

Optimized and Integrated Management of Communications Satellite Transponders

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The management of communications satellite transponders (which in occasions may be shared by hundreds of carriers) while trying to optimize the on-board resources is major challenge for payload engineers. The activity also involves a close coordination with the sales team, in particular to support temporary satellite access. *smartHz*, which is part of the GMV's suite of products for payload operations, is a transponder optimization and frequency plan management tool, allowing communications satellite operators to maximize their space segment capacity in terms of power and bandwidth utilization. The tool features accurate models (for link budget and impairments analysis computations, including the non-linear behavior of transponder amplifiers) supporting various optimization algorithms for the computation of carrier powers in different occupancy scenarios (from a single carrier to hundreds of carriers) as well as the capability of easily simulating and working with different transponder occupancy scenarios in order to decide the best carrier allocation and transponder configuration. The tool graphically shows the transponder occupancy and relevant data, permitting the user to identify at a glance the available/consumed power and bandwidth or the zones with higher intermodulation interference inside the transponder band. From an architectural point of view, *smartHz* is based on J2EE web technology supporting a multi-user environment and access from any computer connected to the IP network and by other non-engineering teams. Taking advantage of the web architecture and multi-user support, different teams (P/L engineering team, the sales team) can share information and coordinate their work. The tool can be deployed either as a standalone tool (optionally along with an optional Capacity Management module) or be fully integrated with other payload related operational systems, such as a CSM system, a payload reconfiguration management tool, a satellite power management tool or a billing system.

I. Introduction

THE definition and management of frequency plans for communications satellites is a time consuming task which usually requires a team of specialized engineers, particularly when a significant portion of the satellite capacity is used by fixed services (such as VSAT networks) often involving a large number of carriers sharing the transponders.

Solutions are required that support, in addition to accurate link budget models and advanced optimization algorithms, a multi-user working environment and efficient information sharing mechanisms. Here it is worth mentioning that information needs to be shared not only among the engineering team members but also with other teams such as the company sales team or even with the external satellite end user technical team.

The optimization of frequency plans is a complex problem, often requiring performing iterations and simulations and that can only be addressed by combining:

- 1) A highly usable Graphical User Interface (GUI) taking advantage of the state-of-the-art GUI technologies delivering to the user the right information, the right amount of data, at the right place and moment.
- 2) Capability to perform simulations and support for working frequency plans (as opposed to the real active frequency plan containing the actual carriers being uplinked to the satellite).
- 3) Accurate models to compute the carrier link budgets and impairments affecting the signal.
- 4) Advanced optimization algorithms.

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This paper presents *smartHz*, a state-of-the-art web-based communications satellite frequency plan management COTS component, and how it addresses the above issues.

In the following sections, the main features of tool are summarized, paying particular attention to the GUI and usability aspects, engineering models and optimization algorithms. A description of the payload modeling process, the tool architecture and its integration capabilities is also provided.

II. Graphical User Interface - Usability Features

A. Graphical Occupancy Representation

The way the transponder occupancy is shown to the user is a key factor due to the large number of carriers that needs to be managed by a frequency transmission plan. *smartHz* provides a graphical representation of the transponder occupancy that helps the user to quickly localize the available bandwidth. The user can also filter the transponders to be visualized by selecting the payload band or panel, the uplink and/or the downlink beam the transponders to be displayed are connected to.

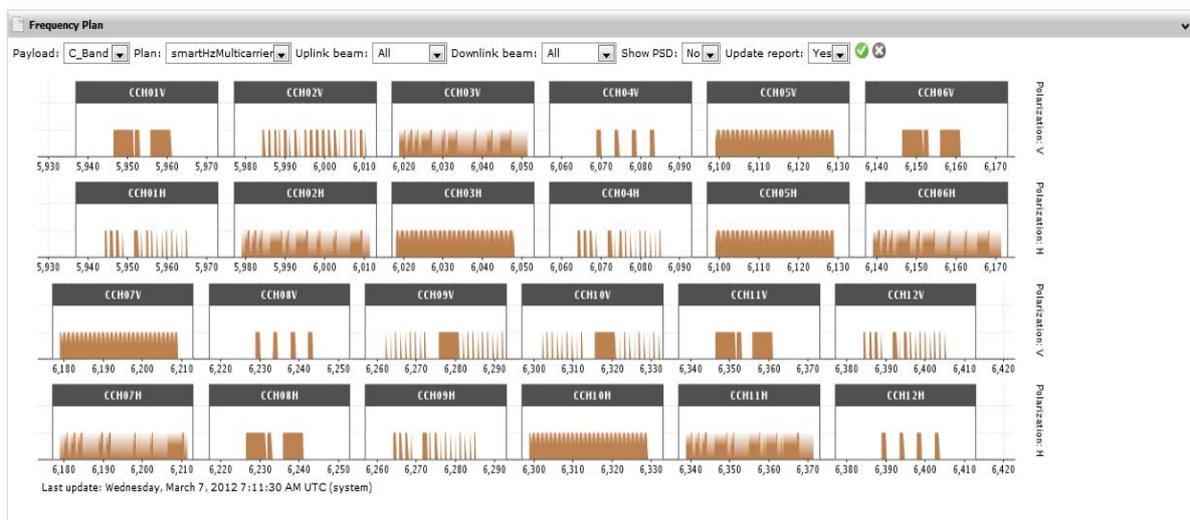


Figure 1. Transponder occupancy graphical view.

In addition to the high level occupancy view and once the user has selected a transponder to work with, a more detailed view can be displayed, only showing the occupancy of this transponder, and optionally a detailed view of the co-transponders occupancy, as well as ancillary data, such as the transponder available/used power and bandwidth.

A control is also provided to graphically display the distribution of the intermodulation interference within the transponder band as was calculated during the last link budget computation.

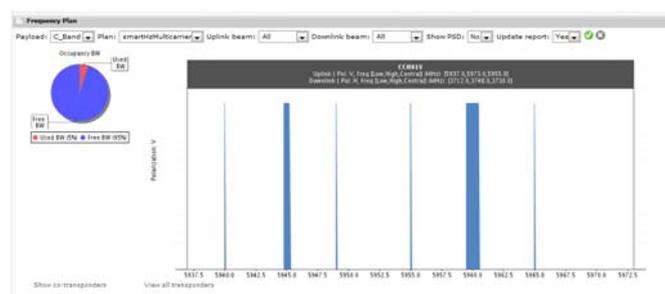


Figure 2. Single transponder view providing detailed information on the transponder occupancy and available/used power and bandwidth.

B. Tabular Information

Along with the graphical view of the carriers, which gives information at a glance on the power and frequency of each carrier, the GUI needs to provide additional mechanisms to display detailed information for a selected set of carriers and to allow the user to define new carriers or edit existing carriers as well as defining the inputs that are required for the link budget computations.

smartHz provides tabular views for presenting detailed data. In particular two table views (refer to Fig. 3 and Fig.4) display the attributes of each carrier and the link budget results, including individual values for each carrier

down link. Filters are provided to select the carriers to be displayed by carrier customer, service, network and transponder. Moreover the user can re-order the table contents based on the values of any of the columns just by clicking its column header.

The (privileged) users can edit the data or defining new carriers directly from the same tables. Thus there is no need to open additional windows, speeding up the overall edition/definition process. Additional mechanisms, such as the capability of defining new carriers by copying existing ones are also provided.

Tx GS	UL Freq. (MHz)	Customer	Service	Network	Transponder	EIRP (dBW)	Avail. (%)	UPC (dB)	Carrier Type	Carrier in Carrier	Valid
GSTX1H_SpainC#GS15944.500		Customer1	service	network	CCH01H		99.0	0.0	CT16	No	No
GSTX1H_SpainC#GS15946.000		Customer1	service	network	CCH01H		99.0	0.0	CT16	No	No
GSTX1H_SpainC#GS15947.500		Customer1	service	network	CCH01H		99.0	0.0	CT16	No	No
GSTX1H_SpainC#GS15948.750		Customer1	service	network	CCH01H		99.0	0.0	CT14	No	No
GSTX1H_SpainC#GS15952.250		Customer1	service	network	CCH01H		99.0	0.0	CT18	No	No
GSTX1H_SpainC#GS15953.500		Customer1	service	network	CCH01H		99.0	0.0	CT14	No	No
GSTX1H_SpainC#GS15955.000		Customer1	service	network	CCH01H		99.0	0.0	CT16	No	No
GSTX1H_SpainC#GS15956.250		Customer1	service	network	CCH01H		99.0	0.0	CT14	No	No
GSTX1H_SpainC#GS15957.500		Customer1	service	network	CCH01H		99.0	0.0	CT14	No	No
GSTX1H_SpainC#GS15958.750		Customer1	service	network	CCH01H		99.0	0.0	CT14	No	No

Figure 3. Carrier table view showing the carrier details. From the table a privileged user can also define new carriers or edit the existing ones.

Transponder	Gain Mode	FGM	Step	Actual Value (dB)	Nominal Value (dB)	ALC	Step	Actual Value (dB)	ALC OBO (dB)	Temperature	IBO type	Carrier Distribution	IBO value (dB)
CCH01V	FGM	19	89.0	19.0		AMBIENT	Fixed	SINGLE_CARRIER	3.0				

Tx GS	UL Freq. (MHz)	Customer	Service	Network	EIRP (dBW)	Avail. (%)	UPC (dB)	Carrier Type	C/N Eb/NO (dB)	Carrier in Carrier	Int analysis: stations	Int analysis: percentage												
												Uplink (%)		Downlink (%)				Valid						
												T	G	S	GS		ASI-G	Co-ch	T	ASI-G	ASI-S	Co-ch		
GSTX1V_SpainC	5949.000000000	Customer1	service	network	90.999715945	99.0	0.0	CT10	5.0	No	✓	✓	✓	3.0	4.0	1.0	2.0	4.0	1.2	0.8	No	No		

Figure 4. Link budget table view showing the link budget details. From the table a privileged user can also modify the link budget inputs and launch new link budget computations.

C. Payload Administration

The configuration of a communications payload is not fixed. It is common that the design permits some transponders to be switched between uplink or downlink beams. Also payload device failures can happen, for instance a receiver or a TWTA can fail and the channel signal would need to be routed to the redundant device. As a result the path followed by a given channel through the different payload devices from the uplink antenna to the downlink antenna can vary over time.

It is important that the GUI provides the capability to cope with changes in the payload communication. As shown in the Fig.5, when there is change in the payload configuration, *smartHz* allows a privileged user to update the configuration of the affected transponder/s through its GUI. In particular it is possible to change for each transponder: the uplink beam, the downlink beam, the path (primary, secondary or user-defined) and the onboard amplifier among others.

The same window allows the administrator to change the on-board amplifiers operational configuration: gain mode (FGM/ALC), gain configuration, additional attenuator configuration, and operational temperature among others.

Transponder Configuration - Payload C_Band											
Transponder	Rx Coverage	Tx Coverage	Carrier Distribution	IBO value (dB)	Path	LCTWTA	IPS (dBm)	SOP (dBm)	Noise Temperature (K)	User update	Time update
CCH01H	C-Beam-1	C-Beam-1	SINGLE_CARRIER	-1.0	PRIMARY	C01H	-68.53	46.91	27.6	system	Mar 5, 2012 9:51:38 AM
CCH01V	C-Beam-1	C-Beam-1	SINGLE_CARRIER	-1.0	PRIMARY	C01V	-68.48	46.85	27.65	system	Mar 5, 2012 9:51:38 AM
CCH02H	C-Beam-1	C-Beam-1	SINGLE_CARRIER	-1.0	PRIMARY	C02H	-68.53	46.79	27.6	system	Mar 5, 2012 9:51:38 AM
CCH02V	C-Beam-1	C-Beam-1	SINGLE_CARRIER	-1.0	PRIMARY	C02V	-68.48	46.76	27.65	system	Mar 5, 2012 9:51:38 AM
CCH03H	C-Beam-1	C-Beam-1	SINGLE_CARRIER	-1.0	PRIMARY	C03H	-68.53	46.84	27.6	system	Mar 5, 2012 9:51:38 AM
CCH03V	C-Beam-1	C-Beam-1	SINGLE_CARRIER	-1.0	PRIMARY	C03V	-68.48	46.81	27.65	system	Mar 5, 2012 9:51:38 AM
CCH04H	C-Beam-1	C-Beam-1	SINGLE_CARRIER	-1.0	PRIMARY	C04H	-68.53	46.67	27.6	system	Mar 5, 2012 9:51:38 AM
CCH04V	C-Beam-1	C-Beam-1	SINGLE_CARRIER	-1.0	PRIMARY	C04V	-68.48	46.78	27.65	system	Mar 5, 2012 9:51:38 AM
CCH05H	C-Beam-1	C-Beam-1	SINGLE_CARRIER	-1.0	PRIMARY	C05H	-68.53	46.57	27.6	system	Mar 5, 2012 9:51:38 AM
CCH05V	C-Beam-1	C-Beam-1	SINGLE_CARRIER	-1.0	PRIMARY	C05V	-68.48	46.57	27.65	system	Mar 5, 2012 9:51:38 AM

LCTWTAs - Payload C_Band														
Name	Gain Mode	FGH			ALC			OPA			Temperature	Transponder	User update	Time update
		Step	Actual Value (dB)	Nominal Value (dB)	Step	Actual Value (dB)	ALC OBO (dB)	Step	Actual Value (dB)	Nominal Value (dB)				
C01H	FGM	18	88.0	18.0				6	-6.04	2.400000000	AMBIENT	CCH01H	system	Mar 5, 2012 9:51:37 AM
C01V	FGM	18	88.0	18.0				6	-6.04	2.400000000	AMBIENT	CCH01V	system	Mar 5, 2012 9:51:37 AM
C02H	FGM	18	88.0	18.0				6	-6.04	2.400000000	AMBIENT	CCH02H	system	Mar 5, 2012 9:51:37 AM
C02V	FGM	18	88.0	18.0				6	-6.04	2.400000000	AMBIENT	CCH02V	system	Mar 5, 2012 9:51:37 AM
C03H	FGM	18	88.0	18.0				6	-6.04	2.400000000	AMBIENT	CCH03H	system	Mar 5, 2012 9:51:37 AM
C03V	FGM	18	88.0	18.0				6	-6.04	2.400000000	AMBIENT	CCH03V	system	Mar 5, 2012 9:51:37 AM
C04H	FGM	18	88.0	18.0				6	-6.04	2.400000000	AMBIENT	CCH04H	system	Mar 5, 2012 9:51:37 AM
C04V	FGM	18	88.0	18.0				6	-6.04	2.400000000	AMBIENT	CCH04V	system	Mar 5, 2012 9:51:37 AM
C05H	FGM	18	88.0	18.0				6	-6.04	2.400000000	AMBIENT	CCH05H	system	Mar 5, 2012 9:51:37 AM
C05V	FGM	18	88.0	18.0				6	-6.04	2.400000000	AMBIENT	CCH05V	system	Mar 5, 2012 9:51:37 AM

Figure 5. Payload administration view. Two different tables allow the administrator to change the transponder configuration and the onboard amplifiers operational configuration.

III. Frequency Plan Management and Simulations Support

In addition to the “real” frequency plan which contains the definition and assigned levels of the carriers being actually uplinked to the satellite it is useful to count on the capability of defining and working with simulated frequency plans.

smartHz supports a protected “real” frequency plan, called the active frequency plan. This can only be edited by privileged users. On the other hand, any number of working frequency plans can be defined which permit the payload engineers to simulate any transponder occupancy, optimize the transponder configuration and analyze and get ready for expected changes in the transponder occupancy.

In particular the tool supports the following capabilities:

- 1) Create an empty working frequency plan
- 2) Copy an existing frequency plan (either the active one or an existing working plan) to create a new one
- 3) Delete a working frequency plan (the active frequency plan cannot be deleted)

An additional tool is provided that allows for a direct update of one or more networks data in the active frequency plan from network data defined in a working frequency plan. Thus the results of the optimizations done in a working frequency plan can be directly brought to the active plan. It also permits, for instance, re-using the work done by a user not having the privilege of directly working with the active plan.

The simulation capabilities supported by working frequency plans include support to change the operational transponder configuration (gain step, step value for FGM or OBO value for ALC mode, operational temperature, nominal carrier distribution, nominal IBO value for link budget computations based on the Fixed IBO algorithm). As shown in the following figure, a transponder configuration table displays the transponder configuration. The table is editable but also for working frequency plans.

Carriers & Link Budget											
Customer: Customer1 Service: service Network: network Transponder: CCH01H											
Orbital incl.: 0 Point: North Maximum Point											
Transponder	Gain Mode	FGH			ALC			Temperature	IBO type	Carrier Distribution	IBO value (dB)
		Step	Actual Value (dB)	Nominal Value (dB)	Step	Actual Value (dB)	ALC OBO (dB)				
CCH01V	FGM	19	89.0	19.0				AMBIENT	Fixed	SINGLE_CARRIER	3.0

Figure 6. Transponder configuration table displaying the transponder configuration and can be edited in the case of a working frequency plan.

In the case of the active frequency plan the transponder configuration can only be done from the Payload Administration Window described above (Fig. 5).

IV. Link Budget Computation and Optimization

smartHz is primarily a link budget engineering tool featuring accurate models and advanced optimization algorithms. Thus, the link budget computation of the carriers is based on accurate signal propagation models and on comprehensive impairments analysis support, which includes all the relevant effects: rain and clouds attenuation, atmospheric gases, focus and defocusing, scintillation and multipath, thermal noise, interference and intermodulation. The link budget module also provides support for computations when the satellite is in inclined orbit.

A. Interference Analysis

The tool supports the following interference analysis computations:

- 1) Calculation of the interfering link budgets in order to determine the interfering power levels at nominal frequencies for the different interfering sources as show in the Fig. 6 due to ground, satellite and terrestrial stations from external networks. The interference is calculated based on real data characterizing the interfering emission. In the event this information is not available, *smartHz* provides an alternative mechanism allowing the user to define the expected interference levels due to some or to all of the interference terms or components (ASI, Ground or Terrestrial) as a percentage of the total link noise.
- 2) Calculation of the co-channel interference due to frequency overlapping among co-transponders.
- 3) Calculation of the intermodulation interference generated in the satellite transponder.
- 4) Calculation of the harmonics interference generated by desired and interfering transmitters.
- 5) Calculation of spurious interference generated by interfering transmitters.

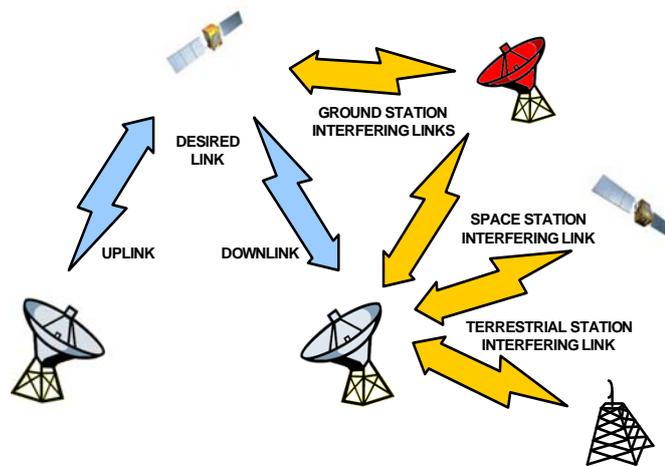


Figure 6. Interfering sources (shown with yellow arrows) computed during a link budget calculation.

B. Non-Linear Distortion

On-board amplifiers are usually operated in the non-linear region close to saturation, so that intermodulation has a major impact on the signal quality. Even when only one carrier is amplified (in this case usually the amplifier works at saturation point) the non-linear behavior of the amplifier causes some distortion such as the spectrum regrowth.

smartHz implements accurate models based upon real measurements (AM/AM, AM/PM, C3IM, and C5IM measurements, when available) for the calculation of the intermodulation generated in the satellite due to non-linear behavior of on-board amplifiers. The Fig. 7 shows two plots corresponding to two linearized TWTAs, one in C Band and the other in Ku-Band, comparing the intermodulation levels computed by the tool with those measured in the laboratory when the tube is excited with two equal single unmodulated carriers. The C/IM values include the total intermodulation levels due to third order and fifth order intermodulation products within the tube bandwidth.

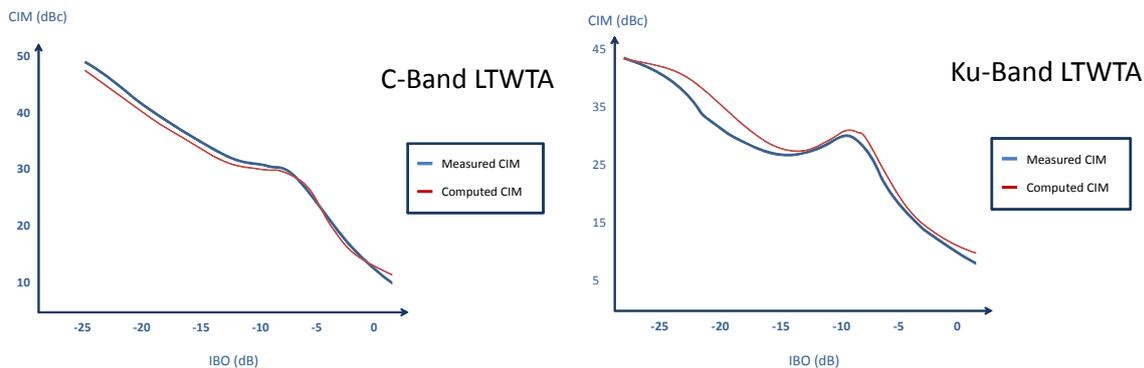


Figure 7. Comparison of the calculated intermodulation level vs. the actual levels measured in laboratory for a C-Band and a Ku-Band linearized TWTA.

C. Optimization Algorithms

The goal of the link budget optimization algorithms is to minimize the required transponder power and the size or power of transmitting ground stations while achieving the required signal quality at the receive end. To this end two optimization algorithms have been developed:

1. Fixed-IBO algorithm

This algorithm makes the assumption that the transponder is operating at a given working point specified in terms of IBO by the user. The definition of the working point allows the tool to estimate the level of intermodulation spectral density in a worst case scenario basis and regardless of the carrier frequency location inside the transponder bandwidth. Worst case intermodulation levels are calculated depending on the type of carrier distribution expected for the transponder in its final configuration. In this sense, single carrier, dual carrier and multicarrier distributions are considered.

2. Free-IBO algorithm

This algorithm does not require the definition of the expected transponder working point and permits an accurate calculation of the intermodulation in a transponder, based on the real carrier levels and carrier frequencies, as defined in the frequency plan. In this way the levels of the selected carriers and the transponder operating point can be further optimized.

D. Radio Climatic Conditions Support

smartHz gives the possibility of link budget calculation in three different types of scenarios in terms of radio climatic conditions:

- 1) Clear sky scenario: Rain attenuation is neither computed for the uplink nor the downlink. Total link availability is 100%.
- 2) Non-Balanced scenario: Rain attenuation is computed for the uplink and the downlink with the applicable values of rainfall rates and the same availability value.
- 3) Balanced scenario: Rainfall rates differences between the uplink and the downlink are compensated balancing the total link availability.

V. Additional Capabilities

The above described features are the main mechanisms to support the payload engineer in the frequency plan optimization task. However they need to be complemented by other capabilities, such as complete reporting capabilities and a comprehensive database. *smartHz* provides a number of additional capabilities outlined below.

A. Reporting and Footprint Maps

Once link budgets have been calculated, three types of reports, each one with different level of details can be generated:

- 1) Full Report: providing full details on the link budget computation and intermediate results. This report is intended for the payload engineer to review the results and eventually check if there is room for further optimization.
- 2) Results report: providing the most relevant link budget results.
- 3) Summary report: it provides a summary of the link budget results and it is intended for the satellite end user to size his station equipment.

The link budget reporting capabilities are complemented by frequency plan reports and a footprint map generation module.

The generation of the footprint map is based on accurate antenna radiation pattern data typically made available by the satellite manufacturer after completing the onboard antenna performance tests. The tool selects the right antenna radiation pattern data based on the relevant transponder frequency.

G/T, transponder EIRP and antenna gain maps are supported as well as carrier EIRP footprint maps. The latter is useful for the end-user to have graphical information on the carrier levels at different receiving stations.

A number of visualization controls are provided allowing the selection of the level curve limits to be represented, the difference between consecutive level curves, the type of coordinates along with a tools bar available once the map is displayed providing a zoom and a pan control.

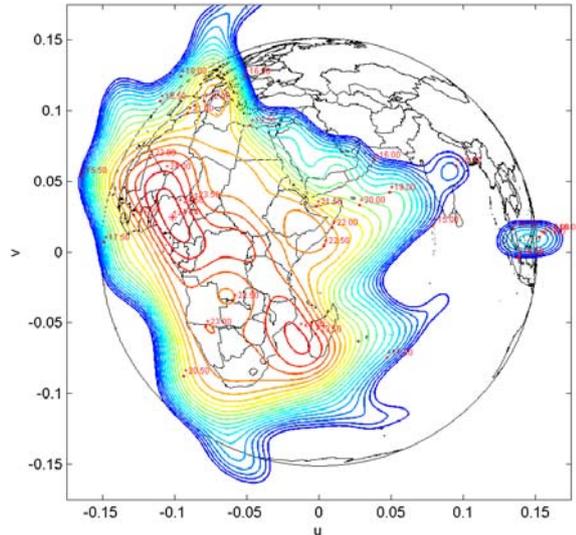


Figure 8. Example of footprint map in (u,v) coordinates.

B. Customers, Stations, Interfering Transmitters and Carrier Types Database

The tool provides a database that permits the user to define all the relevant data which is then used for the link budget calculations. It includes tables defining: customers, earth stations, ground antennas, transmit/receive chains, interfering transmitters, interfering emissions, carrier types, ground antenna radiation patterns databases. All this information needs to be defined once, and then is available to all the users.

The database can be edited by a user with the required privileges. The tool's GUI provides a comprehensive set of mechanisms for searching, sorting and easily editing or entering new data.

The following figure shows, as an example, the Customers table. The table contents can be sorted by clicking any of the columns headers. Also in the header, filters are provided for to search based on the text pattern or value entered by the user.

Since a large amount of information can be stored in the database, *smartHz* provides three mechanisms to save space in the user's screen:

- 1) An accordion control allows collapsing/expanding the tables (only a bar is shown when collapsed), thus the user can select which tables are displayed.
- 2) Subgrids showing additional information for each raw can be opened/closed when required.
- 3) Each table is organized in pages. The user can select how many rows are in each page.

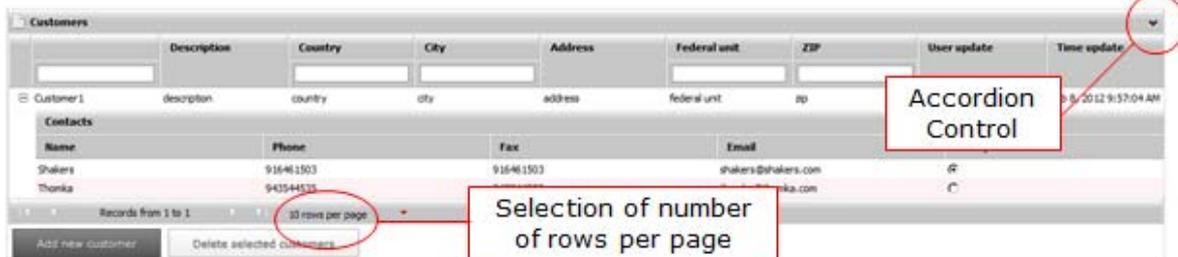


Figure 9. Example of a database table view (Customers table). The accordion control allows collapsing or expanding the table.

C. Events Logger

The tool features an Events Logger recording all the user actions. Besides the text of the event, date, and the origin of the event within the application, the user associated to the event is also identified, so that the activity of each user can be fully tracked. The identification of the user also permits to present to each user only his event or the system-level events in the Events Logger.

The following figure shows the Event Logger window, which is displayed at the bottom in all of the tool's windows. As any other window it can be collapsed through an accordion control, searching filters are provided, contents can be sorted by any column and the entries are grouped in pages with a selectable size.

Date	Severity	Origin	User	Description
Feb 9, 2012 9:54:39 AM	INFO	Payload	admin	Updated Satellite AZ1A
Feb 9, 2012 8:05:46 AM	INFO	Customer and Stations	admin	Deleted Interfering Station AS
Feb 9, 2012 8:01:23 AM	INFO	Customer and Stations	admin	Created Interfering Station AS
Feb 8, 2012 2:43:27 PM	INFO	Link Budget	admin	Link Budget calculated for Frequency Plan Name: smartHzFctl.kb025 Payload: Ku_Band
Feb 8, 2012 2:42:57 PM	INFO	Link Budget	admin	Link Budget calculated for Frequency Plan Name: smartHzFctl.kb025 Payload: Ku_Band
Feb 8, 2012 9:58:44 AM	INFO	Link Budget	admin	Link Budget calculated for Frequency Plan Name: smartHzFctl.kb025 Payload: Ku_Band

Figure 10. Events logger window.

VI. Payload Modeling

A major design driver of eventually any COTS solution must be its configurability, so that the effort and non-recurrent costs required to customize the tool (in the case of *smartHz* in order to support a new payload), are minimized. The configuration of *smartHz* is full database driven. A relational database contains all the payload definition and related data (measured values as provided by the satellite manufacturer and required for accurate link budget calculations, the on-board amplifier models obtained after processing the amplifier testing data). The only exception to this rule is complex data which are usually provided in standard (or de-facto standard) formats (such as the ITU IDWM maps or the satellite antenna radiation patterns).

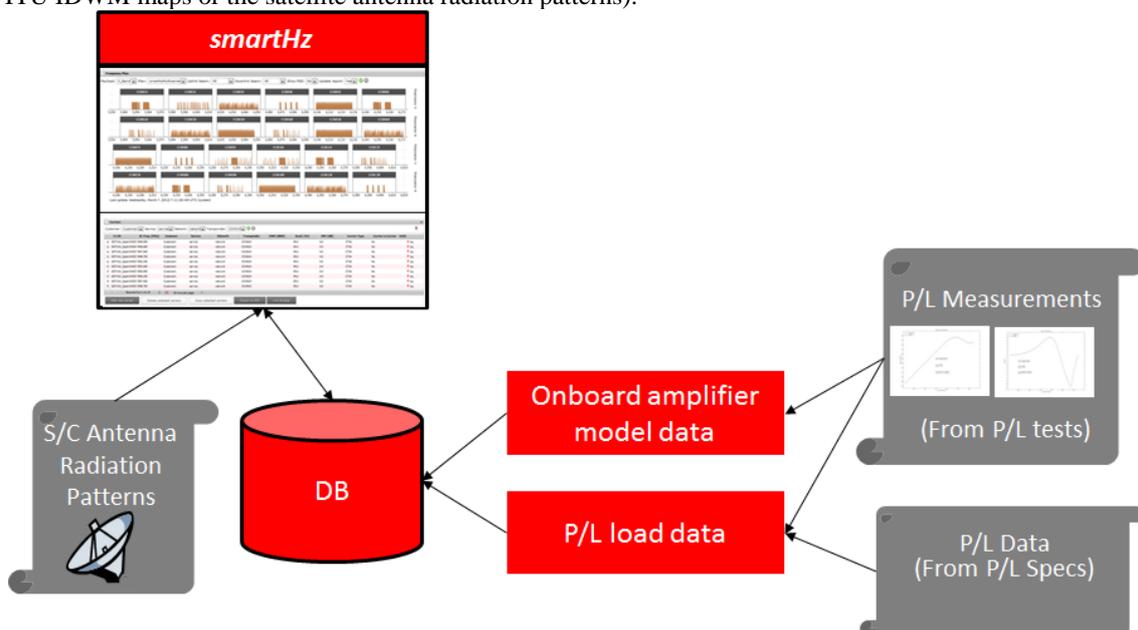


Figure 11. *smartHz* configuration process. The configuration database is loaded with the payload definitions and transponder actual measurement data provided by the satellite manufacturer.

From a point of view of the configurability, several key requirements were considered in the design of the tool:

- 1) Support for any number of transponders and on-board amplifiers, each one with its specific data for accurate link budget calculations.
- 2) Support for any number of beams (to cope with satellites flying Ka-band payloads with multi-spotbeams, which are everyday more common).

- 3) Support for and capability to manage as many uplink-downlink beam transponder switching combinations as supported by the actual payload design.
- 4) Support for and capability to manage the assignment of on-board amplifiers to transponders as supported by the actual payload design.

Availability of a comprehensive set of configuration tools is also required to ease the loading of the data into the database and the overall configuration process.

It is also worth mentioning that the graphical user interface design, including the generation of the dynamically generated visual objects, needs to support the same degree of configurability as the database.

All these drivers were addressed in *smarHz*. As a result, configuring the tool to support a new satellite payload is straightforward and does not require any “adaptation” or “tailoring” other than loading the data. Actually with a limited support from GMV it could be done by the customer.

VII. Multi-User Architecture

A. J2EE Architecture

smarHz is deployed in a J2EE application server, which provides the multi-user access from web browsers, and is implemented according to the J2EE three layer architecture:

- 1) Presentation Layer, which encapsulates the presentation logic required to serve clients
- 2) Business Layer, which contains the business logic and business data.
- 3) Data Layer, which manages the access to resources, such as the database, files, etc., and provides the data to the upper layer

As shown in the following figure, each main functionality is implemented as an independent module. This architecture was selected since it provides long-term maintainability of the software at all levels (corrective, perfective, adaptive) and the required scalability to be able to cope with future developments and extensions. As an example, having a centralized business layer would allow the same business logic to support types of clients other than web browsers such as mobile devices.

smarHz has not any third-party COTS products dependency.

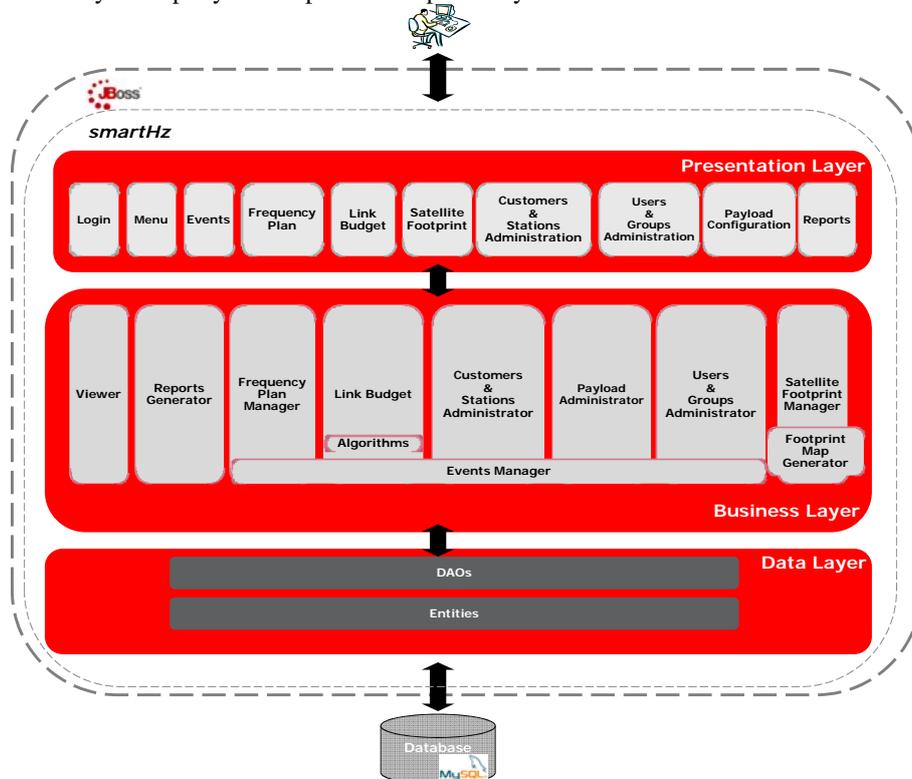


Figure 12. *smarHz* Architecture. *smarHz* is made up of independent modules deployed following a standard J2EE three layer architecture

B. Multi-user Access and User Privileges

The frequency Plan information is intended to be used not only by payload engineers working in a multi-user environment but also by users from other teams, such as the sales team or the technical support team. In *smartHz*, access to the relevant information by a given user is subject to have been granted a specific privilege. Moreover a user can have read-only or read&write privileges for each type of data he can access.

Normally, the different members of a team carry out the same type of activities, so they need to be granted the same privileges. Therefore the tool supports the definition of user groups and the assignment of privileges to each group according the specific needs of each team. The group/s, each user is assigned to, decides the privileges granted to this user.

VIII. Integration Capabilities

Today' customers expect that their operational systems provide superior integration capabilities, so that data can be shared as required and data flows between subsystems are automated as much as possible, even although each tool is provided by a different suppliers.

smartHz can be used as a stand-alone tool or integrated with other systems as described in the following figure. In particular the same database is shared with the *smartHz* Capacity Management optional module. Satellite utilization data can readily be exported to the billing system. The tool can also export the active frequency plan contents to a carrier monitoring system and receive from it real spectrum data to displayed along with the theoretical or expected carrier spectrum.

Additionally for payloads undergoing frequent reconfiguration process, the tool can read the payload tool from *smart rings* (the GMV solution for payload reconfiguration management), so that the administrator can update the new payload configuration just by clicking the “load button”.

Finally the configured transponder operating points can be exported and made available to *smart power* (the GMV solution for on-board power consumption management) or any other similar third party tool, which requires knowing the operating drive levels of each transponder on-board amplifier.

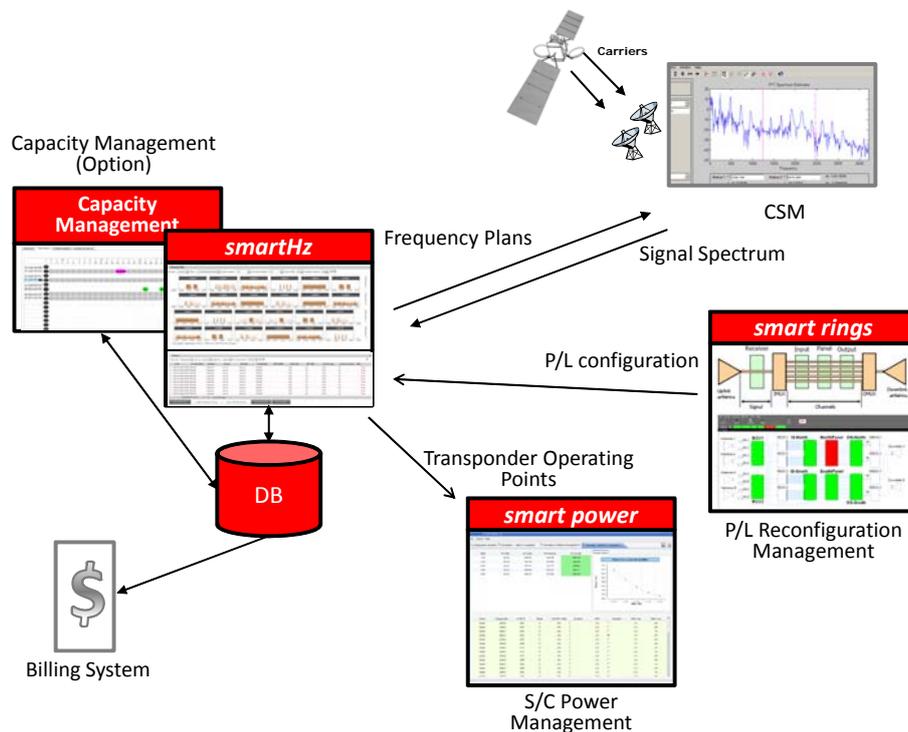


Figure 13. *smartHz* Integration Architecture. *smartHz* can readily integrate with external systems including carrier monitoring, P/L reconfiguration management, satellite power management and billing system.

IX. Conclusions

smartHz represents a new approach to the way payload engineers define and manage the frequency plans for communications satellites which combines an enhanced usability and simulation capabilities with accurate link budget and optimization algorithms. A state-of-the-art web architecture is another key factor to support a multi-user multi-team efficient working environment making possible access to the tool from any computer connected to the IP corporate network or even remotely through internet (after deploying appropriate security infrastructure). This architecture makes the life of the software administrator far easier since no client software needs to be installed in the user's computer. It is also important addressing the different needs of information access each team may have through the provision of a wide range of privileges and support for defining groups of users.

The selected architecture must readily support integration with the rest of systems involved in the payload operations, but also the expected evolution of the customer needs, such as access from mobile devices, which is every day more demanded.

X. Appendix A Acronym List

COTS	Commercial-Off-The-Shelf
GUI	Graphical User Interface
IBO	Input back-off
IDWM	ITU Digitized World Map
IBO	Input Back-Off
ITU	International Telecommunication Union
J2EE	Java 2 Platform, Enterprise Edition
OBO	Output Back-Off
P/L	Payload
S/C	Spacecraft