work on the study of relevant complexity indicators. This conclusion has initiated the *Flight List Complexity* study.

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The ATFCM Concept of Hourly Entry Count versus Occupancy Count Relationship[1] aims to build, for a given sector, abacuses which currently purposes strategic and tactical indications for the strategic and tactical phases as:

- The Occupancy[2] amplitude, respectively Hourly Entry amplitude: the set of the managed Occupancy Count values related to each Hourly Entry Count value, respectively the set of managed Hourly Entry Count values related to each Occupancy Count value.
- The Occupancy duration, respectively Hourly Entry duration: the proportion of time during which each Occupancy Count value is managed related to each Hourly Entry Count value, respectively the proportion of time during which each Hourly Entry Count value is managed related to each Occupancy Count value.

These relationship abacuses especially promise, within the operational ATFCM context and within the study of global system performance evaluation, methods in order to extract during the strategic phase, for each given sector, Monitoring indicators being used in an operational context during the tactical phase as:

- The Standard, Warning and Risk Occupancy values related to given thresholds and related to each Hourly Entry Count value (Sector Work Rate Profile).
- The Traffic Monitoring Value Hourly Rate, the Maximum Value Rate (Warning Density Area).
- The Peak Value Occupancy and the Sustain Value Occupancy (Warning Density Area).

OBJECTIVES

This study aims to know how to tune the relationship and its abacuses indicators up. It purposes a technical validation and proposals of operational use. It consists in:

- Identifying[3] relevant abacuses indicators as Standard, Maximal, Warning and Density.

[1] The Hourly Entry Count versus Occupancy Count Relationship is oriented. It is named Hourly Entry Count versus Occupancy Count and noted HEC → OCC when a set of Occupancy Count values corresponds to a given Hourly Entry Count. It is named OCC → HEC when a set of Hourly Entry Count values corresponds to a given Occupancy Count value.

[2] Occupancy (Hourly Entry) for HEC → OCC (OCC → HEC) relationship orientation.

[3] This first point refers to the technical note named *Hourly Entry Count versus Occupancy Count – Definitions and*

Functional and operational interests of these indicators, calculation methods will be given.

- Proving[4] and evaluating the robustness of the abacuses: it will be proved by means of the Abacus method that they can be predicted according to identified conditions. Issued from the calibration phase, recommendations related to the best conditions increasing their robustness and their prediction will be given.

- Providing abacuses indicators results by means of Abacus method. They will analyse through their use within the operational ATFCM context and through their use within the global system performances evaluation as well.

- Preparing the ground for elaborating working practices using abacuses indicators by means of the Abacus mock up that will be presented. The Abacus mock up will apply the Abacus method.

DOCUMENT (DEFINITIONS AND INDICATORS)

This first document presents the main definitions of the Hourly Entry Count versus Occupancy Count Relationship concept and its relevant indicators.

Indicators (I).

[4] These second and third points refer to the technical note named *Hourly Entry Count versus Occupancy Count – Robustness, Calibration, Application (II)*. The forth point refers to the technical note named *Hourly Entry Count versus Occupancy Count – Abacus Mock Up (III).*

REFERENCES

Instant Load - Occupancy Count

Hourly Entry Count versus Occupancy Count Relationship – Definitions and Indicators (I)
Hourly Entry Count versus Occupancy Count Relationship – Robustness, Calibration, Application (II)
Hourly Entry Count versus Occupancy Count Relationship – Abacus Mock Up (III)

Flight List Complexity

Flight List Complexity – Definitions, Factors and Indicators (I)
Flight List Complexity – Scenarios and Applications (II)
Flight List Complexity – TLMT (Abacus) Mock Up (IV)

COCA

A Complexity Study of the Maastricht Upper Airspace Centre

Complexity Algorithm Mathematical Theory
Methods, Algorithms and Indicators for the Measurement and Prediction of Complexity: a literature Review
Exploring the Non-linear Relationships in Air Traffic Complexity
Complexity Algorithm Integration Plan

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1. RELATIONSHIP CONCEPTS

1.1. HOURLY ENTRY COUNT

1.1.1. Definition

Hourly Entry Count named HEC[5] for a given sector is defined as the number of flights entering in this sector during a selected Hourly Entry Count time period. This selected Hourly Entry Count time period is referred as Hourly Entry Counting Period.

This Hourly Entry Counting Period is defined in terms of a Step and Duration as a picture taken every Step value with an exposure of the Duration value:

- The Step value defines the time difference between the start time of two consecutive Hourly Entry Counting Periods.
- The Duration value defines the time difference between start and end time of each Hourly Entry Counting Period.

For example, for a 20 min. Step value and a 60 min. Duration value, counts correspond to a picture taken every 20 min. with an exposure of 60 min.

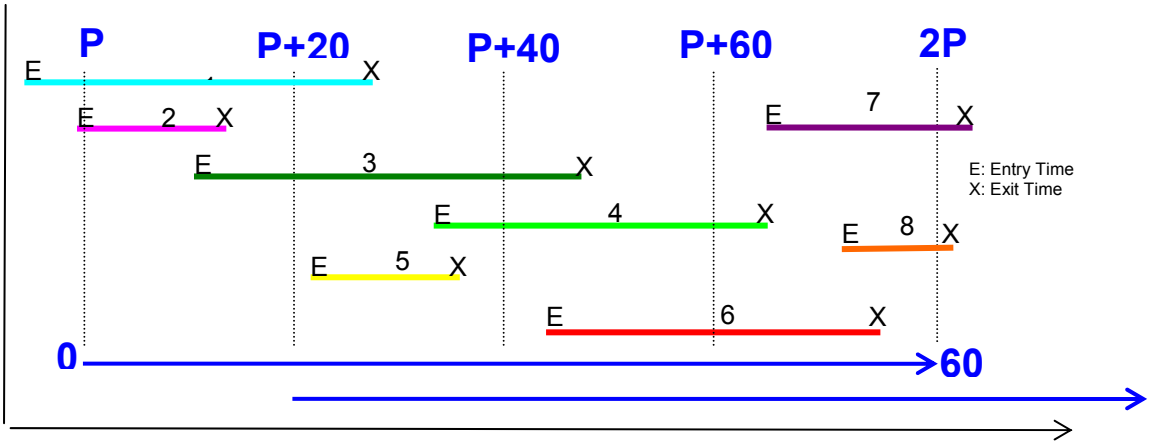


Figure 1 – Hourly Entry – Counting Period – Step = 20 min., Duration = 60 min.

[5] HEC = Hourly Entry Count.

The Hourly Entry Counts corresponding to the set of flights on the Figure 1 at the different moments P with a 60/20[6] Counting Period are:

At P	→	HEC = 6 as {3, 4, 5, 6, 7, 8}
At P + 20	→	HEC = 5 as {4, 5, 6, 7, 8}
At P + 40	→	HEC = 3 as {6, 7, 8}
At P + 60	→	HEC = 2 as {7, 8}

1.1.2. Hourly Entry Count Specificity

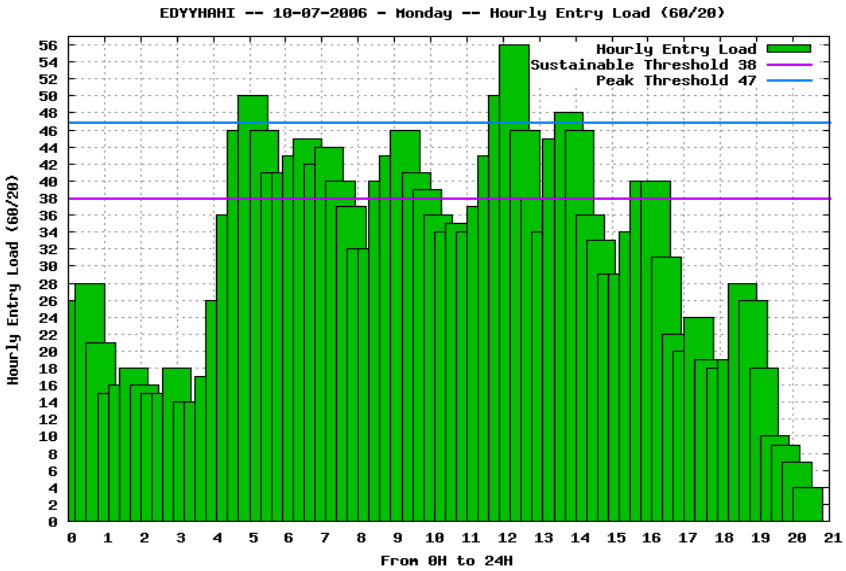


Figure 2 – EDYYHAHI Hourly Entry Count

The Figure 2 shows EDYYHAHI Hourly Entry Count for a 60/20 Counting Period: a 20 min. Step value and a 60 min. Duration value.

1.1.3. Hourly Entry Count Specificity

The Hourly Entry Count calculation method depends on the Hourly Entry Counting Period that is to say on the defined Hourly Entry Step value and the defined Hourly Entry Duration value.

[6] 60/20: Step = 20 min., Duration = 60 min..

1.2. OCCUPANCY COUNT

1.2.1. Definition

Occupancy Count[7] named OCC[8] for a given sector is defined as the number of flights inside the sector during a selected Occupancy Count time period. This selected Occupancy Count Time period is referred as Occupancy Counting Period.

This Occupancy Counting Period is defined in terms of a Step value and Duration value as a picture taken every Step value with an exposure of the Duration value:

- The Step value defines the time difference between the start time of two consecutive Occupancy Counting Periods.
- The Duration value defines the time difference between start and end time of each Occupancy Counting Period.

For example, for a 1 min. Step and a 1 min. Duration, Occupancy Counts correspond to a picture taken every 1 min. with an exposure of 1 min.

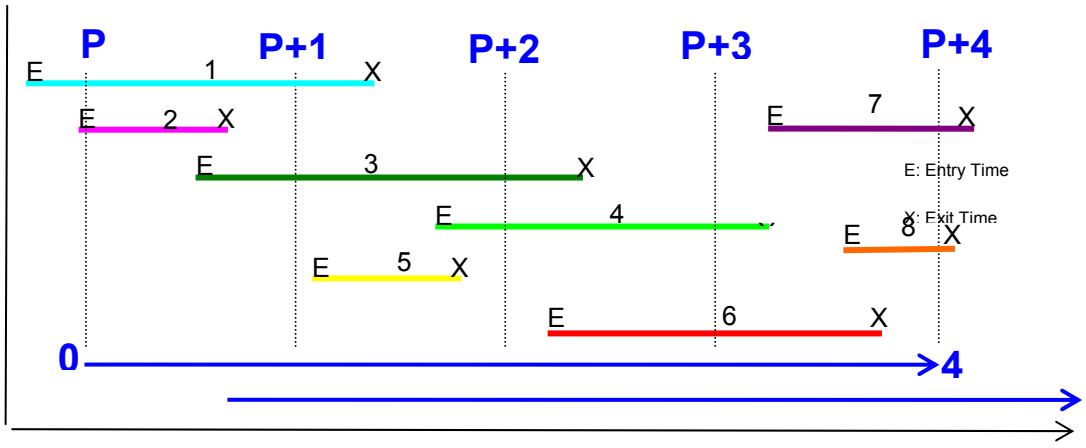


Figure 3 – CFMU12 Occupancy – Step = 1 min., Duration = 1 min.

[7] CFMU12 Definition: Cf. the CFMU Document Occupancy Counts Review Next – Marcel Richard.

[8] OCC = Occupancy Count.

The Occupancy Counts corresponding to the set of flights at the different moments P with a 1/1[9] Counting Period are:

At P	→	1, 2, 3
At P + 1	→	1, 3, 4, 5
At P + 2	→	3, 4, 6
At P + 3	→	4, 6, 7, 8

1.2.2. Occupancy Count Specificity

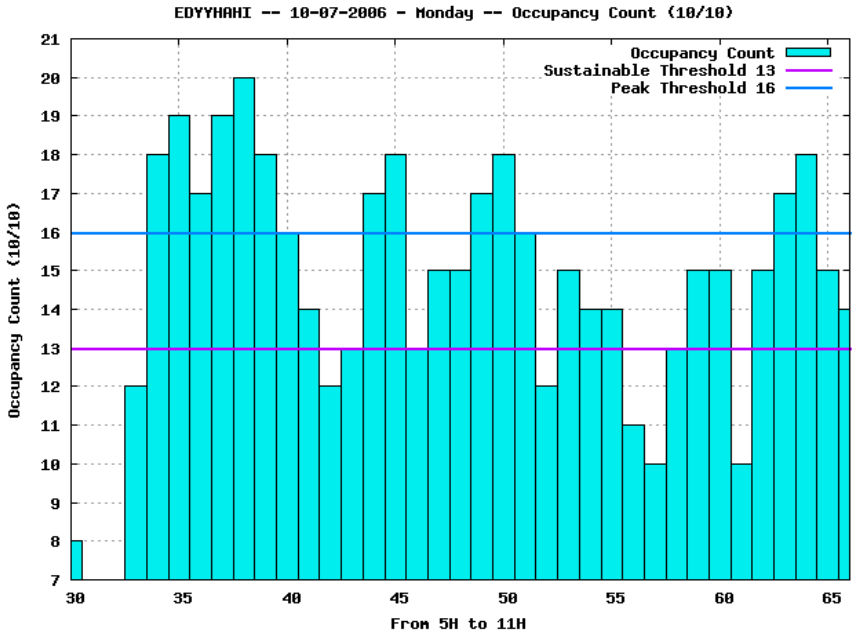


Figure 4 – EDYYHAHI Occupancy Count

The Figure 4 shows the EDYYHAHI Occupancy Count for a 1/1 Counting Period: a 1 min. Step value and a 1 min. Duration value.

The Occupancy Count calculation method depends on the Occupancy Counting Period that is to say on the Occupancy Step value and the Occupancy Duration value.

[9] 1/1: Step = 1 min., Duration = 1 min.

1.3. HOURLY ENTRY COUNT VERSUS OCCUPANCY COUNT RELATIONSHIP

1.3.1. Definitions

Hourly Entry Count versus Occupancy Count

Let consider the set of values of Hourly Entry Count for a given sector during a given time interval. The Hourly Entry Counting Period is 60/20 min..

For example as shown on the Table 1, HEC = {32, 24}.

Let consider a value of an Hourly Entry Count.

For example, HEC = 32.

Let consider the set of values of Occupancy Count for the same given sector during the same given time interval for the Hourly Entry Count value. The Occupancy Count Counting Period is 5/5 min.

For example, for HEC = 32, OCC = {3, 6, 7, 8, 9, 10, 11, 12}.

Let consider the triplet of an Hourly Entry Count value and of an Occupancy Count value among the corresponding set of values of Count and the number of the instances of each pair Hourly Entry Count value, Occupancy Count value named also the simple frequencies.

*For example, for 3 instances of the pair (32, 3), the triplet is (32, 3, 3). It means that the duration or the proportion of time during which the pair (32, 3) is observed is equal to 3 * 5 min. that is to say 15 min.*

So, the interpretations of the Simple Frequency are:

- The number or the proportion of the number of instances of a pair (Hourly Entry Count value, Occupancy Count value).
- The duration or the proportion of time of a pair (Hourly Entry Count value, Occupancy Count value).

Let consider the cloud of points as the set of triplets as described below.

(32, 3, 3), (32, 6, 2), (32, 8, 1), (32, 9, 2), (32, 10, 1), (32, 11, 1), (32, 12, 1)

HEC	OCC	*	HEC	OCC	*
32			24		
	3	3		3	3
	6	2		4	2
	8	1		5	1
	9	2		6	1
	10	1		7	3
	11	1		8	1
	12	1			

Table 1 – Hourly Entry Count versus Occupancy Count Relationship

Occupancy Count versus Hourly Entry Count

Let consider the set of values of Occupancy Count for a given sector during a given time interval.

For example as shown on the Table 2, OCC = {3, 4, 5, 6, 7}.

Let consider a value of an Occupancy Count.

For example, OCC = 3.

Let consider the set of values of Hourly Entry Count for the same given sector during the same given time interval for the Occupancy Count value.

For example, for OCC = 3, HEC = {24, 32}.

Let consider the triplet of an Occupancy Count value and of an Hourly Entry Count value among the corresponding set of values of Hourly Entry Count and the number of the instances of each pair (Occupancy Count value, Hourly Entry Count value) named also the simple frequencies.

For example, for one instance of the pair (3, 24), the triplet is written {3, 24, 1}.

So, the interpretations of the Simple Frequency are:

- The number or the proportion of the number of instances of a pair (Occupancy Count value, Hourly Entry Count value).
- The duration or the proportion of time of a pair (Occupancy Count value, Hourly Entry Count value).

Let consider the cloud of points as the set of triplets as described below.

(3, 24, 1), (3, 32, 1)

OCC	HEC	*	OCC	HEC	*	OCC	HEC	*	OCC	HEC	*	OCC	HEC	*
3			4			5			6			7		
	24	1		24	2		24	1		24	1		24	3
	32	1		32	0		32	0		32	2		32	0

Table 2 – Occupancy Count versus Hourly Entry Count Relationship

1.3.2. Specificities

The relationship calculation method both depends on the Hourly Entry Count calculation method and the Occupancy Count calculation method that is to say on the Hourly Entry Count Counting Period and the Occupancy Count Counting Period.

The relationship is oriented and not symmetric:

- Hourly Entry Count versus Occupancy Count orientated Relationship provides a set of Occupancy Count values related to an Hourly Entry Count value. It is noted HEC → OCC.
- Occupancy Count versus Hourly Entry Count orientated Relationship provides a set of Hourly Entry Count values related to an Occupancy Count value. It is noted OCC → HEC.
- The set of Hourly Entry Count in the OCC → HEC relationship is larger than the set of Occupancy Count in HEC → OCC relationship.

1.3.3. Calculation Method

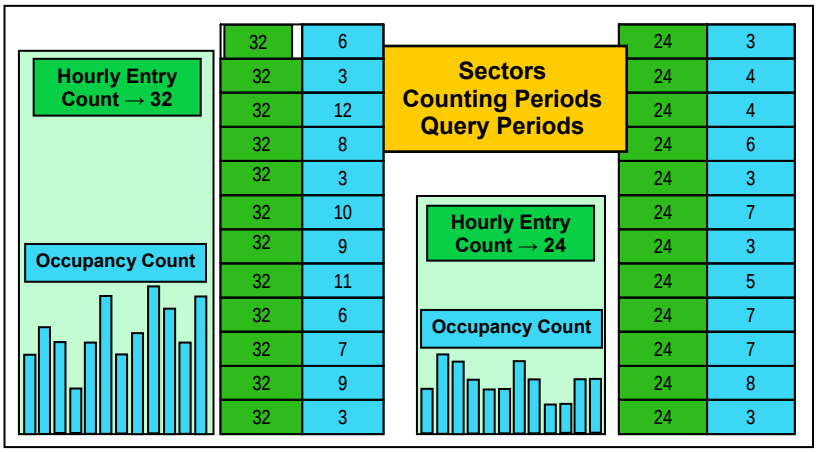


Figure 5 – Relationship Calculation Method

The relationship is oriented and not symmetric: The Figure 5 shows the correspondence between the Hourly Entry Count and the Occupancy Count considering 5/5 min. for Occupancy Count Counting Period and 60/20 min. for Hourly Entry Count Counting Period.

HEC	OCC	*	HEC	OCC	*
32			24		
	3	3		3	3
	6	2		4	2
	8	1		5	1
	9	2		6	1
	10	1		7	3
	11	1		8	1
	12	1			

Table 3 – HEC → OCC Calculation Method

OCC	HEC	*	OCC	HEC	*	OCC	HEC	*	OCC	HEC	*	OCC	HEC	*
3			4			5			6			7		
	24	1		24	2		24	1		24	1		24	3
	32	1		32	0		32	0		32	2		32	0

Table 4 – OCC → HEC Calculation Method

The "*" column in the Table 3 and Table 4 shows respectively the number of instances of the pair (Hourly Entry Count, Occupancy Count) and the number of instances of the pair (Occupancy Count, Hourly Entry Count).

1.3.4. Realtionship as a cloud of points

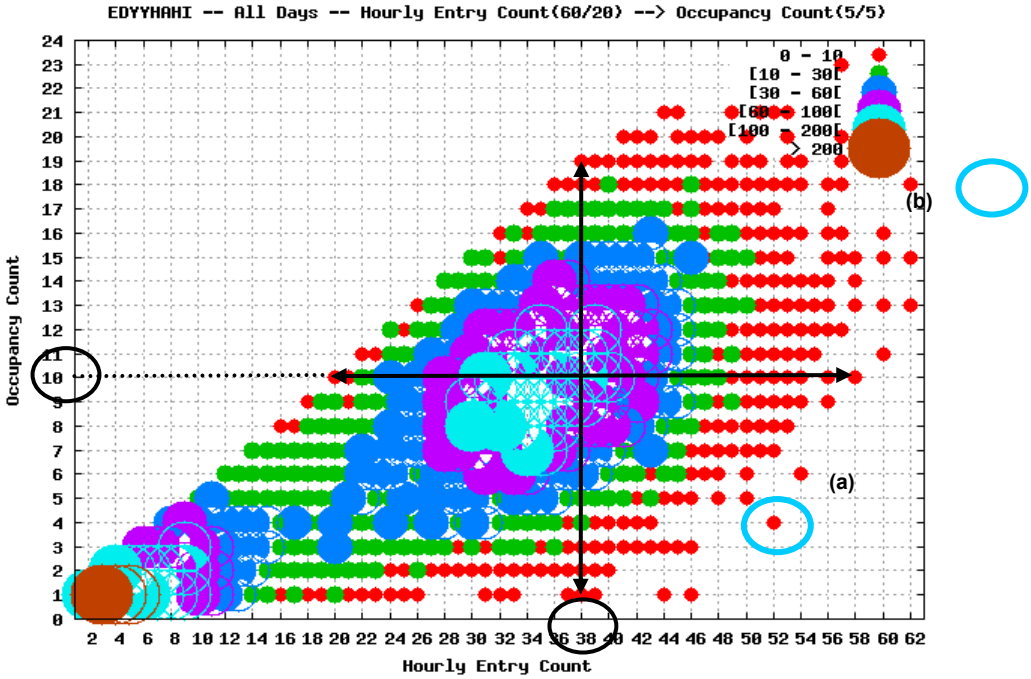


Figure 6 – Relationship Design as a cloud of points

The cloud of points on the Figure 6 computes all the days of the current traffic during three months of 2006 summer for the EDYYHAHI sector.

Each point of the Figure 6 shows the number of instances of the pair (Hourly Entry Count, Occupancy Count), the point's size depending on the class whom the number of the instances belongs.

For example, the pair (52, 4) represented by a red point (a) counts between 0 and 10 instances or still the pair (62, 19)in (b) which are extreme cases.

Let consider the HEC → OCC relationship orientation, 38 as Hourly Entry Count, its set of Occupancy values is observed between 1 and 19 that is to say between 19 different values.

Each Occupancy value occurs a different number of durations or a different proportion of time or a different number of instances. It already appears that 19 is the Maximal Occupancy for an Hourly Entry equal to 38 and that during 100% of time, the Occupancy is less or equal to 19.

Let consider the OCC → HEC relationship orientation, 10 as Occupancy Count, its set of Hourly Entry values is observed between 19 and 58 that is to say between 39 different values.

Each Hourly Entry occurs a different number of durations or a different proportion of time or a different number of instances. It already appears that 58 is the Maximal Hourly Entry for an Occupancy equal to 10 and that during 100% of time, the Hourly Entry is less or equal to 58.

2. MAJOR RELATIONSHIP INDICATORS

2.1. SIMPLE FREQUENCY

2.1.1. Definition

Let consider the triplet as defined above: (Occupancy Count value, Hourly Entry Count value, number of instances of the pair Occupancy Count and Hourly Entry Count).
The number of the instances is named Simple Frequency.

For example as shown on the Table 1, let consider the triplet (32, 6, 2) where 2 is the simple frequency of the pair (32, 6).

2.1.2. Work Rate (Distribution) Indicator

If HEC → OCC is considered, the Simple Frequency reveals, for a given sector:

- The Occupancy amplitude: the Occupancy Count values for each Hourly Entry Count.
- The Occupancy duration: the proportion of time during which each Occupancy Count is managed corresponding to each Hourly Entry Count.
- The Occupancy Count amplitudes matched to their durations model the Occupancy or Instant Work Rate related to a corresponding Hourly Entry Count.

And vice versa, if OCC → HEC is considered, let:

- The Hourly Entry amplitude: the Hourly Entry Count values for each Occupancy Count.
- The Hourly Entry duration: the proportion of time during which each Hourly Entry Count is managed corresponding to each Occupancy Count.
- The Hourly Entry Count amplitudes matched to their durations model the Hourly Work Rate related to a corresponding Occupancy Count.

Some specific Occupancy Count[10] amplitudes and durations for a given Hourly Entry Count are relevant and complementary in an improvement way related to studying system performance and related to being used in an operational strategic or tactical context.

[10] Occupancy Count means that the considered relationship orientation is HEC → OCC.

Let define the **Standard Occupancy**[11] indicator as:

- The most frequent used amplitude.
- The duration of the most frequent used amplitude.

Let define **the Maximal Occupancy**[12] indicator as:

- The maximal amplitude.
- The duration of the maximal amplitude.

Standard and Maximal Occupancy indicators more specifically define the Instant Work Rate, the first being the average Occupancy and the second being the upper limit reached by the Occupancy.

Standard and Maximal Simple Frequency values are associated to Standard and Maximal Occupancy values.

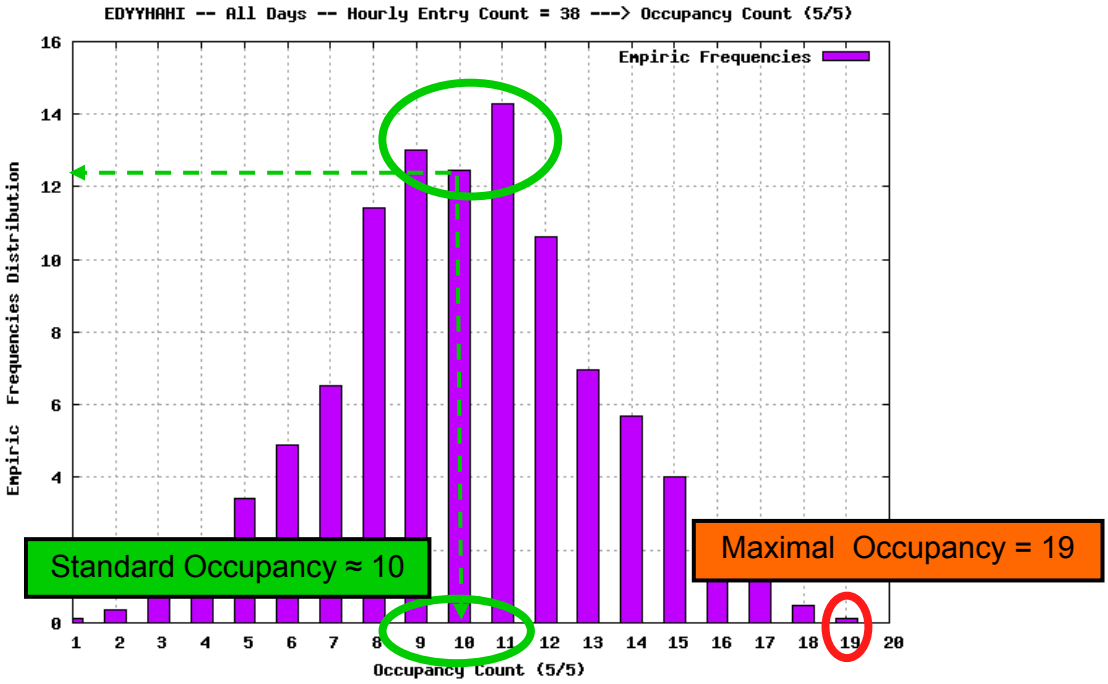


Figure 7 - Occupancy Work Rate (Distribution) for Hourly Entry Count = 38

As shown on the Figure 7, for EDYYHAHI, Standard Occupancy is 10 and Maximal Occupancy is 19, when Hourly Entry Count is 38, if Occupancy Count Counting Period is 5/5 min. and Hourly

[11] Standard: Occupancy means that the relationship orientation is HEC → OCC is considered. The similar Hourly Entry is defined for the considered reciprocal relationship orientation OCC → HEC.

[12] Maximal Occupancy means that the relationship orientation is HEC → OCC is considered. The similar Hourly Entry is defined for the considered reciprocal relationship orientation OCC → HEC.

Entry Count Counting Period is 60/20 min..

2.2. CUMULATED FREQUENCY

2.2.1. Definition

Let consider the simple frequency as noted in the Simple Frequency paragraph.

For example as shown on the Table 1, let consider the triplet (32, 6, 2) where 2 is the simple frequency of the pair (32, 6).

Let consider the cumulated frequency as the sum of the simple frequencies of the instances of each pair Occupancy Count value, Hourly Entry Count value such as Occupancy Count value is less or equal a given Occupancy Count value.

For example as shown on the Table 1, let consider the Occupancy Count 9 value.
Then, let consider the triplet (32, 9, 11) where 11 is the cumulated frequency of the pair (32, 9) as referred in the Table 1 by the list of triplets (32, 3, 3), (32, 6, 2), (32, 8, 1), (32, 9, 2).

2.2.2. Standard, Warning and Risk Indicators

The Occupancy Cumulated Frequency indicator provides for an Hourly Entry value and a given Occupancy value, the cumulated durations of each Occupancy value less or equal to the given Occupancy value. It determines specific thresholds for each given Occupancy value related to an Hourly Entry Count value. Thresholds are dimensional factors.

Some specific Cumulated Frequencies can be automatically defined or given on request and used as Standard and Warning Thresholds. They are interesting in order to define Standard and Warning indicators as:

- The **Standard Occupancy** as the practiced Occupancy during at least 50%[13] of time[14], for example.
- The **Warning Occupancy** as the practiced Occupancy during at least 90%[15] of time[16], for example.
- The **Risk Occupancy** as the practiced Occupancy during 10%[17] of time for Occupancy

[13] 50% is a given Standard Threshold.

[14] 50% of time also means 50% of the number total of instances of a pair.

[15] 90% is a given Warning Threshold.

[16] 90% of time also means 90% of the number total of instances of a pair.

[17] 100% (all the time) - 90% (proportion of time for the Warning Occupancy) = 10%.

values that are over the Warning Occupancy, for example.

Vice versa, related to a given Standard Occupancy and a given Warning Occupancy, automatically defined or given on request, the **Standard Threshold** and the **Warning Threshold** are identified.

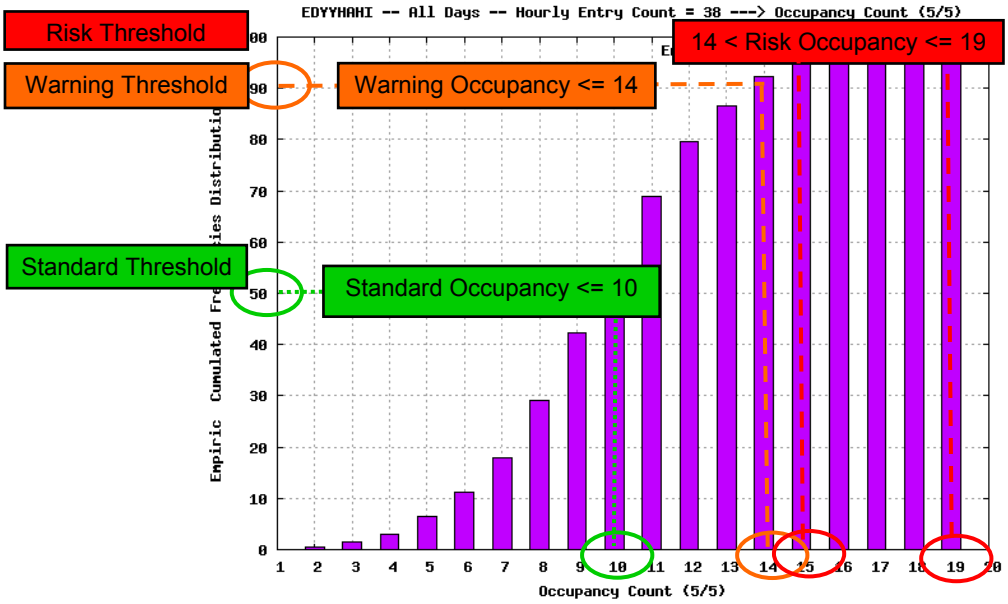


Figure 8 – Empiric Cumulated Frequencies for Hourly Entry Count = 38

The Figure 8 shows specific notable indicators, for a Warning Threshold equal to 90% of time, a Standard Threshold equal to 50% of time, a Risk Threshold equal to 10%, as indicative values:

- The Standard Occupancy less or equal 10.
- The Warning Occupancy less or equal 14.
- The Risk Occupancy is between 15 and 19.

Vice versa, if the Warning Occupancy is given and equal to 14, the Warning Threshold is deduced and equal to 90% of time. The Risk Occupancy is between 15 and 19 during 10% of time.

2.3. DENSITY AREA INDICATOR

Let define the **Density Area Occupancy** as:

- The Occupancy duration[18] class: each of them is issued from the observed simple frequencies[19].
- The Occupancy amplitude area: each of them describes the Occupancy amplitudes related to the Hourly Entry amplitudes for an Occupancy duration class.

The Density Area indicator is dependent on the identified classes. It would be interesting to study different methods to determine the more relevant classes related to criteria that would be defined.

Specific Density Areas Indicators could be extracted and interpreted in order to be used in an operational context:

- The **HEC → OCC Warning Density Area** specifies an interval of Hourly Entry Count values that guaranties a given interval of Occupancy Count values according to dimensional factors or proportions of time covered by each Occupancy values. These indicators determined in the strategic phase could be used in the tactical phase as Monitoring indicators.
- The **HEC → OCC Practiced Density Area** specifies the Practiced Instant Sector Work Rate according to dimensional factors or proportions of time covered by each Occupancy values. These indicators could be used as Performance indicators.

2.3.1. Warning Density Area

Let define the delimited HEC → OCC Density Area which provides, from a set of Hourly Entry Count values, the corresponding set of Occupancy Count values and their simple and cumulated associated frequencies.

The possible operational application concerns the ATFCM Tactical Monitoring. It could be used in a semiautomatic mode or in an automatic mode:

- In the semiautomatique mode, the sustain and peak Occupancy values and the associated thresholds or dimensional factors are given by expert controllers, and from them, the Monitoring Hourly Value (sustain) and the Maximum Hourly Value (peak) are

[18] Duration as Simple Frequency or as proportion of time or as number of instances of a pair (Hourly Entry Count, Occupancy Coun).

[19] Cf. the definition of the Simple Frequency in the paragraph 2.1..

deduced buy means of the abacuses.

- In the automatic mode, sustain and peak Occupancy and sustain and peak Houly Entry are generated.

Semiautomatic Mode

In order to guaranty according to dimensional factors or proportions of time two Occupancy values given as thresholds by expert controllers, Sustain Occupancy and a Peak Occupancy, two Hourly Entry Count values could be extracted automaticaly during the strategic phase and used in the tactical phase:

- ❖ The current Monitoring Value Rate: this rather low rate warns the FMP that he has to examine the traffic related to its characteristics and considers the level of its difficulty (or complexity) in order to apply or not some tactical measures on it.
- ❖ The current Maximum Value Rate: this rather high rate corresponds to a peak of traffic but to a not very difficult traffic (or not complex), or whose the complexity has been reduced after the application of some tactical measures, and rather well smoothed.

The Figure 9 shows the HEC → OCC Warning Density Area which guarantees Occupancy values between a sustainable Occupancy equal to 15 and a peak Occupancy equal to 21 according to their simple and cumulated frequencies:

HEC = {31, 32, …, 61, 62} OCC = {15, 16, 17, 18, 19, 20, 21}

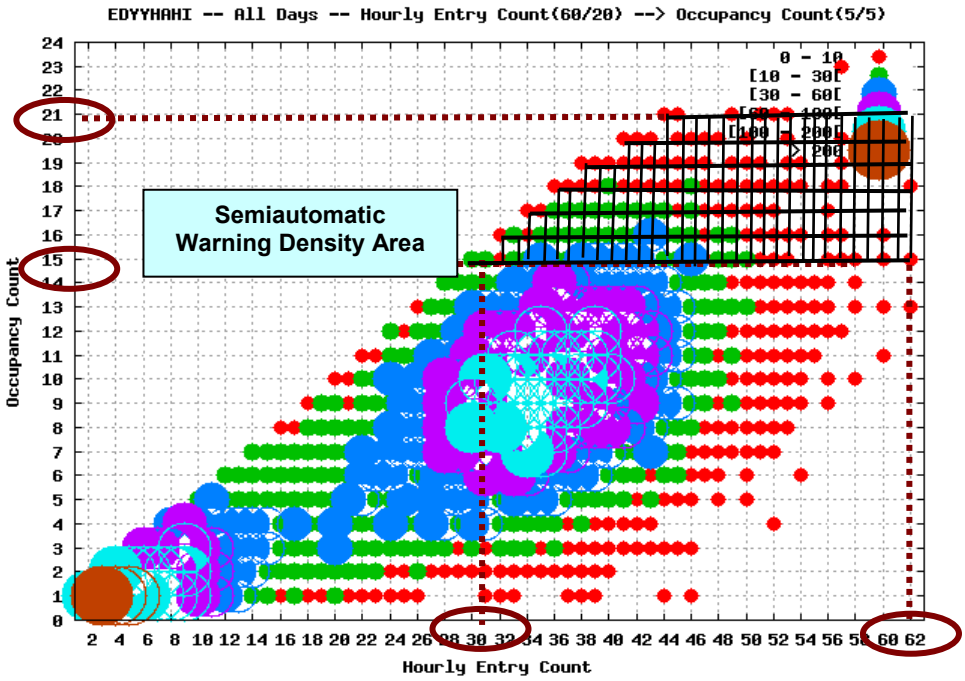


Figure 9 – Semiautomatic Mode– HEC → OCC Warning Density Area

Automatic Mode

The guarantied Sustain Occupancy, the guarantied Peak Occupancy, the Traffic Monitoring Value Hourly Rate and the Maximum Value Rate as described above, could be extracted automatically from the analysis of the observed clouds of points during the strategic phase and used in the tactical phase.

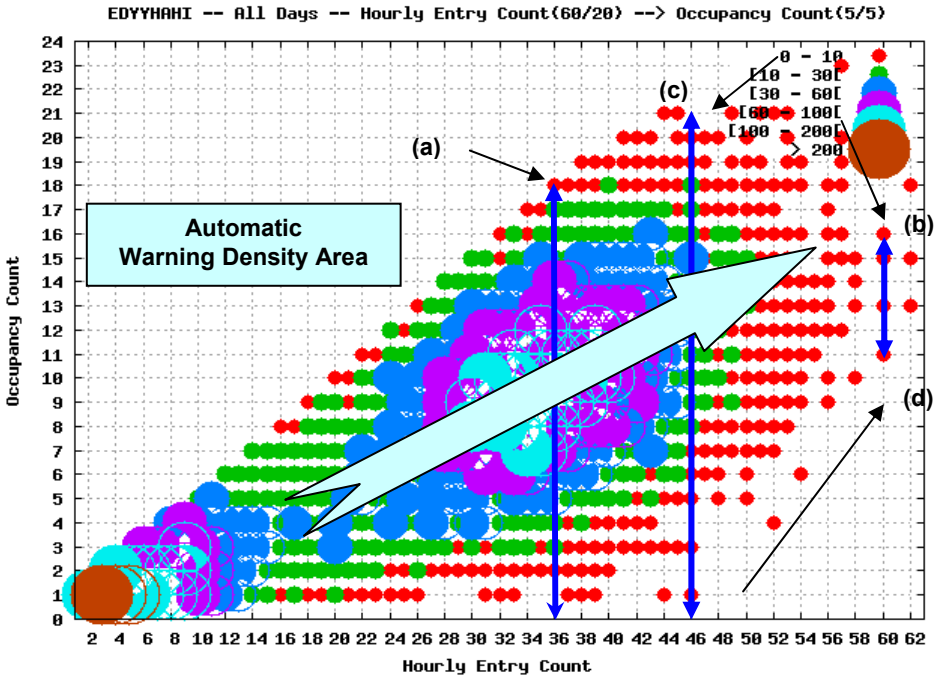


Figure 10 – Automatic Mode – HEC → OCC Warning Density Area

The Maximum Occupancy of 18 is obtained for an Hourly Count of 36 when the Occupancy may vary from 1 to 18 (a).

The Maximum Occupancy of 18 is obtained for an Hourly Count of 62 when the Occupancy vary from 13 to 18 (b).

Inbetween the Maximum Occupancy may reach a maximum never exceeded of 21.

The Maximum Bunching is obtained for an Hourly Count of 44 where the occupancy vary from 1 to 21 (c).

From 46 Hourly Count, the Minimum Occupancy start to grow.

The Figure 10 seems to show that more smoothed the traffic is, higher the Hourly Entry Counts are. Furthermore, the deviation (11 → 16) between the lower Occupancy and the higher Occupancy is weak while the lower Occupancy (11) value is rather high related to the other lower Occupancy values.

From the analysis of some special characteristics of the relationship, related to these empiric observations and after the work of calibration of the relationship, a method in order to extract automatically in the strategic phase the Monitoring indicators being used in the tactical phase, is presented in the next technical note named *Hourly Entry Count versus Occupancy Count – Robustness, Calibration, Application*. This method is now to be matured.

2.3.2. Practiced Density Area

The Practiced Density Area indicator shows the practiced Instant Work Rate according to a duration class or a simple frequency: it shows which Occupancy related to which Hourly Entry and to which duration.

Let define the **Density Rate indicator** as the ratio between the effective Instant Work Rate in a given Density Area and the absolute Instant Work Rate covering on the entire Density Area.

The Density Rate Occupancy indicator provides the effective practiced Instant Work Rate inside a given Density Area. Higher it is, denser the area is and more precise the Instant Work Rate definition is.

Specific duration classes and notable Density areas are relevant in an improvement way related to knowing system performance and related to being used in an operational context.

The densest Density Areas reveals, related to their high duration classes and their high Density Rate, the most frequently used practices for a given sector. They show the limits of the current system. Other specific criteria could be defined to determine notable Density Areas.

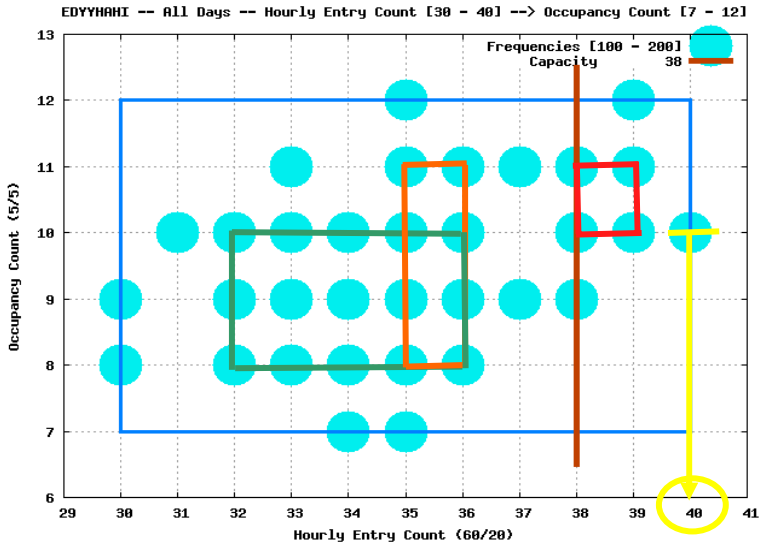


Figure 11 – Most Practiced Density Area: [100, 200], [30, 40] → [7, 12]

The Figure 11 shows the most concentrated high ([100, 200]) Density Area (≈ 50%). The Density Rate Occupancy indicator is high and designs the most concentrated Density Area. So, the most practiced Instant Work Rates are qualified.

Other denser Density Areas (close to 100%) can be defined. The larger of them (number of grouped Occupancy frequencies) is the [100, 200] duration class with he highest Density Area [32, 36] → {8, 9, 10}. Another less large but more sustainable could be the [100, 200] duration class with he highest Density Area [35, 36] → {8, 9, 10, 11}.

It appears that if the indicative Hourly Capacity is 38, the most practiced Occupancy Instant Work

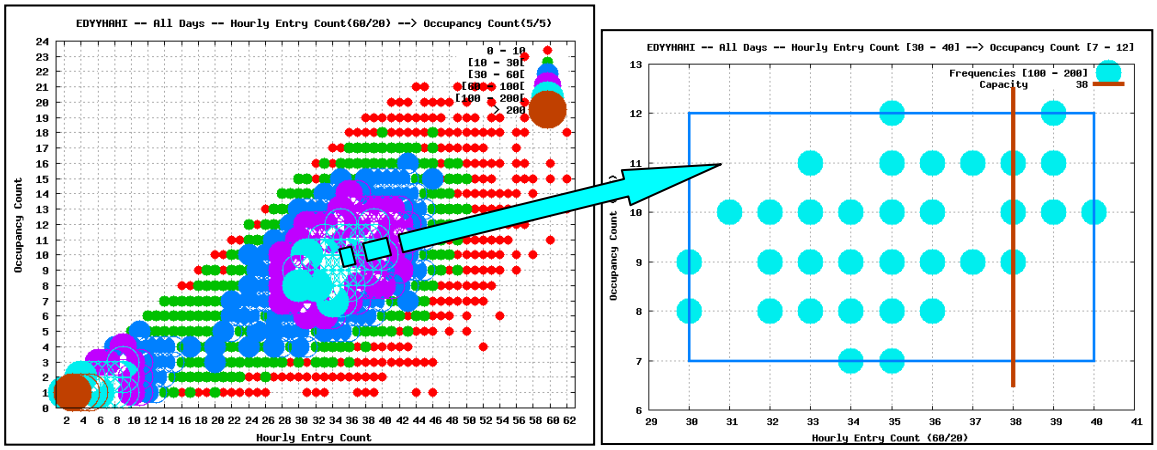
Rate is 38 → {9, 10 and 11}. It appears that the indicative Hourly Capacity is representative of one of the most used practices.

Finally, it could be interesting to find automatically Density Areas corresponding to pre–defined criteria and revealing Sector Work Rate profiles.

For example, let consider the most practiced Work Rate criterion, it corresponds to the Density Areas defined by the highest duration classes and the highest Density Rate. Let also consider the best (safest) practiced Work Rate criterion which would correspond to the Density Areas defined by these objective and constraint:

- Maximise the Hourly Entry value.
- Minimise the deviation between the maximal Occupancy value and the minimal Occupancy value (smoothing effect) related to the maximal Hourly Entry value and related to the highest duration class.

The Density indicators can be used as performance indicators or in an operational strategic or tactical context as well. As a performance indicator, it can used to compare the indicative Hourly Capacity to the most used practices, for example. In an operational context, it can be used as a global indicator in order to identify the most used practices related to some Hourly Entry values.



Min. Freq.	Max. Freq.	Min. HEC	Max. HEC	Min. OCC	Max. OCC.
0	10	22	62	5	23
10	30	22	50	5	18
30	60	22	46	5	16
60	100	28	43	6	14
100	200	30	40	7	12

Highest Empiric Frequencies between 100 and 200 around Indicative Hourly Capacity (38)

Figure 12 – EDYYHAHI Practiced Density Areas

The Practiced Density Areas are determined for five duration classes. They reveal the most practiced Instant Work Rate as Occupancy between 7 and 12 for Hourly Entry between 30 and 40 related to the higher duration class. Related to the system performance, it reveals an effective use of the Indicative Hourly Capacity.

- The revealed under–use of the Indicative Hourly Capacity for an Occupancy value between 0 and 3 for an Hourly Entry value between 2 and 8 is due to periods without traffic, between 0h and 2h, for example.

- Such measures are really interesting in cases of some peak of traffic that is to say when some problems of management of the Occupancy can be anticipated or prevented. When the Traffic is low, they are rather unnecessary.

2.3.3. Indicators revealing Sector Work Rate, Traffic Complexity and Hourly Capacity

The Instant Work Rate provides, for a given sector, the Warning Occupancy related to a Warning Threshold and related to an Hourly Entry Count. *For example, in 95% of cases, the Occupancy is less (or equal) than 14 for EDYYHAHI while the Hourly Entry Count values 38*. It defines some relevant and useful thresholds related to Occupancy and reveals the Sector Instant Work Rate Profile for each Hourly Entry Count that could be used during the tactical phase in order to help to decide about some relevant actions having to be applied on the flights.

The Warning Density Areas indicators provide methods described in the technical note named *Hourly Entry Count versus Occupancy Count – Robustness, Calibration, and Application* in order to evaluate operational Tactical Monitoring indicators.

These measures include and reveal the effective influence of traffic complexity factors. It means that some very high values for Hourly Entry Count would be due to smoothed traffic or traffic turned less complex. They need future analysis and future steps of validation in order to examine the list of flights concerned by such an Instant Work Rate, in order to assess the tactical monitoring indicators values and complete the indication provided by it. These indicators also could be considered as global Complexity indicators for a given sector.

The Density Area indicator can show the most practiced areas. So, it is easy to examine if the indicative Hourly Capacity is representative or not of one of the most used practices.

3. CONCLUSIONS

The Hourly Entry Count versus Occupancy Count Relationship concept and indicators are defined. Empiric Abacuses can be built from Traffic samples. Furthermore, some promising functional points characterize the indicators defining the Hourly Entry Count versus Occupancy Count Relationship that aims to focus a method based on the hypothesis of a probabilistic model in order to study the relationship robustness.

The Hourly Entry Count and the Occupancy Count depend on the Counting Periods. So, the relationship indicators based on the simple and cumulated Frequency also depend on the Counting Periods.

Furthermore, others factors can influence the countings, and the behaviour of the relationship and the resulted abacuses as for example, the structure of the sector or the day of the traffic or still the period in the day. So the sensitivity of the abacuses to these factors is being studied.

The following technical note[20] named *Hourly Entry Count versus Occupancy Count Relationship - Robustness, Calibration, Application* describes the following phases that consist in:

- Proving and evaluating the robustness of these abacuses: it will be proved by means of the Abacus method that they can be predicted according to identified conditions as the best Counting Period and the best Query Period. Issued from the calibration phase, recommendations related to the best conditions increasing their robustness and their prediction will be given.

- Providing abacuses indicators results by means of Abacus method. They will analyse through their use within the operational ATFCM context and through their use within the global system performances evaluation as well.

The following technical note[21] named *Hourly Entry Count versus Occupancy Count Relationship - Abacus Mock Up* describes the following phase that consists in:

- Preparing the ground for elaborating working practices using abacuses indicators by means of the Abacus mock up that will be presented. The Abacus mock up will apply the Abacus method.

[20] Hourly Entry Count versus Occupancy Count Relationship – Robustness, Calibration, Application.

[21] Hourly Entry Count versus Occupancy Count Relationship – Abacus Mock Up.