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CGS for COLUMBUS
Integration and Operation
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CGS for COLUMBUS

- ❑ **The COLUMBUS Module**
- ❑ **Overview COLUMBUS Ground Facilities**
- ❑ **Data Distribution in COLUMBUS Ground Facilities**
- ❑ **CGS extensions for the COLUMBUS Project**
- ❑ **Status of the COLUMBUS Ground Facilities**

The COLUMBUS Module

The COLUMBUS is the European Pressurized Laboratory for Microgravity Missions in the Material, Fluid Physics and compatible Life Science and Technology Disciplines, launched and serviced by the Shuttle/Orbiter, permanently attached to the International Space Station (ISS).



Mission Requirements

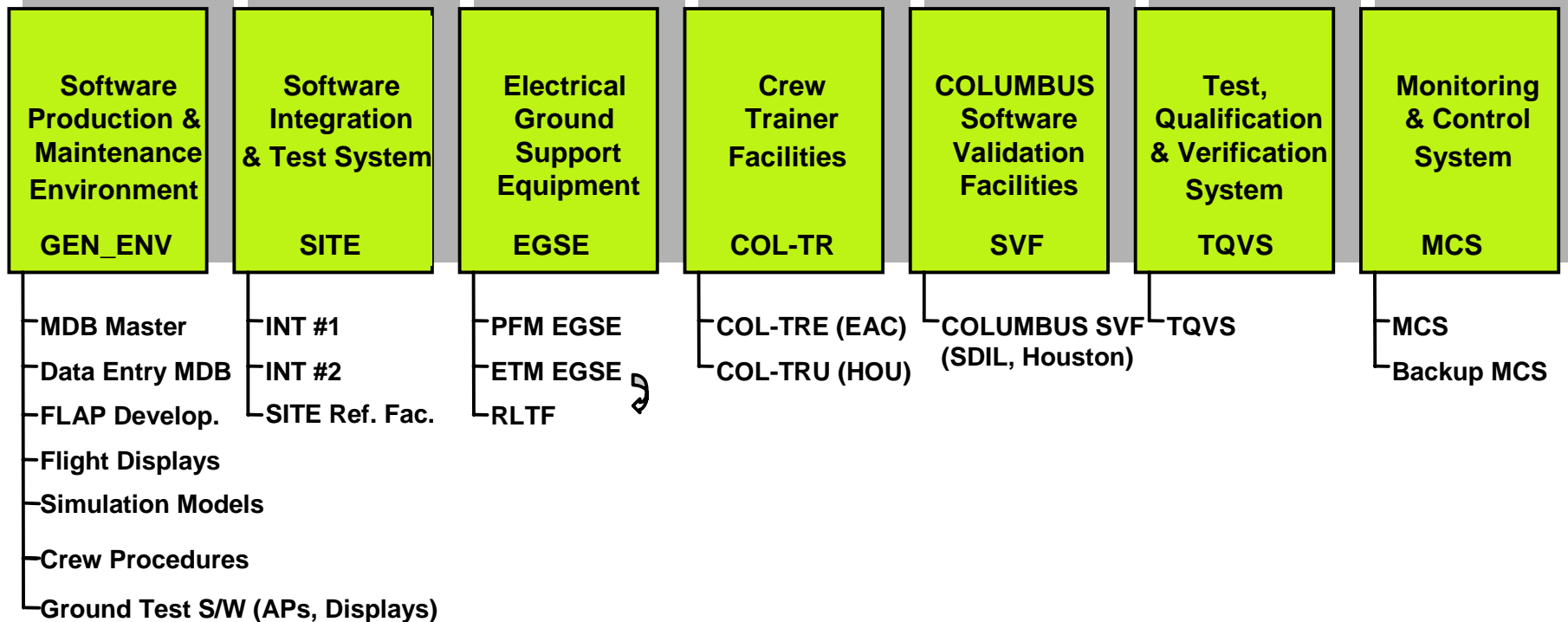
- Orbit 51.6° inclination
- Altitude nominal range between 335 - 500 km
- Mission Duration 10 years with on-orbit maintenance
- Payload Accommodation
 - 10 active International Standard Payload Racks (ISPR)
 - 3 Stowage Racks
 - Utilization of the APM Center Aisle
 - 4 External Payload Mechanisms

System Parameters

- Configuration 4 rack-lengths Pressurized Module permanently attached to ISS
- Dimensions 6.4 m x 4.5 m diameter
- Launch Mass 12,400 kg (incl. Payload 2,500 kg)
- On-Orbit P/L Mass 9,000 kg max.
- Resources provided by the International Space Station, except data processing
- Electr. Power sized for max. 20 kW (120 VDC), 13.5 kW for P/L Operation
- Communications Infrastructure
 - 33 Mbps down via ISS TDRSS
 - 32 Mbps down via JEM Artemis
 - 10 kbps up via ISS S-Band
 - 50 Mbps down Ka-Band (Col-Term. Option)
 - 2 Mbps up via S-Band (Col-Term. Option)
- Environmental Control sized for 3 crew members; heat rejection up to 22 kW
- Data Management Layered Multi Computer Architecture Control via Mil Std 1553 b busses Data Comms via Ethernet LAN
- Video Display, recording, compression and routing

Overview COLUMBUS Ground Facilities

The COLUMBUS Software Production & Test Facilities are grouped by family and built using the common kernel S/W CGS (COLUMBUS Ground Software) as well as common application software built on top of CGS



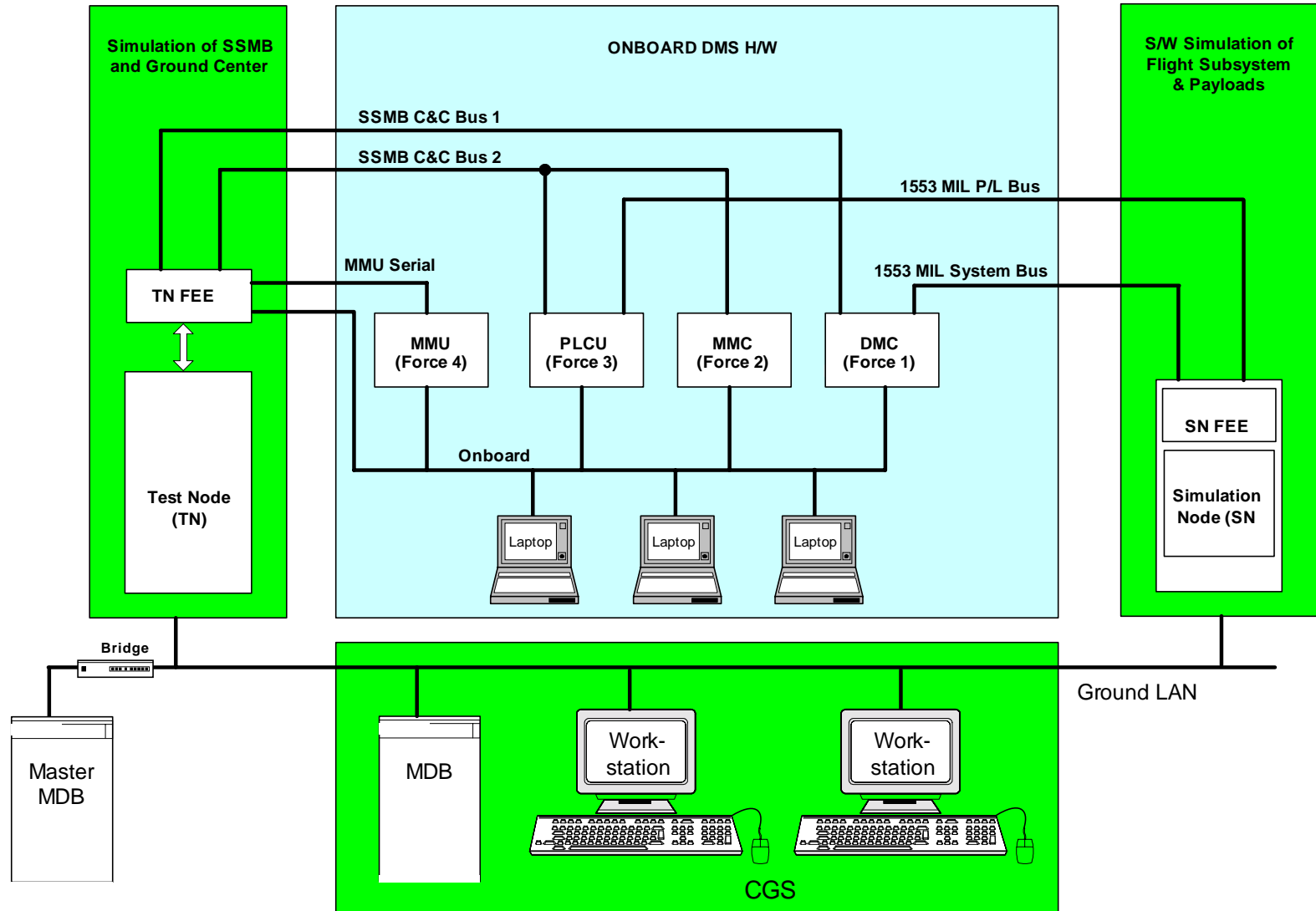
The Software Production Environment (GEN_ENV)

- ❑ **Development and Maintenance of COLUMBUS data**
- ❑ **FLAP, flight synoptics, Crew Procedure development**
- ❑ **Compilation, link of flight source code (Ada/C) and integration with the MDB (⇒SWOPs)**
- ❑ **Generation of flight data tables (⇒CDIs) & ground data tables (e.g. routing tables, event tables)**
- ❑ **Generation of flight displays and crew procedures**
- ❑ **Build of the Flight Mass Memory Image & VTC SW load**
- ❑ **Product generation & delivery to all COLUMBUS facilities**
- ❑ **Platform is based on the COLUMBUS SDDF/CGS**

The Software Integration & Test Environment (SITE)

- ❑ Integration and test of the Flight S/W and data tables
 - ✓ Data Management SW: DMS, COAP, LAPAP
 - ✓ Flight Application Procedures (FLAP)
 - ✓ Flight Displays & Crew Procedures
- ❑ Execution of flight S/W on ground versions of the on-board computers (DMC, MMC, MMU, PLCU, LAPTOP)
- ❑ Simulated VTCs (part of a future upgrade)
- ❑ COLUMBUS Flight H/W (Subsystems and Payloads) simulated by a CGS based model
- ❑ Simulation of SSMB & Ground Center interfaces via subset of EGSE
- ❑ Ground application SW common with EGSE

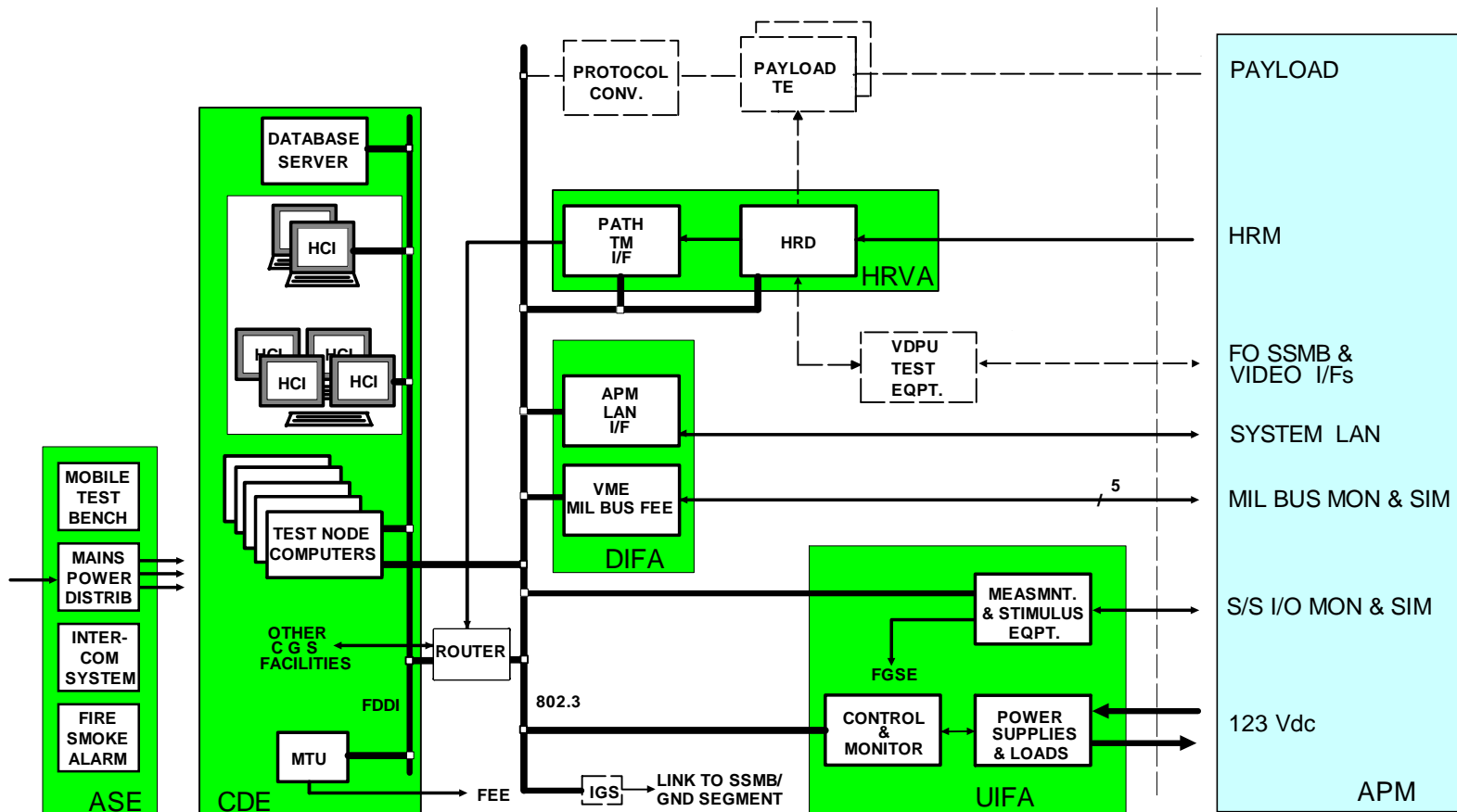
The SITE Architecture



The Electrical Ground Support Equipment (EGSE)

- ❑ Integration and Test of the COLUMBUS Flight Hardware and Software
- ❑ Two sets of EGSE:
 - ✓ PFM EGSE for integration and test of the Flight System
 - ✓ ETM EGSE: For functional tests and qualification of the APM System using the Electrical Test Model
- ❑ Integrated System Test
- ❑ Close-out of System Requirements
- ❑ Upgrade of the ETM EGSE to Rack Level Test Facility (RLTF) to integrate and test the COLUMBUS Payload

The EGSE Architecture



APM ETM / EGSE (Integration Area in Bremen)



APM PFM EGSE (HRVA, DIFA, MSE, Power)



EGSE Control Room



Ground Synoptic Display Example (DMS Activation)

Synoptic Display [7] - ACTIVATE_DMS, path: \APM\INT\AIT\DMS\SYNOPTICS

EQUIPMENT SELECTED FOR ACTIVATION

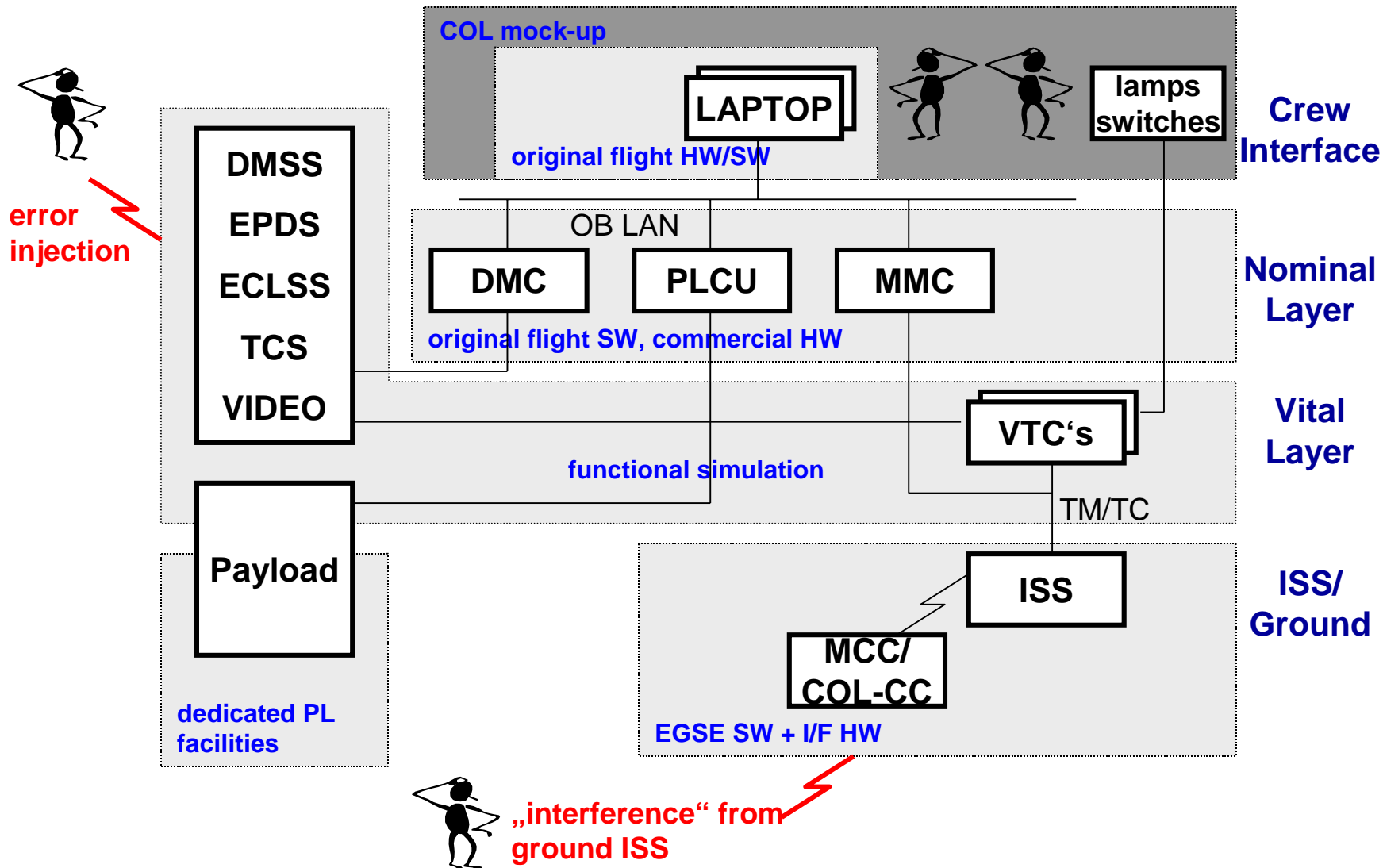
<p>Pred. Modes</p> <p>NONE</p> <p>Select MODE</p>	<p>START RT ACQ</p> <p>YES</p> <p>RT ACQ</p> <p>Start RT Acquisition of CMU 1-4, PDU 1+2 and Cycl. HK DMS_HN</p>	<p>CMU1</p> <p>YES</p>	<p>CMU2</p> <p>YES</p>	<p>MMC</p> <p>YES</p> <p>Select MMC</p>
<p>PDU1 PDU2</p> <p>YES YES</p> <p>Select PDU</p>	<p>EPDS_AUX_PWR</p> <p>NONE</p> <p>AUX_SUPPL</p>	<p>CMU3</p> <p>NO</p>	<p>CMU4</p> <p>NO</p>	<p>DMC</p> <p>YES</p> <p>Select DMC</p>
<p>VTC1 VTC2 POWER ON SELECT</p> <p>VTC1_NOH VTC2_NOH</p> <p>VTC POWER</p>	<p>Enable/Disable Monitoring</p> <p>NO</p> <p>ENA/DIS</p>	<p>HUB/MMU</p> <p>NONE</p> <p>Select HUB</p> <p>NONE</p> <p>Select MMU</p>		<p>PLCU</p> <p>NO</p> <p>Sel. PLCU</p>
<p>MODE SELECT</p> <p>MASTER SLAVE</p> <p>Select VTC</p>	<p>Start / Stop Sequence Count Check</p> <p>STOP</p> <p>Start/Stop</p>	<p>VDPU</p> <p>YES</p> <p>Sel. VDPU</p>		<p>SPARE</p> <p>NO</p> <p>Sel. SPARE</p>
<p>Is this the first Activation Cycle ?</p> <p>YES</p>		<p>HRM</p> <p>YES</p> <p>Select HRM</p>		
		<p>DMC Startup FLAP</p> <p>NO</p> <p>Start FLAP</p>		
		<p style="text-align: center;">Start config now !</p>		

11:43:36

The Crew Trainer Facilities (COL-TR)

- ❑ COL-TRE is located at EAC (Cologne) and used for astronaut training with respect to APM
- ❑ COL-TRU is located in Houston and used for astronaut training with respect to APM and, as an integrated subsystem of SSTF, for inter-element training
- ❑ The configuration is based on the SITE with some additions:
 - ✓ Includes a simulation of VTC's and hence the possibility of error injection at vital layer
 - ✓ includes interfaces for integration of payload simulation facilities, e.g. RLTF
 - ✓ includes interfaces for synchronisation of APM and ISS environment models (in SSTF configuration)

COLUMBUS Simulation Software (Crew Trainer)



COLUMBUS Simulation Model Data

	SITE INT-1/INT-2	COL-TRE COL-TRU	SVF	TQVS	Reference Facility
APM-SIMM	X	X	X	X	X
VLS		X		X	X

APM-SIMM

- system bus measurements: ~ 2.000
- system bus stimuli: ~ 700
- vital bus measurements: ~ 1.200
- vital bus stimuli: ~ 500
- MDM hardwired interfaces: 36
- error injection: > 50.000

Vital Layer Simulation (VLS)

- C&C bus
commands/responses

The COLUMBUS Software Validation Facility (SVF)

- ❑ Used for integrated test (“stage testing”) with the rest of the ISS software
- ❑ Used for re-testing whenever interface software changes on either side of the interface (e.g. VTC S/W update)
- ❑ Located in SDIL facility in Houston and will be integrated into this facility, but will maintain a standalone capability (Delivery July 2003)
- ❑ The configuration is based on the SITE with some additions:
 - ✓ Engineering Model VTC’s and MAL Panel
 - ✓ Flight representative data harness (VTC/PDU) from the ISS to the COLUMBUS module (for initial activation)

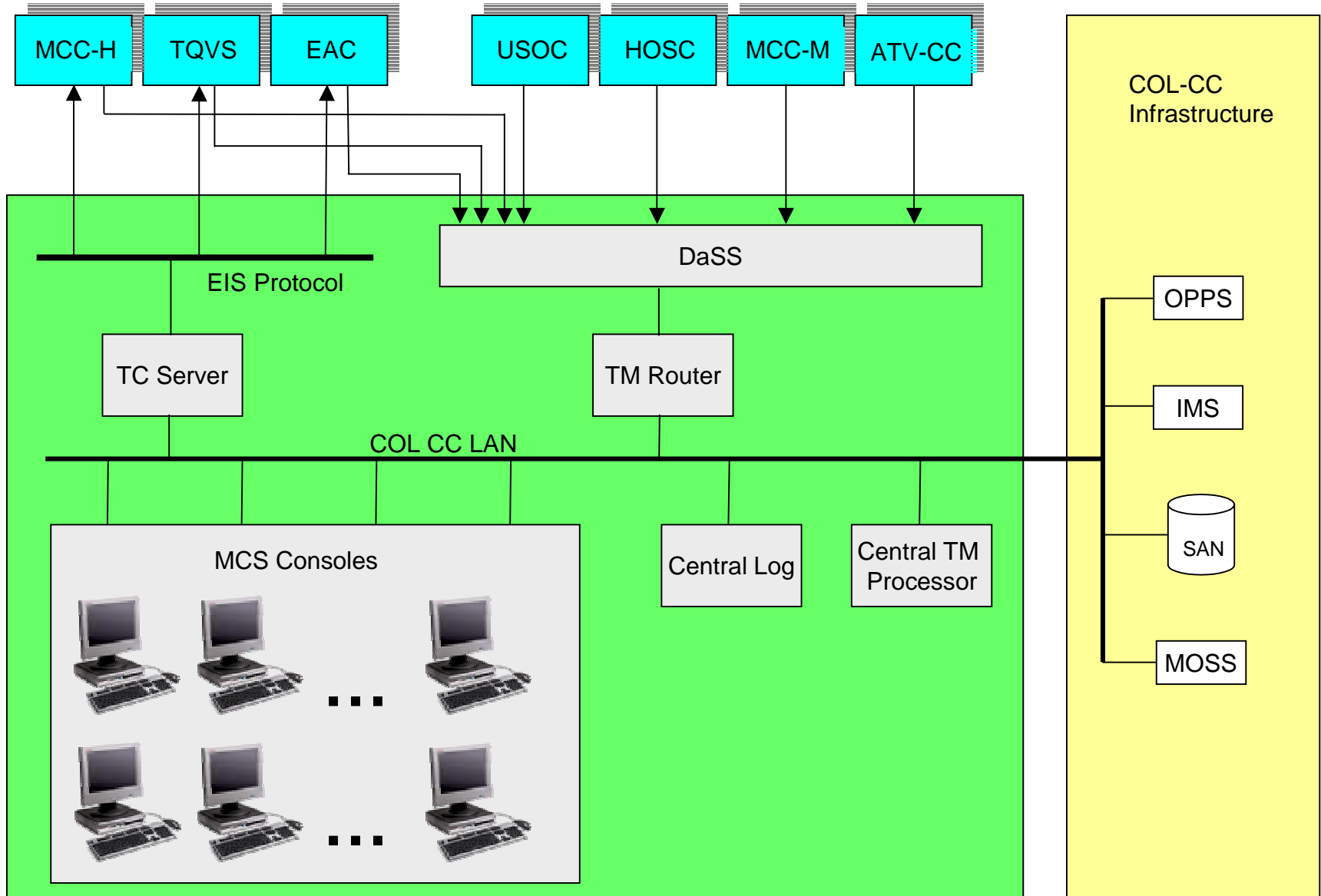
The Test, Qualification & Verification System (TQVS)

- ❑ **Used for Verification of the MCS and for simulations and Training at COL-CC (Flight Control Team)**
- ❑ **Also used for joint testing between the COL-CC and the ETM/PFM**
- ❑ **Based on the SITE configuration with some additions:**
 - ✓ **Includes a simulation of the VTC as provided for the COL-TRE/COL-TRU**
 - ✓ **Includes a simulation of the communications path from the COL-CC to the COLUMBUS module via the MCC-H through the SSMB (S-Band uplink/downlink and C&C MDM)**

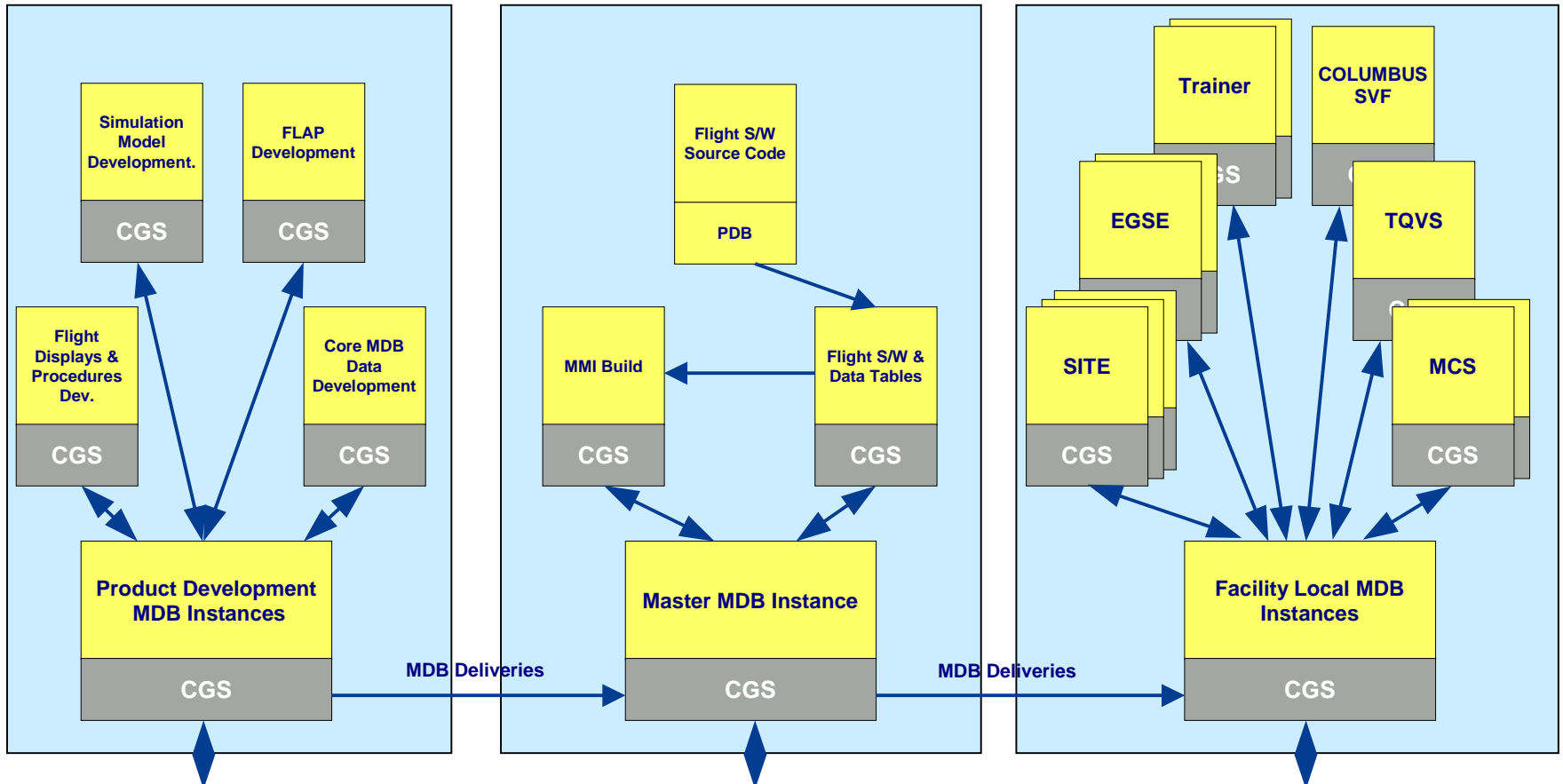
The Monitoring & Control System (MCS)

- ❑ The kernel S/W System to build up the COLUMBUS Control Center (COL-CC) in Oberpfaffenhofen
- ❑ TM Monitoring and Display
- ❑ Commanding to the COLUMBUS Onboard System
- ❑ File Transfer and Onboard SW Maintenance Support
- ❑ Master Timeline Viewing and Regeneration
- ❑ Based on CGS version 6 (LINUX version of CGS)
- ❑ Using the COLUMBUS Mission Database
- ❑ Integrated with COL-CC Subsystems (IMS, MOSS, OPFS, DaSS, IGS/Infrastructure)

The MCS Architecture



Data Distribution in the COLUMBUS Ground Facilities



Master Mission Database (MMDB) as central Engineering Knowledge Repository:

- System Description / Expert - Diagnosis know-how
- Telemetry / Telecommand Data Definitions

- Simulation Software
- Automated Procedures (onboard & ground)
- Display Definitions (onboard & ground)

CGS extensions for Version 4.5.1

All COLUMBUS Ground Facilities are based on CGS version V4.5.1 (except MCS). The main functional improvements for CGS Vs4.5.1 include:

- ❑ Improved user interfaces (monitoring windows, tool invocation from end item, out of limit display)
- ❑ Incremental consistency checks
- ❑ HTML based Database Report (including end item cross links)
- ❑ MDB Excel Tool for data maintenance and “bulk data entry” in the Master Database
- ❑ Flexible XML based database reports
- ❑ Derived Values & Conditional Monitoring

CGS extensions for the MCS

The MCS is based on CGS version V6 including all Vs 4 and Vs 5 functionality. The main new features of MCS are:

- ❑ S/W upgrade to execute under LINUX on INTEL H/W
- ❑ Database running under ORACLE 9
- ❑ Command Stack and History Viewer
- ❑ Central Telemetry Router and Telecommand Server with redundancy capabilities
- ❑ Element Manager for central administration
- ❑ Extended User Roles and Privileges
- ❑ Master Timeline Editing and Viewing Capabilities

Status of the COLUMBUS Ground Facilities

- ❑ **Most of the COLUMBUS Ground Facilities are in operation**
- ❑ **The remainder are in development and will be delivered later this year**
- ❑ **Some Facility Data:**
 - ⇒ **COLUMBUS onboard system: ~900 FLAPs and ~440 Flight Synoptic Displays**
 - ⇒ **EGSE: ~400 Automated Procedures, ~430 Synoptic Displays, 25 HLCL Sequences**
 - ⇒ **SITE (Ground Test S/W): 642 HLCL sequences, 1390 Automated UCL Procedure, 215 Ground Synoptic Displays, 658 EGSE pre-defined commands, 357 SWOP commands**
 - ⇒ **Master MDB: approximately 18000 flight end items and 7000 ground end items**
 - ⇒ **APM Simulation Model (see simulation section)**

Integration Status of COLUMBUS Module



COLUMBUS Module (inside view)

