Human Factors Issues in a Model Based Systems Engineering Perspective Applied to Naval Mission

Speaker: A. Tocci

Agenda

- Human Factors in System Engineering
- Usability Lifecycle
- Human Factors Analysis
- System and Operator Views Interaction
- Human Factors System Modelling
- Benefits
- Conclusions

Human Factors Issue in System Engineering Approach

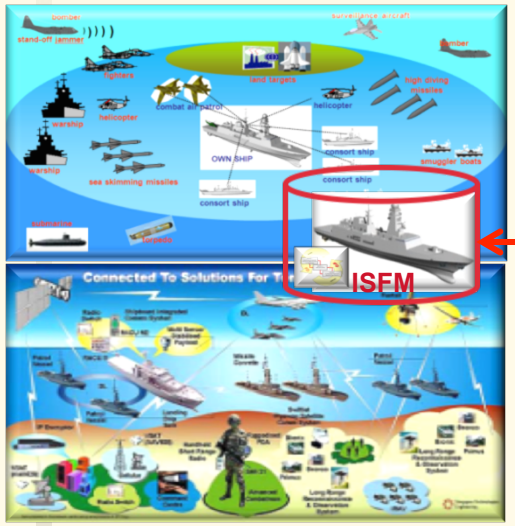
SELEX Sistemi Integrati

INCOSE International Symposium

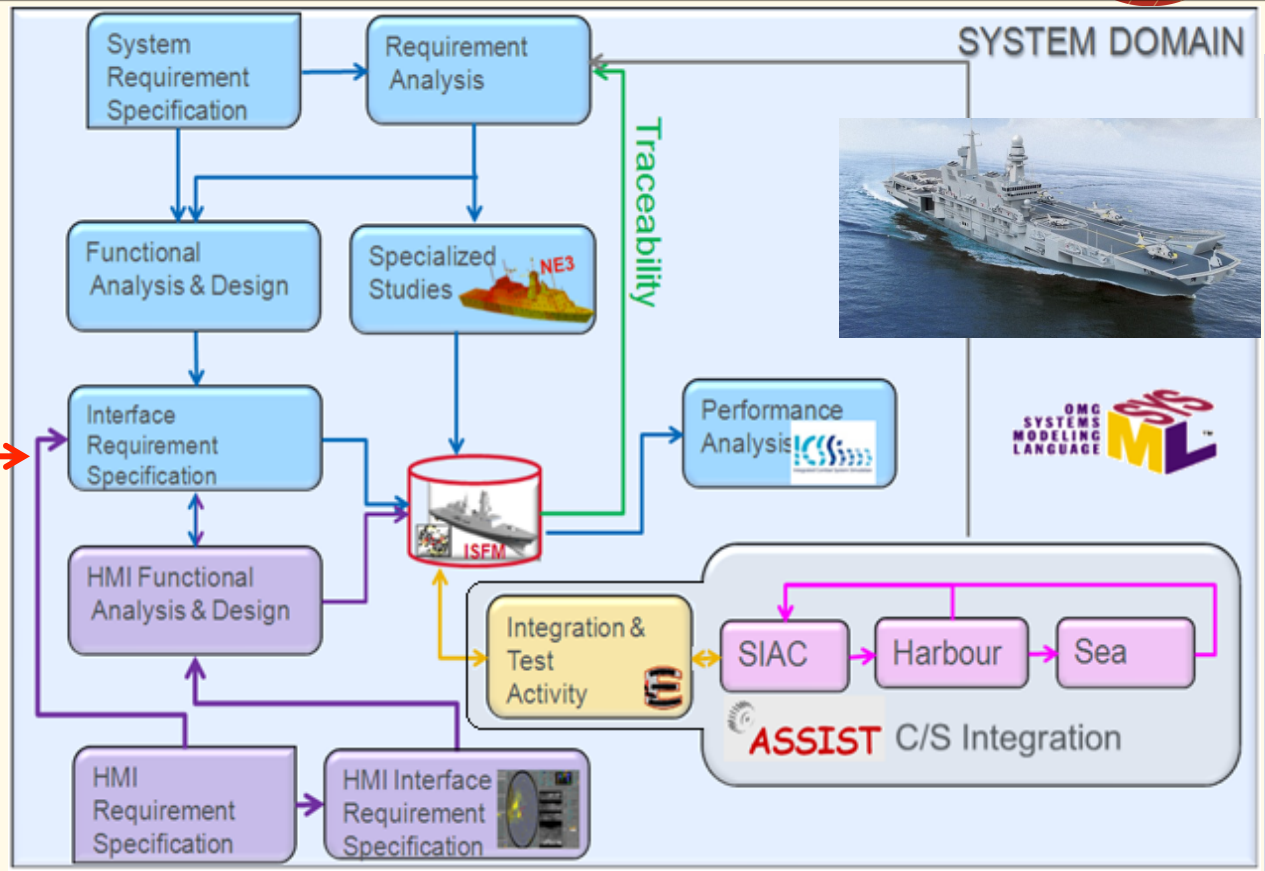
SYSTEM OF SYSTEM DOMAIN

UPDM

Mission Needs

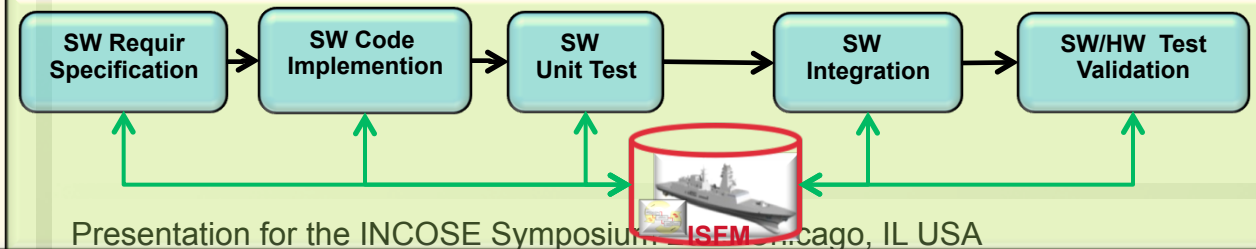


SYSTEM DOMAIN



OMG SYSTEMS MODELING LANGUAGE SysML

CMS SOFTWARE DOMAIN



UNIFIED MODELING LANGUAGE UML

© 2010 SELEX Sistemi Integrati. All rights reserved

Human Factors Modelling in a System Domain Perspective

Mission Needs

SYSTEM DOMAIN

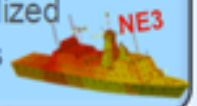
System Requirement Specification

Requirement Analysis

Traceability

Functional Analysis & Design

Specialized Studies



Interface Requirement Specification

Performance Analysis

HMI Functional Analysis & Design

Human Views

Integration & Test Activity

SIAC

Harbour

Sea

ASSIST C/S Integration

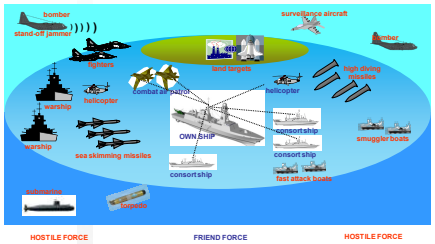
HMI Requirement Specification

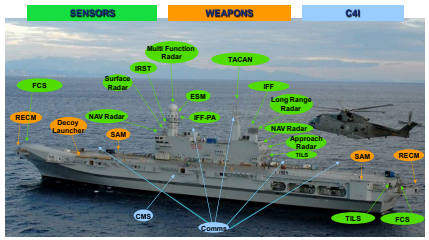
HMI Interface Requirement Specification

© 2010 SELEX Sistemi Integrati. All rights reserved

System Approach to Human Factors Aspect

Ship Mission + Tactical Procedures + Reference Standards

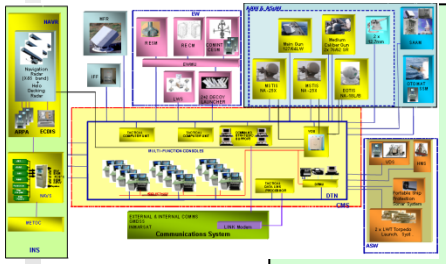




Ship Operational Capabilities
C/S Equipments
Scheme of Complement

HF Studies

- HW Console Study
- Use Study Report
- Operator Interface



C/S and CMS Consoles
C/S and CMS Roles and Duties
System Capabilities
Tasks and Actions Analysis
Tasks-to-Operators Allocation and Readiness States
Operators Workload Assessment
Human-Computer-Interface

© 2010 SELEX Sistemi Integrati. All rights reserved

Definitions

- **Combat System (C/S)**
  - System that performs combat mission on a naval military unit, employing an integrated suite of sensors, weapons, and C4I capabilities;
- **Human Factors**
  - Set of disciplines that define human constraints in the design of a system;
- **Model**
  - Human factors studies' results become part of the System functional Model;
- **HCI Fast Prototyping**
  - From System Model a preliminary version of Human computer Interface panels

© 2010 SELEX Sistemi Integrati. All rights reserved
6

Human Factors in System Engineering

- Human Factors is a group of disciplines that are subdivided in three branches:
  - **Human Factors Science** : The science of understanding the properties of human capability.
  - **Human Factors Engineering** : The application of this understanding to the design, development and deployment of systems and services.
  - **Human Factors Integration** : The art of ensuring successful application of Human Factors Engineering to a program
- Human factors involves the study of all aspects of the way humans relate to the world around them, with the aim of improving operational performance, safety, through life costs and/or adoption through improvement in the experience of the end user.

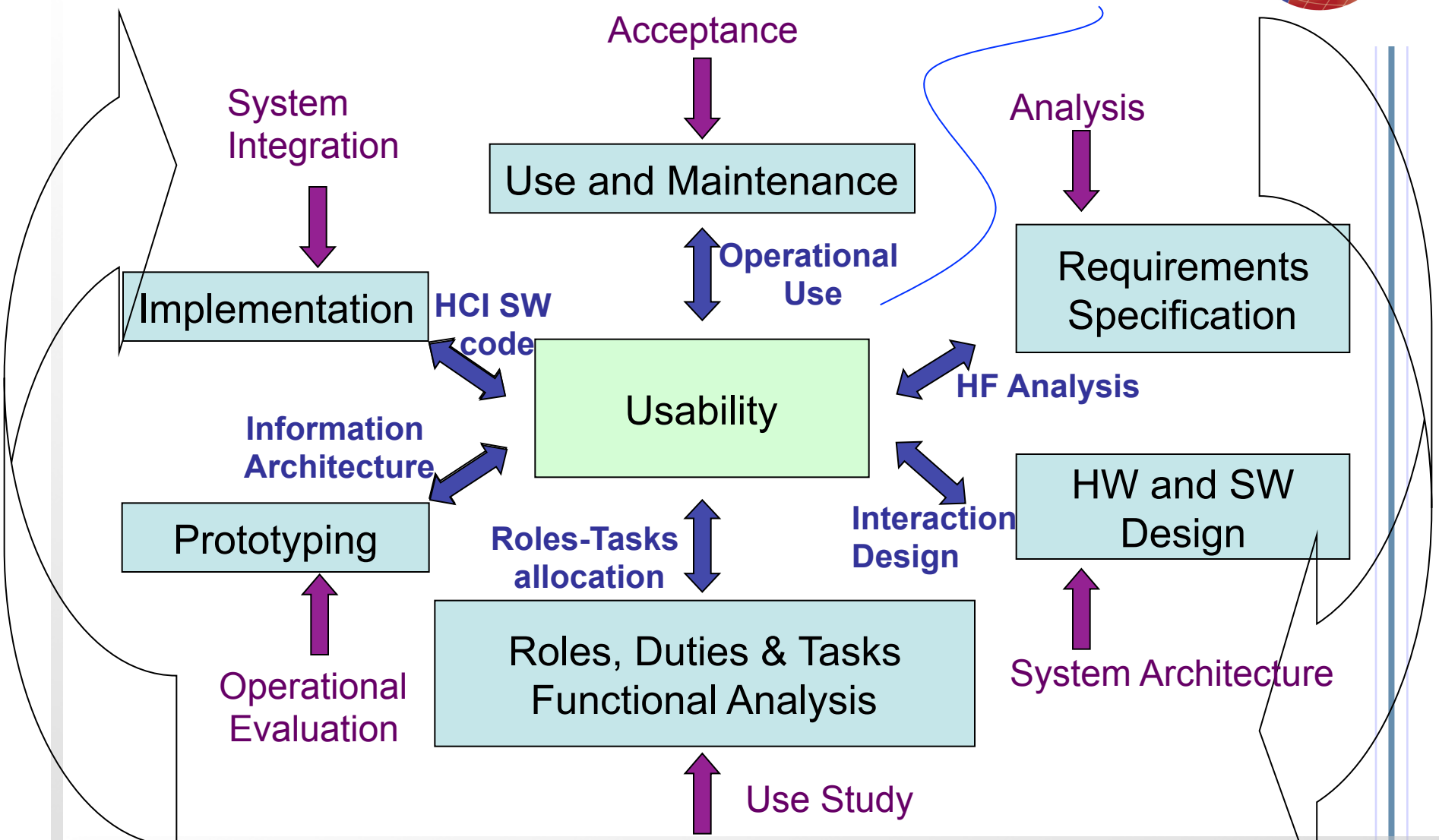
© 2010 SELEX Sistemi Integrati. All rights reserved

Importance of Human Factor Design

- Human Factors Design has seen increase interest in Naval Applications due to
  - **Reductions** of embarked **Crew** Member
  - **Increasing** of equipments and **capabilities** for flexible missions employment of modern multi-role ships.
  - The **acceptance** of the whole integrated system is based on **Usability** assessment by the operational Navies member.

© 2010 SELEX Sistemi Integrati. All rights reserved
8

Human Factors KEY Aspect : Usability



© 2010 SELEX Sistemi Integrati. All rights reserved

9

Usability Attributes

- Important Usability attributes to be reached in Naval Systems:
  - Learnability,
  - Efficiency,
  - Memorability,
  - Robustness,
  - Satisfaction

© 2010 SELEX Sistemi Integrati. All rights reserved
10

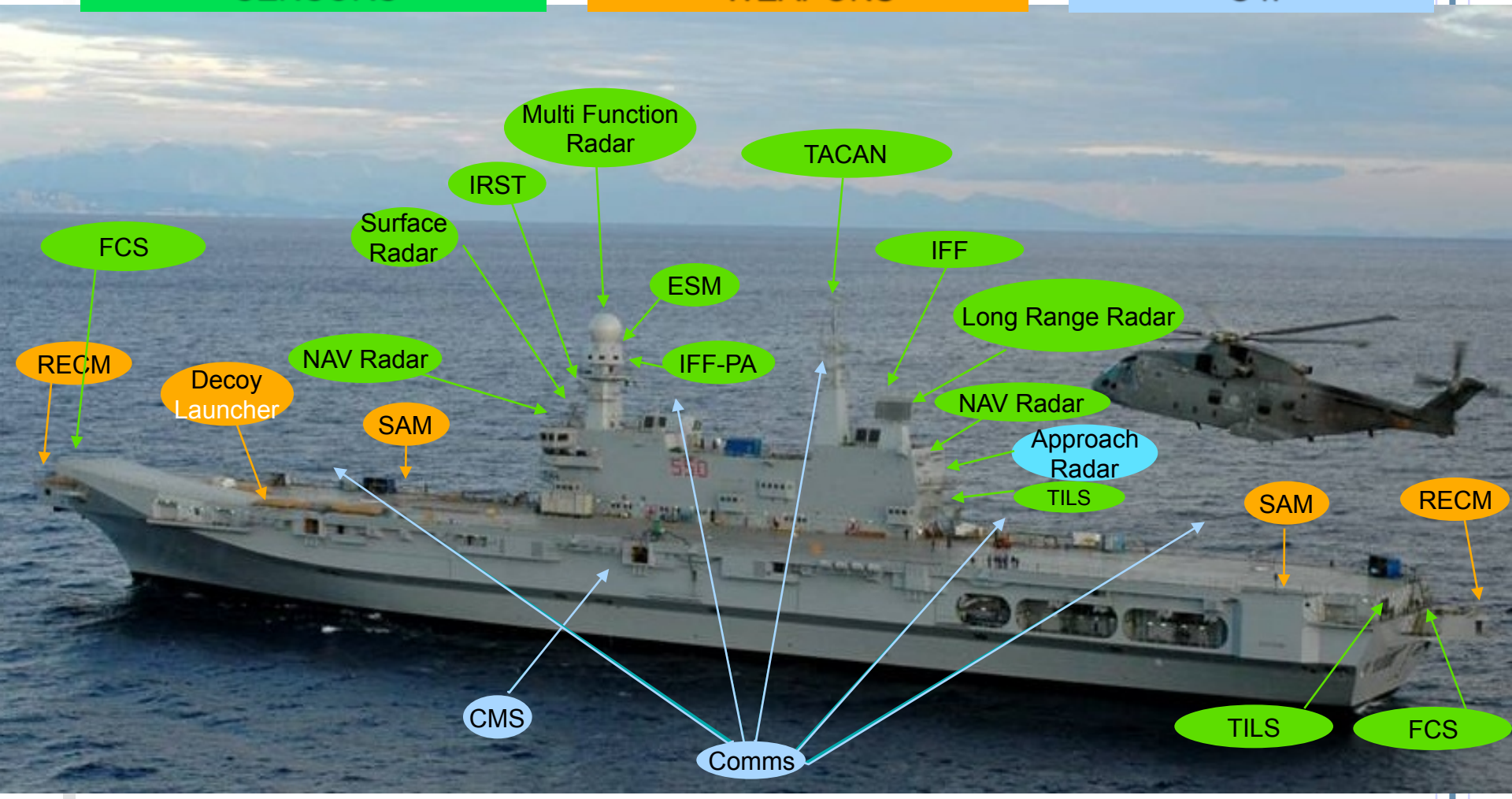
Human Computer Interaction Design

- The key idea of Human Computer Interaction design is to bring the computers/systems/applications closer to the user by making them more usable.

- Key Questions:
  - User (cognitive and physical capabilities) -- Who ?
  - Technology -- By ?
  - Usability -- How ?
  - User's Tasks -- What ?
  - Context of Use -- Where ?

System Complexity

SENSORS | WEAPONS | C4I



© 2010 SELEX Sistemi Integrati. All rights reserved

Design Combat System

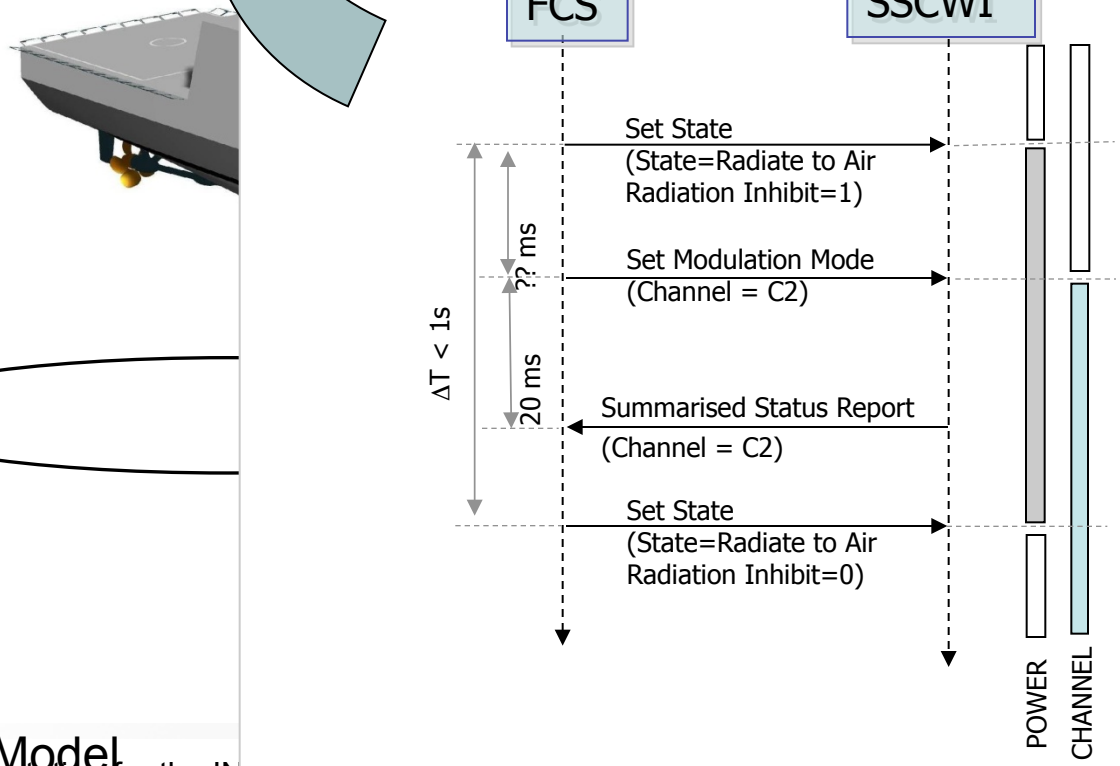
C/S Architectural Design

C/S Functional Design - Breakdown

C/S Functional Design – F. Chain

S/S State Diagram

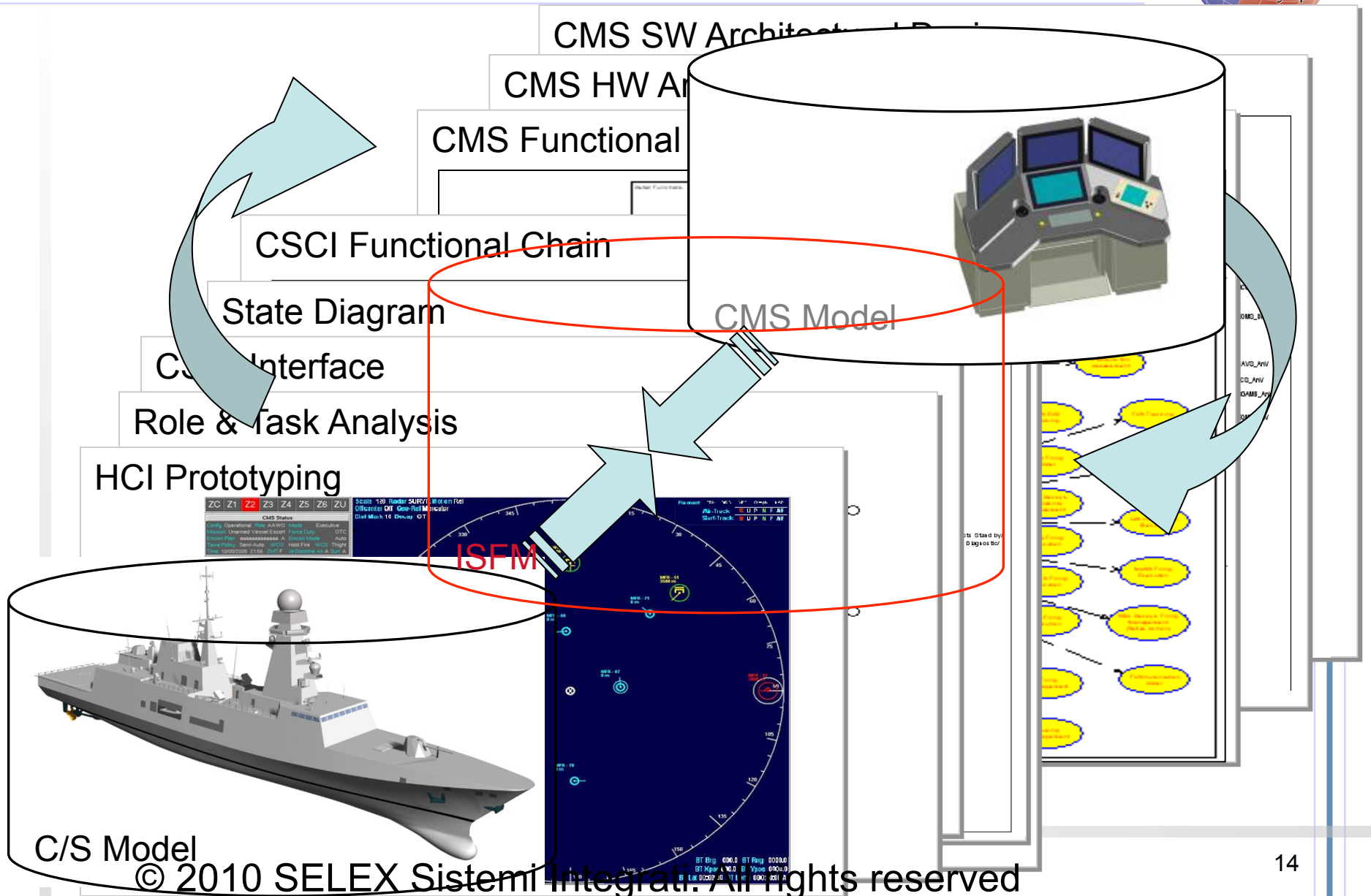
C/S Interface Design



C/S Model

© 2010 SELEX Sistemi Integrati. All rights reserved

Design Combat Management System



© 2010 SELEX Sistemi Integrati. All rights reserved

Naval Humanitarian & Civil Protection Mission Context

support aircraft

Land Disaster Area

Flood refuges

Lost & Injured

Heartquake refuges

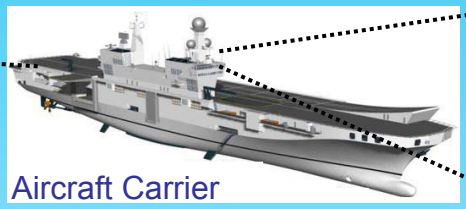
Local Camp Hosptial

Civil Defence Organizzation

International Military Organizzation

shipwreck victim

helicopter



Aircraft Carrier

helicopter

clandestine

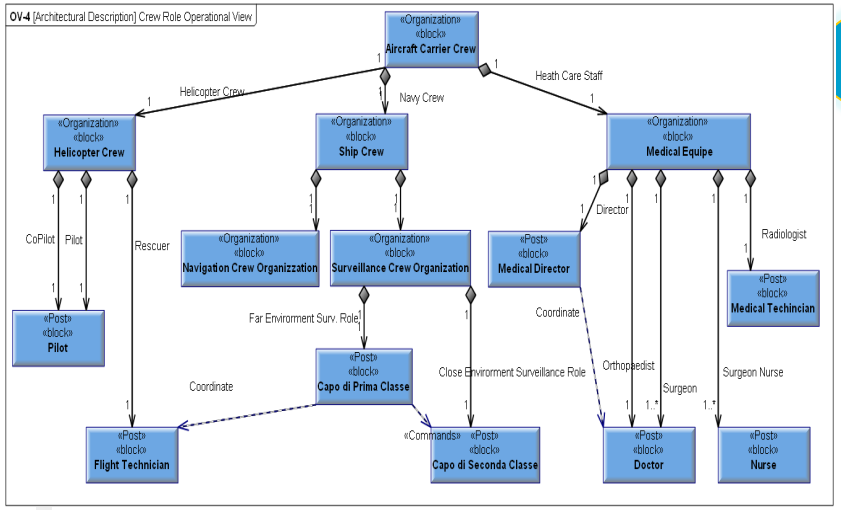
consort ship

DISASTER AREA

FRIEND FORCE

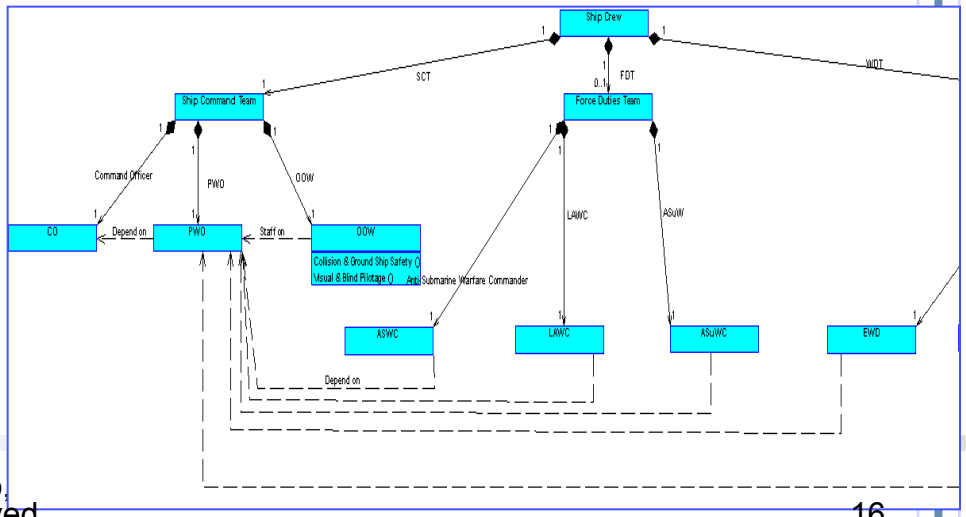
© 2010 SELEX Sistemi Integrati. All rights reserved

From Ship Crew to CMS Operator Role



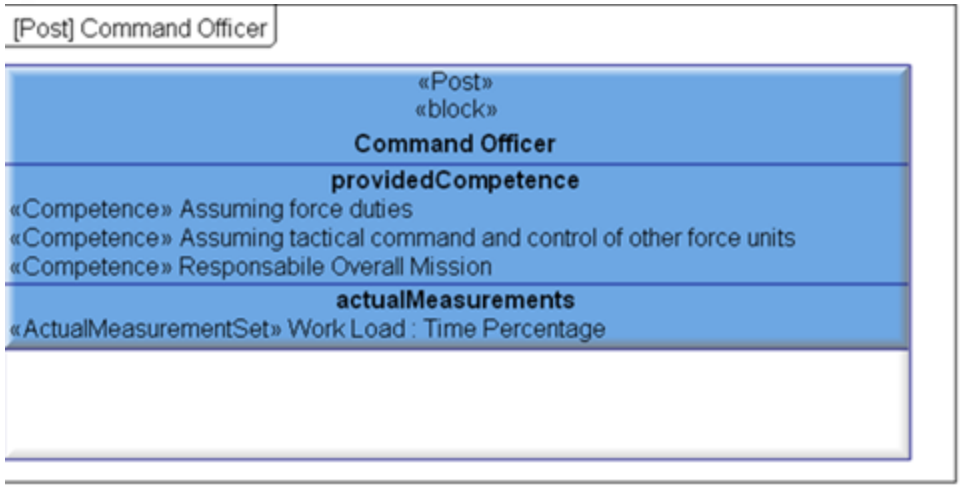
Ship Crew organizzation View

CMS Operator Role View



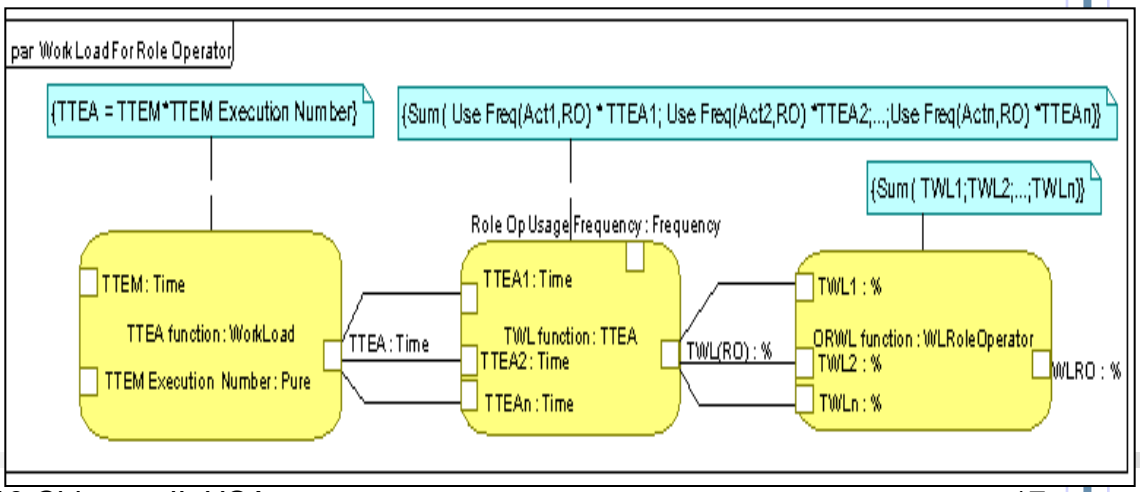
© 2010 SELEX Sistemi Integrati. All rights reserved

Crew Role Competence & Measurement to CMS Operator Role Work Load Analysis



Crew Role Competence & Measurement View

Operator Role Work Load



© 2010 SELEX Sistemi Integrati. All rights reserved
17

Human Factors and System Views

SYSTEM VIEW

OPERATOR VIEW

Event

Sequence

INPUT

System Internal Behaviour

OUTPUT

Operator TASK

OPERATOR

HCI Panel

System

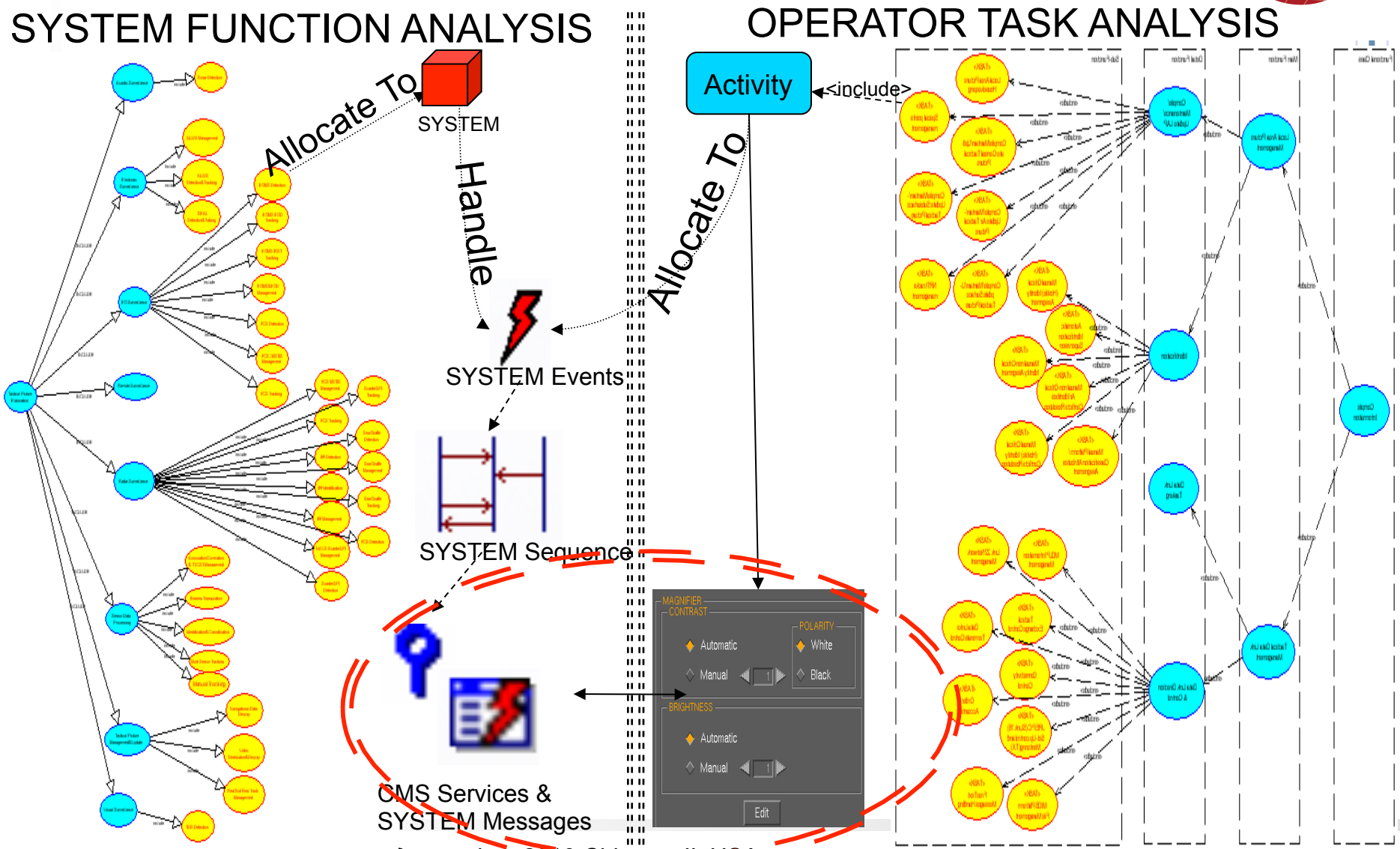
INPUT

OUTPUT

System Model

© 2010 SELEX Sistemi Integrati. All rights reserved

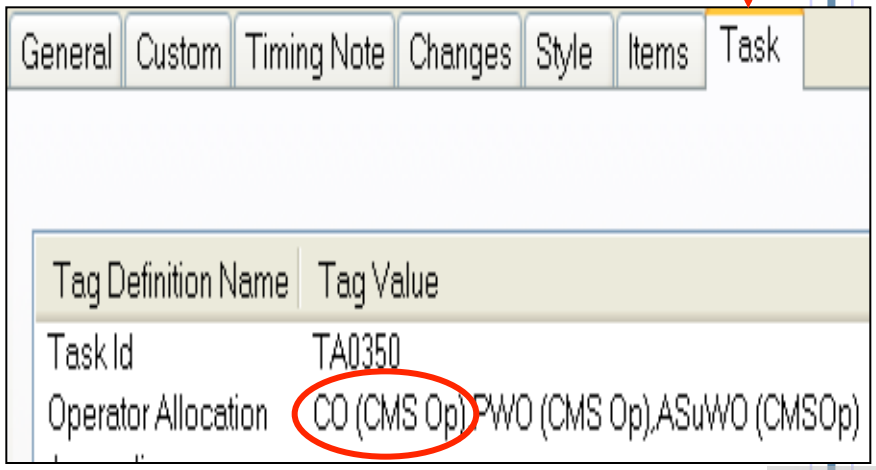
Human Factor Model Vs System Model



© 2010 SELEX Sistemi Integrati. All rights reserved

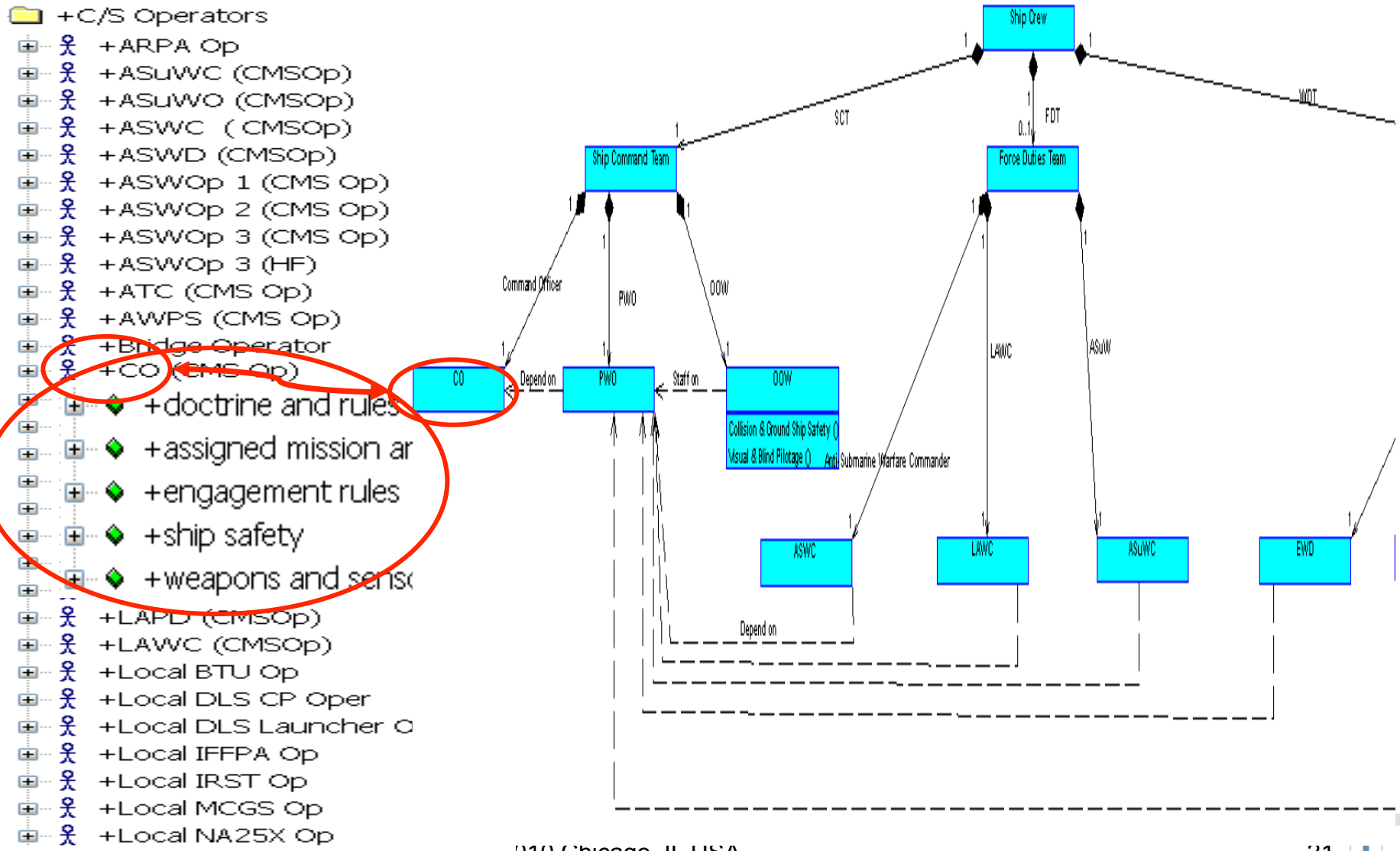
Task Allocation to Human Action & Operator Roles

- +Surface Platform Threat Evaluation (Task)
  - +PTEWA GENERAL DOCTRINE ARO
  - +AWW PTEWA WEAPON SYSTEM DOCTRINE AND TIS STATUS ARO
  - +PTEWA DOCTRINE DISPLAY ARO
  - +PTEWA DOCTRINE MANAGEMENT ARO
- +Surface Platform Weapon Assignment (Task)
  - +PTEWA GENERAL DOCTRINE ARO
  - +AWW PTEWA WEAPON SYSTEM DOCTRINE AND TIS STATUS ARO
  - +PTEWA DOCTRINE DISPLAY ARO
  - +PTEWA DOCTRINE MANAGEMENT ARO
  - +SURFACE PLATFORM THREAT LIST ARO (TBD)
  - +ASUW ENGAGEMENT PLAN ARO
- +Tactical Exchange Control (Task)
- +TLS Control (Engagements) (Task)
- +TLS Direction (Task)
- +TLS Tasking (Task)
- +Training Management (Task)
- +ZIPPO Activation (Task)
- +ZIPPO Direction (Task)
- +ZIPPO Tasking (Task)



© 2010 SELEX Sistemi Integrati. All rights reserved

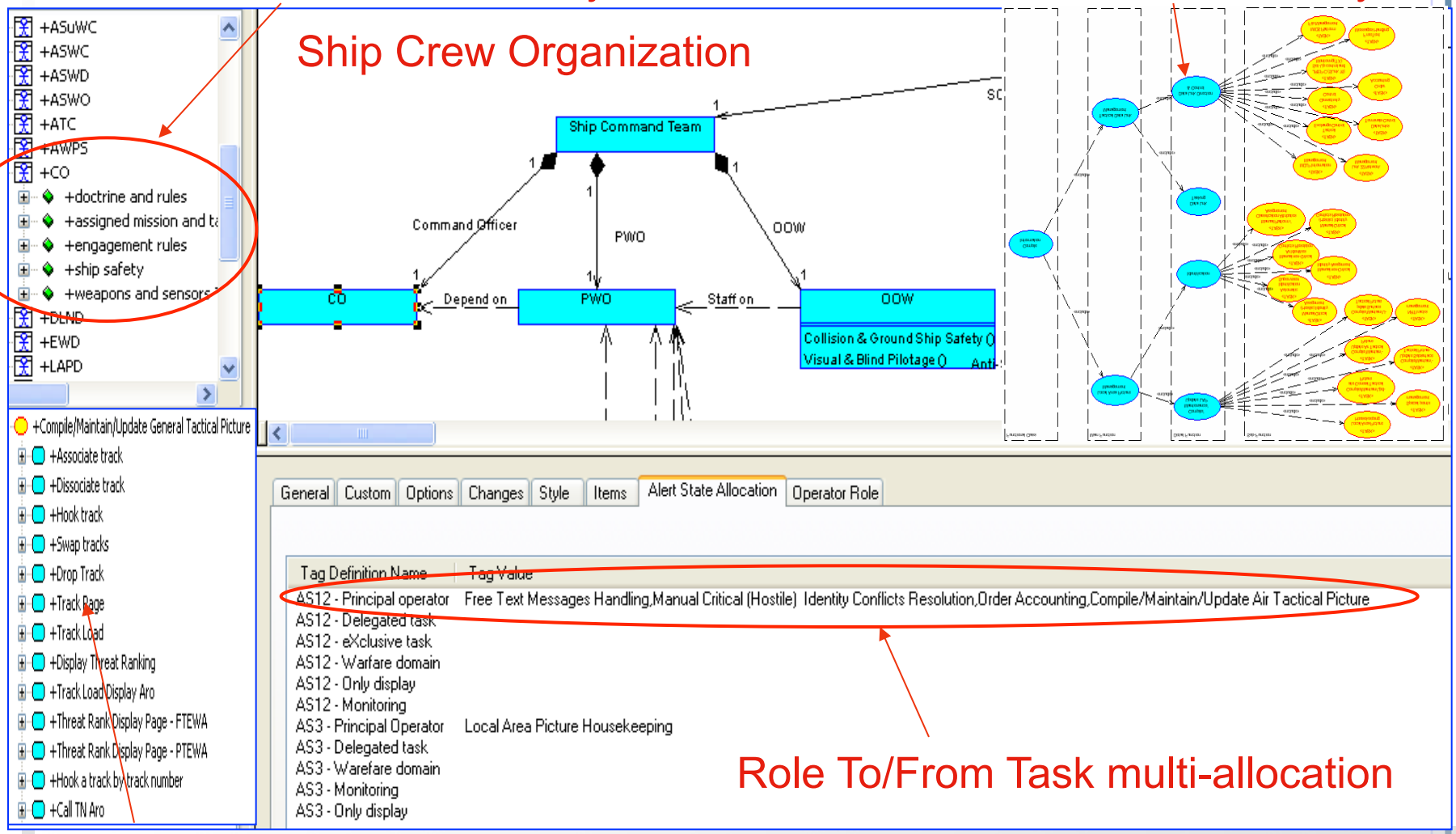
Model Combat System Operator Role Definition



Human Factor Modelling Overview

Role Definition and duty

Task Function Analysis



Role To/From Task multi-allocation

Task Action Definition

© 2010 SELEX Sistemi Integrati. All rights reserved

System Requirement Development Views

System Development

Human Factor Development

+CMS-MTP-OPR-3950
NRT Manual initialisation

+Real/Not Real Track Management

+Non real time track management

+Facade for Operator Action Management

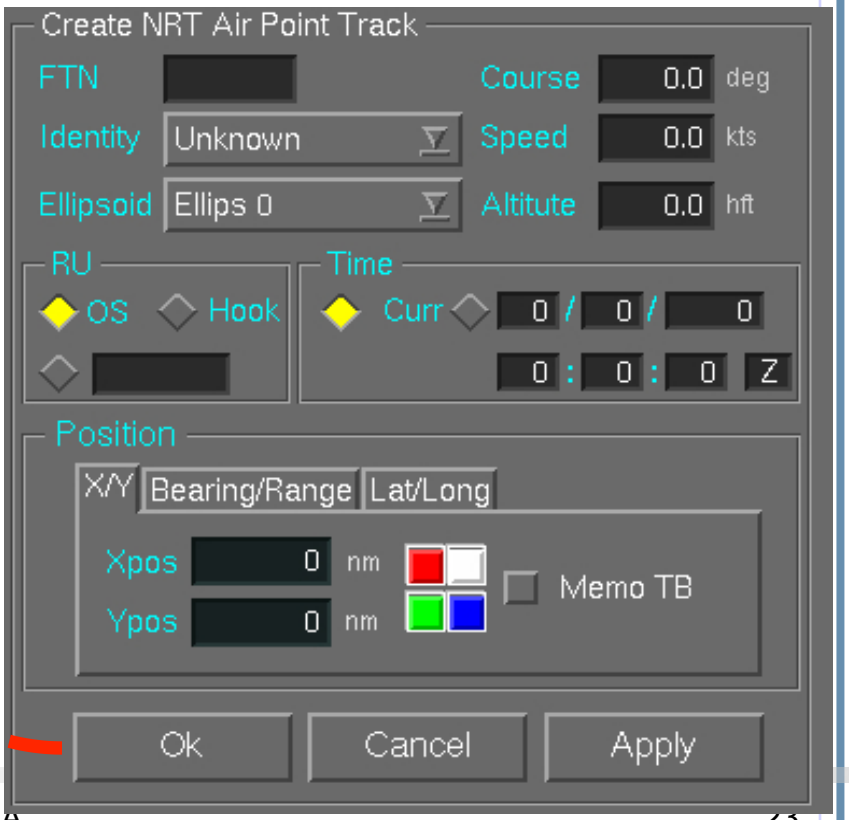
+CreatePointNRT_ARP

+HCI_TPM_CreatePointNRT_ARP_MSG

- -header : Message_Header_Type
- -oaSubHeader : HCI_Header_Type
- -positionXY : T_2DCartesianCoordinates
- -arpSignature : T_UnsignedInteger32
- -course : T_Float
- -speed : T_Float
- -altitude : T_Float
- -combatSystemTime : T_CSTime
- -environment : T_Environment
- -identity : T_Identity
- -ftn : T_UnsignedInteger32
- -subSurfaceClassConfidence : T_SubsurfaceClassifConfidence

+NRT tracks management

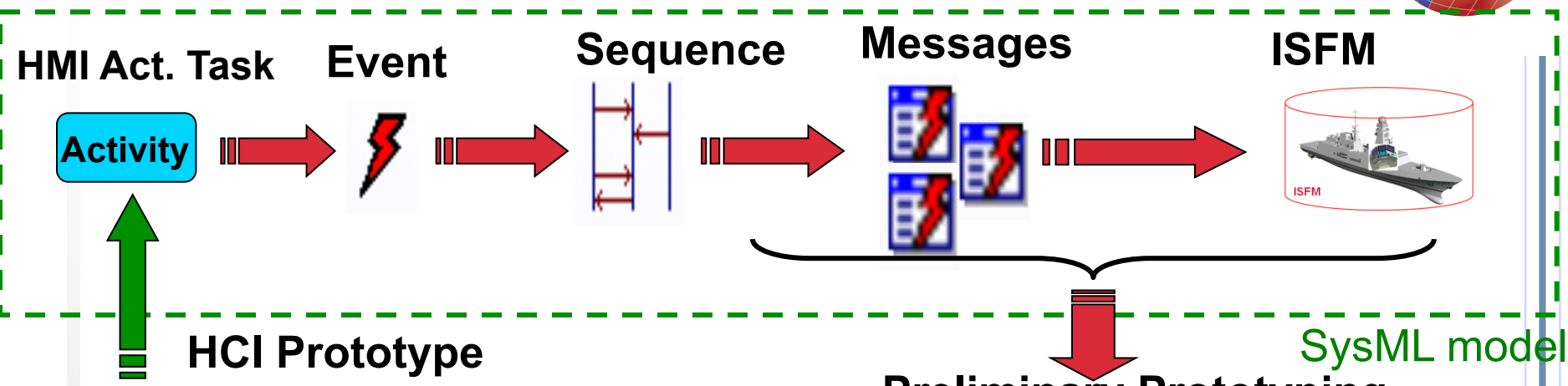
+Create NRT Air Point Track



© 2010 SELEX Sistemi Integrati. All rights reserved

23

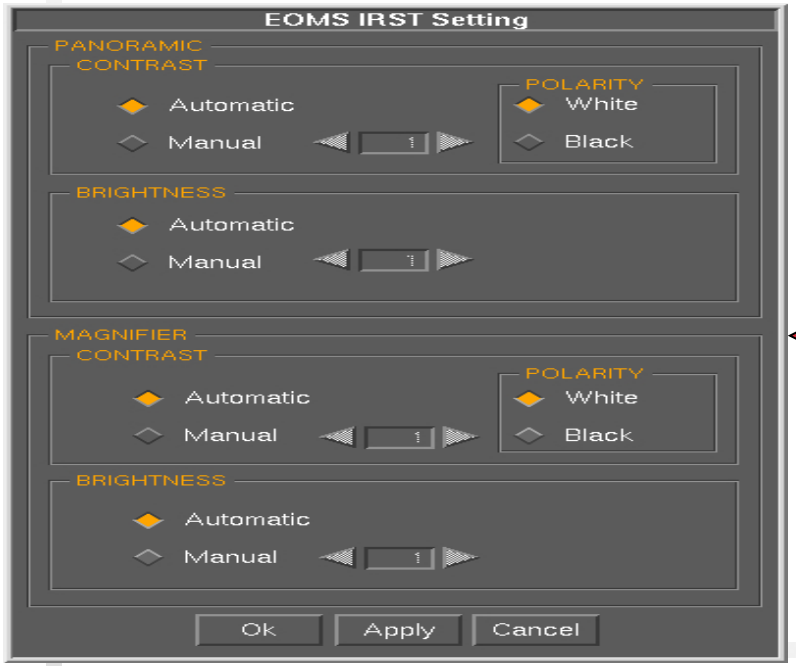
From SysML Model to HCI Prototype

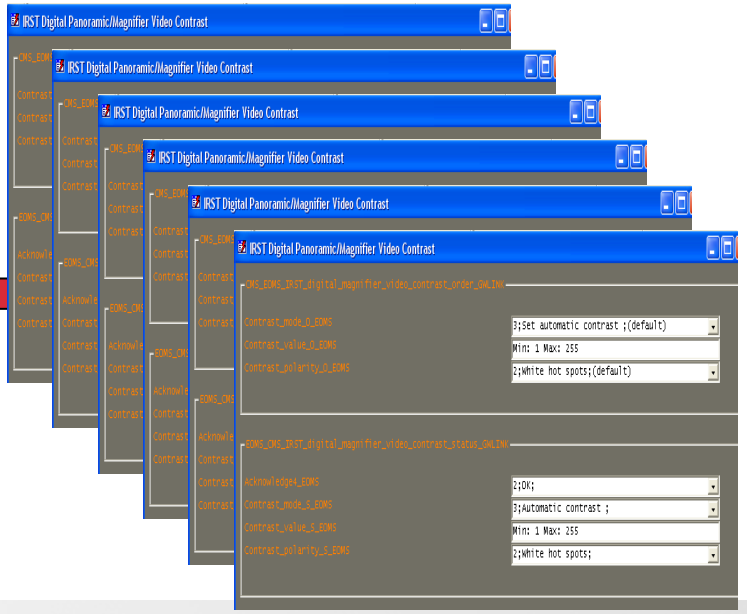


SysML model

HCI Prototype

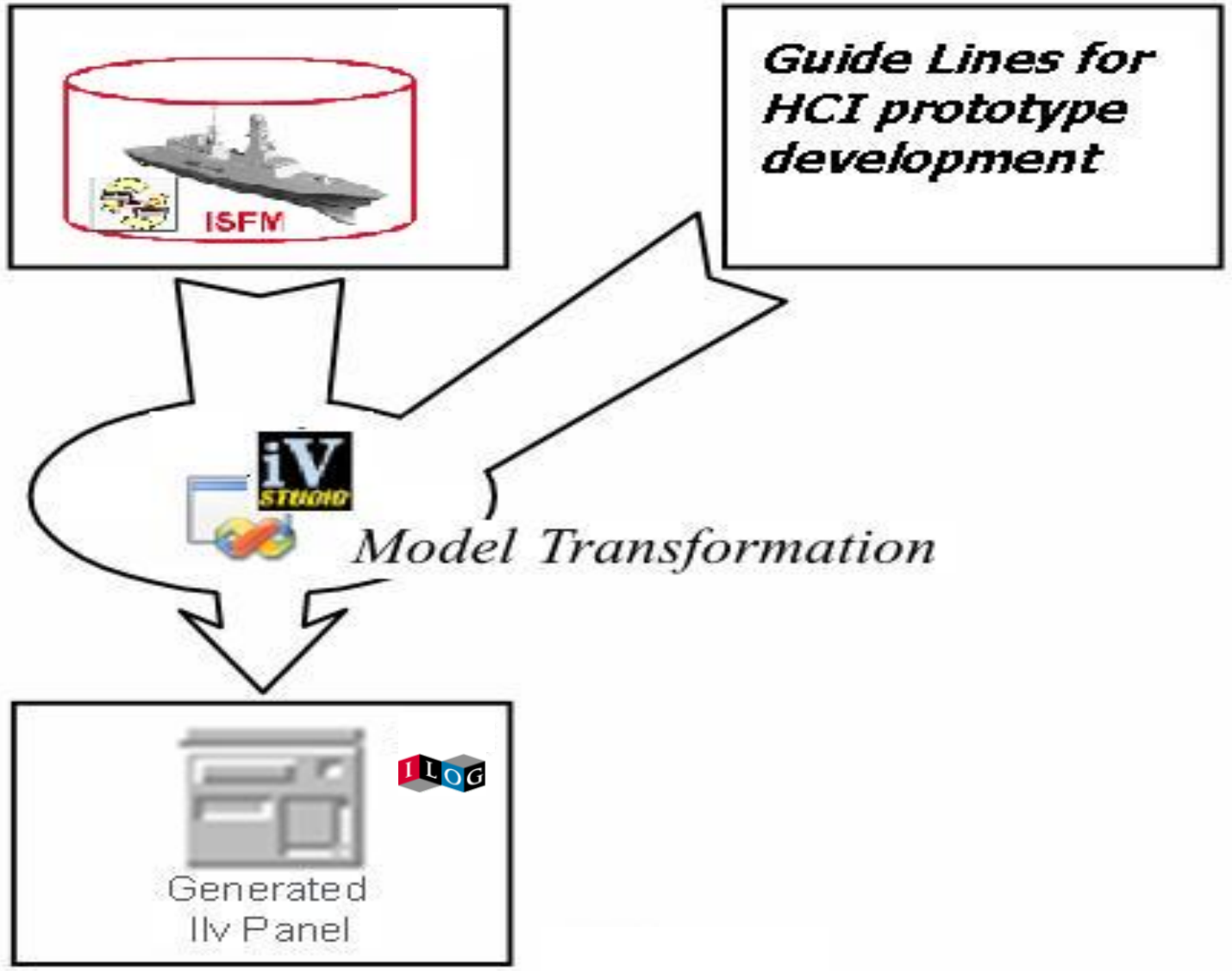
Preliminary Prototyping





© 2010 SELEX Sistemi Integrati. All rights reserved

HCI Fast Prototyping: Model Driven Approach



© 2010 SELEX Sistemi Integrati. All rights reserved
25

Benefits in the Project phases

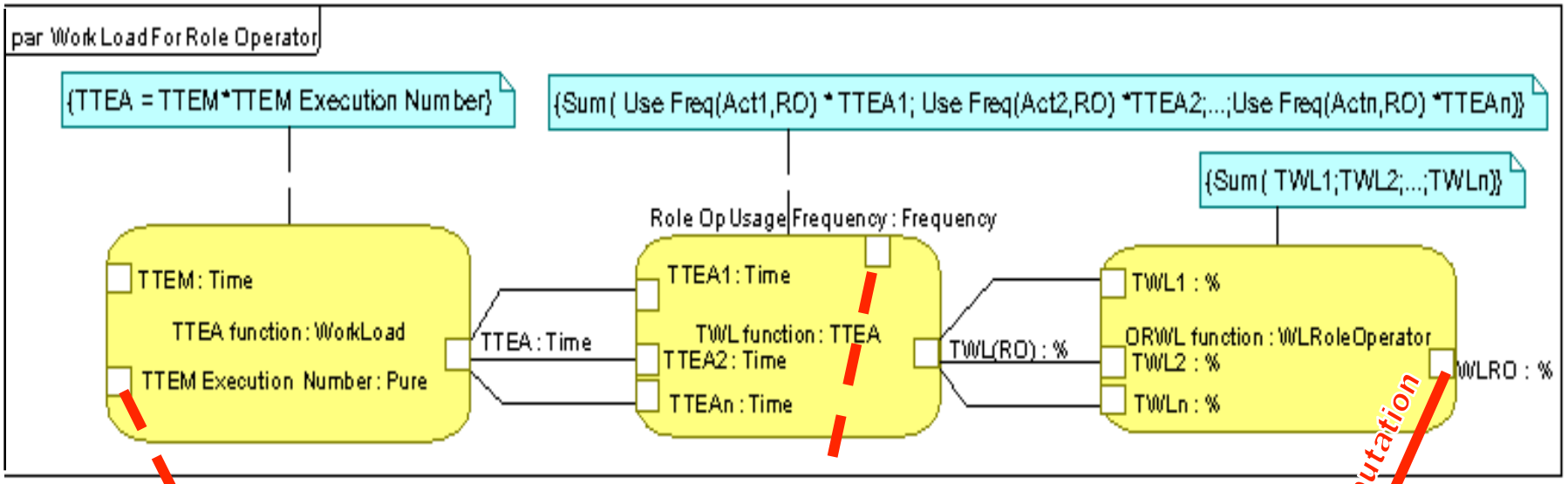
- **Design Phase:**
  - -Consistent Check of HCI Data and System Data.
  - -Balance among information layout display and system information constraints

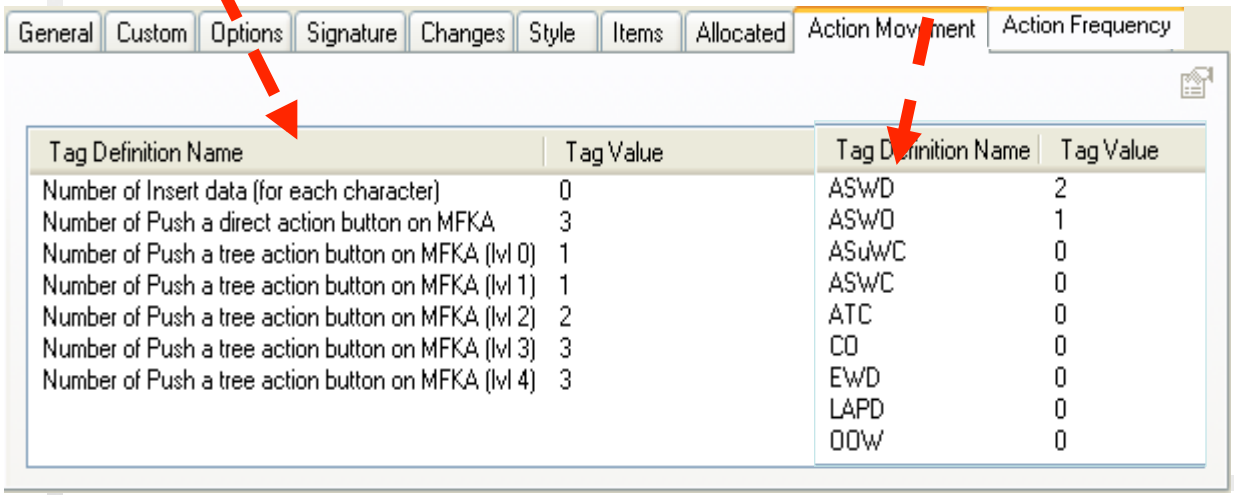
- **Development Phase**:
  - -HCI preliminary fast prototyping.
  - -HCI prototyping with integrated Interface Requirements System.

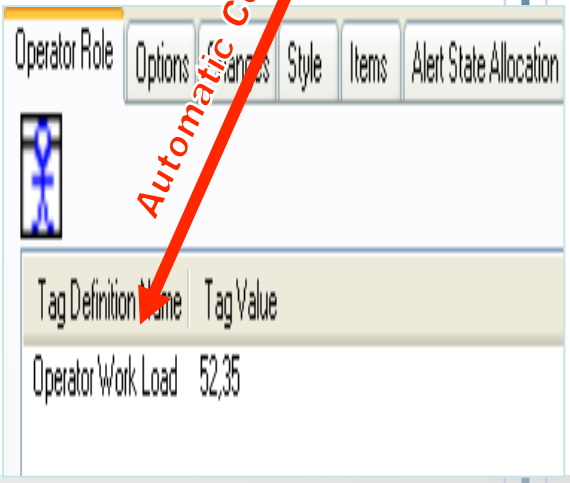
- **Integration Phase:** Follow the Operator action from the Display Interface to the C/S message exchange and CMS Service calls.

© 2010 SELEX Sistemi Integrati. All rights reserved
26

Benefits on Operator Workload studies







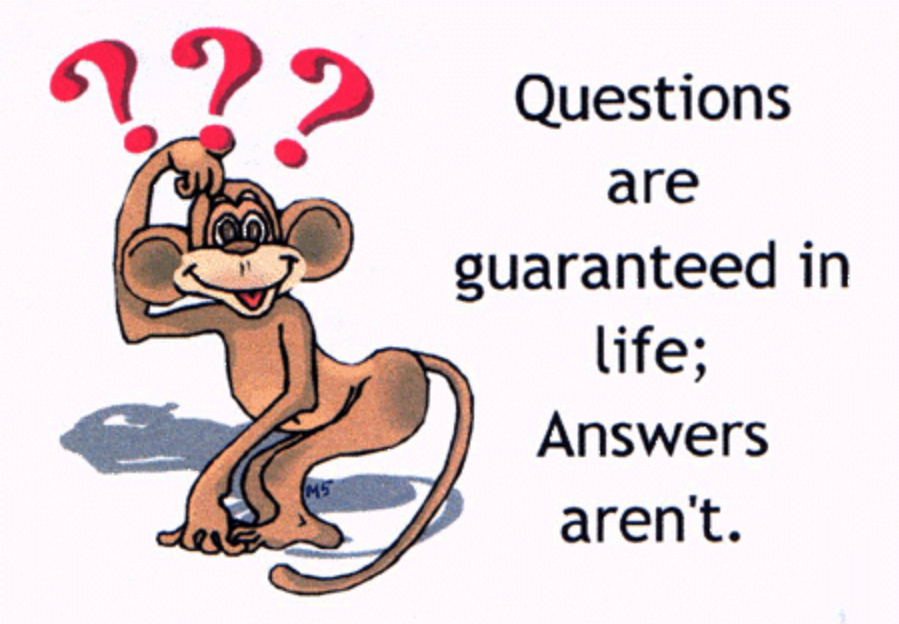
© 2010 SELEX Sistemi Integrati. All rights reserved

Conclusions

- Integration of Human Factors View into a unique System Model has brought a lot of benefits such as data consistence and Fast prototype generation.
- Model the Human Factors aspects had made possible to automatically generate the project documentation with time redaction.
- In System Integration phase it has been possible to verify the functional chains
- The unique model increase thanks to the relationship the efficency and the system reuse.

© 2010 SELEX Sistemi Integrati. All rights reserved
28

Questions



Contacts

Andrea Tocci
SELEX SISTEMI INTEGRATI
B.U. Sistemi Difesa
Ph. +39.06.4150.5572
Fax +39.06.4150.4259
e-mail: atocci@selex-si.com

Francesco Ciambra
B.U. Sistemi Difesa
Ph. +39.06.4150.3926
Fax +39.06.4150.4259
e-mail: fciambra@selex-si.com