

IBM Software Group

## Plataforma de Desarrollo y Validación de Sistemas

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**Rational** software

→ Go to IBM

**IV Mejores Prácticas en el Desarrollo de Sistemas**  
**27 Mayo 2009 - Madrid**

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## Agenda

- **Tendencias, retos y estado actual de la industria**
- **Plataforma para el desarrollo y validación de sistemas**



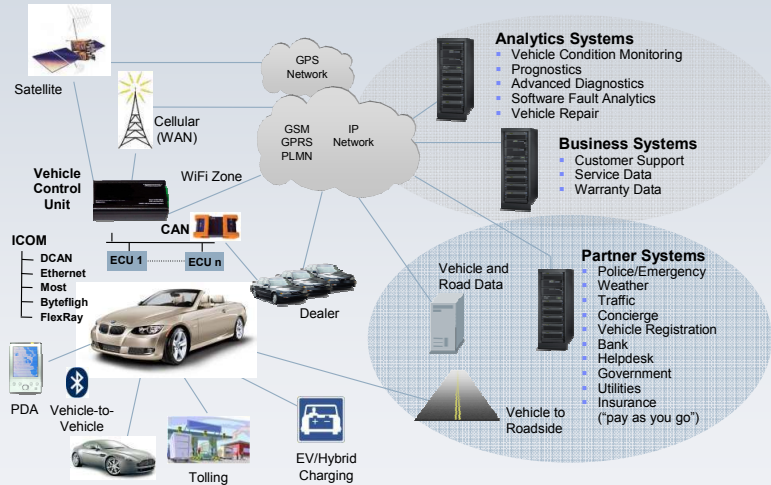
## Agenda

- **Tendencias, retos y estado actual de la industria**
- Plataforma para el desarrollo y validación de sistemas



# Tendencias en la industria

## Sistemas cada vez más complejos: sistemas de sistemas



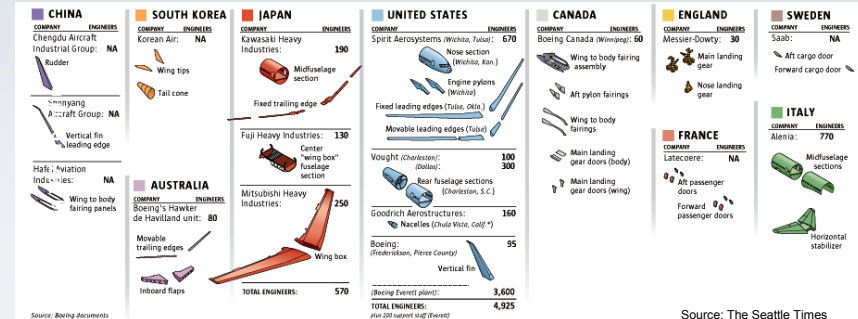
## Desarrollo y construcción distribuida Boeing Commercial Aircraft: 787 Development Program



Number of parts: 6 million  
Peak number of suppliers: 2,600

### Who makes the parts and where the engineering jobs are:

Boeing 787: # of engineers are 2005 projections and may not include all engineering specialties. Production workers are not included.



Source: The Seattle Times

## Cada vez más software, y cada vez más importante...

1968

e.g. VW Squareback



- Fuel injection
- Manifold pressure control
- Digital clock

1983

e.g. Chrysler Imperial



- Ignition
- Engine controls
- Instrumentation

1995

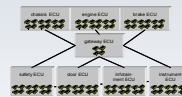
e.g. Honda CRX Si



- Engine management
- ABS
- Digital dashboard
- Electronic seats / doors
- Automated climate control
- Safety sensors

2008

e.g. BMW 7 Series Sedan

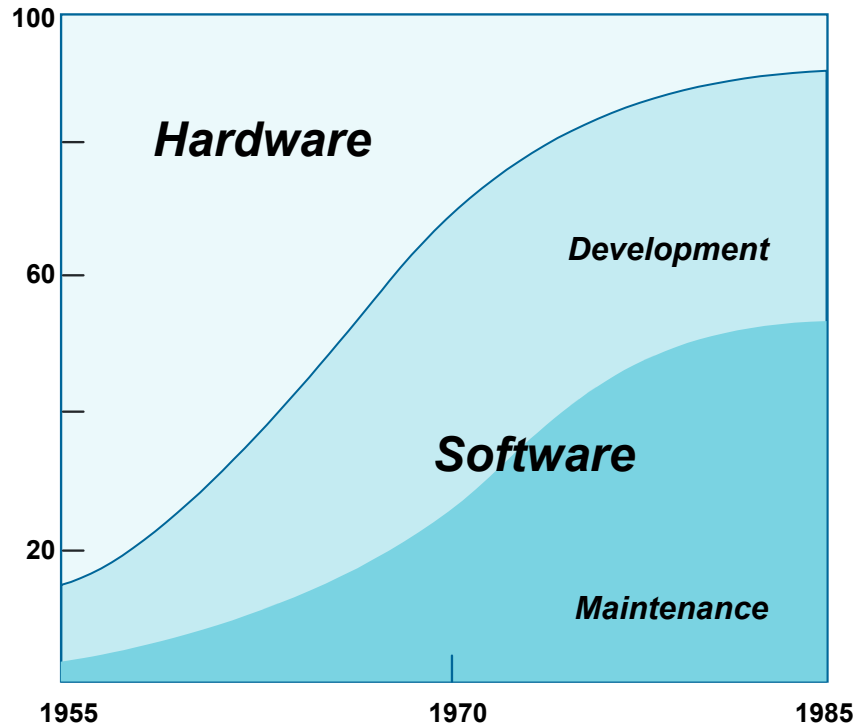


- Dynamic Damping Control
- Brake Energy Regeneration
- Integral Active Steering
- Electrically controlled air vents
- Night Vision
- Lane Departure Warning
- Lane Change Warning
- Adaptive Headlights
- Head-Up Display
- Active Cruise Control
- Camera systems
- Driver assistant systems

Platform	Year	% of Specification Requirements requiring SW Control
F-4	1960	8%
A-7	1964	10%
F-111	1970	20%
F-15	1975	35%
F-16	1982	45%
B-2	1990	65%
F-22	2000	80%

# El software ha incrementado su presencia e importancia hasta diez veces en los últimos años...

**Relative Distribution of Software/Hardware Costs**  
(Percent of total cost)



Platform	Year	Percent of Specification Requirements Requiring Software Control
F-4	1960	8%
A-7	1964	10%
F-111	1970	20%
F-15	1975	35%
F-16	1982	45%
B-2	1990	65%
F-22	2000	80%

Source: Software Engineering, IEEE Transactions on Computers December 1976

Source: The Australian Software Acquisition Management Course, Defense Systems Management College, March 2000



# Fallos en el software pueden ser dramáticos en sistemas complejos

## Agencia Aeroespacial

*Prototipo de cohete de \$1B se autodestruyó 40 segundos después de despegar por un error en el software del sistema de teledirección*



## F-22, línea de cambio de fecha

*Todos los sistemas de software dejaron de funcionar cuando el F22 pasó sobre la línea del cambio de fecha en un vuelo de prueba*



## Constructor de automóviles

*Sensores de lluvia no funcionales por incompatibilidad entre el sensor y el grosor del limpiaparabrisas*



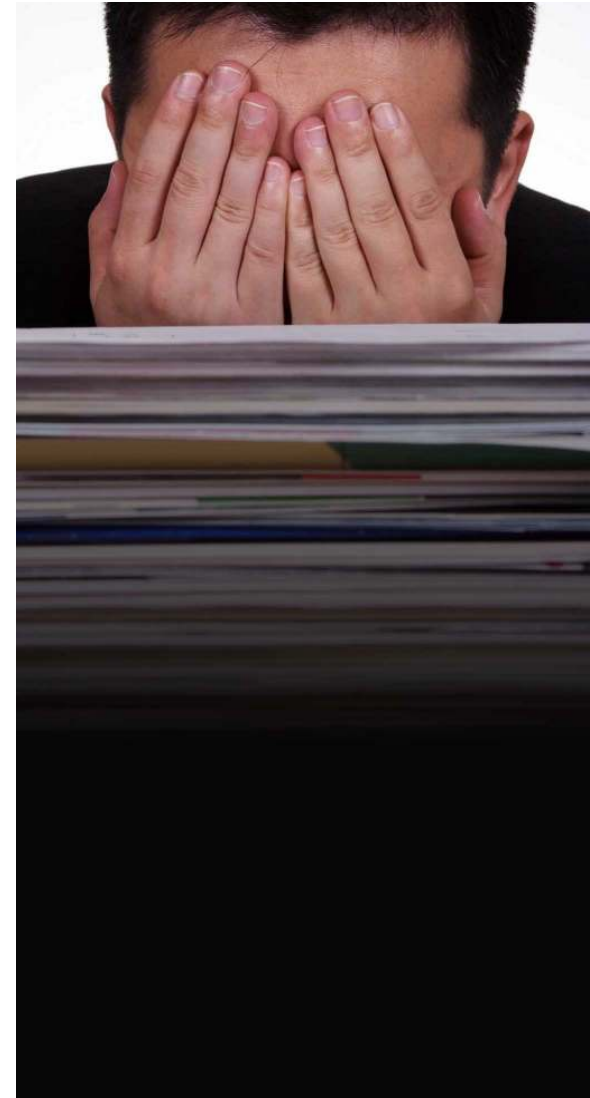
## Microsoft Zune

*1 millón de usuarios se levantaron una mañana y su dispositivo mp3 no funcionaba. El software no era capaz de manejar el día extra del nuevo año bisiesto*



## Retos en el desarrollo de sistemas en la actualidad

- La **complejidad** de los productos es cada vez mayor: sistemas de sistemas
- La **construcción** de los productos cada vez se encuentra más **distribuida**
- Cada vez **más software** y desempeñando un papel **más importante**
- Tradicionalmente **falta de comunicación entre disciplinas**: ingenieros de sistemas, ingenieros mecánicos, ingenieros eléctricos, ingenieros de software, ...
- Se requieren productos cada vez de **mayor calidad** y **libres de fallos** (integridad de las personas)
- **Presupuestos** y **tiempos de desarrollo** cada vez más **ajustados**
- El desarrollo de productos está cada vez **más regulado**. Cumplimiento de normativas y estándares, demostración de evidencias



## Agenda

- Tendencias, retos y estado actual de la industria
- **Plataforma para el desarrollo y validación de sistemas**





## El equipo piensa como mejorar ...

"Si tuviera una única vista de los requisitos del producto, su evolución en desarrollo sw y construcción del hw correspondiente y como se validan, tendría un control total sobre el desarrollo del producto "



Jefe de proyecto/programa

Ingeniero de sistemas



"El producto es cada vez más complejo, necesitaría diseñar su arquitectura de una manera entendible por todos los ingenieros de forma que se represente claramente todos los componentes sw y hw del sistema, su interconexión y cómo satisfacen los requisitos del sistema"

"Si detectase errores en el diseño de la arquitectura del sistema durante su elaboración, evitaría el alto coste de arreglarlo si se detecta cuando el sistema esté construido"

"Los cambios en un componente eléctrico puede requerir cambios en el software o en un componente mecánico. Necesito coordinar los cambios a nivel de producto, no sólo a nivel aislado por disciplina"

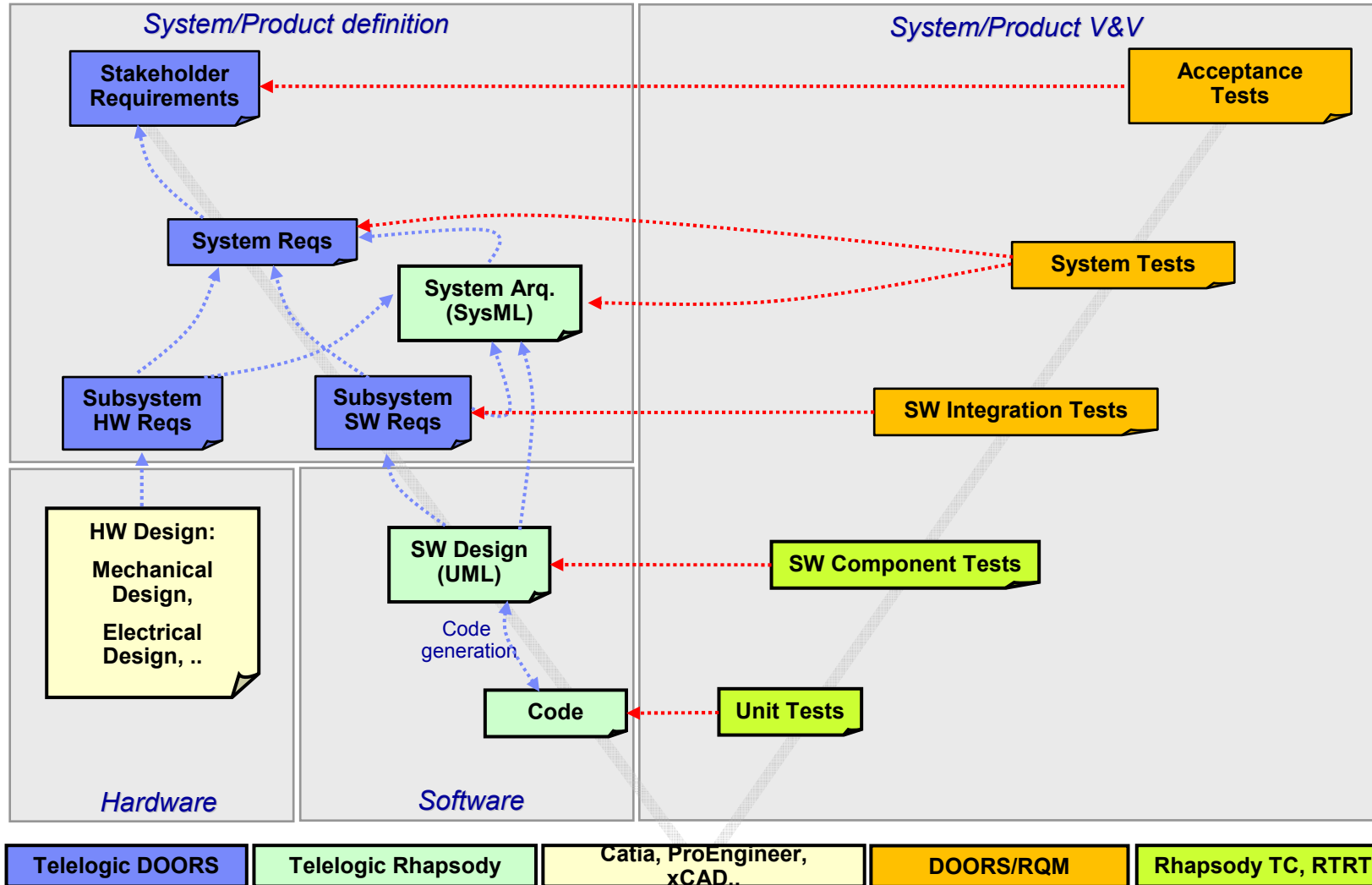


Responsable del control de cambios,  
miembro del CCB



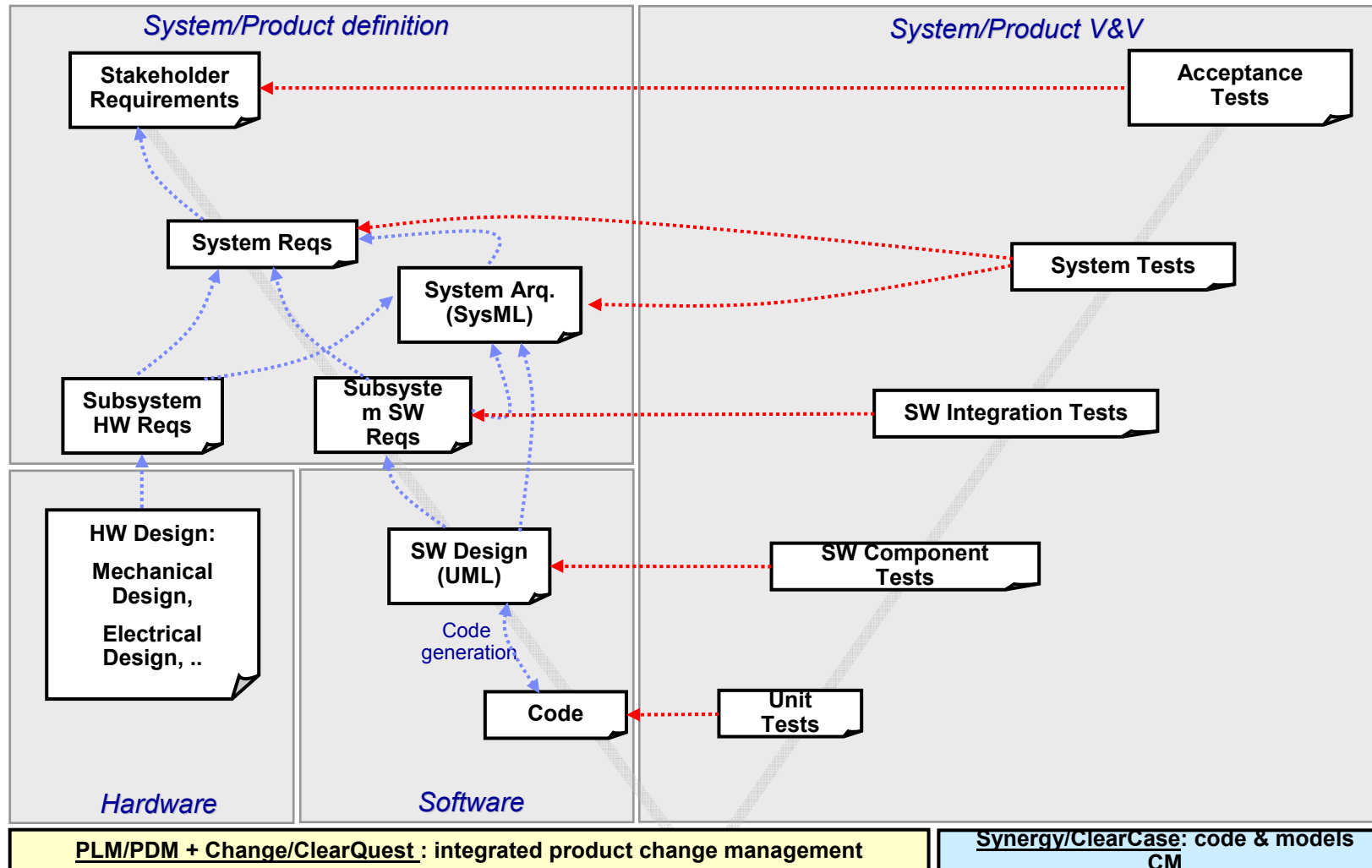
# Plataforma para desarrollo de sistemas (I)

*Definición, Desarrollo, Construcción y Verificación & Validación*



# Plataforma para desarrollo de sistemas (II)

## Gestión de Cambios y de la Configuración

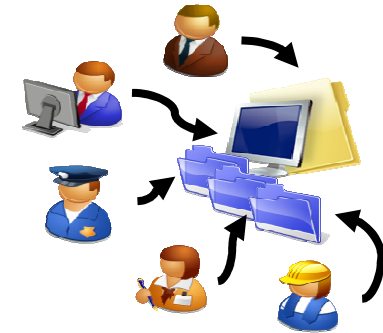


# IBM Telelogic DOORS



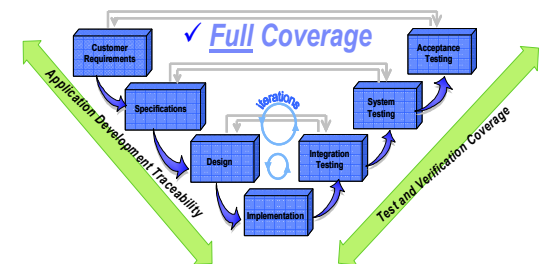
## Plataforma de colaboración

- ▶ Centralizar, organizar, estructurar, trazar y gestionar los requisitos del producto
- ▶ Información actualizada accesible para todos los miembros del equipo. Facilita la colaboración y comunicación entre ellos.
- ▶ Acceso controlado, permisos de acceso



## Trazabilidad

- ▶ Establecer relaciones entre requisitos, entre requisitos y pruebas, entre requisitos y diseño software, entre requisitos y diseño hardware (diseño mecánico, eléctrico, etc)
- ▶ Demostrar que el sistema final cumple los requisitos de cliente
- ▶ Demostrar que el sistema final está probado
- ▶ Control de los procesos de desarrollo/construcción y verificación&validación desde los requisitos

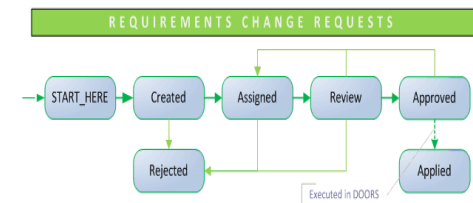


## Gestión del cambio

- ▶ Análisis de impacto de cambios, seguimiento del estado de los cambios

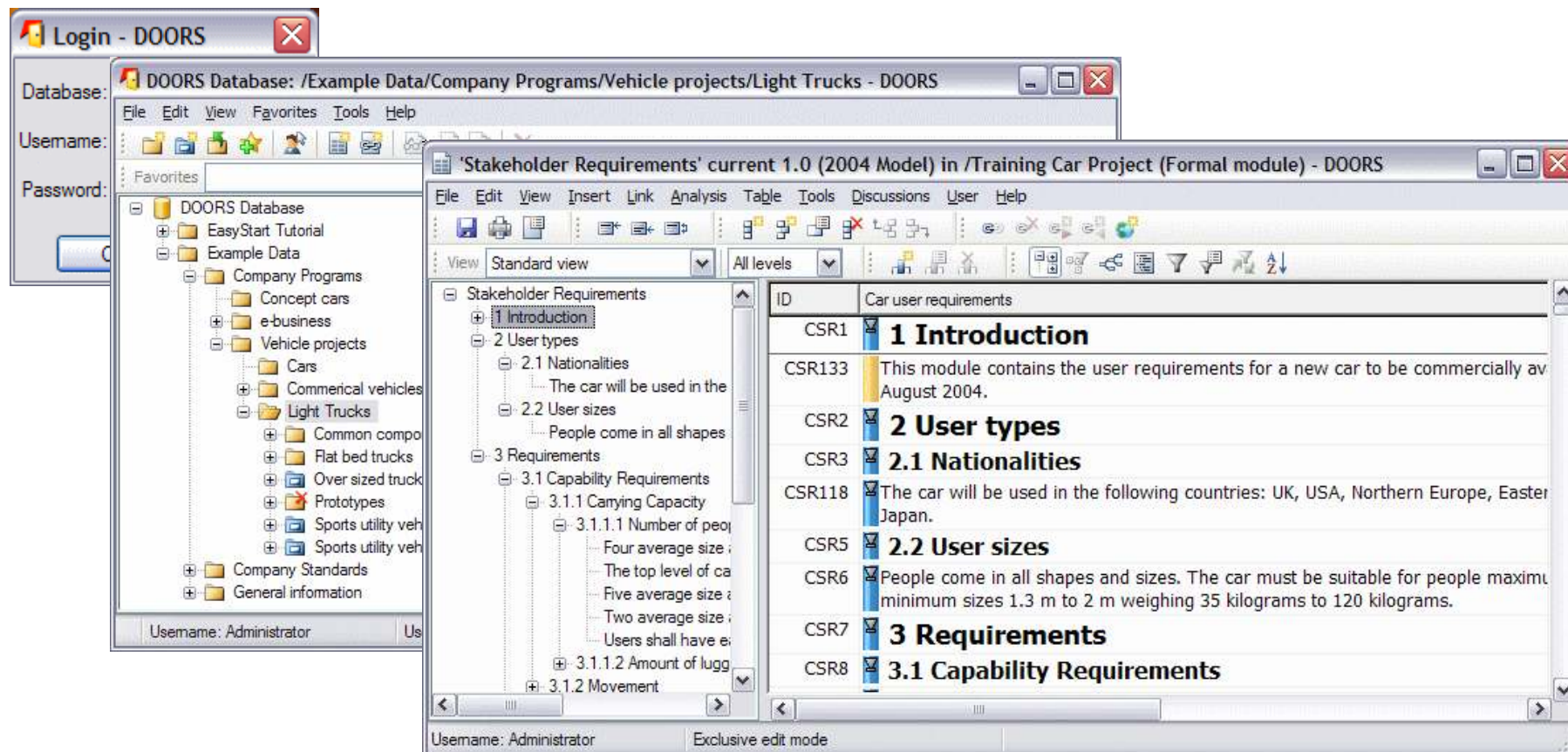
## Flexibilidad

- ▶ Fácil implementación de cualquier proceso de desarrollo



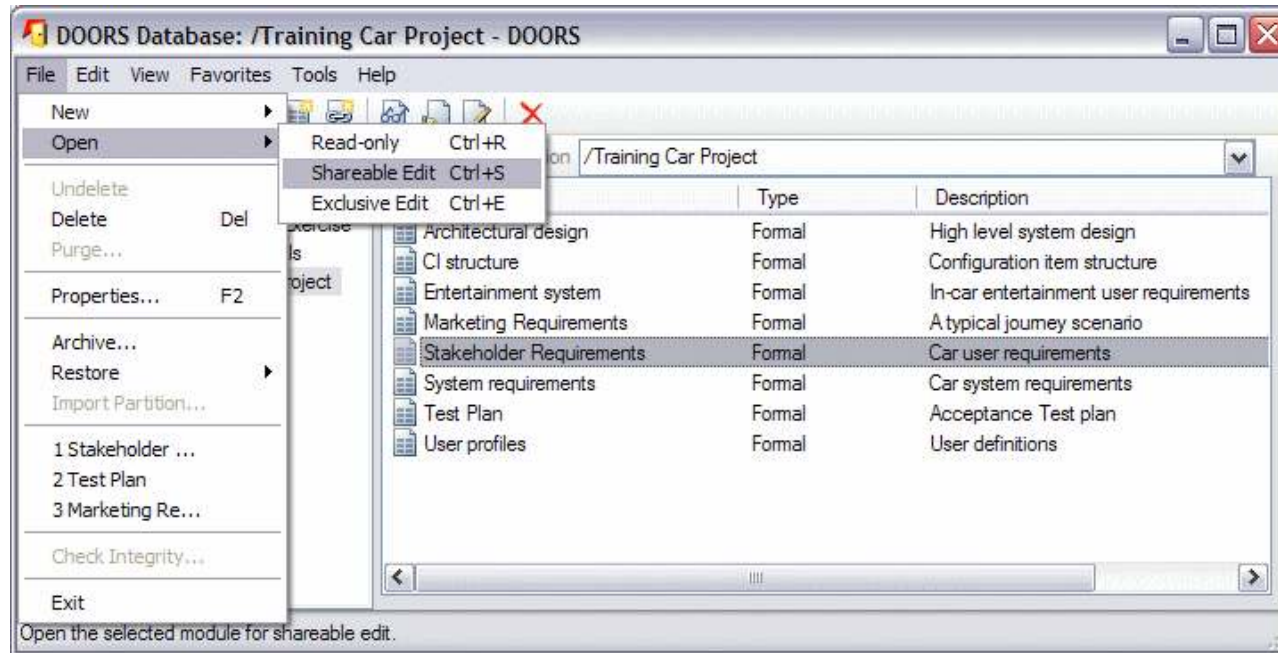
# IBM Telelogic DOORS

*Acceso controlado y organización de la información*






# IBM Telelogic DOORS

## Colaboración



### Modo de apertura:

- Sólo lectura**  acceso sólo lectura, permite editar a otros usuarios
- Edición compartida**  permite editar a varios usuarios simultáneamente
- Edición exclusiva**  edición exclusiva del documento

# IBM Telelogic DOORS

## Establecimiento de relaciones

**Stakeholder Requirements Specification** current 0.1 in /1. Stakeholder Requirements Specification (Formal module) - DOORS

ID	Object Type	Stakeholder Requirements Specification for the Coyote UAV
UAV-5	*	<b>2 Requirements</b>
UAV-6	Requirement	The UAV is shall be a multipurpose and reusable U... multimission capability.
UAV-74	Requirement	The UAV shall...
UAV-75	Requirement	This is a new stakeholder requirement
UAV-7	Requirement	It shall operate at altitudes of up to 30,000 feet.
UAV-8	Requirement	It shall operate at altitudes of up to 30,000 feet.
UAV-9	Requirement	It shall operate at altitudes of up to 30,000 feet.
UAV-10	Requirement	It shall operate at altitudes of up to 30,000 feet.
UAV-11	Requirement	The UAV shall be capable of flying complex flight...
UAV-12	Requirement	The UAV shall be capable of flying complex flight...
UAV-13	Requirement	The UAV shall be capable of flying complex flight...
UAV-14	Requirement	The UAV shall be capable of flying complex flight...
UAV-15	Requirement	The UAV shall be capable of flying complex flight...
UAV-16	Requirement	The UAV and manned control capability from the g...

**System Requirements Specification** current 0.0 in /2. System Requirements Specifications (Formal module) - DOORS

ID	Object Type	System Requirements Specification	Priority
SRSUAV-1	*	<b>1 Overview</b>	
SRSUAV-2	*	The Unmanned Air Vehicle System is a system solution to a medium-range reconnaissance in hostile environments with limited attack capability.	
SRSUAV-3	*	It is a medium-range long endurance UAV system that can carry a variety of payloads to assist in ground, air and sea operations.	
SRSUAV-4	*	A full UAVS consist of four UAVs and a ground Mission Planning and Control System.	
SRSUAV-5	*	<b>2 System Requirements</b>	
SRSUAV-74	*	<b>2.1 UAV Vehicle</b>	
SRSUAV-6	Requirement	The CUAV is shall be a multipurpose and reusable UAV with multimission capability.	High
SRSUAV-78	Requirement	This is a new system requirement..	Medium
SRSUAV-7	Requirement	It shall operate at altitudes of up to 30,000 feet.	High
SRSUAV-8	Requirement	It shall operate at altitudes of up to 30,000 feet.	High
SRSUAV-9	Requirement	It shall operate at altitudes of up to 30,000 feet.	Medium
SRSUAV-10	Requirement	It shall operate at altitudes of up to 30,000 feet.	Medium
SRSUAV-11	Requirement	The UAV shall be capable of flying complex flight plans with the operational goal of ground route or road based (synonym) search.	Medium
SRSUAV-12	Requirement	The UAV shall be controllable from the ground station CMPCS.	High
SRSUAV-13	Requirement	The UAV shall be capable of flying complex flight plans with the operational goal of systematic area search.	High
SRSUAV-14	Requirement	The UAV shall be capable of flying complex flight plans with the operational goal of ground route or road based (synonym) search.	High

**Creación con drag & drop**

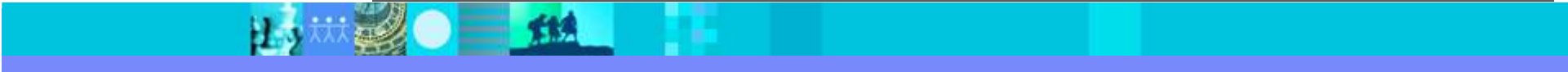


# IBM Telelogic DOORS

## Trazabilidad a varios niveles

The screenshot displays the 'Stakeholder Requirements Specification' for the Coyote UAV. The table below summarizes the requirements and their traceability:

ID	Object Type	Stakeholder Requirements Specification for the Coyote UAV	System <- Missile Control Subsystem	System <- Flight Management Subsystem
UAV-5	*	<b>2 Requirements</b>		
UAV-6	Requirement	The UAV is shall be a multipurpose and reusable UAV with multimission capability.	SRSUAV-6	SRSUAV-6
UAV-74	Requirement	The UAV shall...	SRSUAV-78	SRSUAV-78
UAV-75	Requirement	This is a new stakeholder requirement	SRSUAV-78	SRSUAV-78
UAV-7	Requirement	It shall operate at altitudes of up to 30,000 feet.	SRSUAV-7	SRSUAV-7
			MCS-11	FMS-11
			MCS-13	SRSUAV-14
			MCS-20	FMS-14
			SRSUAV-14	
			MCS-13	
			MCS-14	
UAV-8	Requirement	It shall reach ground speeds of up to 100 knots in cruise mode.	SRSUAV-8	SRSUAV-8
UAV-9	Requirement	It shall reach ground speeds of 150 knots in dash mode.	SRSUAV-9	SRSUAV-9
UAV-10	Requirement	It shall carry payloads up to 450 lbs for durations exceeding 24 hours.	SRSUAV-10	SRSUAV-10
UAV-11	Requirement	The UAV shall fly unimpeded in low visibility environments while carrying reconnaissance or attack payloads.		
UAV-12	Requirement	The UAV shall be controllable from the ground station CMPCS.	SRSUAV-12	SRSUAV-12
UAV-13	Requirement	The UAV shall be capable of of flying complex flight plans with the operational goal of systematic area search.	SRSUAV-13	SRSUAV-13
			MCS-13	FMS-13
UAV-14	Requirement	The UAV shall be capable of of flying complex flight plans with the operational goal of ground route or road based (synonym) search.	SRSUAV-14	SRSUAV-14
			MCS-13	FMS-14
			MCS-14	
UAV-15	Requirement	The UAV shall be capable of of flying complex flight plans	SRSUAV-15	SRSUAV-15





# IBM Telelogic DOORS

## Trazabilidad a diseño software

'System Requirements Specification' current 0.0 in /2. System Requirements Specifications (Formal module) - DOORS

File Edit View Insert Link Analysis Table Tools Discussions User Publish WEXP Rhapsody 7.4 RG Analyst Change Management Harmony/ESW  
Harmony/ITSW Harmony/SE TAU Help

View E1 - Allocated to All levels

ID	Object Type	System Requirements Specification	Allocated to (System Architecture)
SRSUAV-3	*	It is a medium-range long endurance UAV system that can carry a variety of payloads to assist in ground, air and sea operations.	
SRSUAV-4	*	A full UAVS consist of four UAVs and a ground Mission Planning and Control System.	
SRSUAV-5	*	<b>2 System Requirements</b>	
SRSUAV-74	*	<b>2.1 UAV Vehicle</b>	
SRSUAV-6	Requirement	The CUAV is shall be a multipurpose and reusable UAV with multimission capability.	Package: UAV_Vehicle
SRSUAV-78	Requirement	This is a new system requirement..	Package: UAV_Vehicle
SRSUAV-7	Requirement	It shall operate at altitudes of up to 30,000 feet.	Package: UAV_Vehicle
SRSUAV-8	Requirement	It shall reach ground speeds of up to 100 knots in cruise mode.	Package: UAV_Vehicle
SRSUAV-9	Requirement	It shall reach ground speeds of 150 knots in dash mode.	Package: UAV_Vehicle
SRSUAV-10	Requirement	It shall carry payloads up to 450 lbs for durations exceeding 24 hours.	Package: UAV_Vehicle
SRSUAV-11	Requirement	The UAV shall fly unimpeded in low visibility environments while carrying reconnaissance or attack payloads.	Package: UAV_Vehicle block: Flight_Management
SRSUAV-12	Requirement	The UAV shall be controllable from the ground station CMPCS.	Package: UAV_Vehicle
SRSUAV-13	Requirement	The UAV shall be capable of of flying complex flight plans with the operational goal of systematic area search.	Package: UAV_Vehicle
SRSUAV-14	Requirement	The UAV shall be capable of of flying complex flight plans with the operational goal of ground route or road based (synonym)	Package: UAV_Vehicle

Username: Administrator Exclusive edit mode



# IBM Telelogic DOORS

## Trazabilidad a diseño hardware

The screenshot shows the IBM DOORS software interface. The main window displays a table with the following columns: DOORS UID, Platform System Specifications, CATO, Technical Documentation Associated, and Remarks. The table contains four rows of data. A red box highlights the 'Technical Documentation Associated' column for the first row, and a callout box points to it with the text 'Diseños mecánicos, eléctricos, informes técnicos asociados con el requisito'.

DOORS UID	Platform System Specifications	CATO	Technical Documentation Associated	Remarks
PS000 - 4	This Specification defines details of Contractual technical aspects, i.e., ship's features, components, equipment, structure and materials, to be fulfilled during the ship's.	Inspection	<b>0736350020R</b> NOISE REPORT INF.LR 20080527  <b>1111000010S</b> SHELL EXPANSION APR.LR 20080508	
PS000 - 10	A margin provided in the ship design so that future systems can be added after the Ship is commissioned to the Commonwealth. FOR INFORMATION: XXX	Analysis		
PS000 - 12	This margin covers potential modifications in relation to GFE throughout design and construction with regard to GFE identified in the Contract.			
PS000 - 14	With the purpose of defining a later installation / integration of systems not installed in the ship			

Callout text: Diseños mecánicos, eléctricos, informes técnicos asociados con el requisito

Username: flopez Exclusive edit mode



# IBM Telelogic DOORS

## Análisis de impacto de cambios

ID	User Requirements	Functional Requirements	Design	Test Plan
TRN-CSR-55	<b>3.1.6.1.3 Clutch</b>			
TRN-CSR-56	Users shall be able to operate the clutch, if fitted, in standard footwear.	FR-167 There shall be a standard lightweight clutch.	TRN-AD-45 Clutch	TRN-TP-36 Lightweight footwear control test
TRN-CSR-57	<b>3.1.6.1.4 Gears</b>			
TRN-CSR-58	Users shall be able to operate gears, if fitted, with minimal effort.	FR-169 The car shall be fitted with a lightweight 5 speed manually operated gearbox.	TRN-AD-44 Gearbox	TRN-TP-36 Lightweight footwear control test
TRN-CSR-59	<b>3.1.7 Visibility</b>			
TRN-CSR-60	<b>3.1.7.1 Day light</b>			
TRN-CSR-61	Users shall have maximum daylight visibility from within the vehicle.			
TRN-	<b>3.1.7.2 Night time</b>			

Evaluación del impacto de cambios de forma rápida y fiable a través de links

Un cambio en

impacta en

y en



# IBM Telelogic DOORS

## Progreso del proyecto

ID	User Requirements	Functional Requirements	Design	Test Plan
TRN-CSR-55	<b>3.1.6.1.3 Clutch</b>			
TRN-CSR-56	Users shall be able to operate the clutch, if fitted, in standard footwear.	FR-167 There shall be a standard lightweight clutch.	TRN-AD-45 Clutch	TRN-TP-36 Lightweight footwear control test
TRN-CSR-57	<b>3.1.6.1.4 Gears</b>			
TRN-CSR-58	Users shall be able to operate gears, if fitted, with minimal effort.	FR-169 The car shall be fitted with a lightweight 5 speed manually operated gearbox.	TRN-AD-44 Gearbox	TRN-TP-36 Lightweight footwear control test
TRN-CSR-59	<b>3.1.7 Visibility</b>			
TRN-CSR-60	<b>3.1.7.1 Daylight</b>			
TRN-CSR-61	Users shall have maximum daylight visibility from within the vehicle.			
TRN-	<b>3.1.7.2 Night time</b>			

Fácil detección de requisitos no satisfechos, sin prueba asociada, etc...

Los huecos muestran los requisitos no satisfechos, trabajo que falta por hacer



# IBM Telelogic DOORS

## Progreso del proyecto con respecto a las pruebas

'System requirements' current 0.2 (a) in /Training Car Project (Formal module) - DOORS

ID	Car system requirements	Requirement Status	Associated Tests & Status
SR1635	<b>1.1.2.1 Without Winds</b>	✓	
SR1009	The car shall be able to accelerate from 0 to 100 Kilometers per hour in 10 seconds on standard flat roads with winds of 0 kilometers per hour.	✓	<b>TP-26.1</b> Action: In a flat road without winds, accelerate the car from 0 to 100 Km/h and observe the time taken Expected Result: The time taken must be less or equal than 10 seconds. Test Status: Pass
SR1010	The car shall be able to accelerate from 100 to 150 kilometers per hour at a rate of 5 kilometers per second on standard flat roads with winds of 0 kilometers per hour.	✓	<b>TP-26.1</b> Action: In a flat road without winds, accelerate the car from 0 to 100 Km/h and observe the time taken Expected Result: The time taken must be less or equal than 10 seconds Test Status: Pass <b>TP-26.2</b> Action: Continue accelerating from 100 to 150 Km/h and observe the total time taken (from 0 km/h) Expected Result: The time taken from the beginning must be less or equal than 20 seconds. Test Status: Pass
SR1011	The car shall be able to accelerate from 150 to 200 kilometers per hour at a rate of 3 kilometers per second on standard flat roads with winds of 0 kilometers per hour.	✓	<b>TP-26.1</b> Action: In a flat road without winds, accelerate the car from 0 to 100 Km/h and observe the time taken Expected Result: The time taken must be less or equal than 10 seconds. Test Status: Pass <b>TP-26.2</b> Action: Continue accelerating from 100 to 150 Km/h and observe the total time taken (from 0 km/h) Expected Result: The time taken from the beginning must be less or equal than 20 seconds. Test Status: Pass <b>TP-26.3</b> Action: Continue accelerating from 150 to 200 Km/h and observe the total time taken (from 0 km/h) Expected Result: The time taken from the beginning must be less or equal than 38 seconds. Test Status: Pass
SR1636	<b>1.1.2.2 With winds from 10 to 20 km/h</b>	✗	
SR1632	The car shall be able to accelerate from 0 to 100 Kilometers per hour in 12 seconds on standard flat roads with winds from 10 to 20 kilometers per hour.	✗	<b>TP-36.1</b> Action: In a flat road without winds, accelerate the car from 0 to 100 Km/h and observe the time taken Expected Result: The time taken must be less or equal than 12 seconds. Test Status: Undetermined

Username: Administrator Exclusive edit mode



## Beneficios Gestión de trazabilidad con DOORS

- **Permite realizar una **gestión de requisitos formal****
  - ▶ **Control** de los requisitos durante todo el proceso de desarrollo
  - ▶ **Cumplimiento** con estándares y normativas
    - CMMI: trazabilidad bi-direccional
    - FDA, IEC 61508, DO-178B: trazabilidad hasta código
    - ...
- **La gestión de la trazabilidad con DOORS facilita actividades de **análisis** como:**
  - ▶ Análisis de **impacto de cambios**
  - ▶ Control y seguimiento del **progreso** del proyecto
  - ▶ **Cobertura de pruebas**



# IBM Telelogic Rhapsody

## Model Driven Development



### ■ Diseño Arquitectura del Sistema (SysML)



- ▶ Mejora la comunicación y el entendimiento entre disciplinas
- ▶ Trazabilidad a requisitos
- ▶ Simulación del modelo. Verificación temprana.
  - Detección de errores en fases iniciales, reducción de costes.
  - Validación de los requisitos en fase de diseño

*Modelado y simulación proporciona un ROI del 30% según Gartner y una reducción del 25% del time-to-market según Nokia*

### ■ Diseño y desarrollo de Software (UML)



- ▶ Generación automática de código a partir del modelo
- ▶ Simulación del modelo. Depuración en tiempo de diseño. Detección de errores en fase de diseño.
- ▶ Despliegue en cualquier plataforma de destino: VxWorks, Linux, etc

### ■ Pruebas dirigidas por modelos (MDT – Model Driven Testing)

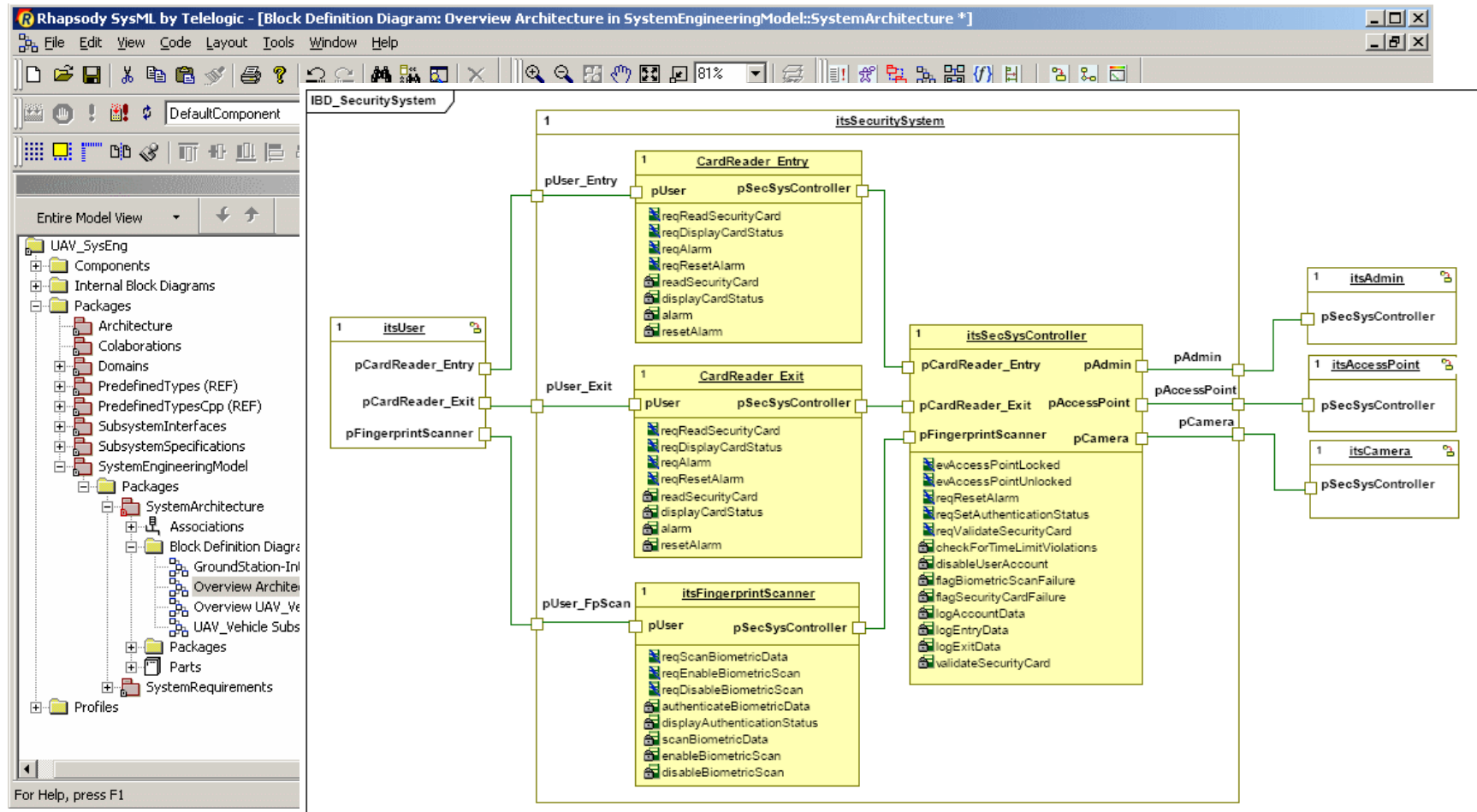
- ▶ Pruebas generadas automáticamente desde el diseño, sincronización constante.
- ▶ Mayor productividad en los procesos de prueba

### ■ Colaboración equipos distribuidos.



# IBM Telelogic Rhapsody

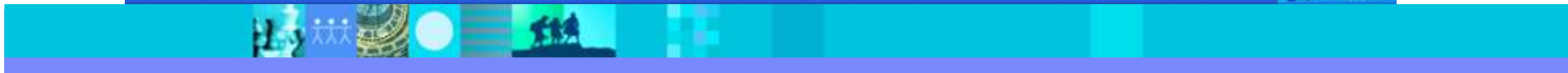
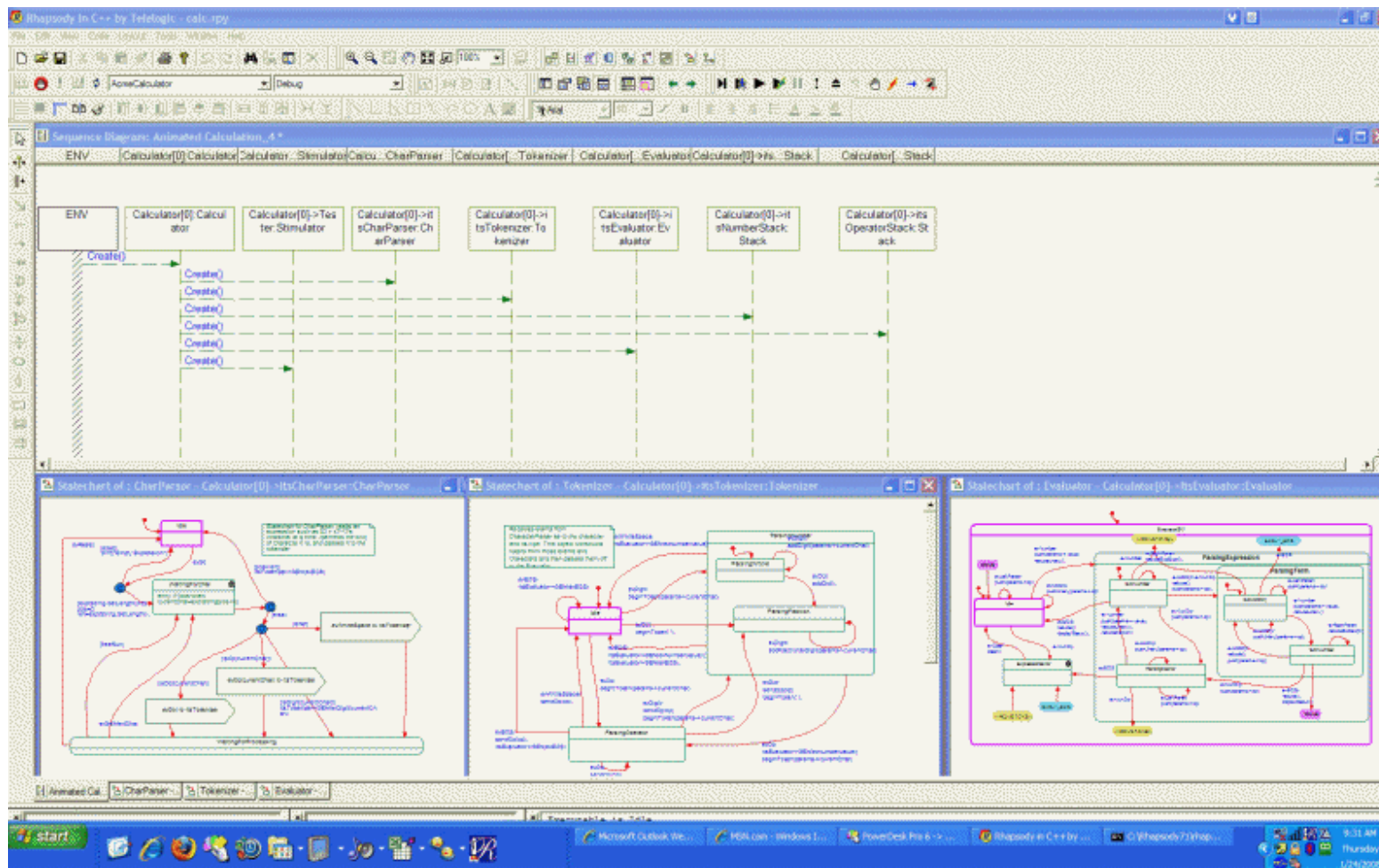
## *Diseño de la arquitectura del sistema*



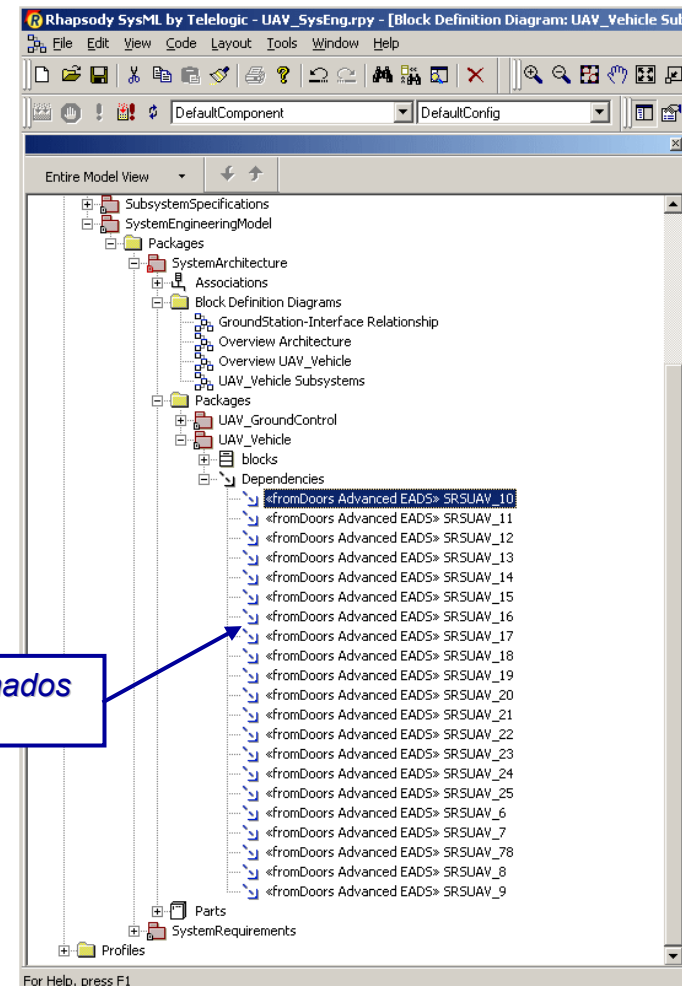
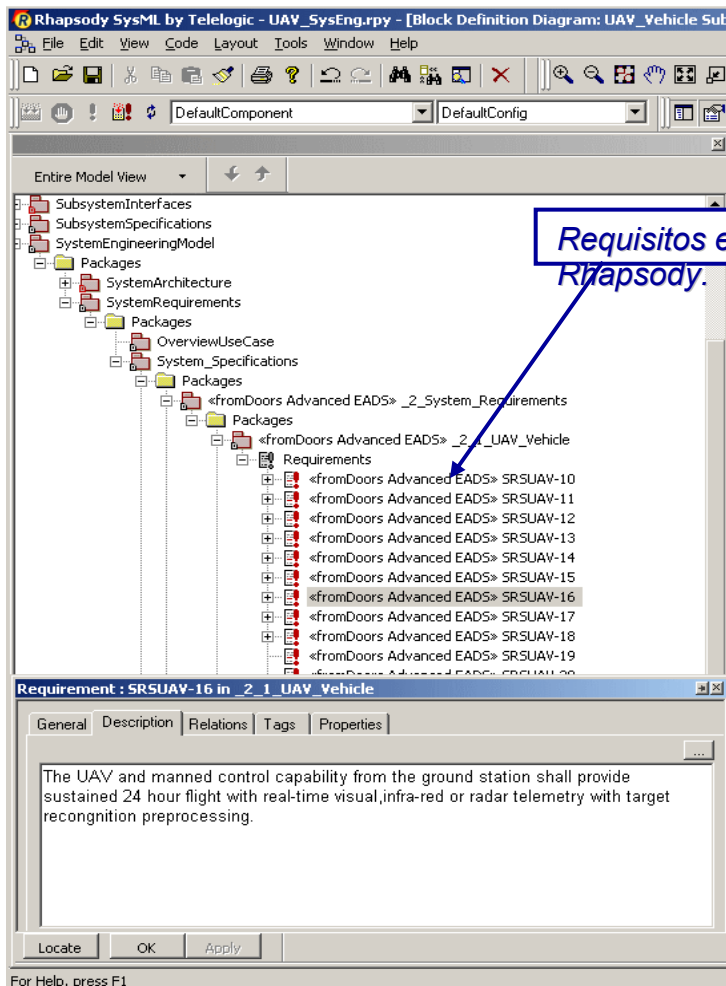


# IBM Telelogic Rhapsody

*Simulación, verificación temprana*



# IBM Telelogic Rhapsody Gateway - Trazabilidad a Requisitos



## Gestión Integrada del Cambio

- **Procesos integrados para la gestión de cambios en el sistema**

- ▶ Petición de cambio sobre el sistema (mejora, defecto, cambio sw, hw,...), iniciada en cualquier punto, se comunica automáticamente al resto de miembros del equipo

- **Eliminación de barreras de comunicación**

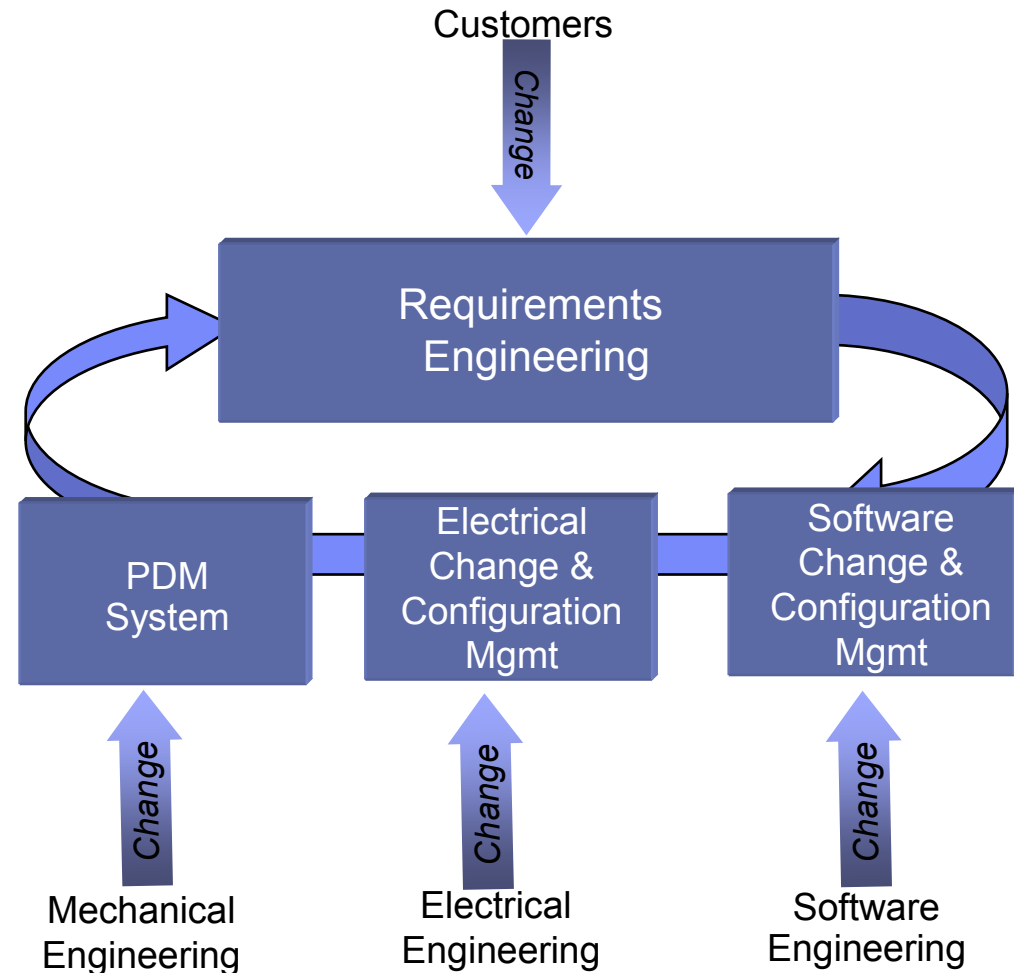
- ▶ Permite que SW, HW y electrónica trabajen como departamentos integrados
- ▶ Facilita la integración de sistemas y reduce los errores producidos por una incorrecta integración

- **Gestión de Configuración del Producto**

- ▶ Permite sincronizar la entregas de SW y las versiones de HW para tener una versión coherente del producto final

- **Integración entre herramientas:**

- ▶ IBM Rational para la gestión del cambio y la configuración: ClearCase, ClearQuest, Synergy, Change, RTC
- ▶ Sistemas PLM/PDM: Dassault, Siemens, PTC



## Beneficios plataforma desarrollo y validación de sistemas

- **Mejora la comunicación** entre las diferentes disciplinas: ingenieros mecánicos, eléctricos, ingenieros de sistemas, etc. Reducción del riesgo de fallo por integración.
- **Control de los procesos de construcción** del producto: trazabilidad desde requisitos de producto hasta el diseño hardware y software (trazabilidad hasta el código en sw)
- **Control de los procesos de verificación y validación**: gestión de las pruebas y trazabilidad a requisitos y diseño
- Proceso de **control de cambios** integrado: impacto de cambios a todos los niveles
- **Cumplimiento con estándares y regulaciones**. Demostración del cumplimiento de los requisitos del cliente.





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