

In-Flight Entertainment & Communications Systems 101

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- » **History of the IFEC Industry**
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» Business Jets (bizjet: no more than 19 seats)

- Airbus, Boeing, Embraer, Bombardier, Gulfstream, Dassault Falcon, Cessna, Hawker Beechcraft, Eclipse, Honda...
- Went from car radios to very sophisticated home theater systems certified for aircraft cabin
- Three modes of operations:
 - Flying to a meeting: Office & Communications
 - Flying back: Relaxation & Entertainment
 - Weekend Flights: Family Entertainment with latest BD & Games

» Regional Jets

- Embraer, Fairchild-Dornier, Bombardier, Mitsubishi...
- From nothing to audio only to overhead entertainment to wireless (with PAX Payment)

» “Narrow-Body” (Single-aisle)

- Airbus A320, Boeing 737, Embraer E-jet...
- From nothing to audio only to overhead entertainment to wireless (with PAX Payment)

» “Wide-Body” (Twin-aisle)

- Airbus A330, A340, A350, A380, Boeing B747, B767, B777, B787...
- IFEC systems

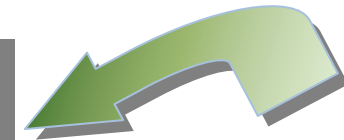
What are IFEC Systems?



✓ Overhead Video Systems



✓ In-seat Audio/Video On-Demand (AVOD) Systems



Systems and Services



✓ Media Services

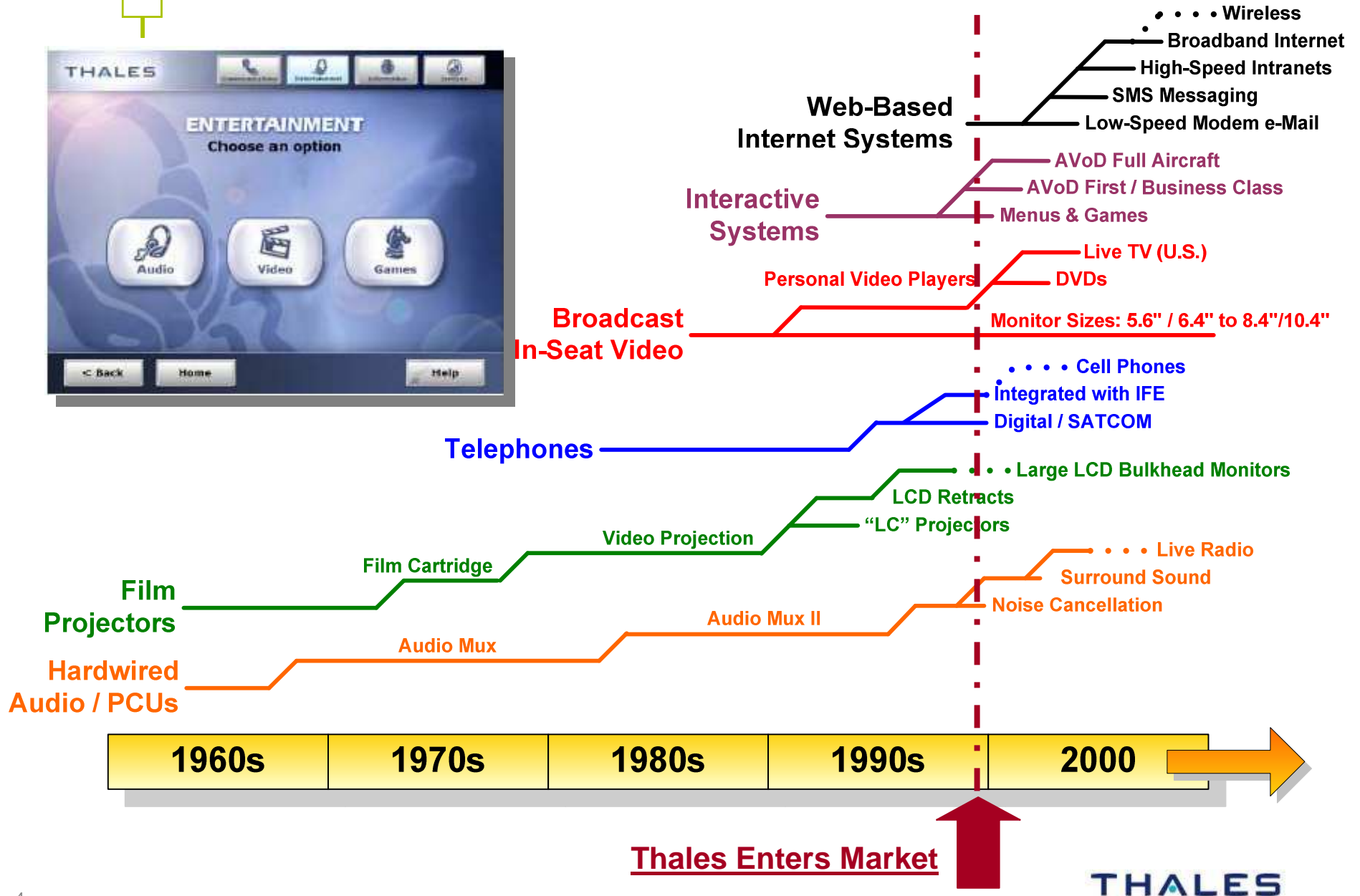


✓ Connectivity Services

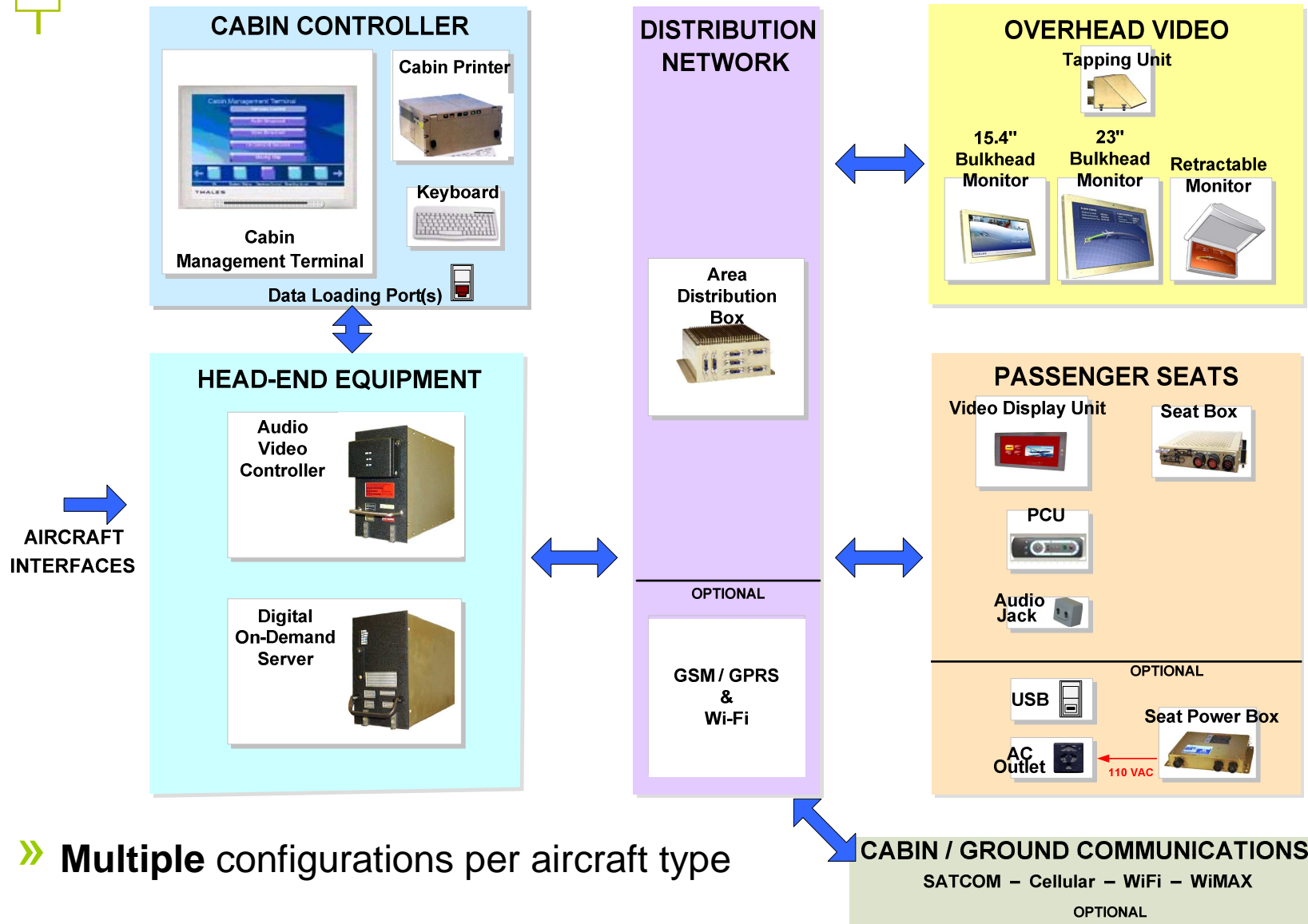


✓ Customer Support Services

History of the IFEC Industry



Complexity of IFEC Systems





»» Complex Network of 1000+ Clients

- Servers, Distribution, Clients
- Interfaces to aircraft systems
 - Flight Management Computers
 - PA & PA interrupts
 - Attendant Call
 - PAX Seat Light
- Ground Communications
 - SATCOM, Cellular, Wi-Fi, WiMAX

»» An Aircraft System Providing:

- Video – Broadcast and On Demand
- Audio – Broadcast and On Demand
- Games (single player, multi-player, web-based)
- Flight Information (map) (broadcast and interactive)
- Enhanced Passenger Service
 - Meal Ordering, Drink Ordering
 - Surveys
- Shopping
 - Duty Free, Home Delivery
- Intranet Surfing (cached web sites)
- Connectivity
 - E-Mail, SMS, Web Browsing, GSM, GPRS, Wi-Fi
- Passenger Device Support
 - AC Power, USB Power, Video, Audio



» Modularity and Functional Partitioning

- Family of “Interoperable” Components
- Feature Based Components
- “Right-Sized” Equipment for Scaled Application
 - Multiple, Independent Units for Larger Systems
- Careful Partitioning – Standard Interfaces

» Technologies

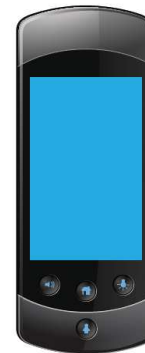
- High Performance Servers
- Switched Ethernet Data Network
- Highly Integrated IP Networks
- Fault Tolerant Architecture
- MPEG Streaming
- Web Programming Model
- Credit Card Processing
- SAT Radio / SAT TV / SATCOM
- Wi-Fi, WiMAX, GSM, GPRS
- Encryption / Decryption
- Security
- ...



Server



Distribution Box



PCU



PED Power



AC Power Distribution

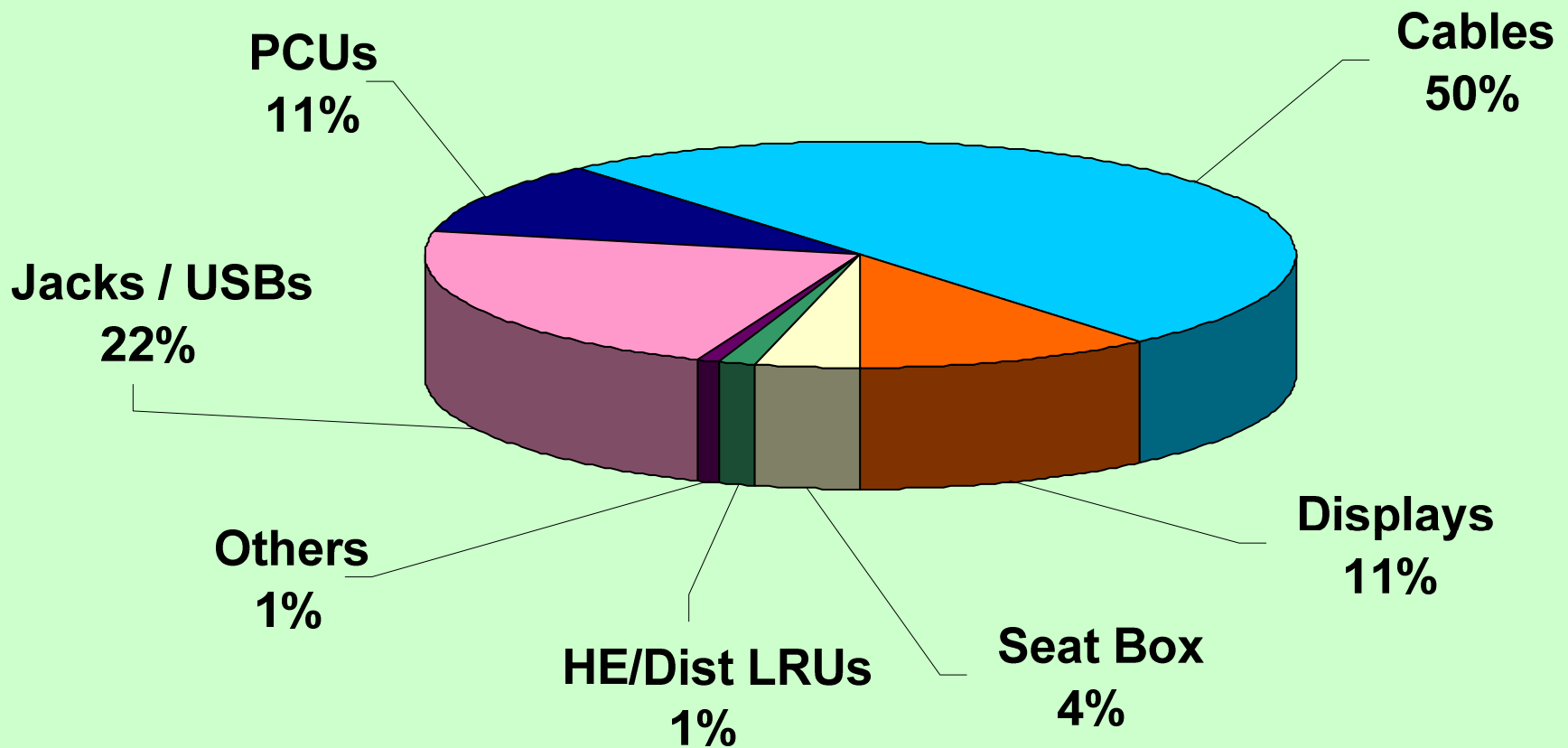


PCU

IFEC Systems – Hardware Elements



A330-300, 380 PAX, 3,500 Total Parts





- » **Over 3 million lines of code**
- » **Service-oriented architecture (SOA)**
 - LAMP (Linux, Apache, MySQL and Perl/PHP/Python)
 - Android OS
 - Web services
- » **Programming Languages**
 - C / C++ / C#
 - Java and Java related technologies
 - HTML / Qt / PHP
- » **Security**
 - Cabin LAN connected to Internet (Firewalls, VPNs,...)
 - PCI-DSS for e-Commerce (Payment Card Industry Data Security Standards)
 - Copyrighted Content Protection per WAEA/APEX

IFEC Systems - Design Constraints



- Light Weight
- Low Power
- Small Size
- Low Cooling
- High Reliability (better than Consumer Electronic)
- High Longevity (7 to 10 Years)
- Low Price (Consumer Electronic based Designs)
- Highly Secure
- BITE Accuracy (Faults/Failures Reporting)
- Self-Healing (Redundancies, SW restart)
- No Single Failure SHALL Take the IFEC System Down
- Easy to Manage by Crew
- Easy to Maintain by Airline Personnel
- Easy to Load and Stream Lots of Content
- Intuitive GUIs – Fast Response Time
- International Languages Support

IFEC Systems – HW Certification

» **ALL HW shall pass RTCA DO-160E tests**

- Radio Technical Commission for Aeronautics
- Environmental Conditions and Test Procedures for Airborne Equipment
- Tests selection based on LRU Location

Section 4.0	Temperature and Altitude	Section 16.0	Power Input
Section 5.0	Temperature Variation	Section 17.0	Voltage Spike
Section 6.0	Humidity	Section 18.0	Audio Frequency Conducted Susceptibility – Power Inputs
Section 7.0	Operational Shocks and Crash Safety	Section 19.0	Induced Signal Susceptibility
Section 8.0	Vibration	Section 20.0	Radio Frequency Susceptibility (Radiated & Conducted)
Section 9.0	Explosion Proofness	Section 21.0	Emission of Radio Frequency Energy
Section 10.0	Waterproofness	Section 22.0	Lightning Induced Transient Susceptibility
Section 11.0	Fluids Susceptibility	Section 23.0	Lightning Direct Effects
Section 12.0	Sand and Dust	Section 24.0	Icing
Section 13.0	Fungus Resistance	Section 25.0	Electrostatic Discharge
Section 14.0	Salt Spray	Section 26.0	Fire, Flammability
Section 15.0	Magnetic Effect		

IFEC Systems – SW Certification



» ALL SW Processes shall comply with RTCA DO-178B

- Software Considerations in Airborne Systems and Equipment Certification
- IFEC SW is certified as Level E
 - SW whose anomalous behavior would cause or contribute to a failure of system function with no effect on aircraft operational capability or pilot workload
 - No further guidelines of this document apply

Section 3	SW Life Cycle	Section 7	SW Configuration Management
Section 4	SW Planning Process	Section 8	SW Quality Assurance
Section 5	SW Development Process	Section 9	Certification Liaison Process
Section 6	SW Verification		

» Represent the airline image



Applications



Audio/Video on-Demand



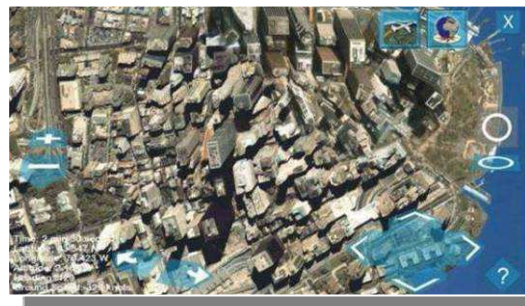
3D Interactive Moving Map



Targeted Advertising



Games



Hi Resolution City Views



Onboard Shopping



File & Picture Viewer



Print Media



Content Delivery Methods

» Media

- Daily News Clips
- Monthly Content Loads

» IFE Data

- Usage Stats
- Survey Results
- Transaction Data

CONTENT
DELIVERY CENTER

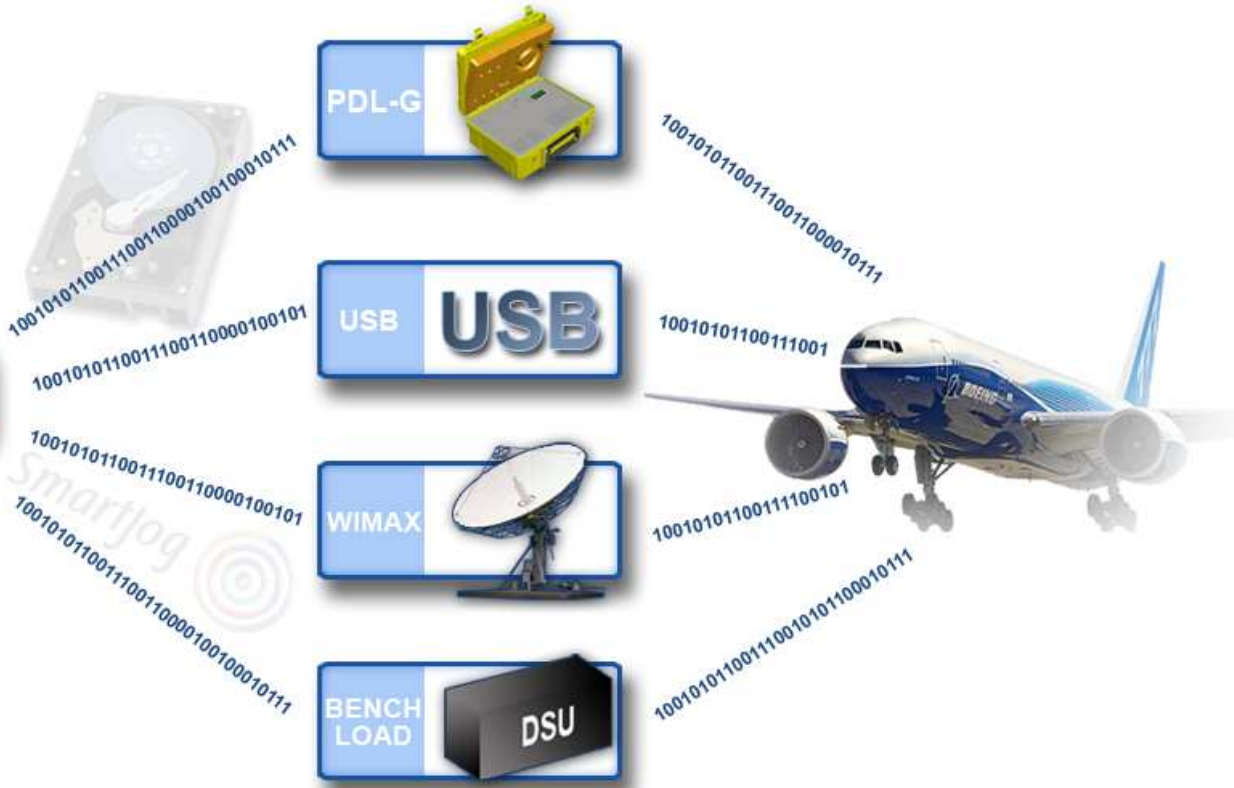
» Cabin Crew Data

- Crew Reports
- Logs
- Manuals
- Manifest

» PAX Manifest

- FF Data

» BITE/Maintenance Data





» MPEG = Moving Picture Experts Group

- Working Group from ISO and IEC experts to standardize A/V compressions.
- Started in 1988.
- Goal 1: Standardization of MPEG Decoders.
 - MPEG Encoders are improving with time.
- Goal 2: Standardization of Multiplex.

» APEX = Airline Passenger Experience Association

- Association of businesses and professionals that create, deliver, and manage the airline passenger experience.
 - Over 300 international and regional airlines, aircraft manufacturers, motion picture studios/producers/distributors, broadcast networks, electronic-content creators, music programmers, record companies, magazine publishers, post-production houses, licensing bodies, avionics systems manufacturers, audio/video equipment manufacturers, and communications companies.
- Started in 1979 as WAEA = World Airline Entertainment Association.
- Goal: To provide industry information, APEX members list, standards, publications, education opportunities, conferences, exhibitions and networking events.



» MPEG standards specify:

- Profiles that define a set of available tools (algorithms).
 - Example: Simple, Main, High Profiles...
- Levels that define the range of the tool's properties.
 - Example: Low, Main, High Levels...

» MPEG-1: ISO/IEC 11172 (1993)

- A/V compression for CD storage (1.5 Mbps). Used in Video CD or VCD.

» MPEG-2: ISO/IEC 13818 (1995)

- A/V and Transport standards for broadcast-quality television. Used in DTV, DVD, and BD.

» MPEG-4: ISO/IEC 14496 (1998)

- Encoding of A/V objects into shapes and surface texture. Decoder is a rendering processor. AVC is used in BD along with VC-1 and MPEG-2.

» MPEG-7: ISO/IEC 15938 (2002)

- Multimedia content description interface (Metadata).

» MPEG-21: ISO/IEC 21000 (2001)

- Multimedia framework for Intellectual Property (IP) management and protection.



» Present IFEC Systems supports NTSC only:

- Resolutions:
 - 352 x 240 (SIF) for displays up to and including 15 inches measured diagonally
 - Note: SIF = Source Input Format (not Common Interface Format (CIF))
 - 352 x 480 (Half D-1) for any display size
 - 720 x 480 (Full D-1) for any display size
- Aspect Ratios:
 - either 4:3 or 16:9 (widescreen)
- Frame Rates
 - 23.976 Hz for film sources
 - 29.97 Hz for video sources

» Future IFEC Systems will support HD content as defined by APEX:

- Note: APEX HD Specification due in 11/11/2011
- Resolutions:
 - “720p”: 1280x720, for displays up to and including 50 inches measured diagonally
 - “1080p”: 1920x1080, with no size limitation
- Aspect Ratio:
 - 16:9
- Frame Rates
 - 23.976 fps, 25 fps and 29.97 fps
 - Content originated at film rates should be available as 23.976 HD masters, and shall be encoded at that rate.
 - Content mastered at 25fps shall be encoded as 25P or converted to 23P.
 - Higher frame rates, such as 50P, 50i, 60P and 60i shall be reduced to a frame rate available in the standard.
 - When the content to be encoded is presented as 29.97 fps or 59.94 fps video, best practice is to, if possible, reverse telecine down to a film frame rate and encode as 23.976. In any event the source shall be de-interlaced before encoding.

Motion Pictures versus SD Television

» Movies and 480i TV have different frame rates:

- Movies: 24 frames per second
- 480i: 30 fps (60 fields per second)

» Telecine (Movie → TV)

- In USA, with 60 Hz vertical scanning, video is broadcast at 29.97 fps.
 - $23.976/29.97 = 4/5$
 - A-A-B-B-B-C-C-D-D-D
 - 2-3-2-3
 - 2-3 pulldown
- In Europe, with 50 Hz vertical scanning, video is broadcast at 25 fps.
 - Movies are viewed at 25 fps (+4%)

Movie Frame	480i Odd Field	480i Even Field	Video Frame
A	Ao	Ae	A
B	Bo	Be	B
C	Bo	Ce	Bo+Ce
D	Co	De	Co+De
	Do	De	D

» Reverse Telecine

- Required for 24 fps content “adapted for television” before MPEG encoding.
- Not required for TV series, documentaries made for television and sports. They have already been shot with 30 fps cameras.



» Spatial Redundancy (between pixels)

- Resolution, oversampling (8x8 block of pixels)
- bit depth, number of levels for gray and color (8-bit to 16-bit per color)
- *Discrete Cosine Transform (DCT)*
- *Quantization of DCT coefficients*
- *Encoding of quantized coefficients into serial bit stream (entropy coding: Huffman code)*

» Spectral Redundancy (between colors)

- Color conversion from RGB to Y,Cb,Cr [(Y, Y-B, Y-R) and (Y, U, V) used in analog]
- (4:4:4), (4:2:2), (4:2:0), (4:1:1)
- *Chroma subsampling*

» Temporal Redundancy (between frames or between fields)

- Too many frames per second (10 fps to 25-30 fps)
- *Predictive Coding, Motion Estimation*

» Code only parts of signal important to human vision



» I: Intraframe

- Similar to JPEG. No prediction
- Group of Pictures

» P: Predicted Frame (2 to 3 times less data than I)

- Uses temporal redundancy from previous I or P frames (FWD prediction)

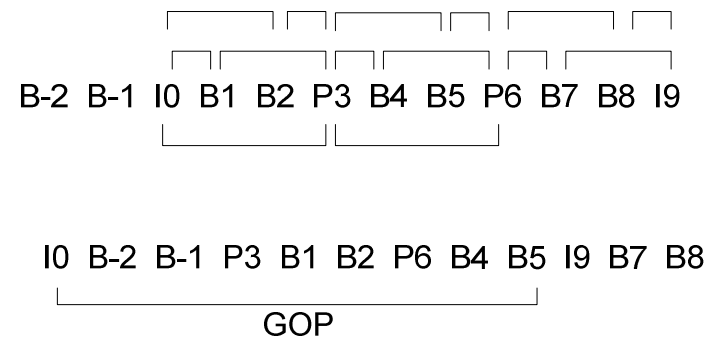
» B: Bi-directionally interpolated Frame (3 to 4 times less data than P)

- Uses temporal redundancy from both I and P frames

» Example: Frame display order:

» Frame transmit order:

- Tx order different from display order
- Need for buffers
- Delays in decoding

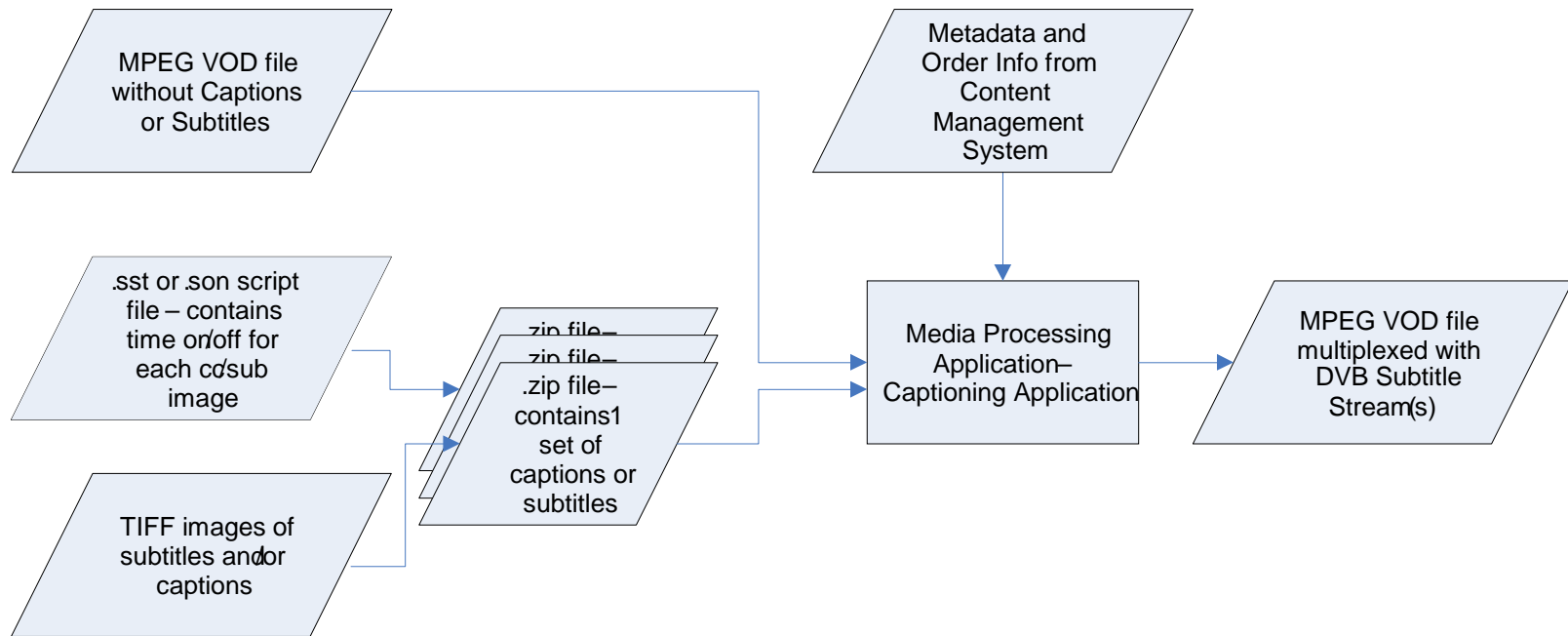


Audio Compression Principles



- » **Oversampling**
 - 44.1KHz, 48KHz
- » **Too many audio levels**
 - Dynamic range compression (40 dB)
 - 16-bit per sample
- » **Removal of redundant sounds in multiple channels (stereo imaging removal)**
 - Joint Stereo
- » **More sounds than ears can hear**
 - Bandwidth reduction: 50 Hz to 15 KHz
 - Psychoacoustic masking
 - Frequency masking: Louder sounds mask softer sounds at nearby frequencies
 - Temporal masking: Louder sounds mask softer sounds at nearby times
 - *Subband Filterbanks (MP1, MP2 = 32 bands)*
 - *Or Transform (MP3 (576/192 subbands), AC-3 (256/128 subbands))*
 - *Assignment of bits to bands based on psychoacoustic model*
 - *MPEG: FWD adaptive bit allocation, AC-3 uses forward/backward adaptive bit allocation*
 - *Encoding of allocated bits into serial bit stream (Huffman coding for MP3 & AC-3)*
- » **Code only parts of signal important to human hearing**

Closed-Captions & Subtitles Principles



» Input: Sonic Scenarist® SD DVD authoring format for subtitling

- Zip file containing:
 - TIFF images and
 - Display schedule file with time-on/off for each CC/Subtitle image

» Output: DVB Subtitle Stream

- The average bit rate of each subtitle stream (at MPEG-2 TS encapsulated layer) shall be less than 15 Kbps.



» MPEG Systems Stream: Multiplex with Timing for synchronous presentation of decoded video, audio and CC/subtitles.

- Elementary Stream to Packetized Elementary Stream (PES)
- PTS: Presentation Time Stamp added during A/V encoding process
- SCR: System Clock Reference added during MUX process (sync & buffer mgmt) in MPEG-1
- PCR: Program Clock Reference in MPEG-2

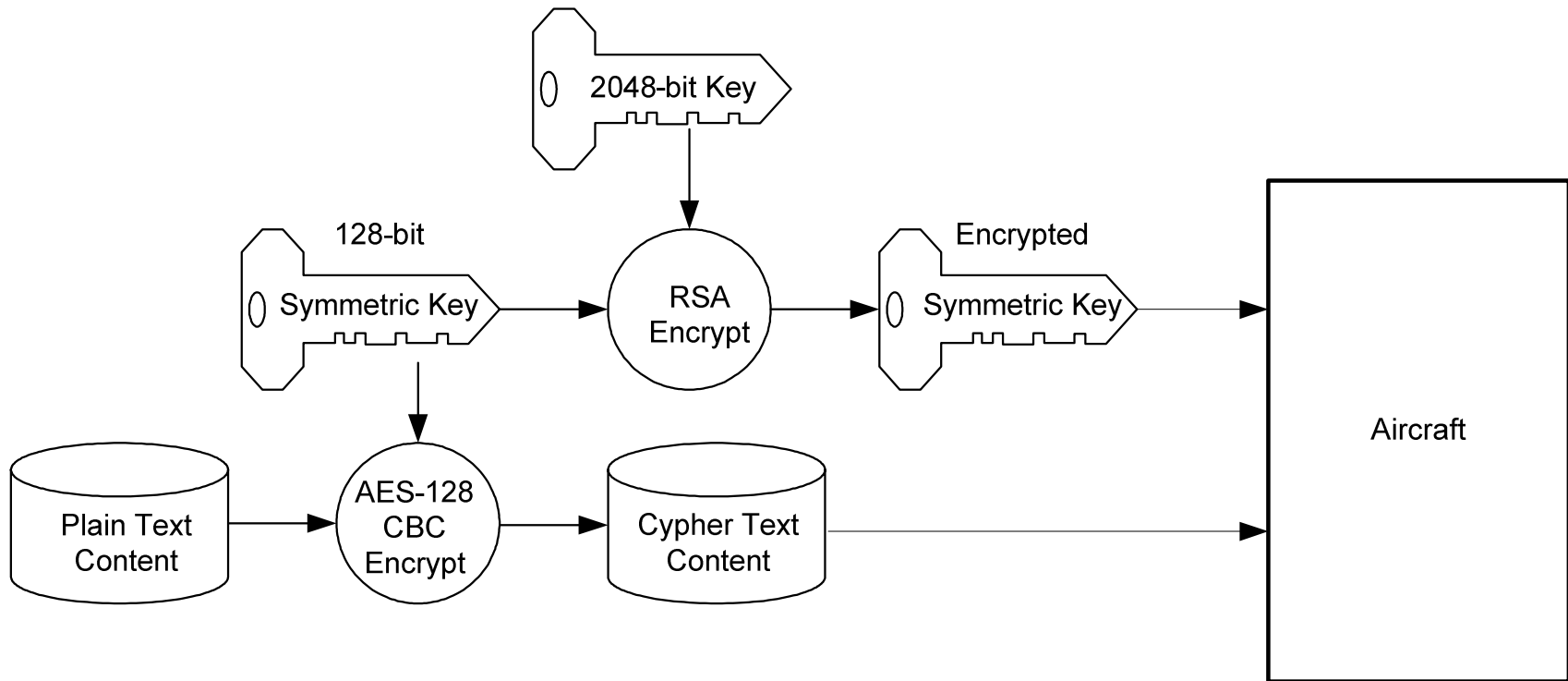
» MPEG-1/-2 Program Stream

- Multiplex of PES with a common timebase (SCR in MPEG-1 or PCR in MPEG-2) in a single stream
- Use in error free environments (DVD players)

» MPEG-2 Transport Stream

- Multiplex of one or more programs with one or more independent time bases in a single stream
- Use in error prone environments (Broadcast)
- Transport packets are fixed length: 188 bytes
- PID: Packet Identification
- PSI: Program Specific Information (every 10 or 20 Hz)
 - PAT: Program Association Table
 - PMT Program Map Table
- Conditional access (encryption)

Content Encryption Principles



WAEA 0395 & WAEA 0403 Overview

» WAEA 0395

- Started in March 1995, 2nd release in Nov 2001.
- Video:
 - SIF in MPEG-1 @ 1.5 Mbps CBR.
 - Half & Full D-1 in MPEG-2 @ 3.5 Mbps CBR (MP@ML).
- Audio:
 - Dynamic Range Compression @ no more than 40 dB.
 - MP2 – MPEG-1, Layer II.
 - 44.1 kHz sampling rate.
 - Joint Stereo @ 128 kbps data rate.
 - Dual Channel or Independent Stereo @ 256 kbps data rate.
 - Single Channel @ 128 kbps data rate.
- CC/Subtitles:
 - DVB Standard. Image based.
- Multiplex:
 - 1 Video Stream.
 - up to 16 Audio Streams.
 - up to 1 Open Caption (encoded into Video).
 - or up to 12 Closed Caption Streams.
 - or up to 12 Subtitle Streams.
 - or up to 12 Closed Caption and Subtitle Streams combination.
- Security:
 - File level encryption for copyrighted content.
 - For MPEG-1 encoded content, Data Encryption Standard (DES) with a 56-bit key.
 - For MPEG-2 encoded content, three key Triple-DES with 56-bit keys.
 - Public and Private Key pair created with RSA algorithm with a 1024-bit key strength.
 - Content encryption key shall be RSA encrypted.

WAEA 0395 & WAEA 0403 Overview (Cont'd)



» WAEA 0403

- Started in April 2003, 2nd release in February 2009.
- Video:
 - MPEG-4 Part 10, Main Profile, Level 3.1, CBR.
 - 720 x 480 (“Full D-1”, ITU-R Recommendation BT.601-5).
 - Bit rate: 1.5Mbps to 2.0Mbps with a default value of 1.5Mbps.
- Audio:
 - Dynamic Range Compression @ no more than 40 dB.
 - LC-AAC (Low Complexity Advanced Audio Codec) or
 - MP3 – MPEG-1, Layer III.
 - 44.1 kHz sampling rate.
 - Joint Stereo @ 128 kbps data rate.
 - Dual Channel or Independent Stereo @ 256 kbps data rate.
 - Single Channel @ 128 kbps data rate.
- CC/Subtitles & Multiplex:
 - Same as above.
- Security:
 - File level encryption for copyrighted content.
 - AES-128, cipher-block chaining (CBC) mode for MPEG-4 encoded content.
 - RSA algorithm, modulus 2048, with SHA-256 hash generation for secure key distribution.

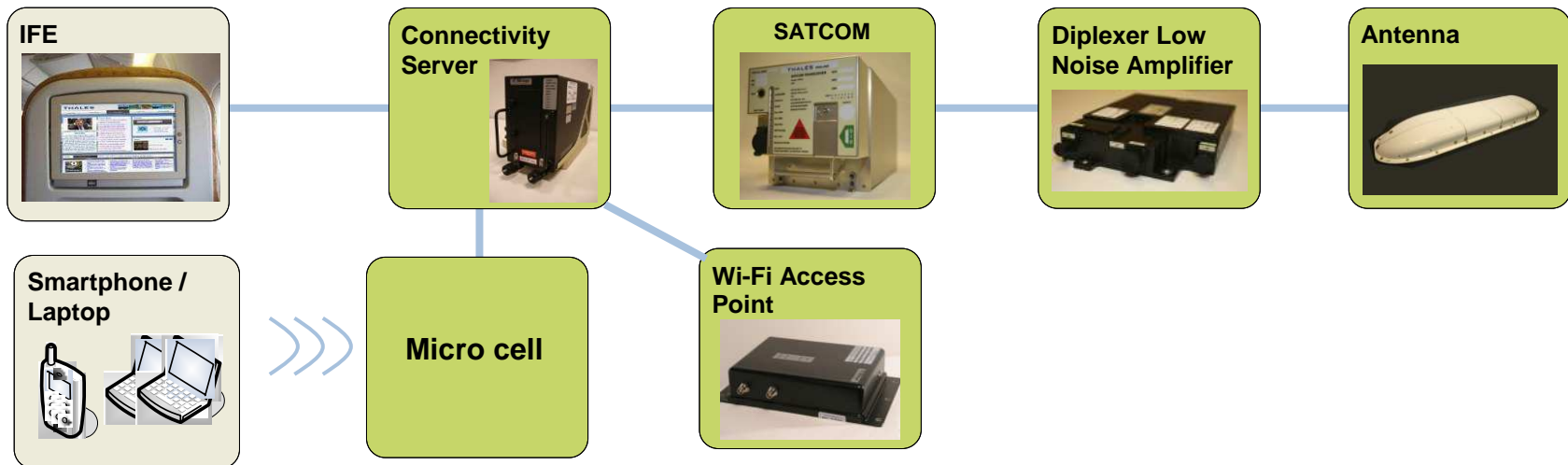
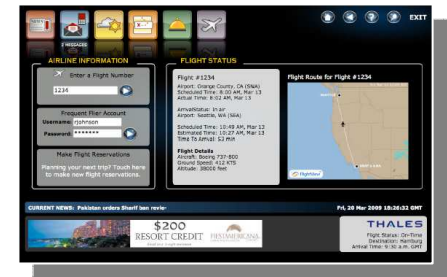
Cabin Connectivity



- » Supporting IFE - Connectivity Based Applications with Managed Internet Access
- » Bringing airlines the most comprehensive package of passenger services available in the market today
 - New ways to market services
 - New advertising revenues
 - Refresh their content on a frequent basis
- » Including News Web Portals, Messaging (SMS, E-mail), Destination Information, Concierge Services, Airline Information

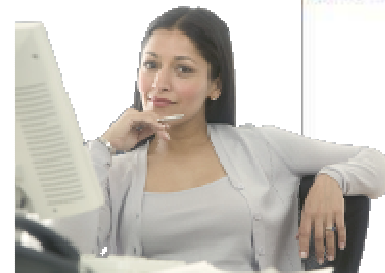


Web-Based Applications



Support Services

- » From basic to World-Wide Turnkey Services
- » From Entry-Into-Service to Recurrent Training to Life Cycle Support, including
 - Training (CBT)
 - On-board Services
 - Bench and Shop Repair
 - Technical Support
 - Heavy Check Support
 - Technical Publications



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- Principal Application Development Engineers
- Principal Architects
- Integration Engineer
- Principal Android, QML, MySQL, QT, GUI Engineers
- Principal SW Project Managers

Product Development Engineering

- Principal Electrical Engineer – Project Lead

Customer Engineering

- SW Integration Engineers
- Systems Engineers
- Project Engineers

Installations Engineering

- Senior Installations Engineer

Systems Engineering

- Principal Network Engineer
- Specs / Architecture Engineers
- Applications Engineer
- Senior Applications Engineers
- Platform Lead Senior Engineer
- Senior System SW Integration Engineer

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