Sample Model Highlights
In-Flight Entertainment v1.0

ARCADIA

Capella
The system used as an example in this model does not reflect any existing Thales product. It is an overly simplified vision of what a real in-flight entertainment system is.

This model is partial, and mainly designed for educational purposes.

For any question about Arcadia or Capella, please post a question in the forum or use the contact addresses available on the Capella website.

Forum:
https://polarsys.org/forums/index.php/f/10/

Website:
http://www.polarsys.org/capella
The objective of this document is to browse the sample IFE model through the 5 Arcadia engineering steps.

These slides mainly rely on extracts of diagrams and form a kind of “reading path” through the model.

Noteworthy tooling, engineering or method aspects are highlighted throughout the document.

<table>
<thead>
<tr>
<th>Version</th>
<th>Date</th>
<th>Author(s)</th>
<th>Notes</th>
</tr>
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<tr>
<td>1.0</td>
<td>Feb 24th, 2015</td>
<td>Stéphane Bonnet (Thales)</td>
<td>Initialization</td>
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What **the users** of the system need to accomplish
The Operational Analysis is partial and minimal in this version. It basically introduces what kind of activities are performed by the Cabin Crew and the Passengers.
Operational Entities and Capabilities

**[OEBD] Operational Entities and Actors**

- Crew
- Aircraft
- Airline Company
- Cabin Crew
- Pilot
- Ground Operator
- Passenger
- Personal Device

**[OCB] Operational Capabilities**

- Entertain During Flight
  - Passenger
- Perform Flight On-Board Announcements
  - Cabin Crew
  - Pilot
- Implement a Commercial Strategy
  - Airline Company
[OAB] High-Level Expected Activities

- Watch Movie
- Listen to Audio
- Watch Moving Map
- Play Games
- Browse the Internet

[OAIB] Watch Movie

- Chosen Movie
- Movie Selection
- Imposed Movie
- Broadcast Movies
- Commercial Ads
- Safety Instructions
- Play Imposed Movie
Overview of all Operational Entities and Activities

[OAB] All Operational Activities and Entities

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[OPD] Perform Audio Announcement

[OAB] All Operational Activities and Entities
Operational Context: Flying Phases

The state machine is defined on the “Aircraft” Operational Entity.

The scenario is defined on the « Entertain During Flight » Operational Capability.
What the system has to accomplish for the users
Not all the IFE system is modelled. Focus is put on VOD service, audio announcement and imposed videos (safety instructions, ads, etc.).

While interesting, the topic of the integration of the IFE with the aircraft is kept minimal (according to flying conditions, the IFE system is supposed to behave differently).

Not all possible Scenarios and Functional Chains have been created.

The system is globally organized as follows:
- Cabin crew services are always available, passenger services have to be activated. Their availability depends on the flying conditions and on the class the passengers are flying in.
- The system is able to store digital media content.
- Most of the interactions of the passengers with their services (navigating between menus, selecting movies, etc.) are captured in functions called “Run <xxx> service”.
- Services rely on audio and video broadcast means.
- Maintenance and configuration topics are only evoked.
[MCB] Capabilities
[CM] Provide Cabin Management Solutions

The content of contextual Mission and contextual Capability diagrams is computed automatically.

[CC] Provide Audio and Video Intercommunication Means

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The aircraft is an Actor of the IFE system even though the system is inside the aircraft. This is because the Aircraft is providing information and means to the IFE.
Top-Level Dataflow: The System, The Actors

[SDFB] Top Level Functional Overview
The SAB diagram is often a very entry point to the model. The idea is to display high-level Functions, and navigate / zoom inside the Functions to explore in greater detail the functional analysis.
Composite functions have their name in italic. Explore their internal content by navigating on the diagram describing them.
In Operational Analysis, cabin crew is performing audio announcement.

But in System Need Analysis, the cabin crew actor does not have a corresponding Function.

Rationale: Audio announcements are safety critical and cannot be dependent of the IFE. Audio announcements are performed through the aircraft hardware, even though the IFE system is still responsible for displaying an interruption screen and for broadcasting the announcement in the headphones of each passenger.

The IFE actually receives an audio stream from the aircraft (that will trigger the interruption). The fact that the cabin crew is actually performing the announcement is out of scope.
Capabilities are usually a organizational unit for models: They can be used to distribute responsibilities between different contributors, they are useful when planning IV&V campaigns, etc.
Displaying or creating Functions in a Dataflow diagram attached to a Capability automatically creates reference/exploitation relationships from the Capability to the Functions. This improves later impact analyses.

An easy way to display all Functions involved in a Capability is to use the modeling accelerators allowing to display at once all Functional Chain and Scenario elements.
[SFBD] All System Functions

- [SFBD] Run Services
  - Run Video On-Demand Service
  - Run Sensor Service
  - Run Any Other Service
  - Run Aircraft Channel Service

- [SFBD] Call Center
  - Call Center Intrusion
  - Message Passenger Service Interruptions

- [SFBD] All Actor Functions
  - Provide Aircraft Information, Commands and Messages
    - Provide Satellite Communication Services
    - Provide Aircraft GNSS Position
    - Provide Electrical Power
    - Provide Exterior Video
    - Provide Aircraft Speed and Heading Parameters
    - Play Sound in Cabin
    - Send Deconfliction Notification

- Communications
  - Command VOD Service
  - Watch Video on Private Screen
  - Listen to Audio Announcement
  - Watch Video on Cabin Screen
  - Select Passenger Service

- Perform Cabin Management Activities
  - Perform Audio Announcement
  - Plan In-Flight Entertainment
  - Launch Pre-Flight Tasks
  - Manage the System
  - Launch and Analyze Tasks
  - Select Passenger Service Authorization
  - Initialize Media Content

Function breakdown are typically generated on the basis of the work performed in dataflow diagrams.

Avoiding to mix System and Actor functions in the same hierarchy is a good practice.
The data exchanged between Functions and between the System and the Actors could already be formalized in the System Need Analysis step. This is not the case in this sample model, the goal of this independent domain model is to give a small idea of the concepts the system will use / fits in.

This dictionary provides a basic overview of the concepts the IFE system fits in.

These elements are present for information purpose only and are not related to the Functional Analysis.
Keeping the layout consistent across diagram is a good way to improve diagram readability.
In this model, all diagrams illustrating the internal content of a function are prefixed by [CTX]. The contextual elements (the one on which refresh rules are based) are in bold.

Diagram can be set contextual to elements using the property view.

Most of these diagrams have been set as unsynchronized, in order to only display what is relevant to the current context. See the documentation.
Functional Chains and Scenarios are specific paths use cases, they illustrate the Capabilities. In order to be an important asset for the global engineering picture (see Arcadia), creating them is a good way to check the design completeness.

Functional Chains can be displayed in dataflow diagrams and architecture diagrams.

**[SFCD] Watch Imposed Video on Private Screen**
3 main kinds of Scenarios:
- Function Scenarios (lifeline = Functions)
- Exchange Scenarios (lifelines = component and actors)
- Interface Scenarios (sequence messages are Exchange Items)

Capella provides automated initializations from one to another.

[FS] Perform Audio Announcement

[ES] Perform Audio Announcement
Relate the transitions and states to other elements of the model. Warning: Capella is not restrictive enough in the choices it proposes and validation is not complete either.

ONGOING WORK
[M&S] Seat TV Modes

This mode machine is not complete. It mainly focuses on VOD and Audio Announcement Services.
Traceability is partially created when performing automated transitions from Operational Analysis to System Need Analysis. The remaining part has to be created manually, using element property editors or dedicated matrices.

<table>
<thead>
<tr>
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<th>Activity</th>
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<tr>
<td>Perform Cabin Management Activities</td>
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<td>Provide Aircraft Localization</td>
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<td>Use Entertainment Services</td>
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<td>Watch Movie</td>
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<td>Listen to Audio</td>
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<td>Browse the Internet</td>
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<td>Watch Moving Map</td>
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<td>Play Gaming</td>
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<td>Provide Aircraft Information, Commands and Messages</td>
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<td>Provide Satellite Communication Means</td>
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<td>Provide Aircraft GPS Position</td>
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<td>Provide Electrical Power</td>
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<td>Provide External Video</td>
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<td>Play Sound in Cabin</td>
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<td>Send Dearness Communication Notification</td>
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<td>Provide Access to Digital Media</td>
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<td>Store Digital Media</td>
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<td>Load Digital Media</td>
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<td>Manage Passenger Services Lifecycle</td>
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<tr>
<td>Determine Service Availability</td>
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<td>Handle Service Activation Requests</td>
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<td>Run Services</td>
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<tr>
<td>Run Video-On-Demand Service</td>
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<tr>
<td>Handle VOD Movie Controls</td>
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<td>Preserve VOD Movie Data</td>
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<tr>
<td>Run Camera Intercommunication Services</td>
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<tr>
<td>Handle Expanded Video Controls</td>
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How the system will work so as to fulfill the expectations
Use transition tools to initialize the design at Logical Architecture level (Functions, Actors, Scenarios, etc.).

Use the Diagram content creation accelerator.
Design choices for Logical Architecture

- **Architecture driver #1**
  - Organization of the architecture in 4 main parts in order to take into account the topology of the aircraft and anticipate integration concerns:
    - Front Servers + Cabin Terminal for Cabin Crew and Maintenance
    - Distribution network
    - Private TV on Seats
    - Cabin Screens

- **Architecture driver #2**
  - Functional grouping in order to reduce interfaces, optimize performance, etc.

- **Architecture driver #3**
  - Architecture patterns are implemented to anticipate product customisation and product line policy.
    - Product Customisation: Aircraft- and airline-specific functionality are segregated in separated components in order to be easily removed / replaced.
    - Product Line Policy: Currently not illustrated in this sample model (requires a Variability viewpoint).

- **Modeling choice: No network modelling**
  - While it is obvious all communications will ultimately go through a network, this is ignored at this stage.
Definition of Architecture Drivers

[LCBD] Architecture Drivers

ARCHITECTURE DRIVER #1:
Organization of the architecture in 4 main parts in order to take into account the topology of the aircraft and anticipate integration concerns:
- Power Networks + Cabin Terminal for Cabin Crew and Maintenance
- Distribution network
- Privacy TV on Seats
- Cabin Screens

ARCHITECTURE DRIVER #2:
Functional grouping of functions to reduce interfaces, optimize performance, etc.

ARCHITECTURE DRIVER #3:
Architecture patterns are implemented to anticipate product customisation and product line policy.
- Product Customisation: aircraft- and airline-specific functionalities are segregated in separate components in order to be easily removed/ replaced.
- Product Line Policy: Variability in core components can be managed through a separate viewpoint allowing to express variability in components' functions and interfaces. This is not illustrated in this sample model.
[LAB] IFE System - All Components, CEs
The new Functions can either be created directly from the breakdown diagram or be created while refining dataflow diagrams. Here, the Functions added at Logical level have been marked in flashy green.
Design decision: Creation of a generic interface with the aircraft

Description of how

SA
- Determine Service Availability
- Handle Service Activation Requests

LA
- Determine Passenger Service Availability
- Start/Resume Service
- Store Passenger Service State
- Display Homepage on Seat TV
- Capture Passenger Service Selection
- Interrupt Current Service

Description of how

SA
- Broadcast Audio Video Streams

LA
- Display Video and Play Audio
- Process Audio Announcement
- Broadcast Stored Audio and Video
- Process Imposed Video Controls
- Play Audio Video Stream on Seat TV
- Prepare Broadcasts
- Broadcast Audio Video Stream
Other example: The high level function in charge of managing the audio and video diffusion is split in 4 sub functions: process/analyze the requests, broadcast existing digital media, broadcast live audio (audio announcements) and display/play the video/audio streams. Each of these Functions are further decomposed.
To improve productivity, it is often interesting to brush layout from one diagram to another or to clone diagrams.

Here, a template has been created and is used for a few other architecture diagrams.
Not all diagrams are intended to be published. Some diagrams only exist temporarily for building or analysing purposes.

Such diagrams have been marked in this model with the tag [BUILD].

Here, the diagrams is a clone of the template where all Functions and all exchanges are displayed. While not adapted to publication, it is useful to check the design, visualize Functional Chains, etc.
The Functional Chains obtained after the automated transition will most likely be incomplete/invalid after the functional analysis refinement.

Fixing the Functional Chains at Logical Level is a mandatory task, which often leads to fixing inconsistencies in the functional refinement.

Functional Chains are a powerful way to ensure the design completeness.
How to quickly obtain this LAB diagram?

1. Clone the LAB template, remove all Functions
2. Set the diagram to be contextual to the Functional Chain, perform a diagram refresh
3. In the original LAB template diagram, copy the layout
4. Paste the layout in current diagram
5. Arrange the Functional Exchanges routing, remove unnecessary Components
Use automated transitions to initialize the design of Logical Scenarios

Correct and enrich the result with the existing Functions and Functional Exchanges or create the missing ones.

[ES] Start Playing VOD Movie

To be enriched and completed
When sequence diagrams become too complex or when a pattern is repeated often, use Scenario References!
A first level of data modelling is performed in the Logical Architecture of this model.

The goal is to better describe the exchanges between Functions (and thus, Components).

In this example, the data model is designed as a database, and the Exchange Items reference entirely of partly one or several data.
Exchange Items are used to relate Data and Functional Exchanges.

For example, it is the only mean to express that two distinct Functional Exchange actually carry the same of common data.

In dataflow and architecture diagrams, filters allow to display the names of the carried Exchange Items instead of the Functional Exchanges labels.
[M&S] Seat TV - Movie Player Modes
Capella does not provide means (yet) to really formalize the guards in Transitions.

However, it provides a constraint-based mechanism allowing to keep references between model elements (use CTRL-SPACE when editing constraints). If the name of the Enumeration Literal changes, the Guard will be kept synchronized.
How the **system** will be developed and built
- The interactions of the Passenger with the Seat TV are performed through a remote control.
- The interactions of the cabin crew with the Central Management Unit are based on a Touch Screen.

- The modelling of the network is kept minimal:
  - In an IFE, the network distribution is an essential aspect (one of the goals is to reduce the length – and mass – of the network cables). This is not covered in this model where all switches are represented by one single component.
  - No network routing functions. The only the setup and configuration basic Functions are created.

- Streaming is a bit more detailed, without encompassing what would be the responsibility of the SW subsystems. The chosen stopping criterion is to be able to perform basic latency non-functional analysis.

- The replication of streaming servers is not (yet) modelled. Scenarios and Mode machines have not been propagated (they should be).
[PAB] Implementation and Behaviour Components
Interactions based on a remote control on passenger side

- Passenger Remote Control
- Private Video Display Unit
- PVDU Processor
- BUS
- PVDU Screen

Dedicated audio and video processors

No intelligence in cabin displays

- Cabin Video Display Unit
- HDMI Cable
- Cabin Screen Video Splitter
- HDMI Cable
- Application Server Unit
  - Internal BUS

Touch Screen for Cabin Crew

- Cabin Management Unit
  - CMU Touch Screen

PVDU Audio Processing Unit

PVDU MPEG Decoder
[PCBD] Behavioral Components

Physical Architecture – Behaviour Components (1/2)
Physical Architecture – Behaviour Components (2/2)

Breakdown to take into account the HW components: DAC and audio/video dedicated processors

Breakdown to take into account the choice of relying on a remote control rather than on a Touch Screen for the Seat TV

[PCBD] Behavioral Components

Breakdown to take into account concerns which were ignored in Logical Architecture: Network, Screens
[PAB] Implementation and Behaviour Components
Several drivers for Functional Analysis refinement.

Topics not covered in Logical Architecture (Network, Screens, etc.) and further description of specific topics (management of audio and video streams)
One of the drivers for refining the Functional Analysis here is to add enough detail about the streaming mechanisms, in order to be able to perform non-functional analysis later on (for example, latency analyses).

Simplified streaming steps (packeting, etc.) are therefore described.
Refinement (and Composition) of Functional Chains

[PFCD] Start Playing VOD Movie

1. Command VOD Session
   - VOD Movie Play Selection
2. Capture VOD Selections
   - VOD Movie Play Command
3. Process VOD Movie Controls
   - VOD Movie Control Command
4. Prepare Broadcasts
   - Media Request
5. Store Digital Media
   - Media Files
6. Prepare Broadcasts
   - Broadcast Data
7. Broadcast VOD Movie

[PFCD] Broadcast VOD Movie

1. Inbound Audio Video Stream
   - Audio Video Packets
2. Split Audio Video Streams
   - Packetized Audio Video Stream
3. Receive and Buffer Audio Packets
   - Audio Packets
   - Decoded Audio Stream
   - Audio Signal
   - Listen to Audio Announcement
4. Decode Audio Packets
   - Audio Packets
5. Convert Audio
   - Audio Signal
   - Watch Movie on Private Screen
6. Display Video on Seat TV
   - Video Packets
   - Video Frames
   - Displayed Audio Video

[PFCD] Resume VOD Movie

1. Handle VOD Service Activation and VOD Movie Status
2. Store interrupted VOD Movie Status
3. VOD Movie Resume Command
4. VOD Movie Control Command
5. Prepare Broadcasts
   - Media Request
6. Store Digital Media
   - Media Files
7. Prepare Broadcasts
   - Broadcast Data
8. Broadcast VOD Movie
The PVDU architecture is based on an internal bus connecting the processor, the media decoders and the DAC.

The BUS is modeled with a specific Implementation Component and a Physical Path linking all the elements connected to the BUS.

Here, the packets exchanged between the player and the decoder go through the "Packet Transmission" Component Exchange. The Component Exchange is transported by the "PVDU BUS" Physical Path.
Building diagrams

**Template.** To gain in productivity, it is often interesting to brush layout from one diagram to another or to clone diagrams. Here, a template has been created and is used for a few other architecture diagrams.

**All PCs, PFs, FE**s. The diagram is a clone of the template where all Functions and all exchanges are displayed. While not adapted to publication, it is useful to check the design, visualize Functional Chains, etc.

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Management of Network Components (1/4)

The Network adapter is present on several components, with the same functionality.

Instead of modelling several times the same thing, the Replicable Elements mechanisms are used. Definition (REC) and instances (RPLs) can be kept synchronized.

This component contributes to the definition of a REC. It is isolated in a specific location in the model.
A REC is created and is instantiated several times. When no dedicated library is used, the organization of the model tree has to be carefully defined, in order to distinguish between “types” and “instances”.

The REC content is in the model, but somehow isolated from the other elements (it could be in a library).

The connection between the RPLs are managed manually (ONGOING work in Capella).
REC - Unit Network Adapter

This component contributes to the definition of a REC. It is located in a specific location in the model.

Run Network Tests

RPL - Instantiations of Unit Network Adapter

Implement Network Configuration

Run Network Tests

[REC] Focus on Network Setup, Configuration and Tests

Private Video Display Unit

PMU Processor

Unit Network Adapter - PMU

PMU Processor

Application Server Unit

ASU Processor

Aircraft-Specific Network Manager

Run Network Tests

Reconfigure Network

Define Initial Network Configuration

Orchestrate Network Tests

Run Network Tests

The connections (Functional Exchanges) between the RPLs (replicas) are performed manually.

Digital Ethernet

Network Test Sequences

Ethernet Switches

Internal BUS

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Illustration of the network carrying exchanges.

There is no added-value in this model in modelling the functional part of the transport over the network. Only network setup and configuration is modelled.

The transport between components are modelled with Physical Links. Here, the Physical Path "Network Path" is set to transport the Component Exchange "Streaming Protocol", showing that all packets between "Send" and "Split" Functions as well as the stream Header actually go through the Ethernet network and switches.
Refinement of the data model:
- New streaming concepts taken into account, such as packets, stream headers, codecs, etc.
- Unlike the data model in Logical Architecture, the (arbitrary) choice is made here not to rely on a database-like design but on standalone types (constraint of the targeted SW environment)
In the current version of the model, the data modelling has only been performed partly, focusing on the “Start Playing Video Movie” Functional Chain

[PAB] [CTX] Start Playing VOD Movie FC
Capella provides means to generate a first version of the interfaces of a component based on the incoming/outgoing Component Exchanges, Functional Exchanges, Exchange Items.
Definition/justification of Interfaces: Summary

Functional exchanges & ports carry Exchange items

Use semantic Browser to navigate between these concepts & relations

Exchange items group data to be carried together

Functional exchanges & ports are allocated to component exchanges & ports

Interfaces group & reference Exchange items

Interfaces are provided/required by Component Ports

Component exchanges & ports are allocated to Physical links/paths & ports
What is **expected from each designer / sub-contractor**
Several drivers can orient the choices for Configuration Items. One goal of EPBS is to define an architectural frame to master component development and integration.

In this sample model, different rationales:
- Group all streaming SW components into one single Configuration Item
- Group all airline-specific SW components into one single Configuration Item
- Create all Network setup and configuration SW into one single Configuration Item
- Have a Non Developed Configuration Item all network equipment and cables
- Etc.
Examples of Configuration Items

[EAB] Configuration Items and Realized Artefacts
Considered future evolutions for this sample model

- Multi-viewpoint analysis, including
  - Reliability analysis, with replication of video servers
  - Sizing (network)
  - Mass

- Refinement of Modes/States modelling (enhancement of the relationship with functions and functional exchanges)

- (Automated) transition towards subsystem

- Completeness + functional scope enrichment
Questions on this model?

Use the Arcadia Forum:
https://polarsys.org/forums/index.php/f/12/
Feel like contributing?

- Directly submit us your enrichments
- Contact us to converge on a specific scope