1998-2038
40 years of Satellite Ground Systems

DEFENCE AND SPACE

Laurent MONTOYA, Patrick PLECZON
27 February 2018

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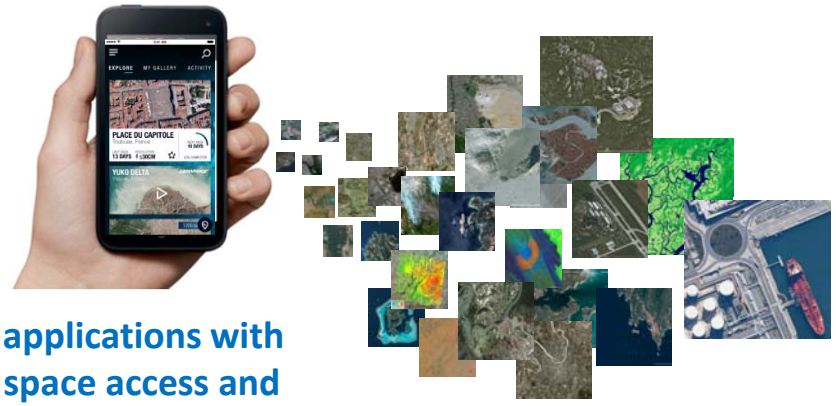
Welcome in 2038

42nd edition of GSAW

fiction

Fully-autonomous mega-constellations and inter-connected systems

Automatic and autonomous in-orbit services



Smart applications with direct space access and tasking by anyone, anywhere

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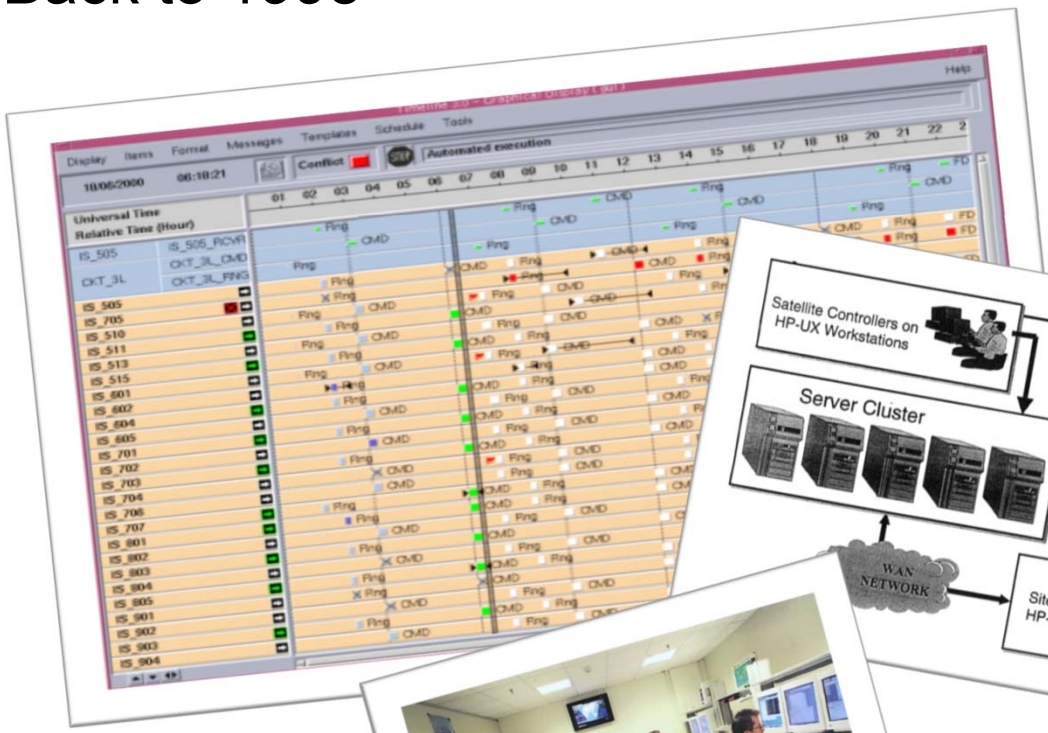
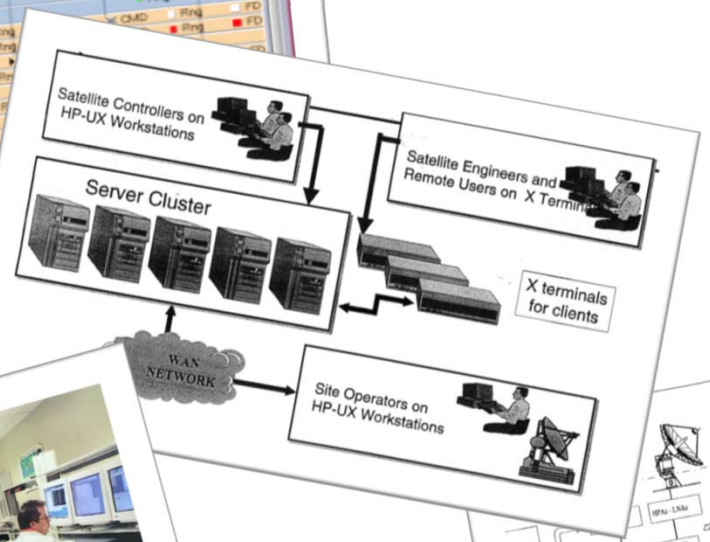
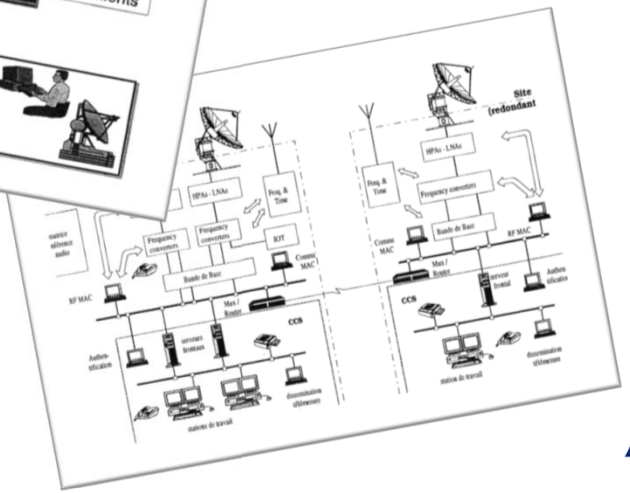
Back to 1998







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1998: start of the journey

- **Already “modern” ground systems: GUIs, automation, demanding processing, multi-satellites**

- Develop almost everything by ourselves
- Long development times

- C++
- Closed-source & expensive COTS

- UNIX: Solaris, HP-UX, Dec Ultrix…
- Standalone servers & workstations
- « Bare metal » installations
- Complex obsolescence management

- Private networks
- Limited external communications

- C++ Gurus
- OS Gurus

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1998-2008: the Internet and open source revolution

- **Major market evolutions with internet, mobile satellite phones, GPS**
- **More end-user oriented: communications, cartography – Demand changes and increases**
- **New needs, new end-users**
- **First shift in development approaches**

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1998-2008: the Internet and open source revolution

- Less coding
- More code reuse & integration

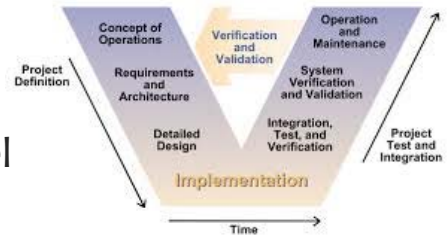
- Open Source
- Upgrade GUIs in Java
- Develop new systems in Java
- Decisional tools

- LINUX
- Virtualized servers
- Blade servers
- Ad-hoc redundancy management

- Private networks + INTERNET + VPN
- Very few systems interconnections

- FOSS specialist
- Virtualization
- Security

- Waterfall model



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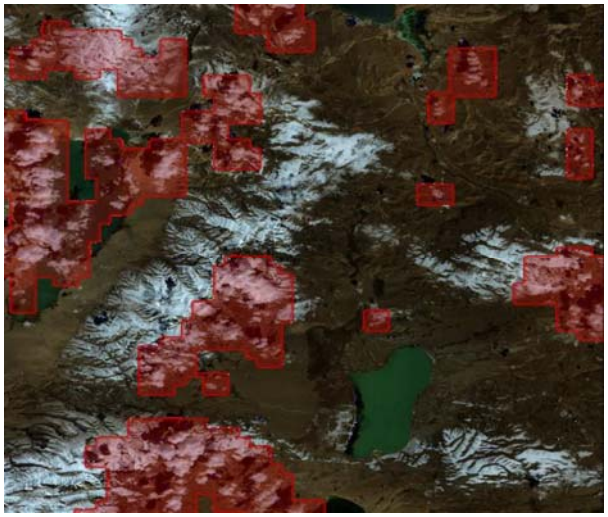
2008-2018: the massive processing and automation age

- Growing systems complexity
- Cloud Computing becomes a key enabler
- Deep learning is operational
- Public Cloud used operationally
- Cyber-security



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2008-2018: the massive processing and automation age

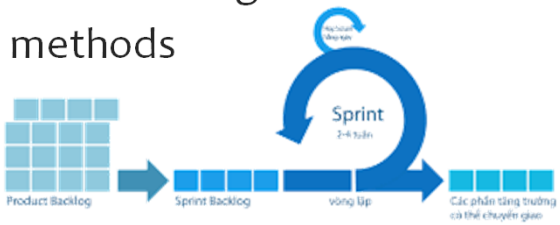
- Deep Learning on ground
- Lift and Shift cloud migration

- Web technologies, Web standards, light clients
- Open Source AI

- Hyper-converged hardware
- Infrastructure/Platform as a Service
- Containers, Cloud
- Virtualization layers based redundancy

- Public Cloud based services
- Data as a Service

- Automated testing
- Agile methods



- Web
- Data analysts
- Machine learning

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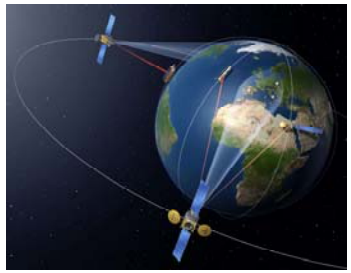
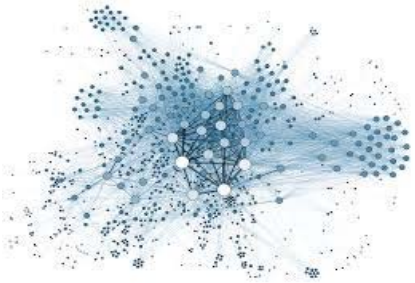
2018-2028: The data age

- Increased data rates, data volumes, data diversity
- Space Data Highways, Optical communications
- Increased importance of safety, security, data integrity, system resilience
- Multi-layered systems: satellites, Unmanned Aerial Vehicles and High Altitude Pseudo-Satellites
- Reactive systems, Complex on-board processing
- Complex systems overall operations optimisation
- Automatic tasking and information extraction
- New human-system interactions (e.g. cognitive assistant)





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2018-2028: The data age

- Software Defined Everything
- Cloud optimized applications
- Micro-services
- Machine designed algorithms
- Collaborative & crowd processing

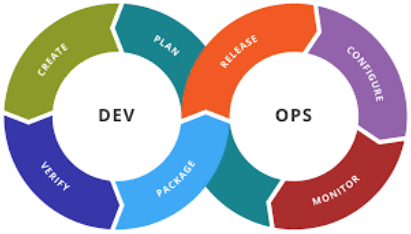
- Data labelling
- AI layer configuration

- Edge computing
- Hybrid Cloud
- Cloud based redundancy

- Software as a Service
- Systems interconnection

- AI / Deep Learning
- Federated Cloud
- Cyber-security

- Deployment flexibility
- Continuous delivery



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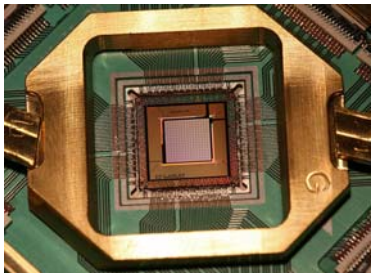
2028-2038: the smart autonomy age

- **Autonomous smart systems: On-board/on-ground intelligent agents collaboration**
- **Internet of satellites: permanent connection to ground, standardisation**
- **Amazing number of satellites – New types of operations**
- **Data explosion - Smart data selection and reactive information generation**
- **Highly interconnected and federated multi-layers systems**
- **Direct system interactions with final users**



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2028-2038: the smart autonomy age

- Machine “decided” algorithms
- Quantum computing

  (NP-complete problems solved quickly with full optimization)

- Highly abstracted and adaptative shared infrastructures

- Problem description
- Task oriented programming

- Space-Ground network convergence

- AI blocks understanding, selection, assembly & validation
- Autonomy specialists

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Conclusion – the facts and the trends

In 40 years, several revolutions in **technologies**, **systems' architecture**, **development approach**, **number of satellites**, **volume of data to handle**, **operations**

Ground processing is a precursor of what is done next on-board

but always, even with future growing on-board autonomy & intelligence,

the **Ground Systems directly fosters systems' performances and attractiveness**

It is the **key node of the system**, to provide **smart access to space resources**, **connect with other systems** and **extract added-value information for smart decisions making**

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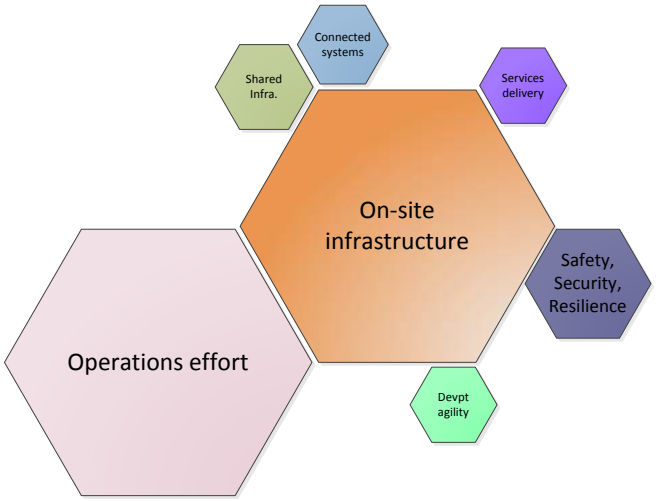
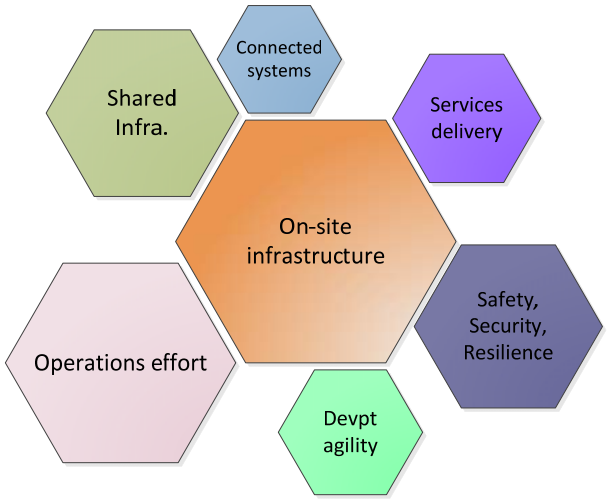
Conclusion – the facts and the trends

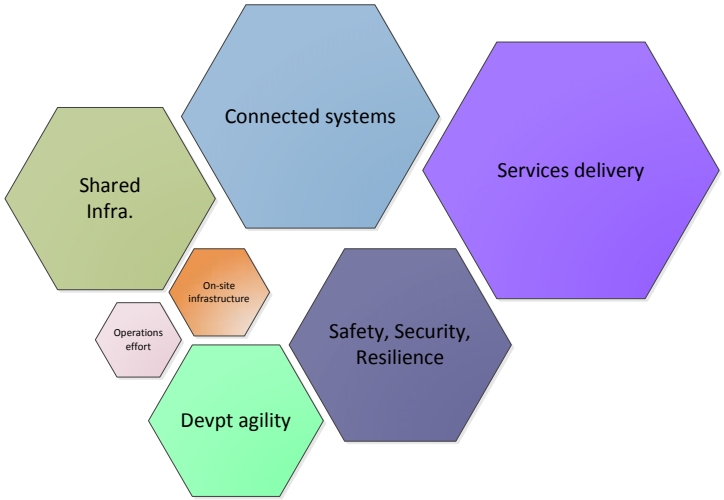
1998



2018



2038



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Thank you

Contacts:

laurent.l.montoya@airbus.com
patrick.pleczon@airbus.com

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