GEO Occupancy Historic Analyze

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44th Scientific and Technical Sub commision

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INTRODUCTION

- The Geostationary Orbit, well known as “GEO” is an essential element for the world telecommunications infrastructure.
- GEO orbit has been exploded during more than 40 years, with more than 650 satellites launched on this period
- This Tool aims to analyze the historical GEO occupancy regarding the usage of orbit-spectrum resource

INTRODUCTION

- A geostationary satellite occupies a relative unique fixed position relative to the earth surface, and from there, it radiates one or several frequency bands, to some given areas of the planet, according to its antenna beams. Hence, GEO resource includes three elements:

- ***Position:*** where satellite is placed in the GEO arc?
- ***Spectrum:*** Which frequencies are used?
- ***Coverage***: Which earth areas are radiated?

The ensemble of these three elements composes the so called Orbit-Spectrum Resource, OSR

INTRODUCTION

Trough ITU and other UN conferences, it is worldwide accepted that the OSR has three main attributes:

- - ***Natural Resource***: Determined by laws of the nature, being an humanity's patrimony.
- - ***Not renewable***: The geostationary orbit requires a unique combination of orbit parameters, and its reproduction is beyond the human capacities.
- - ***Scarce***: To avoid interferences, a minimum angular separation among GEO satellites is required, when they share operating frequencies and covered zones; therefore, the number of satellites that can be located at the GEO is limited. Hence, the spectral part of the OSR determines its scarceness.

INTRODUCTION

Because of these unique attributes, countries have agreed that the GEO exploitation should be:

- - ***Rational***: avoiding the spoil of this scare resource
- - ***Efficient***: profiting as much as possible of a granted OSR
- - ***Equitable***: guaranteeing the non-discriminatory access to all the countries.

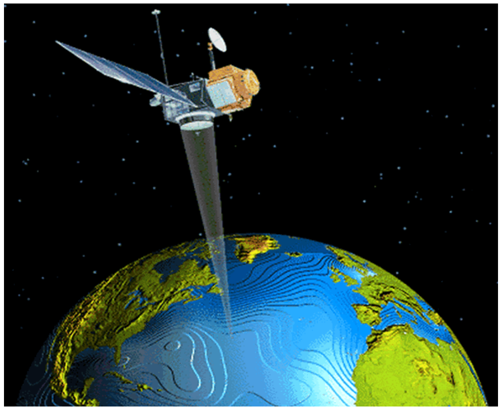
But, after more than 40 years of GEO exploitation, its associated OSR has been actually used:

efficiently?; rationally?; equitable?

To analyze the GEO occupancy, a software tool was developed and analyses using it has been performed.

WHAT IS GOAT?

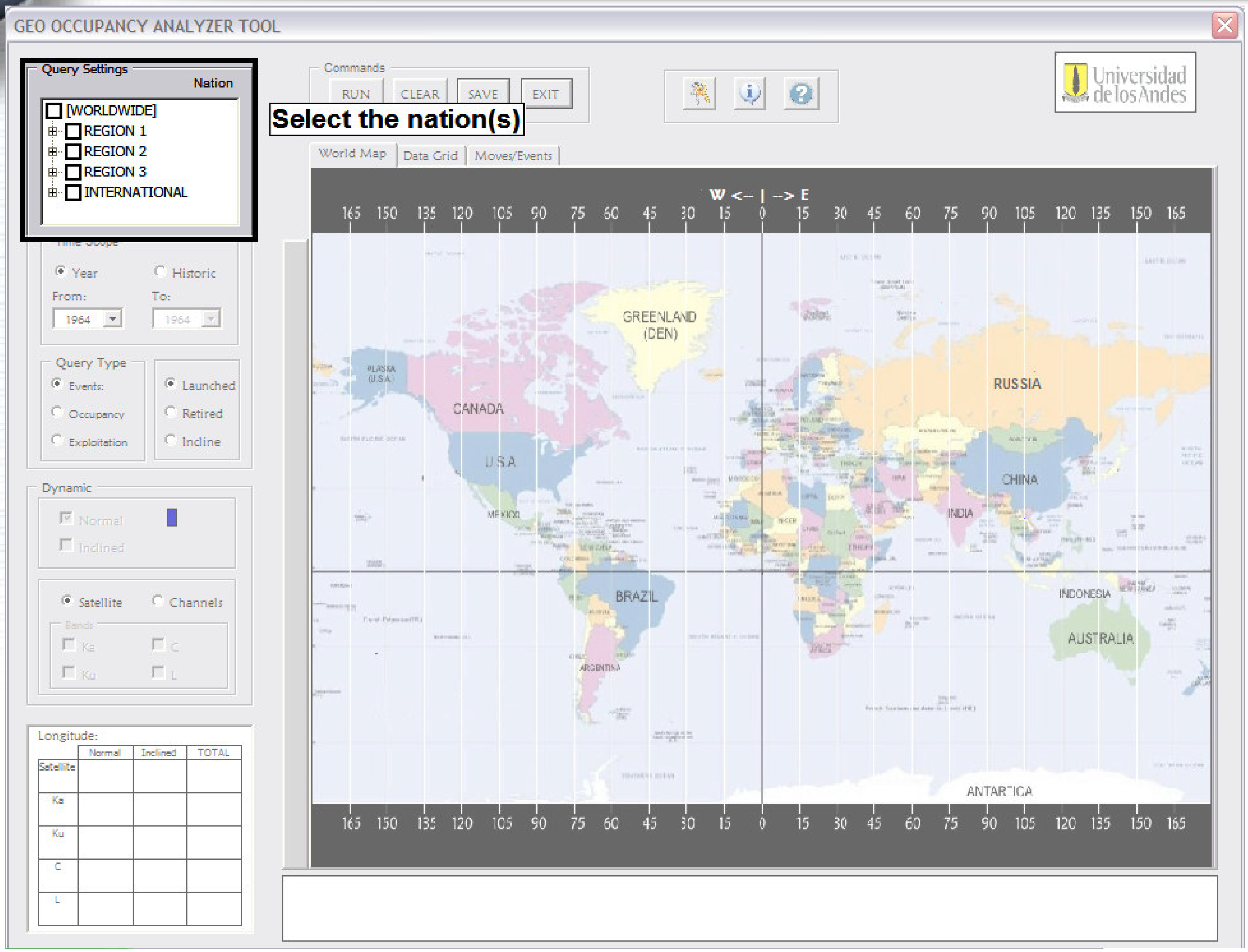
- **GOAT**, standing for "GEO Occupancy Analizer Tool", is an Excel oriented Visual Basic application, that performs historic analysis of the GEO occupation, through queries on a satellite data base.



HOW DOES IT WORK?

1. Open "GOAT2007.xls" file (If MACROS security message appears, click OK and go to Tools/Macro/Security…" and select "Medium level")
2. Specify your query selecting options in the "Query Settings" panel (left panel)
3. Click "RUN" button
4. See results in the world map or in the data grid (right panel) and the complementary data in the Moves/Events tab.
5. Click "SAVE" button or repeat steps 2 to 4

HOW DOES IT WORK?



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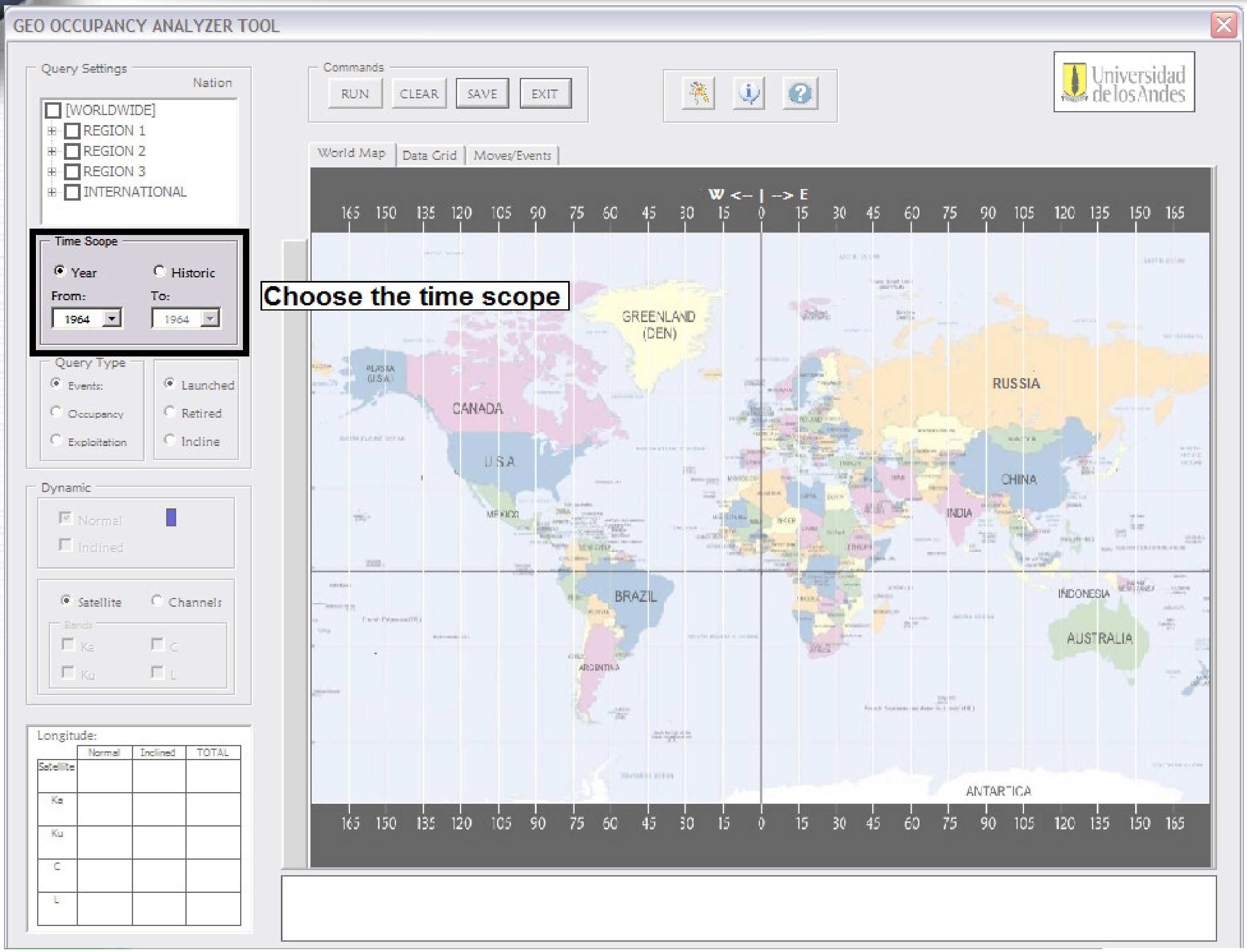

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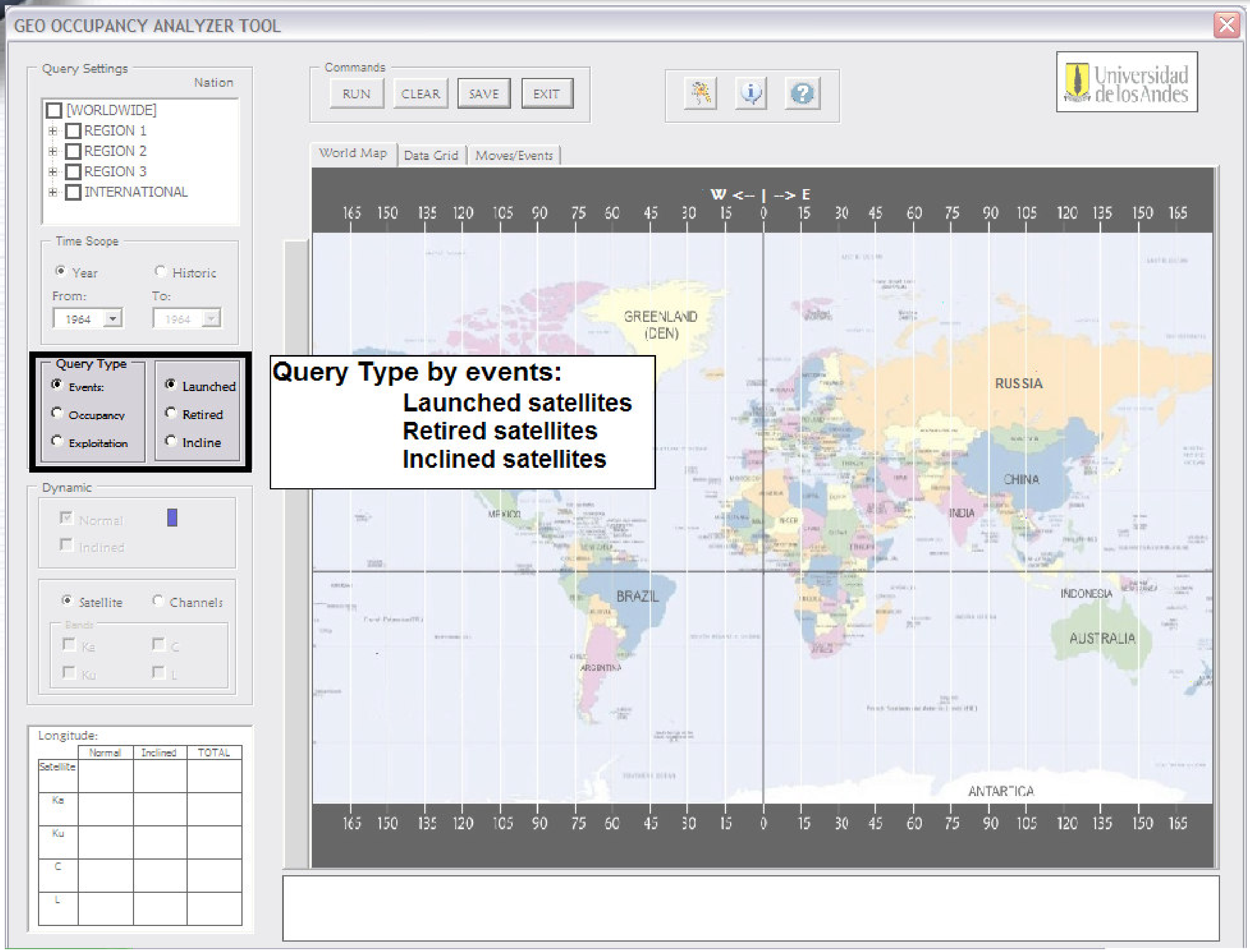

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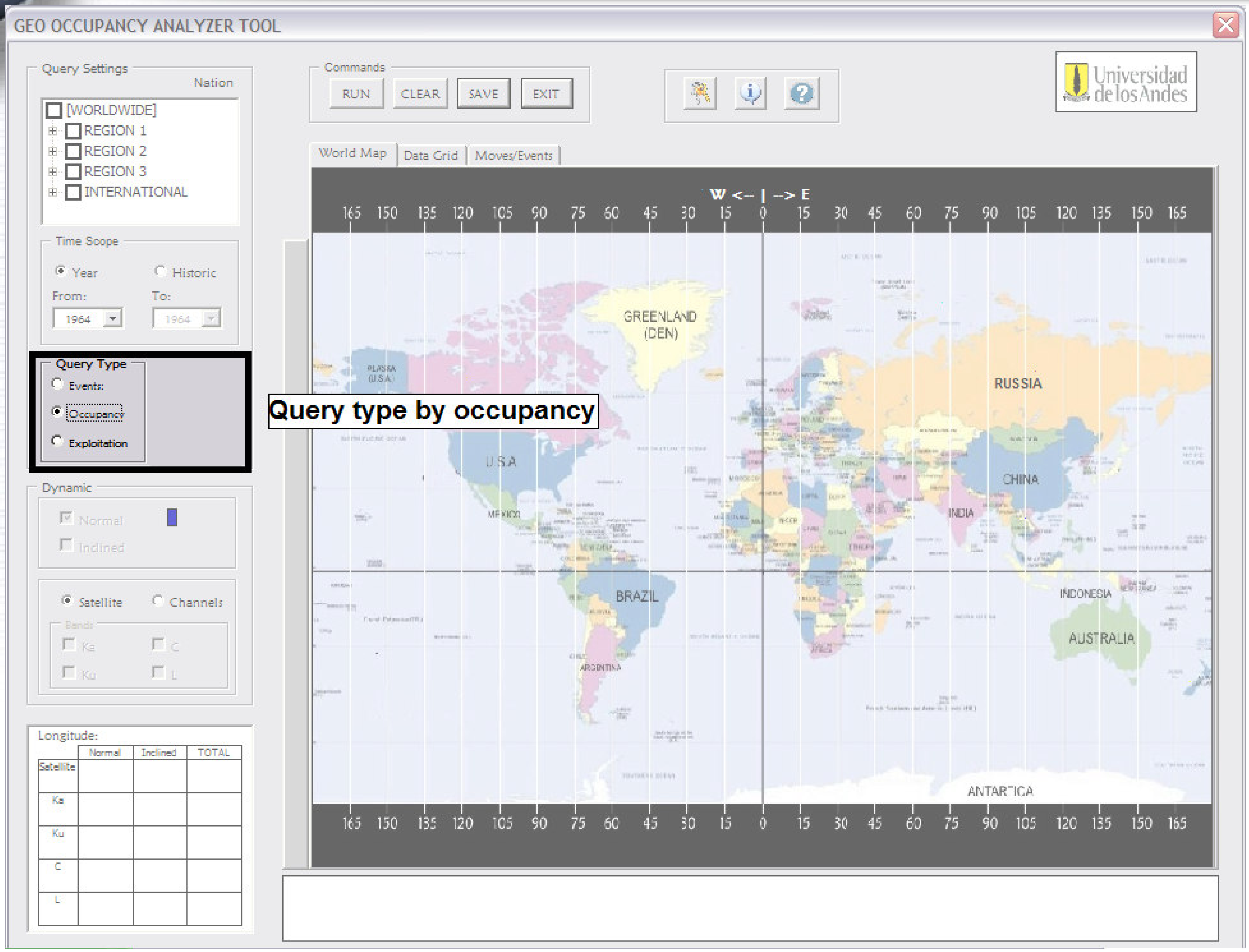

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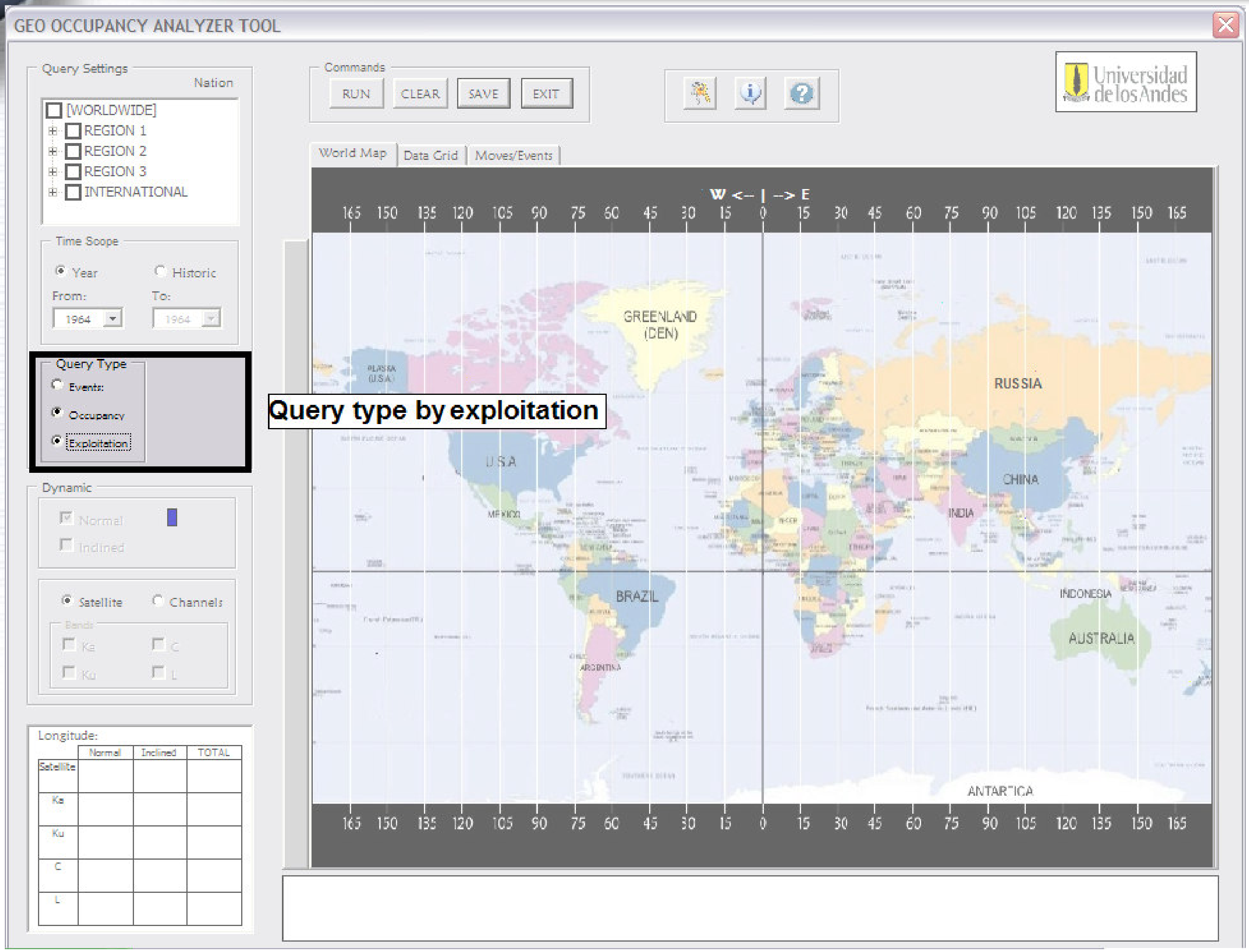

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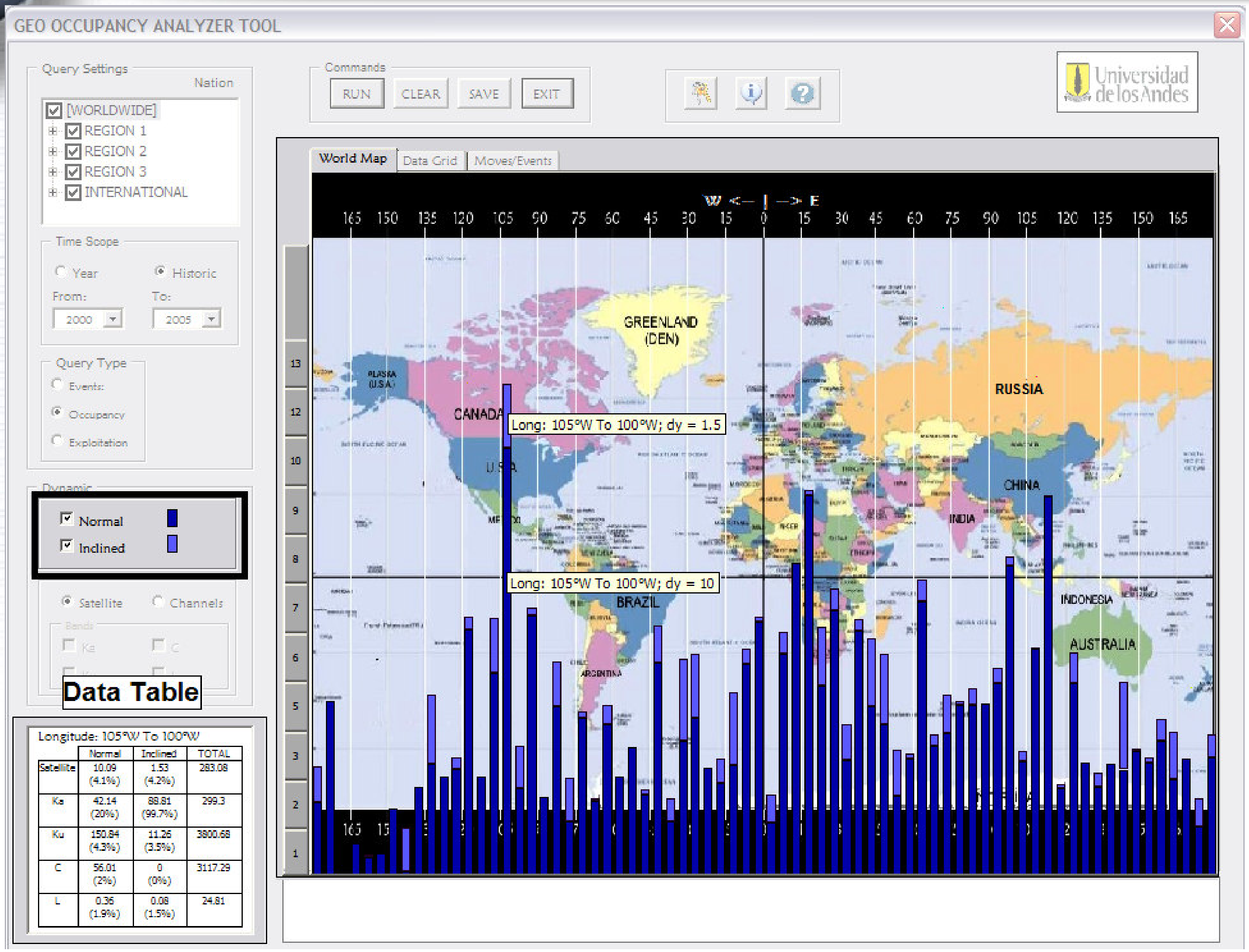
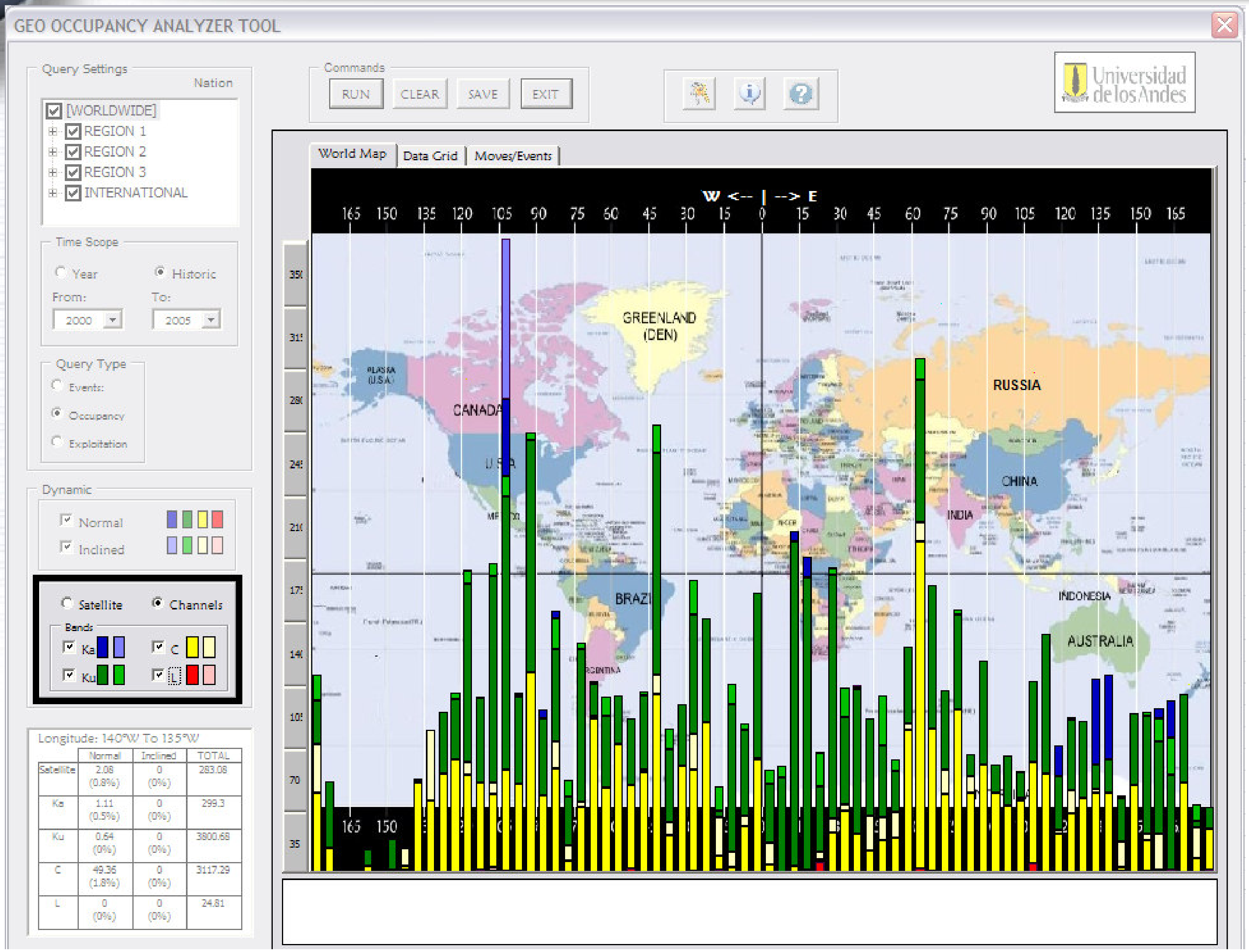
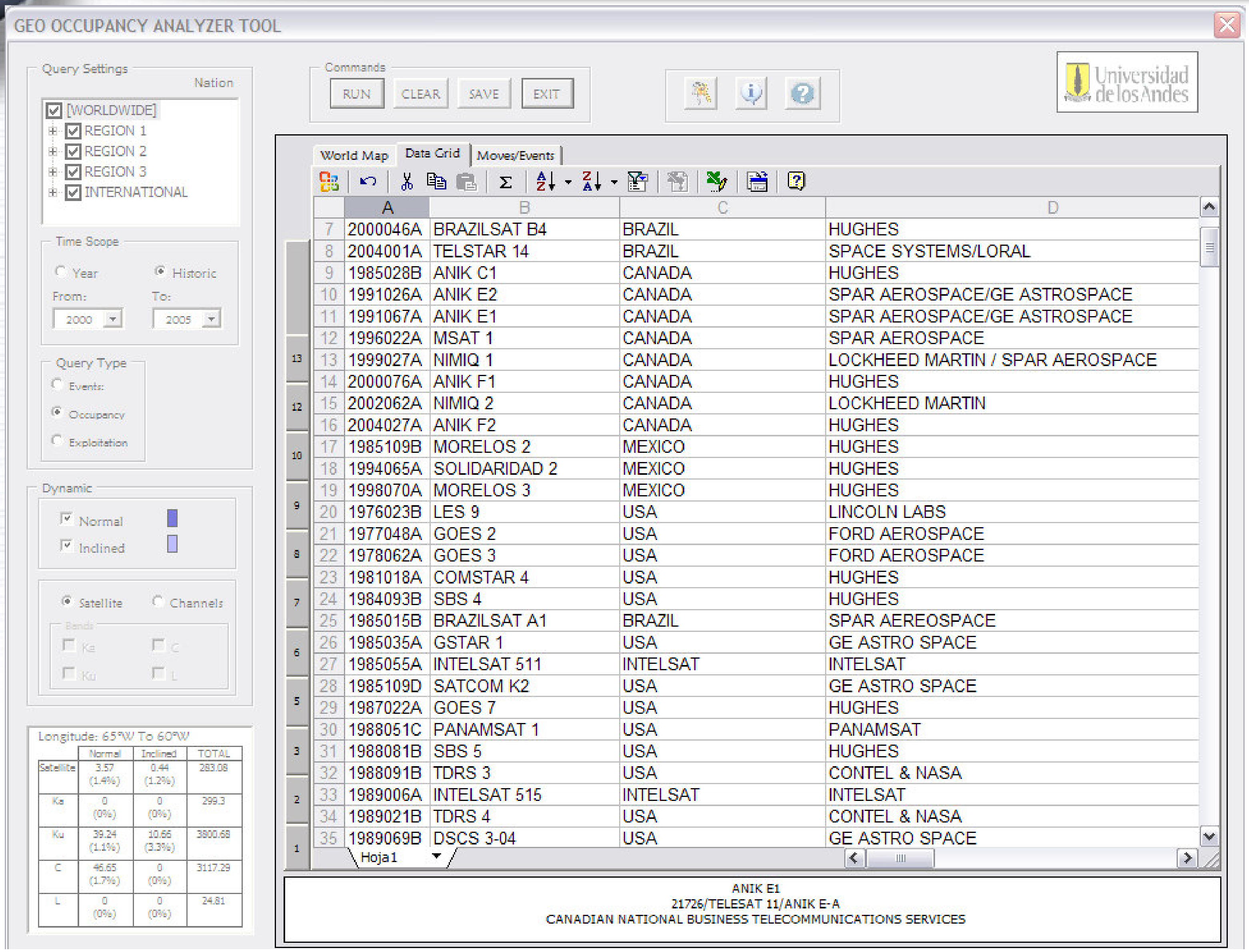


	Normal	Inclined	TOTAL
Satellite	10.09 (4.1%)	1.53 (4.2%)	283.08
Ka	42.14 (20%)	88.81 (99.7%)	299.3
Ku	150.84 (4.3%)	11.26 (3.5%)	3800.68
C	56.01 (2%)	0 (0%)	3117.29
L	0.36 (1.9%)	0.08 (1.5%)	24.81

HOW DOES IT WORK?



HOW DOES IT WORK?

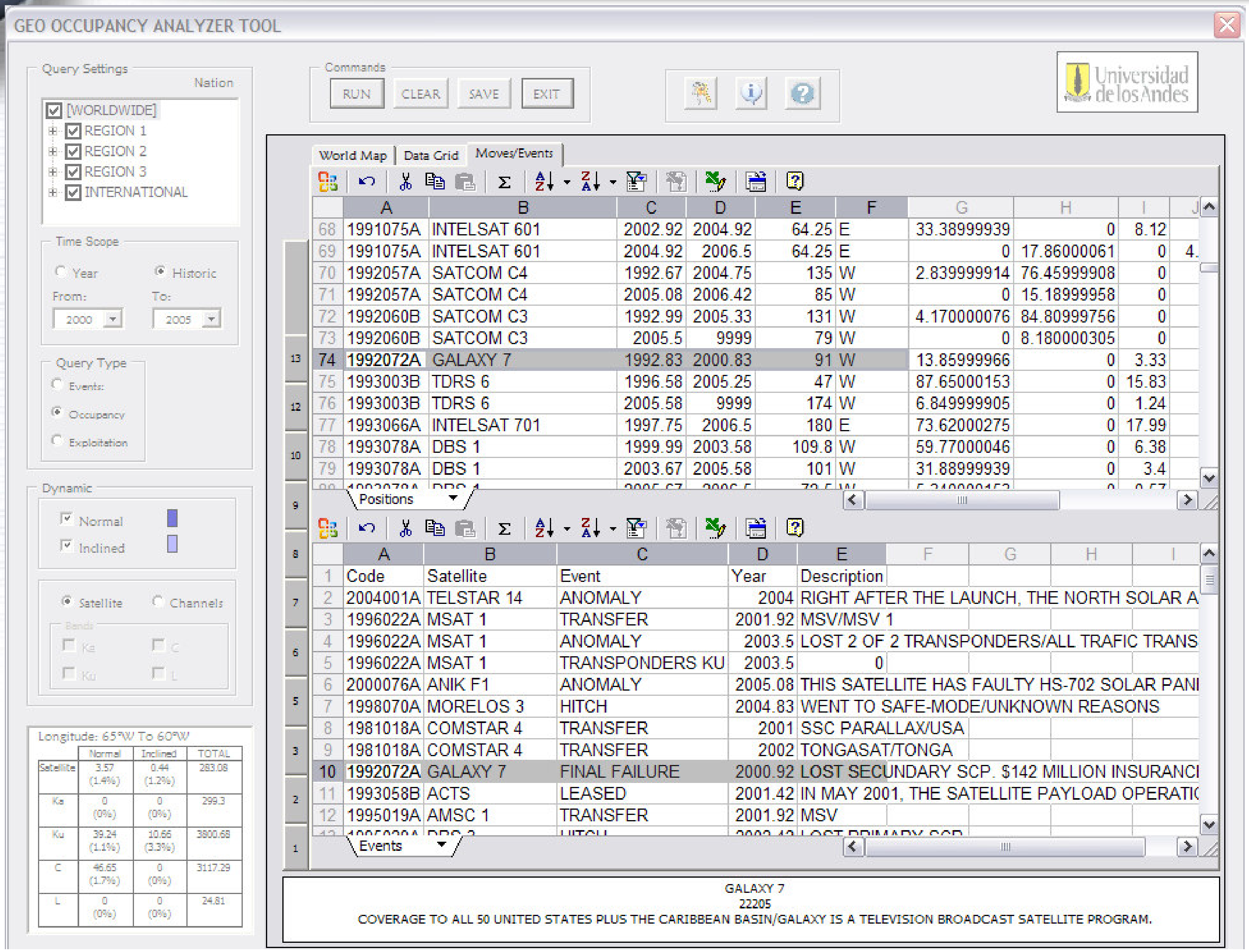


Longitude: 65°W To 60°W

	Normal	Inclined	TOTAL
Satellite	3.57 (1.4%)	0.44 (1.2%)	283.08
Ka	0 (0%)	0 (0%)	299.3
Ku	39.24 (1.1%)	10.66 (3.3%)	3800.68
C	46.65 (1.7%)	0 (0%)	3117.29
L	0 (0%)	0 (0%)	24.81

	A	B	C	D
7	2000046A	BRAZILSAT B4	BRAZIL	HUGHES
8	2004001A	TELSTAR 14	BRAZIL	SPACE SYSTEMS/LORAL
9	1985028B	ANIK C1	CANADA	HUGHES
10	1991026A	ANIK E2	CANADA	SPAR AEROSPACE/GE ASTROSPACE
11	1991067A	ANIK E1	CANADA	SPAR AEROSPACE/GE ASTROSPACE
12	1996022A	MSAT 1	CANADA	SPAR AEROSPACE
13	1999027A	NIMIQ 1	CANADA	LOCKHEED MARTIN / SPAR AEROSPACE
14	2000076A	ANIK F1	CANADA	HUGHES
15	2002062A	NIMIQ 2	CANADA	LOCKHEED MARTIN
16	2004027A	ANIK F2	CANADA	HUGHES
17	1985109B	MORELOS 2	MEXICO	HUGHES
18	1994065A	SOLIDARIDAD 2	MEXICO	HUGHES
19	1998070A	MORELOS 3	MEXICO	HUGHES
20	1976023B	LES 9	USA	LINCOLN LABS
21	1977048A	GOES 2	USA	FORD AEROSPACE
22	1978062A	GOES 3	USA	FORD AEROSPACE
23	1981018A	COMSTAR 4	USA	HUGHES
24	1984093B	SBS 4	USA	HUGHES
25	1985015B	BRAZILSAT A1	BRAZIL	SPAR AEREOSPACE
26	1985035A	GSTAR 1	USA	GE ASTRO SPACE
27	1985055A	INTELSAT 511	INTELSAT	INTELSAT
28	1985109D	SATCOM K2	USA	GE ASTRO SPACE
29	1987022A	GOES 7	USA	HUGHES
30	1988051C	PANAMSAT 1	USA	PANAMSAT
31	1988081B	SBS 5	USA	HUGHES
32	1988091B	TDRS 3	USA	CONTEL & NASA
33	1989006A	INTELSAT 515	INTELSAT	INTELSAT
34	1989021B	TDRS 4	USA	CONTEL & NASA
35	1989069B	DSCS 3-04	USA	GE ASTRO SPACE

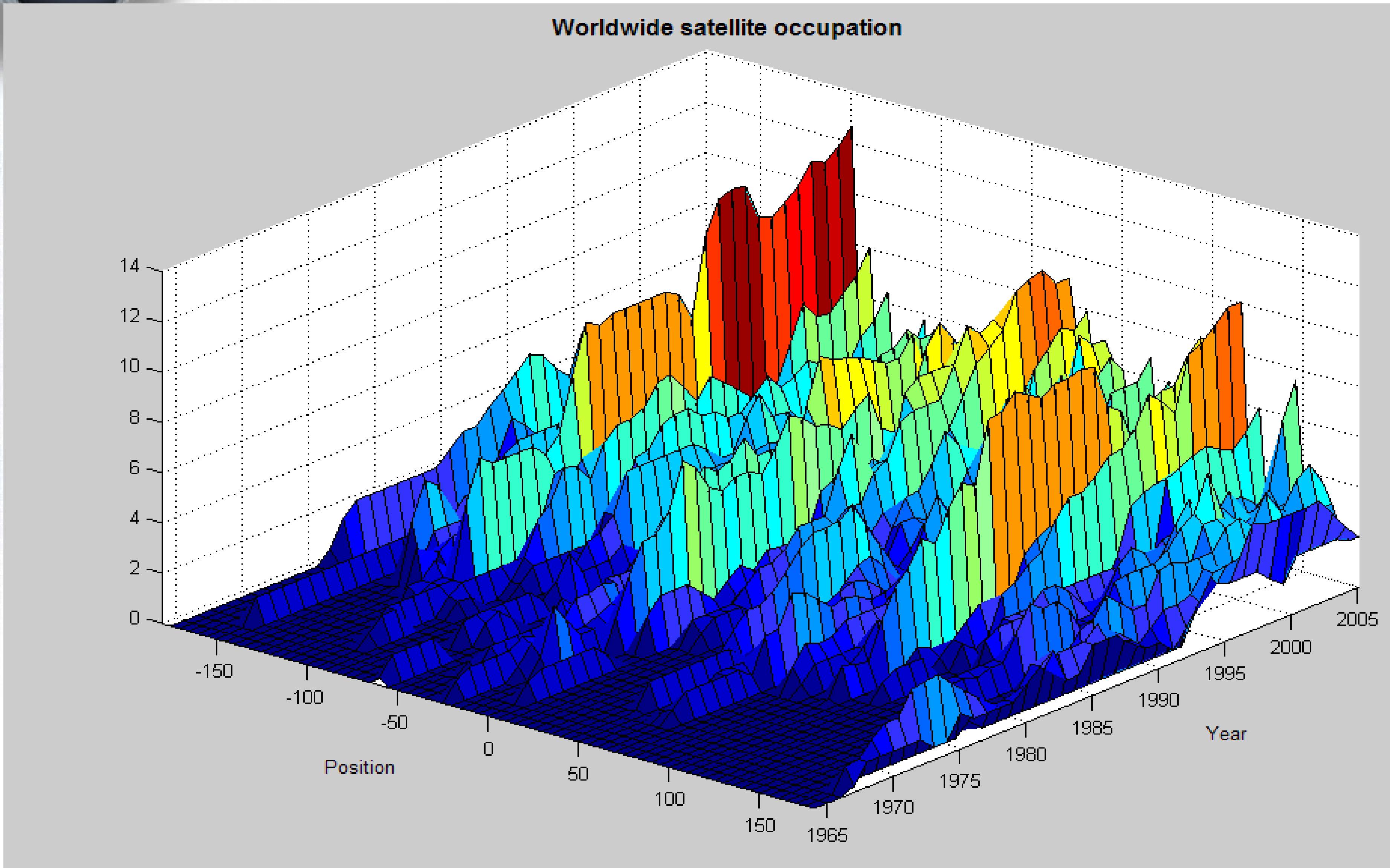
HOW DOES IT WORK?



QUERY CONTROLS DESCRIPTION

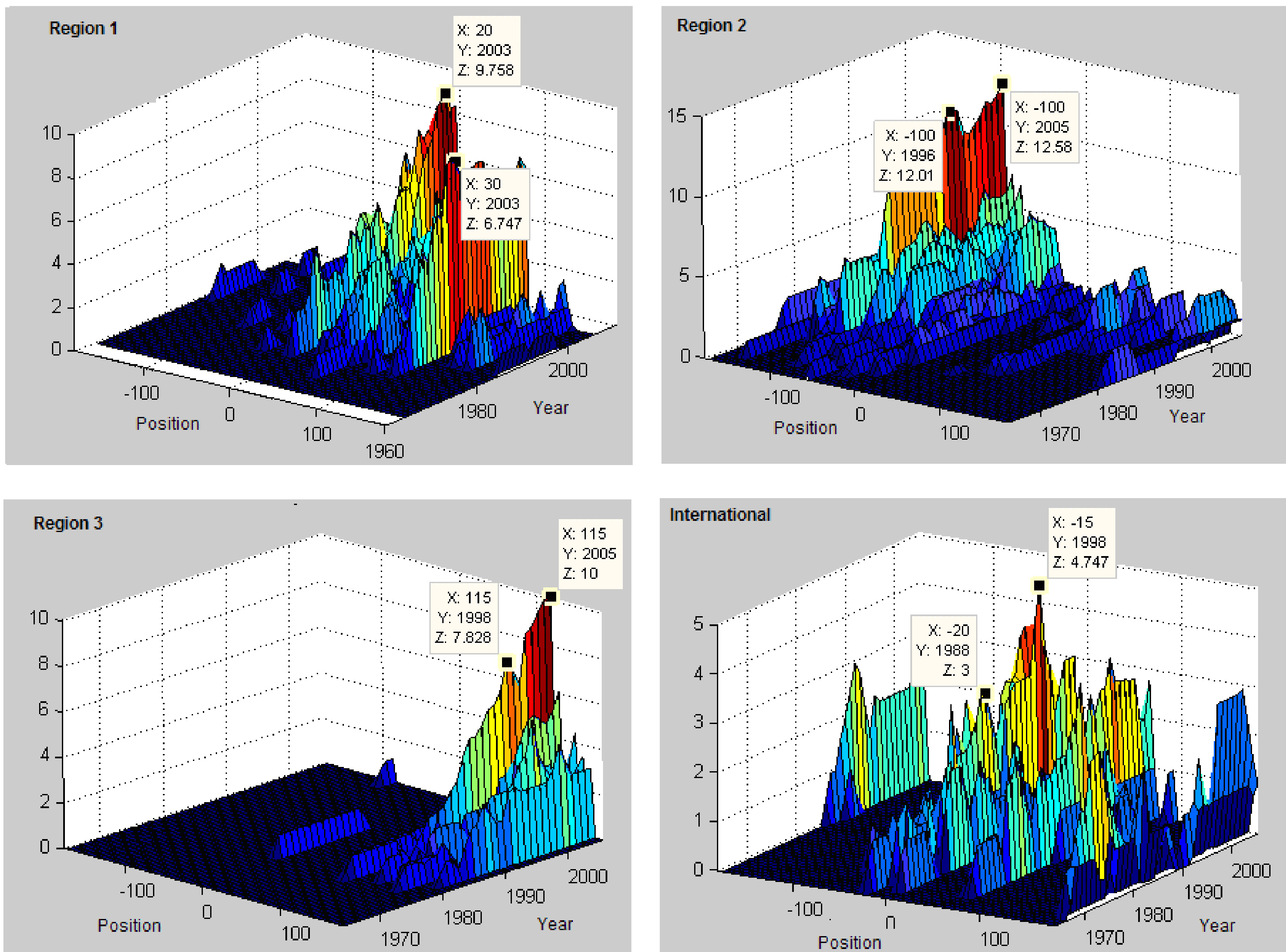
Query Settings	
Nation	Allows to choose the country or countries for analyze
Time scope	Select a particular year or a range of years
Query type	•Events: launched, inclined or retired •Occupancy •Exploitation
Dynamic Settings	
Status	Operative or inclined
Query type	•Search by satellites or by channels (C, Ku, Ka, L bands)

RESULTS


Worldwide satellite occupation
14
12
10
8
6
4
2
0
-150
-100
-50
0
50
100
150
Position
1965
1970
1975
1980
1985
1990
1995
2000
2005
Year

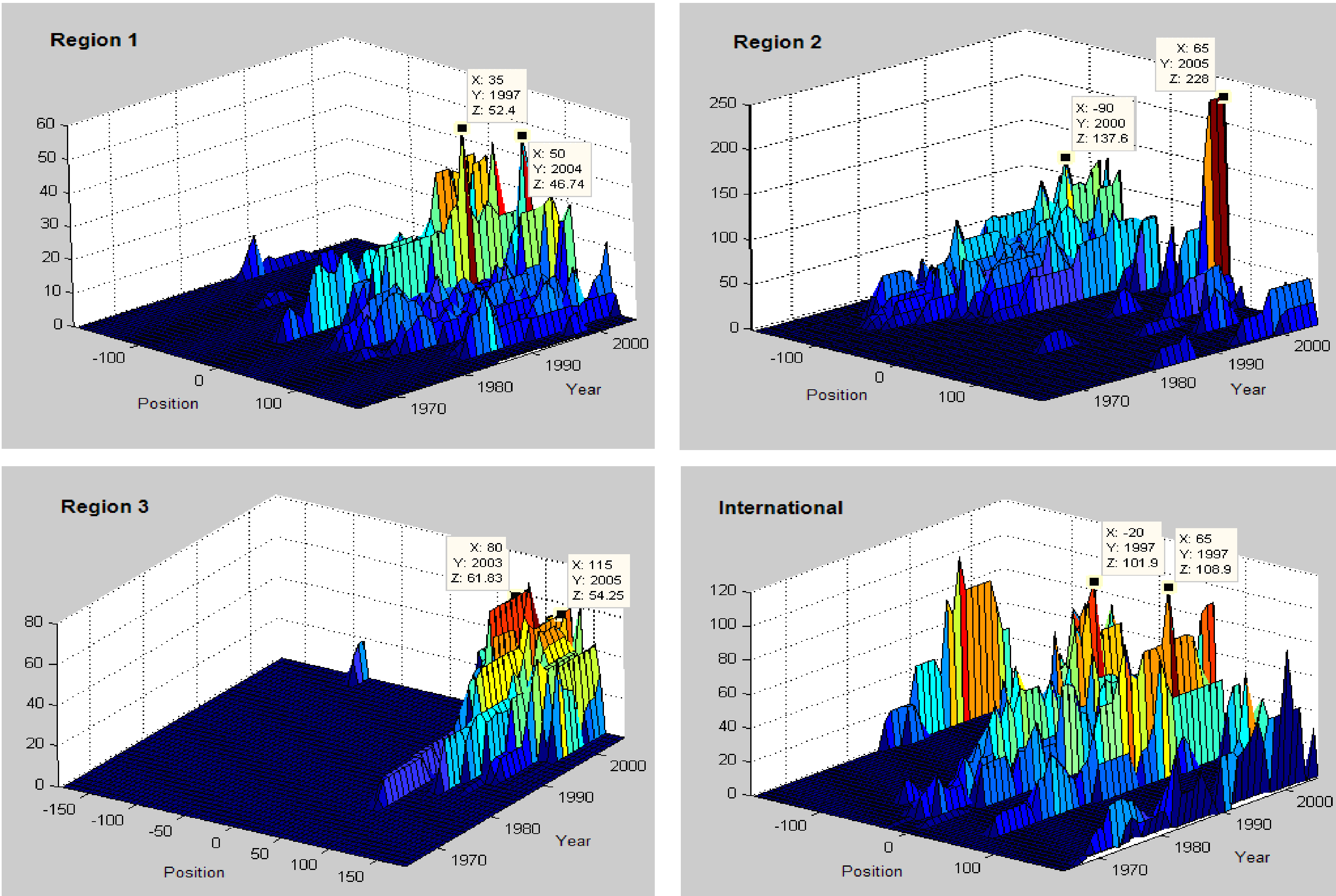
RESULTS

Historical occupation by satellites and regions



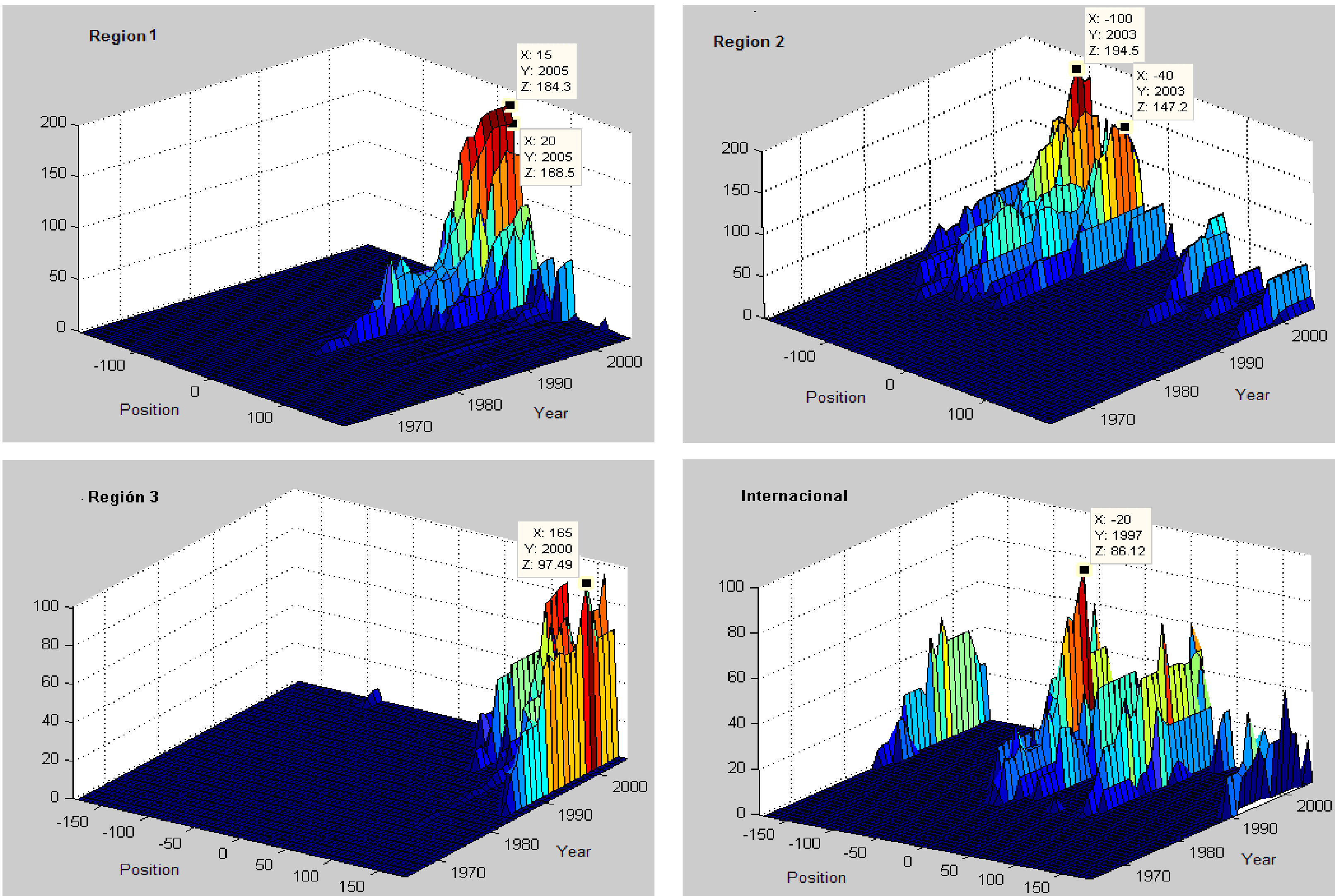
RESULTS

Historical occupation by transponders and regions - C band



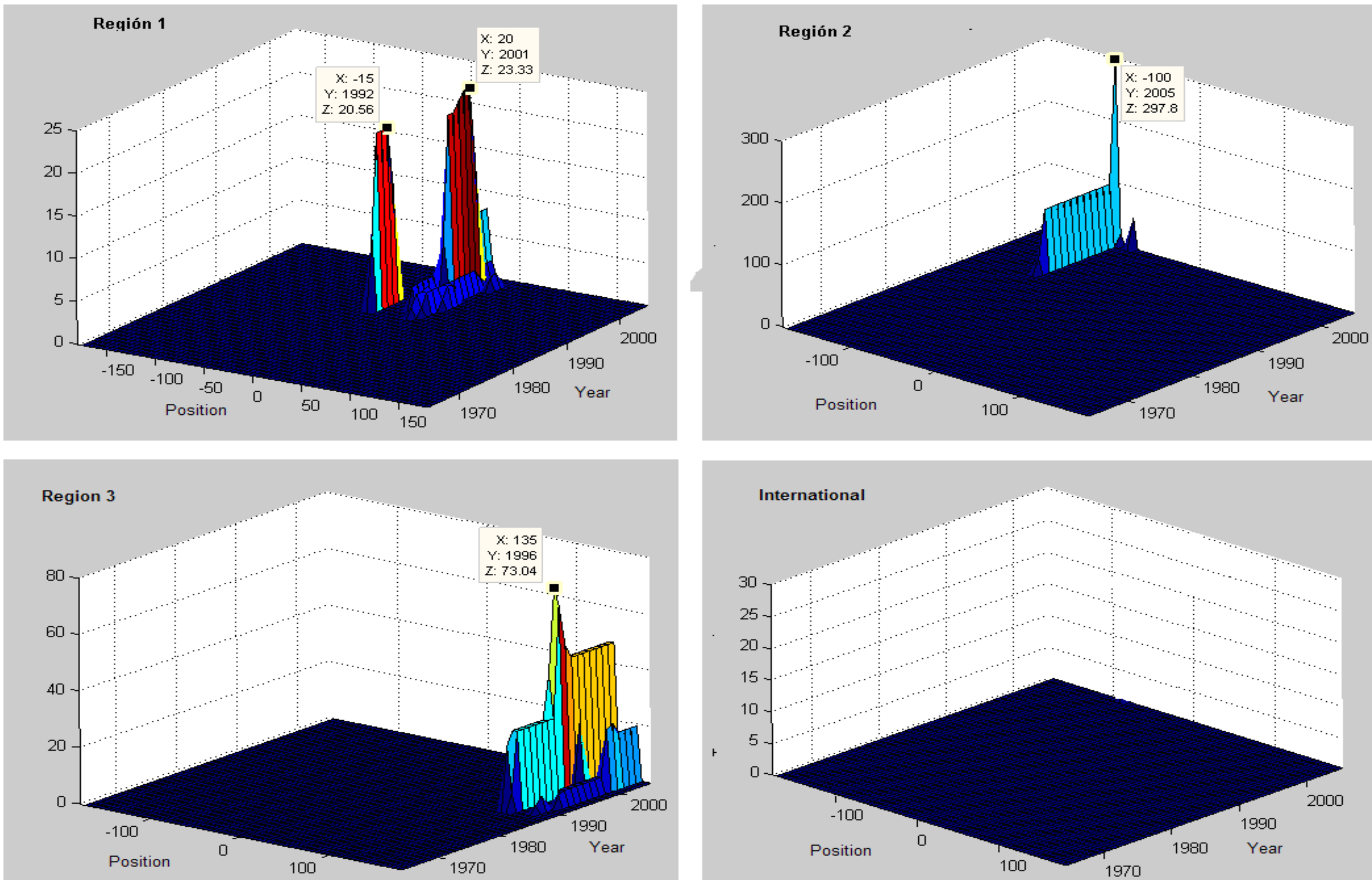
RESULTS

Historical occupation by transponders and by regions - Ku band

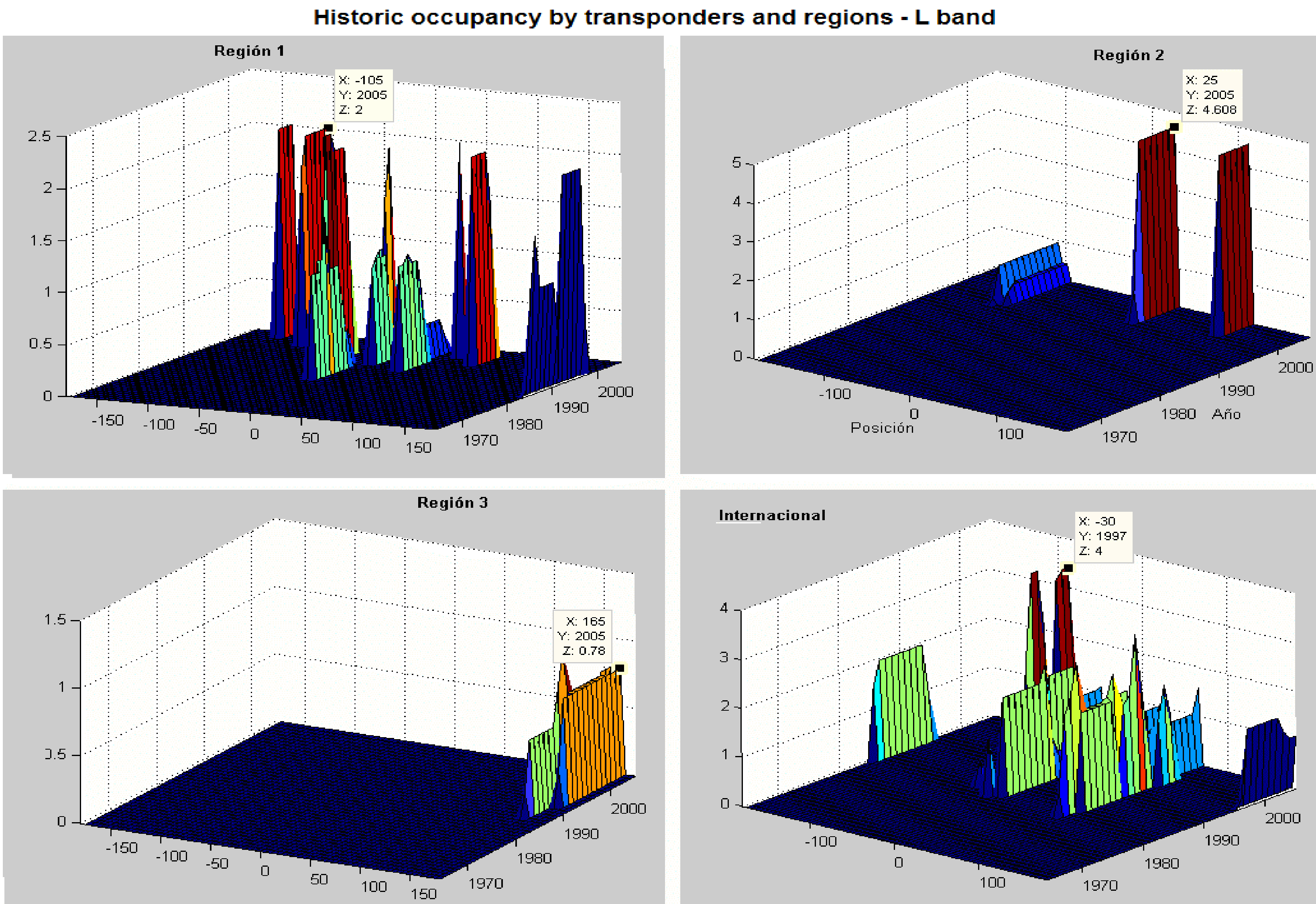


RESULTS

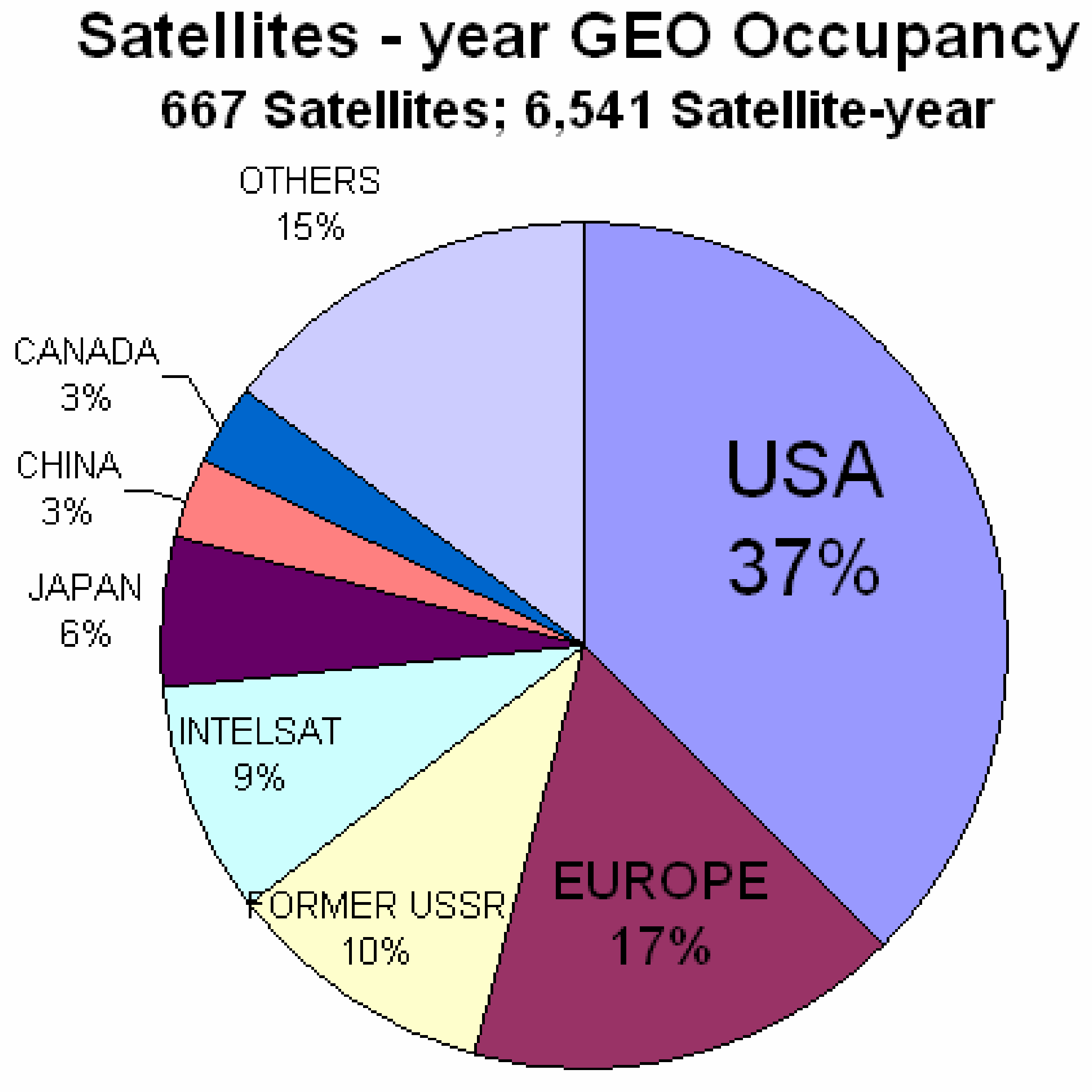
Historic occupation by transponders and regions - Ka band



RESULTS

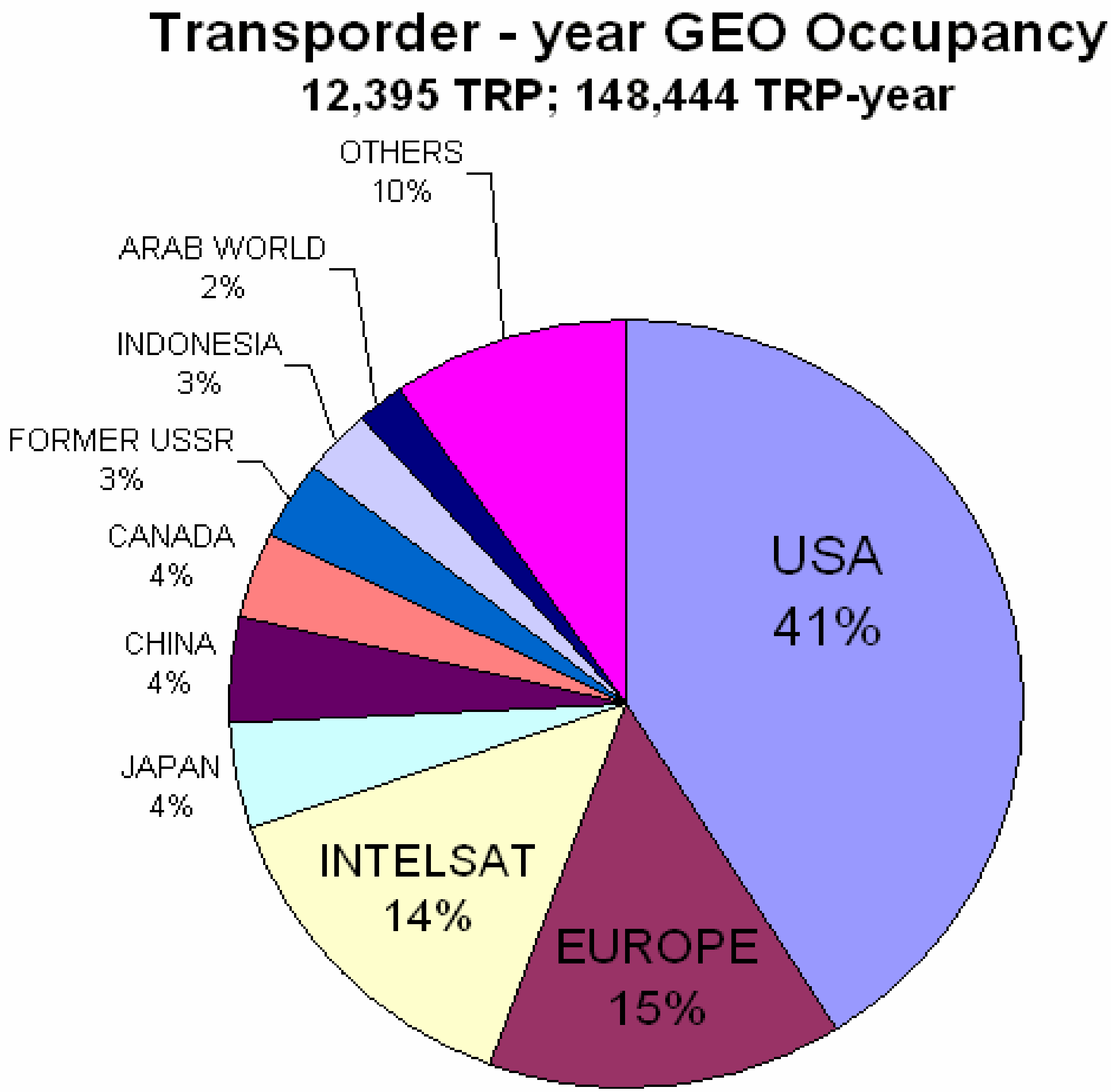

Historic occupancy by transponders and regions - L band
Región 1
X: -105
Y: 2005
Z: 2
Región 2
X: 25
Y: 2005
Z: 4.608
Posición
Año
Región 3
X: 165
Y: 2005
Z: 0.78
Internacional
X: -30
Y: 1997
Z: 4

RESULTS



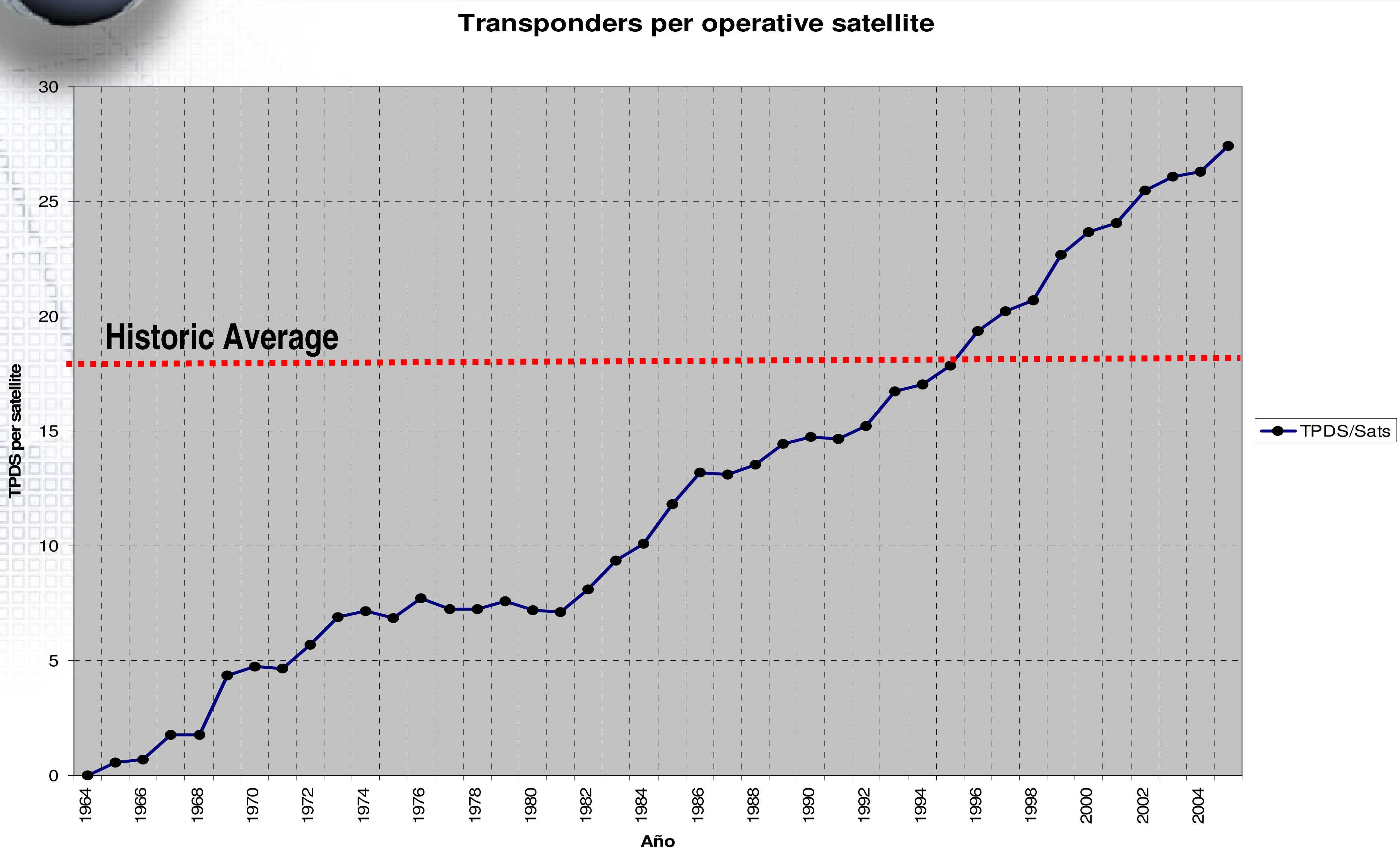
Observation Period	August 1964 – December 2005
Number of satellites	667
Satellite – year	$\sum$ Satellites x life time
Total satellites - year	6,540.8
Average Satellite Lifetime	9.81 years

RESULTS



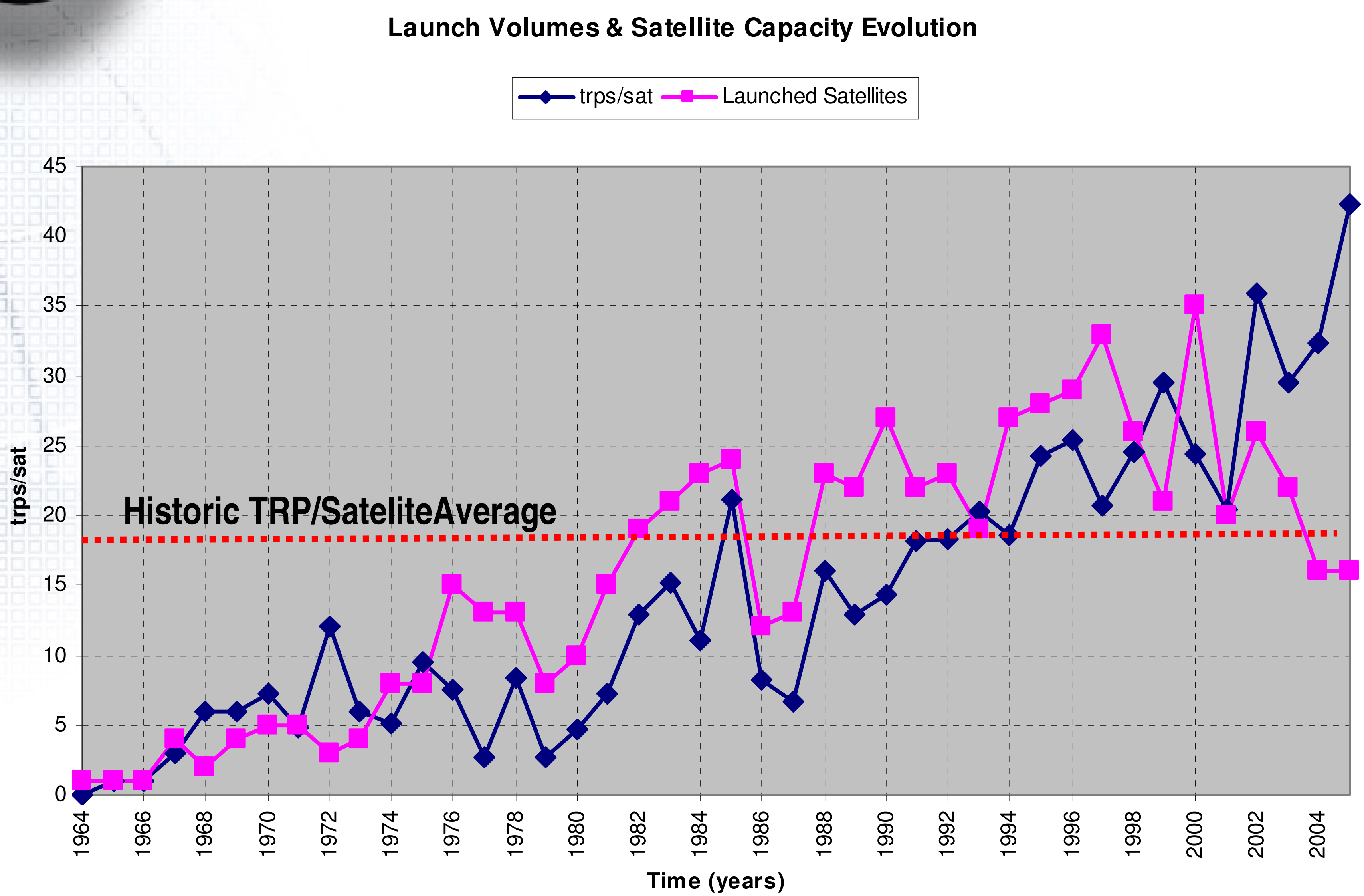
Observation Period	August 1964 – December 2005
Number of TRP	12,394.17
TRP – year	∑Transponders x life time
Total TRP-year	148,444.3
Average Satellite Size	18.58 eTRP

RESULTS



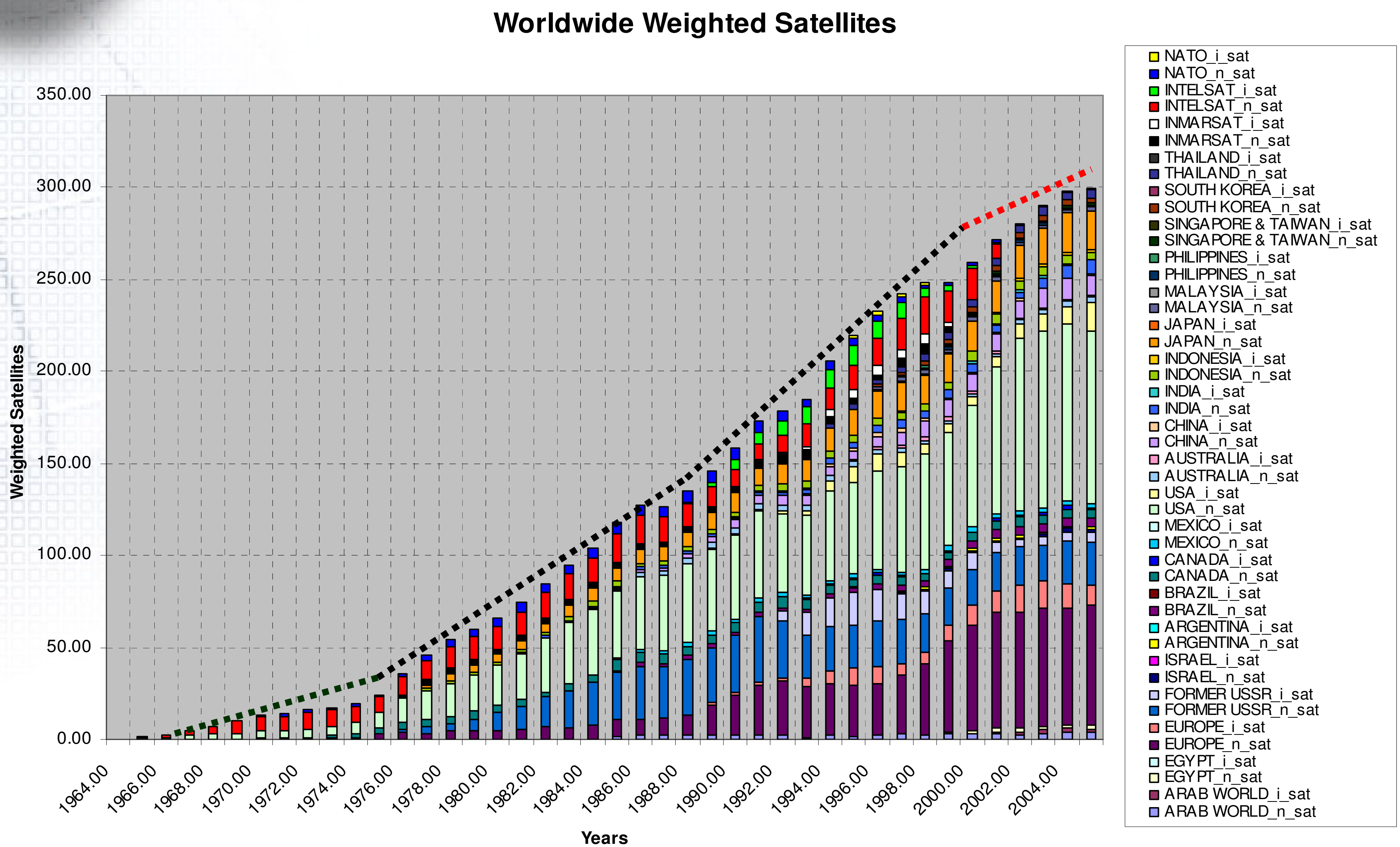
Transponders per operative satellite
TPDS per satellite
Historic Average
Año
TPDS/Sats
0
5
10
15
20
25
30
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004

RESULTS



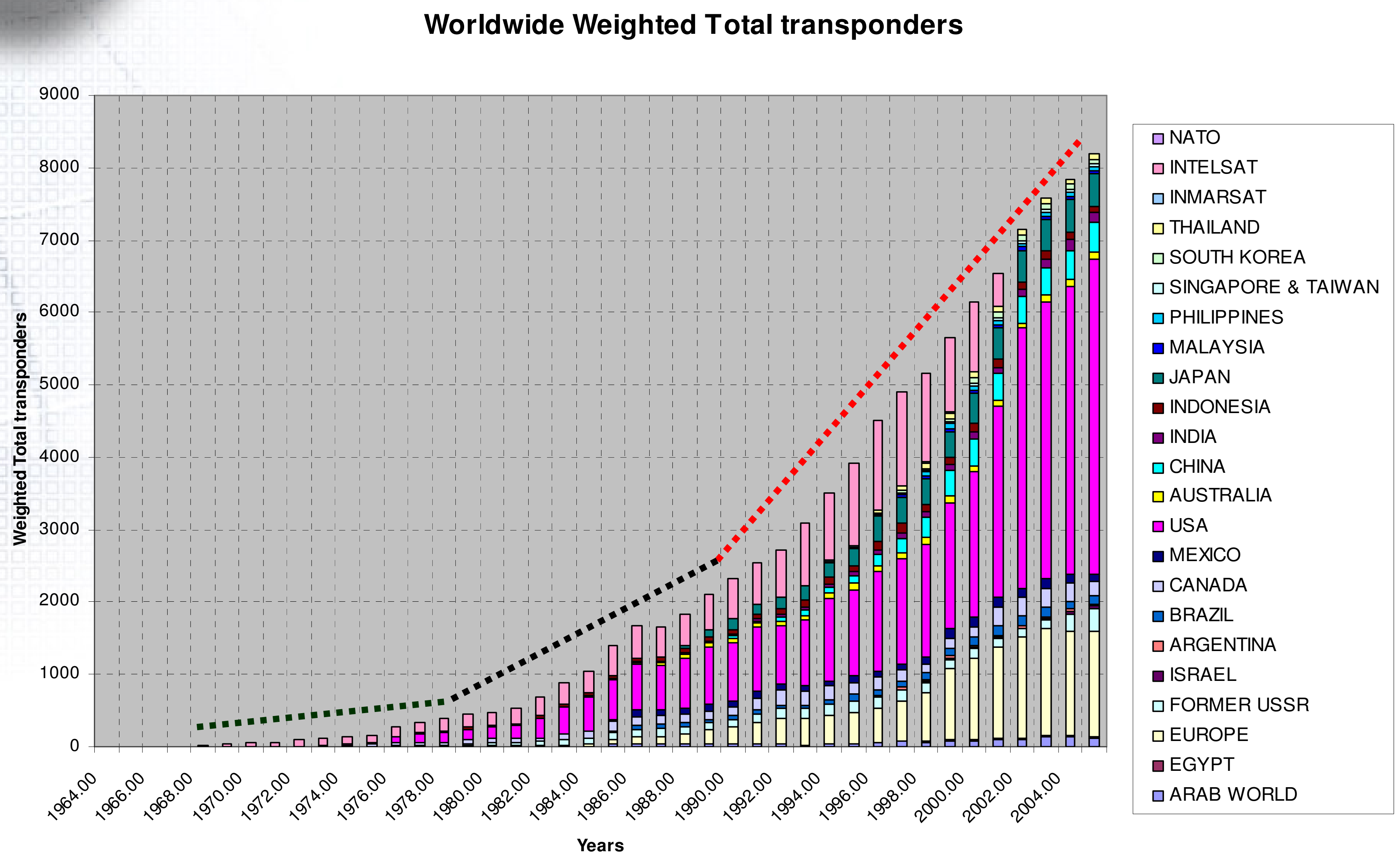
Launch Volumes & Satellite Capacity Evolution
trps/sat
Launched Satellites
Historic TRP/SateliteAverage
trps/sat
0
5
10
15
20
25
30
35
40
45
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
Time (years)

RESULTS



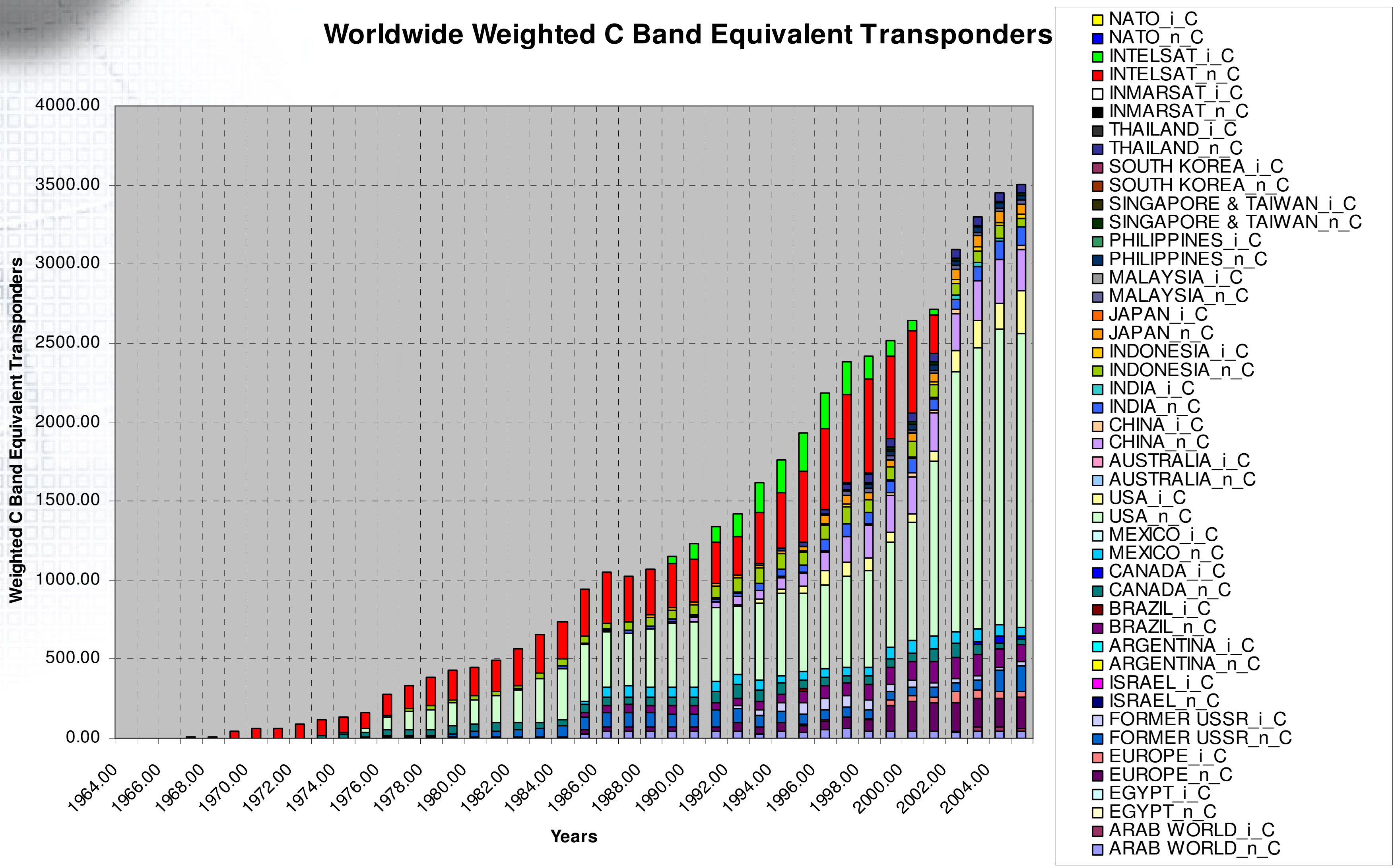
Worldwide Weighted Satellites
Weighted Satellites
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
1964.00
1966.00
1968.00
1970.00
1972.00
1974.00
1976.00
1978.00
1980.00
1982.00
1984.00
1986.00
1988.00
1990.00
1992.00
1994.00
1996.00
1998.00
2000.00
2002.00
2004.00
Years
NATO_i_sat
NATO_n_sat
INTELSAT_i_sat
INTELSAT_n_sat
INMARSAT_i_sat
INMARSAT_n_sat
THAILAND_i_sat
THAILAND_n_sat
SOUTH KOREA_i_sat
SOUTH KOREA_n_sat
SINGAPORE & TAIWAN_i_sat
SINGAPORE & TAIWAN_n_sat
PHILIPPINES_i_sat
PHILIPPINES_n_sat
MALAYSIA_i_sat
MALAYSIA_n_sat
JAPAN_i_sat
JAPAN_n_sat
INDONESIA_i_sat
INDONESIA_n_sat
INDIA_i_sat
INDIA_n_sat
CHINA_i_sat
CHINA_n_sat
AUSTRALIA_i_sat
AUSTRALIA_n_sat
USA_i_sat
USA_n_sat
MEXICO_i_sat
MEXICO_n_sat
CANADA_i_sat
CANADA_n_sat
BRAZIL_i_sat
BRAZIL_n_sat
ARGENTINA_i_sat
ARGENTINA_n_sat
ISRAEL_i_sat
ISRAEL_n_sat
FORMER USSR_i_sat
FORMER USSR_n_sat
EUROPE_i_sat
EUROPE_n_sat
EGYPT_i_sat
EGYPT_n_sat
ARAB WORLD_i_sat
ARAB WORLD_n_sat

RESULTS



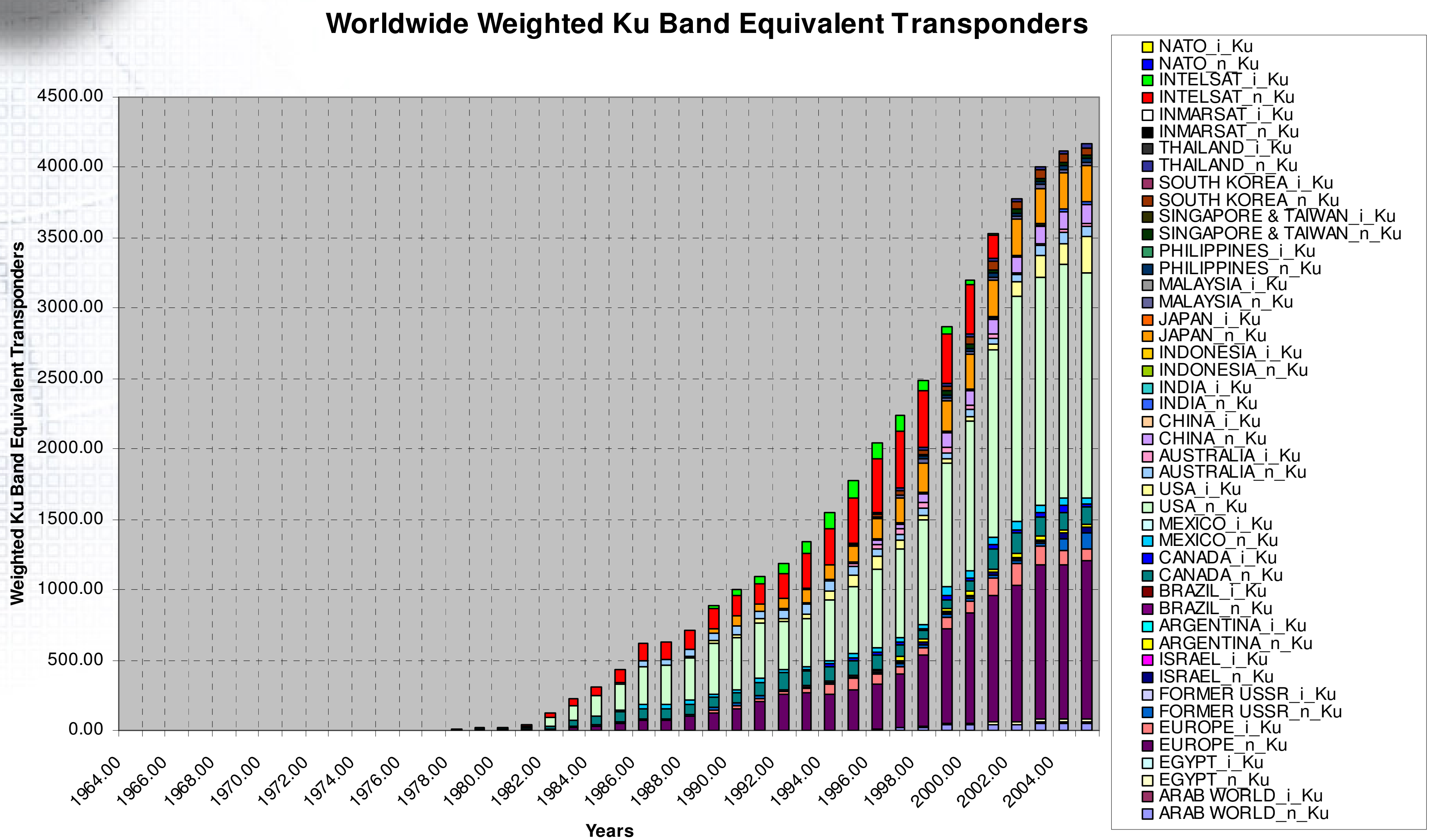
Worldwide Weighted Total transponders
Weighted Total transponders
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
1964.00
1966.00
1968.00
1970.00
1972.00
1974.00
1976.00
1978.00
1980.00
1982.00
1984.00
1986.00
1988.00
1990.00
1992.00
1994.00
1996.00
1998.00
2000.00
2002.00
2004.00
Years
NATO
INTELSAT
INMARSAT
THAILAND
SOUTH KOREA
SINGAPORE & TAIWAN
PHILIPPINES
MALAYSIA
JAPAN
INDONESIA
INDIA
CHINA
AUSTRALIA
USA
MEXICO
CANADA
BRAZIL
ARGENTINA
ISRAEL
FORMER USSR
EUROPE
EGYPT
ARAB WORLD

RESULTS



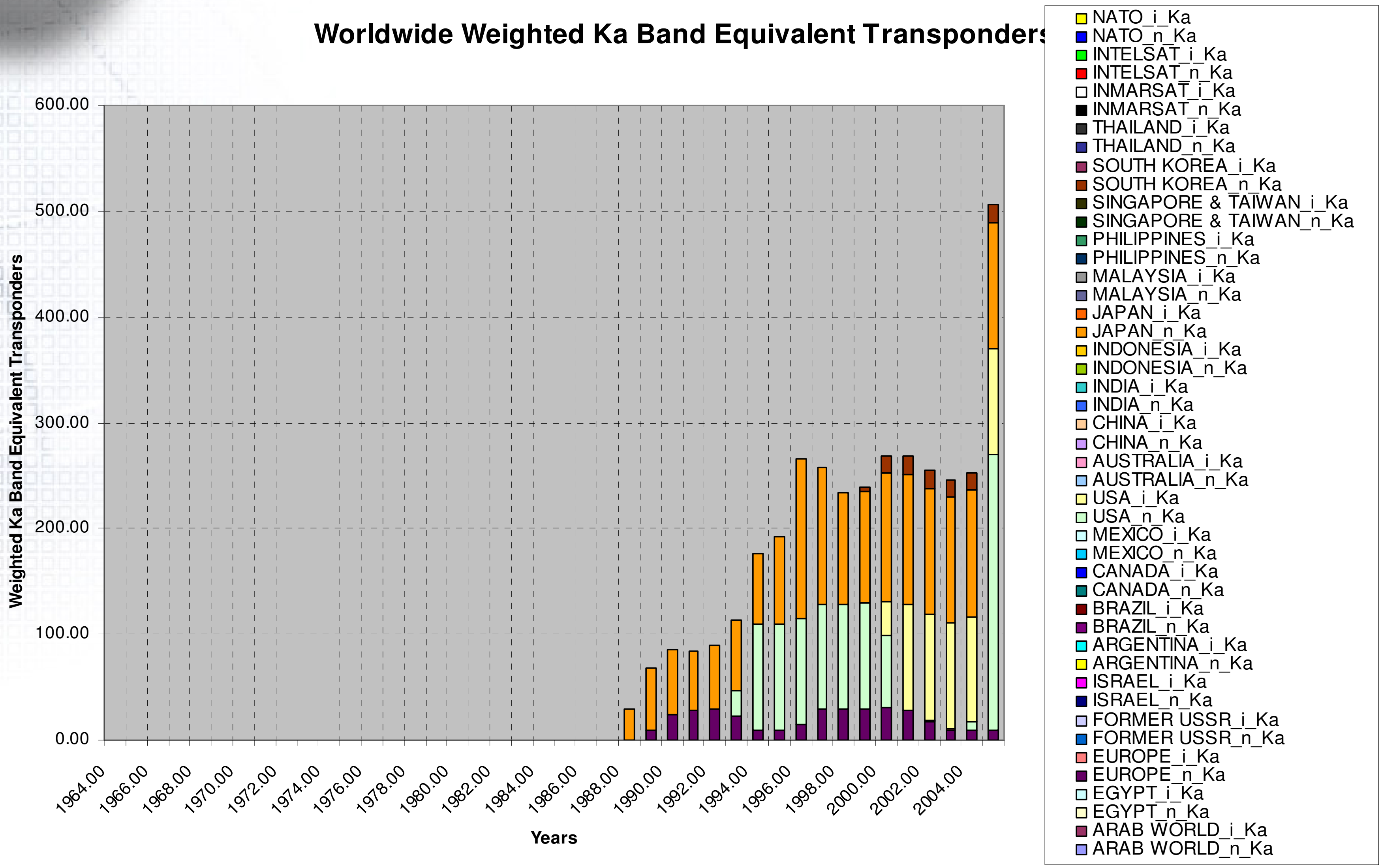
Worldwide Weighted C Band Equivalent Transponders
Weighted C Band Equivalent Transponders
4000.00
3500.00
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
1964.00
1966.00
1968.00
1970.00
1972.00
1974.00
1976.00
1978.00
1980.00
1982.00
1984.00
1986.00
1988.00
1990.00
1992.00
1994.00
1996.00
1998.00
2000.00
2002.00
2004.00
Years
NATO_i_C
NATO_n_C
INTELSAT_i_C
INTELSAT_n_C
INMARSAT_i_C
INMARSAT_n_C
THAILAND_i_C
THAILAND_n_C
SOUTH KOREA_i_C
SOUTH KOREA_n_C
SINGAPORE & TAIWAN_i_C
SINGAPORE & TAIWAN_n_C
PHILIPPINES_i_C
PHILIPPINES_n_C
MALAYSIA_i_C
MALAYSIA_n_C
JAPAN_i_C
JAPAN_n_C
INDONESIA_i_C
INDONESIA_n_C
INDIA_i_C
INDIA_n_C
CHINA_i_C
CHINA_n_C
AUSTRALIA_i_C
AUSTRALIA_n_C
USA_i_C
USA_n_C
MEXICO_i_C
MEXICO_n_C
CANADA_i_C
CANADA_n_C
BRAZIL_i_C
BRAZIL_n_C
ARGENTINA_i_C
ARGENTINA_n_C
ISRAEL_i_C
ISRAEL_n_C
FORMER USSR_i_C
FORMER USSR_n_C
EUROPE_i_C
EUROPE_n_C
EGYPT_i_C
EGYPT_n_C
ARAB WORLD_i_C
ARAB WORLD_n_C

RESULTS



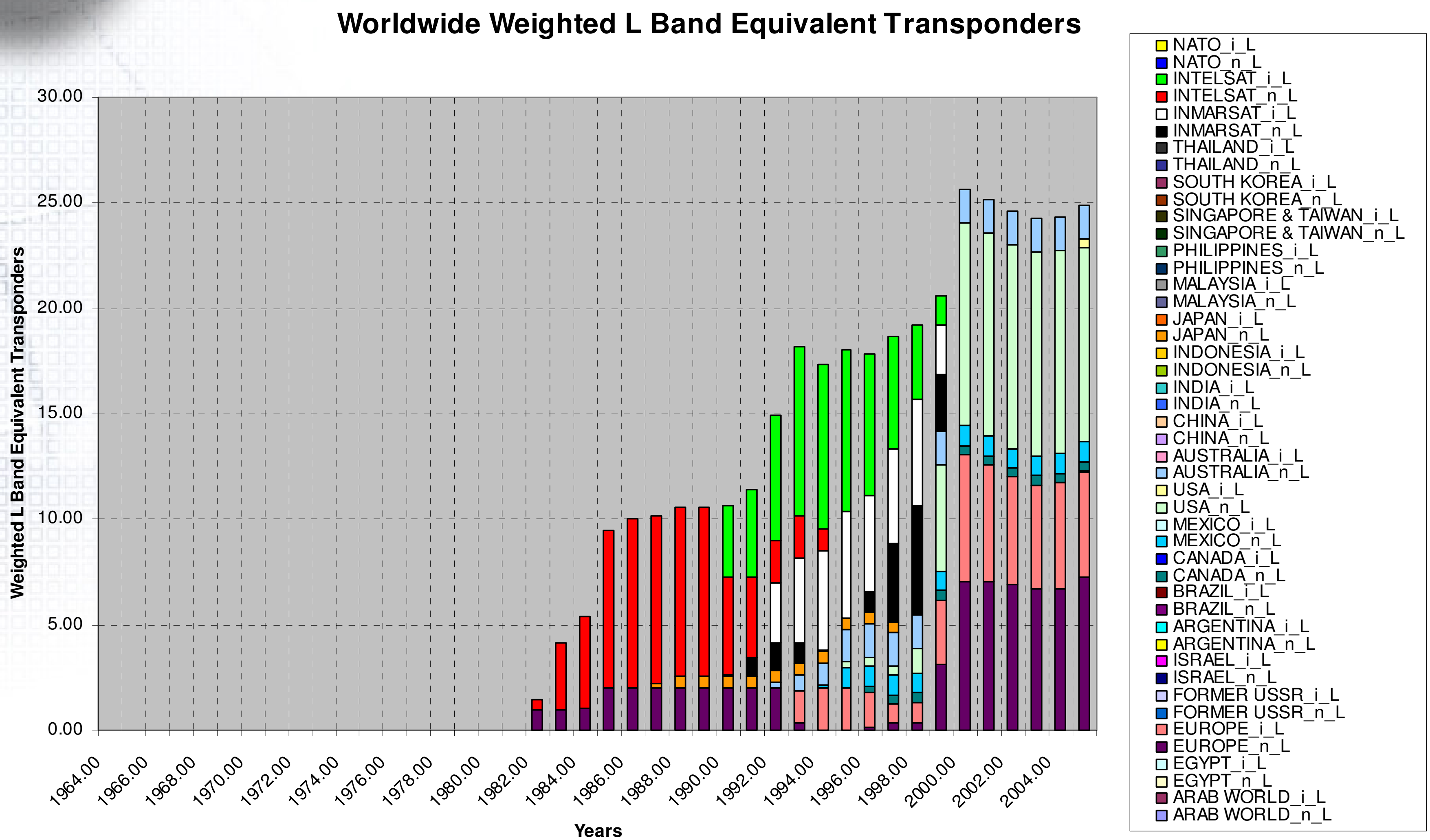
Worldwide Weighted Ku Band Equivalent Transponders
Weighted Ku Band Equivalent Transponders
4500.00
4000.00
3500.00
3000.00
2500.00
2000.00
1500.00
1000.00
500.00
0.00
1964.00
1966.00
1968.00
1970.00
1972.00
1974.00
1976.00
1978.00
1980.00
1982.00
1984.00
1986.00
1988.00
1990.00
1992.00
1994.00
1996.00
1998.00
2000.00
2002.00
2004.00
Years
NATO_i_Ku
NATO_n_Ku
INTELSAT_i_Ku
INTELSAT_n_Ku
INMARSAT_i_Ku
INMARSAT_n_Ku
THAILAND_i_Ku
THAILAND_n_Ku
SOUTH KOREA_i_Ku
SOUTH KOREA_n_Ku
SINGAPORE & TAIWAN_i_Ku
SINGAPORE & TAIWAN_n_Ku
PHILIPPINES_i_Ku
PHILIPPINES_n_Ku
MALAYSIA_i_Ku
MALAYSIA_n_Ku
JAPAN_i_Ku
JAPAN_n_Ku
INDONESIA_i_Ku
INDONESIA_n_Ku
INDIA_i_Ku
INDIA_n_Ku
CHINA_i_Ku
CHINA_n_Ku
AUSTRALIA_i_Ku
AUSTRALIA_n_Ku
USA_i_Ku
USA_n_Ku
MEXICO_i_Ku
MEXICO_n_Ku
CANADA_i_Ku
CANADA_n_Ku
BRAZIL_i_Ku
BRAZIL_n_Ku
ARGENTINA_i_Ku
ARGENTINA_n_Ku
ISRAEL_i_Ku
ISRAEL_n_Ku
FORMER USSR_i_Ku
FORMER USSR_n_Ku
EUROPE_i_Ku
EUROPE_n_Ku
EGYPT_i_Ku
EGYPT_n_Ku
ARAB WORLD_i_Ku
ARAB WORLD_n_Ku

RESULTS



Worldwide Weighted Ka Band Equivalent Transponders
Weighted Ka Band Equivalent Transponders
600.00
500.00
400.00
300.00
200.00
100.00
0.00
1964.00
1966.00
1968.00
1970.00
1972.00
1974.00
1976.00
1978.00
1980.00
1982.00
1984.00
1986.00
1988.00
1990.00
1992.00
1994.00
1996.00
1998.00
2000.00
2002.00
2004.00
Years
NATO_i_Ka
NATO_n_Ka
INTELSAT_i_Ka
INTELSAT_n_Ka
INMARSAT_i_Ka
INMARSAT_n_Ka
THAILAND_i_Ka
THAILAND_n_Ka
SOUTH KOREA_i_Ka
SOUTH KOREA_n_Ka
SINGAPORE & TAIWAN_i_Ka
SINGAPORE & TAIWAN_n_Ka
PHILIPPINES_i_Ka
PHILIPPINES_n_Ka
MALAYSIA_i_Ka
MALAYSIA_n_Ka
JAPAN_i_Ka
JAPAN_n_Ka
INDONESIA_i_Ka
INDONESIA_n_Ka
INDIA_i_Ka
INDIA_n_Ka
CHINA_i_Ka
CHINA_n_Ka
AUSTRALIA_i_Ka
AUSTRALIA_n_Ka
USA_i_Ka
USA_n_Ka
MEXICO_i_Ka
MEXICO_n_Ka
CANADA_i_Ka
CANADA_n_Ka
BRAZIL_i_Ka
BRAZIL_n_Ka
ARGENTINA_i_Ka
ARGENTINA_n_Ka
ISRAEL_i_Ka
ISRAEL_n_Ka
FORMER USSR_i_Ka
FORMER USSR_n_Ka
EUROPE_i_Ka
EUROPE_n_Ka
EGYPT_i_Ka
EGYPT_n_Ka
ARAB WORLD_i_Ka
ARAB WORLD_n_Ka

RESULTS


Worldwide Weighted L Band Equivalent Transponders
Weighted L Band Equivalent Transponders
30.00
25.00
20.00
15.00
10.00
5.00
0.00
1964.00
1966.00
1968.00
1970.00
1972.00
1974.00
1976.00
1978.00
1980.00
1982.00
1984.00
1986.00
1988.00
1990.00
1992.00
1994.00
1996.00
1998.00
2000.00
2002.00
2004.00
Years
NATO_i_L
NATO_n_L
INTELSAT_i_L
INTELSAT_n_L
INMARSAT_i_L
INMARSAT_n_L
THAILAND_i_L
THAILAND_n_L
SOUTH KOREA_i_L
SOUTH KOREA_n_L
SINGAPORE & TAIWAN_i_L
SINGAPORE & TAIWAN_n_L
PHILIPPINES_i_L
PHILIPPINES_n_L
MALAYSIA_i_L
MALAYSIA_n_L
JAPAN_i_L
JAPAN_n_L
INDONESIA_i_L
INDONESIA_n_L
INDIA_i_L
INDIA_n_L
CHINA_i_L
CHINA_n_L
AUSTRALIA_i_L
AUSTRALIA_n_L
USA_i_L
USA_n_L
MEXICO_i_L
MEXICO_n_L
CANADA_i_L
CANADA_n_L
BRAZIL_i_L
BRAZIL_n_L
ARGENTINA_i_L
ARGENTINA_n_L
ISRAEL_i_L
ISRAEL_n_L
FORMER USSR_i_L
FORMER USSR_n_L
EUROPE_i_L
EUROPE_n_L
EGYPT_i_L
EGYPT_n_L
ARAB WORLD_i_L
ARAB WORLD_n_L

CONCLUSIONS

- The Occupancy of the Orbit Spectrum Resource, OSR associated to the Geostationary Earth Orbit, GEO has been historically heterogeneous, concentrated in some privileged positions, related with the intended coverage area.
- There is a trend of larger satellites, in terms of TRP, with larger lifetime, which reduce the cadence of entering satellites, but increase significantly the consumption of ORS.
- GEO occupancy is directly related with the space fair capacity of nations, and in this regard, non fairy nations have very low or not presence in GEO Occupancy
- Use of different frequency Bands change by regions. The C Band is largely used in tropical regions, while temperate regions privilege the use of Ku Band which allows smaller earth antennas. Ka and L Bands occupancy is concentrated by very developed space fairing nations

THANK YOU..!

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