



Aeronautical Networks from the Ground Up
The Challenges of Complex Systems Engineering and
System(s) of Systems

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Context

- Airbus + Astrium + Cassidian + IW + Eurocopter +... = EADS
- Fixed and mobile networks + PMR + Cyber* + *System Integration* + Defense = Cassidian
- EADS makes everything that flies and supplies all the supporting services
- Mainly professional systems but...
- Also systems that the public is a part of and depends on

Lesser Problems

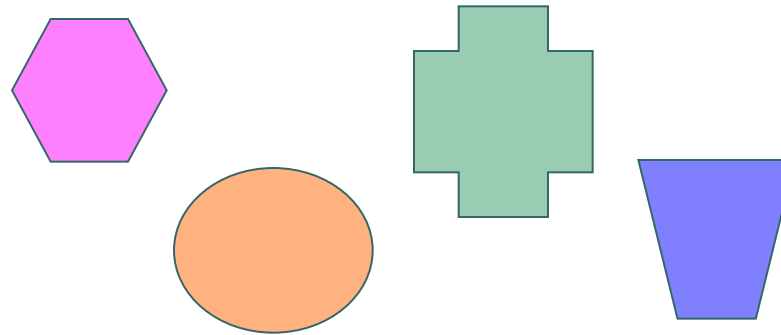
- IP or not IP – use the best, but it must be an International Standard
- Internet of Things, sensors, actuators, SCADA
- Solution selection, design and implementation – from the top down
 - Complexity can often be managed
- Security and cyber* issues
 - Cost, mobility, latency and heterogeneity excepted
- Hardware, software, human in the loop
- Multi/interdisciplinarity

Problems

- Legacy integration, stranded assets, future growth
 - Coexistence, interworking and interoperability
 - Some services do not (easily) cross internetwork boundaries
- Things do not interoperate anyway
- How to write, implement and enforce SLAs
 - QoS, grade of service, metrics & KPIs
- Privacy – especially for you and me
- Information networking – how do we find out what we know?
 - Existential epistemology
 - How do we allow/stop others knowing?

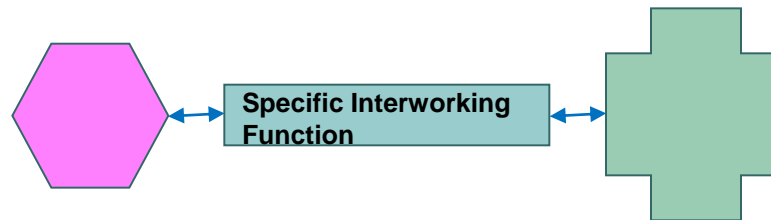
The Disaster Area of Bottom-Up Legacy Integration

Co-existence



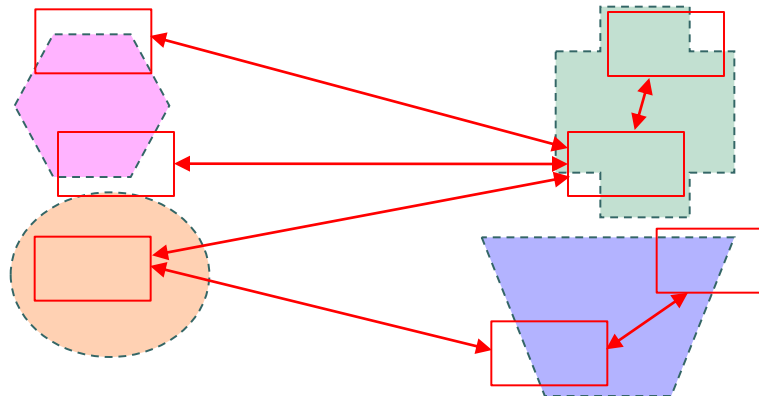
Various systems work successfully in the same environment – they do not share anything

Interworking



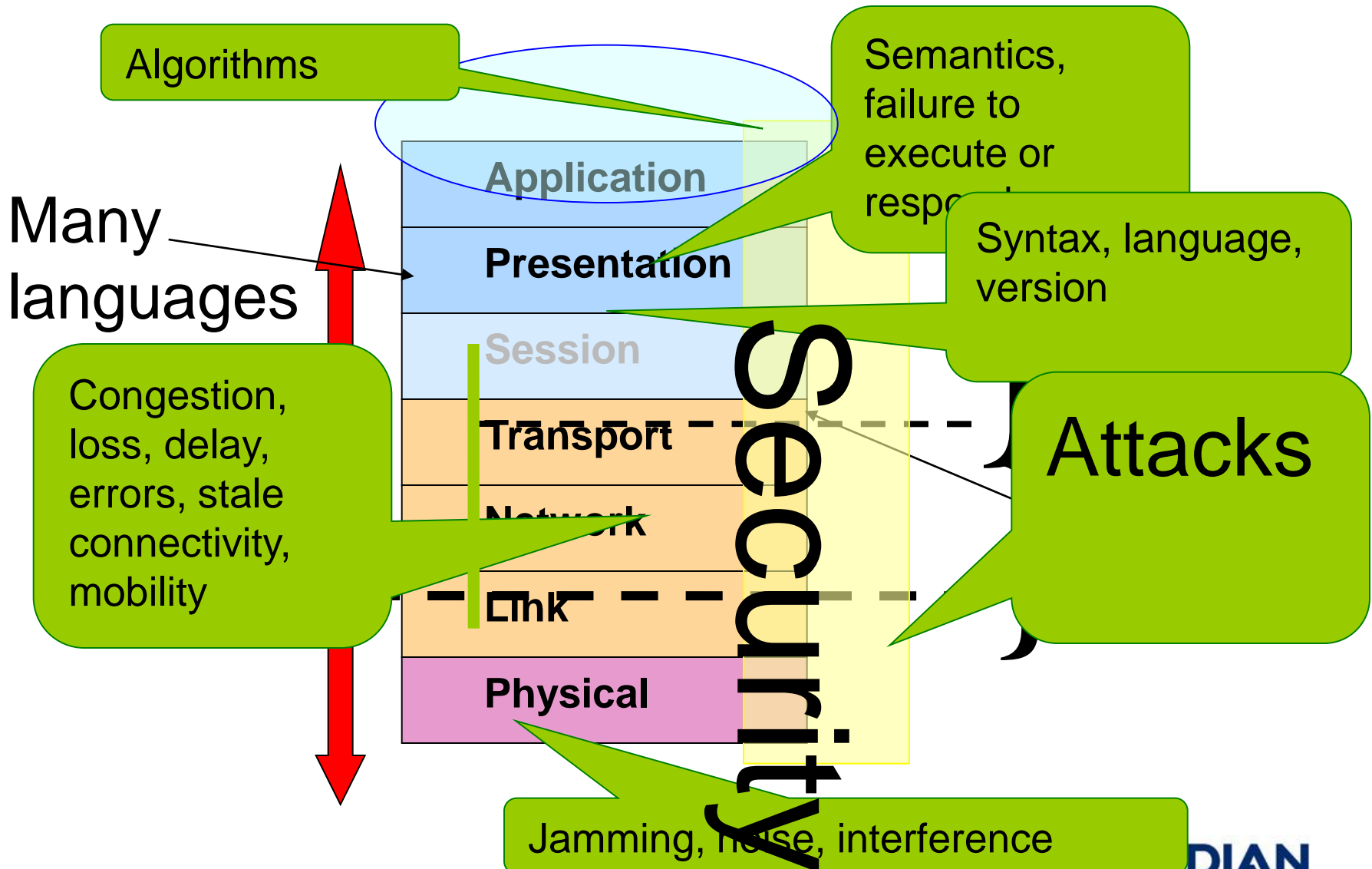
Two system types adapt to each other's protocols and share resources for a specific application

Interoperability

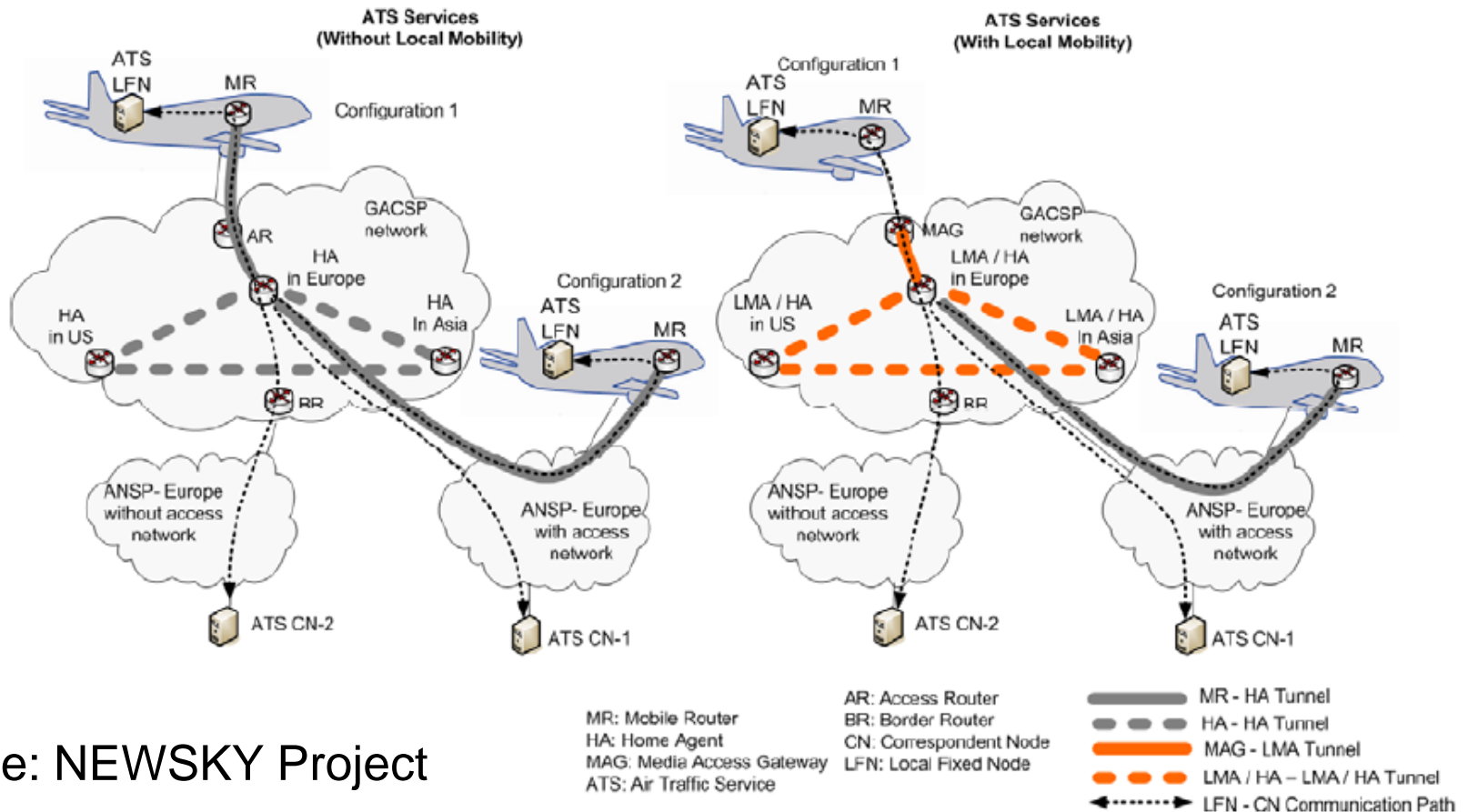


Many systems and many applications work together successfully sharing resources

What Could Possibly Go Wrong?

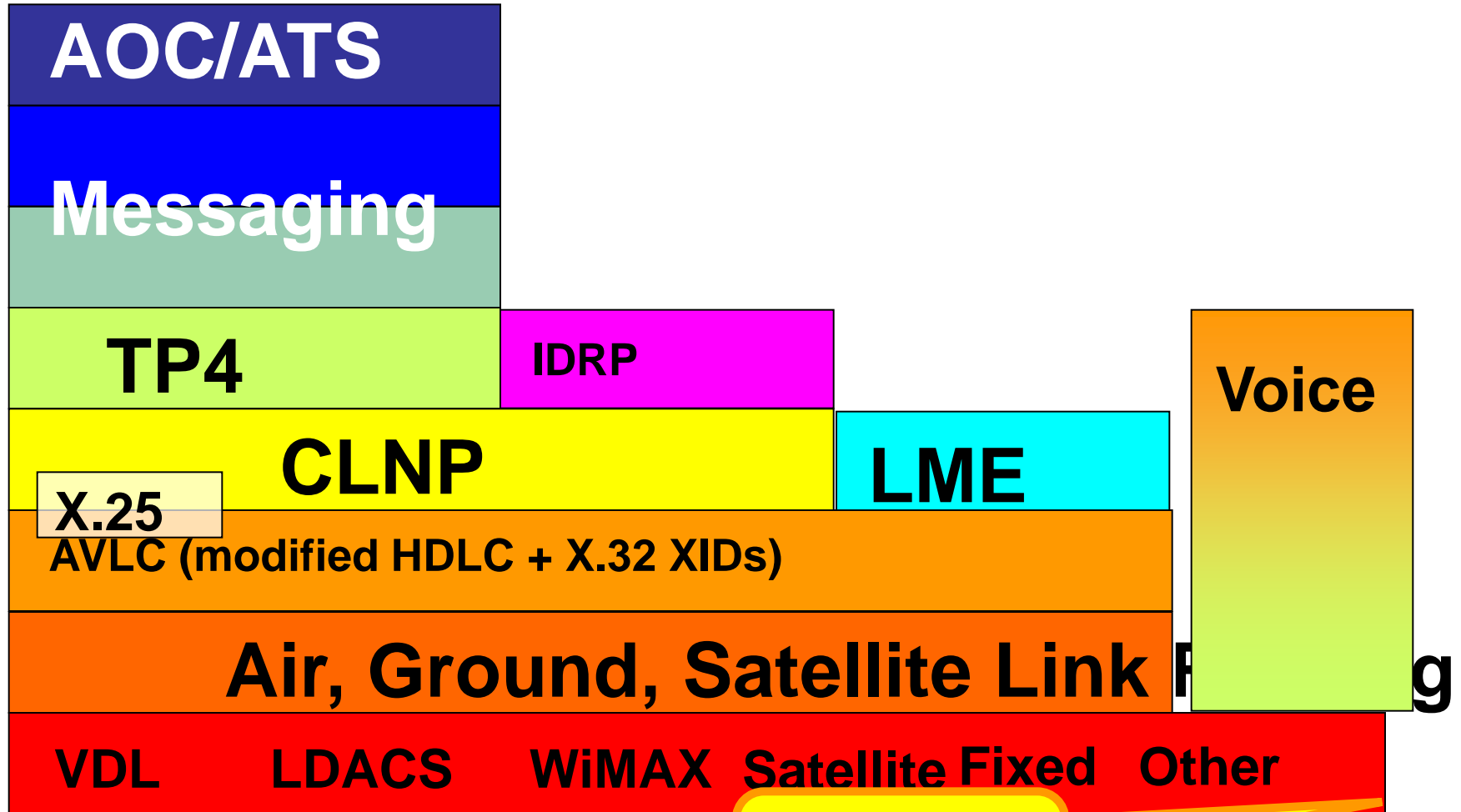


ATN of the Future?



Source: NEWSKY Project

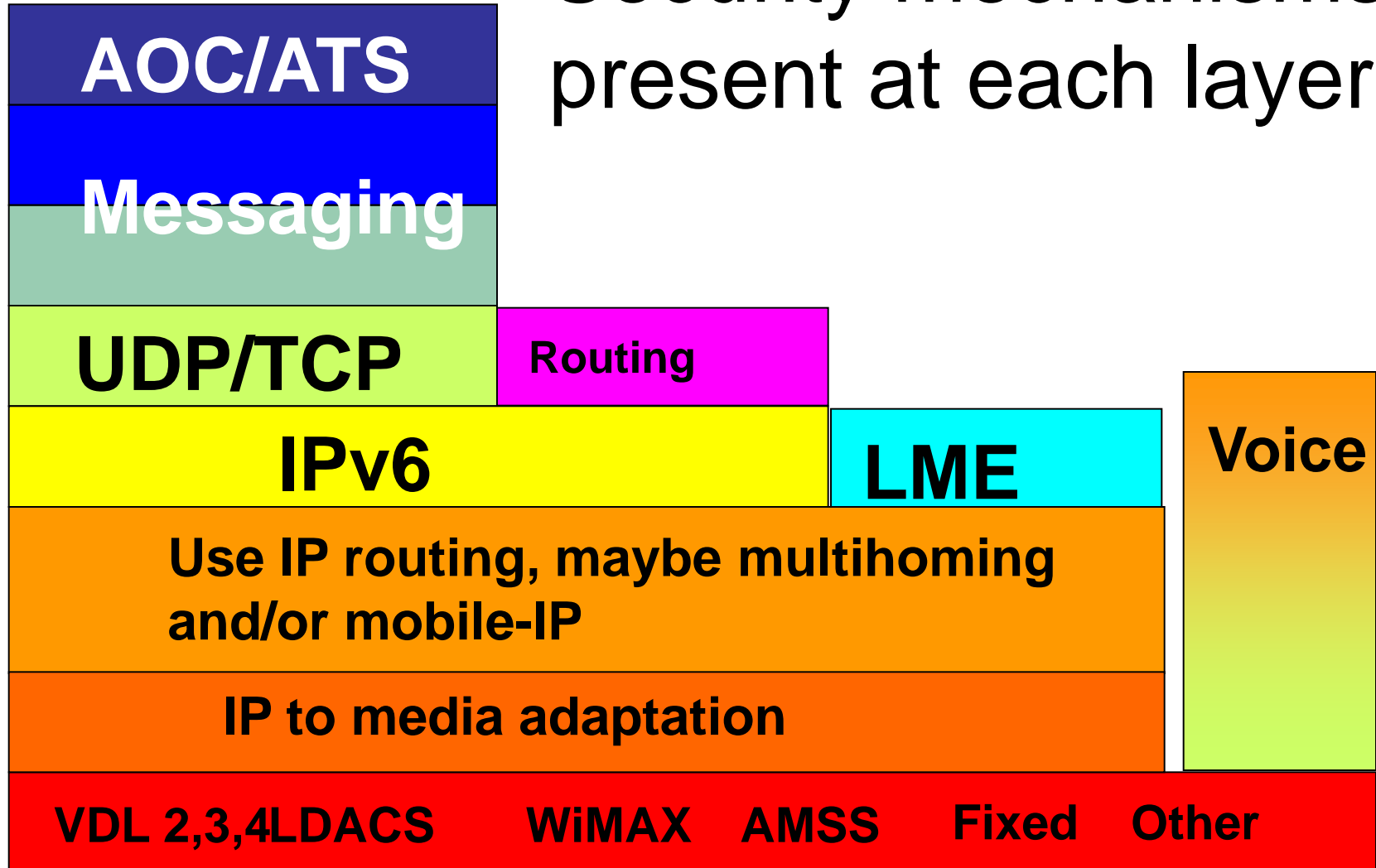
ATN Stack: ATN/ISO



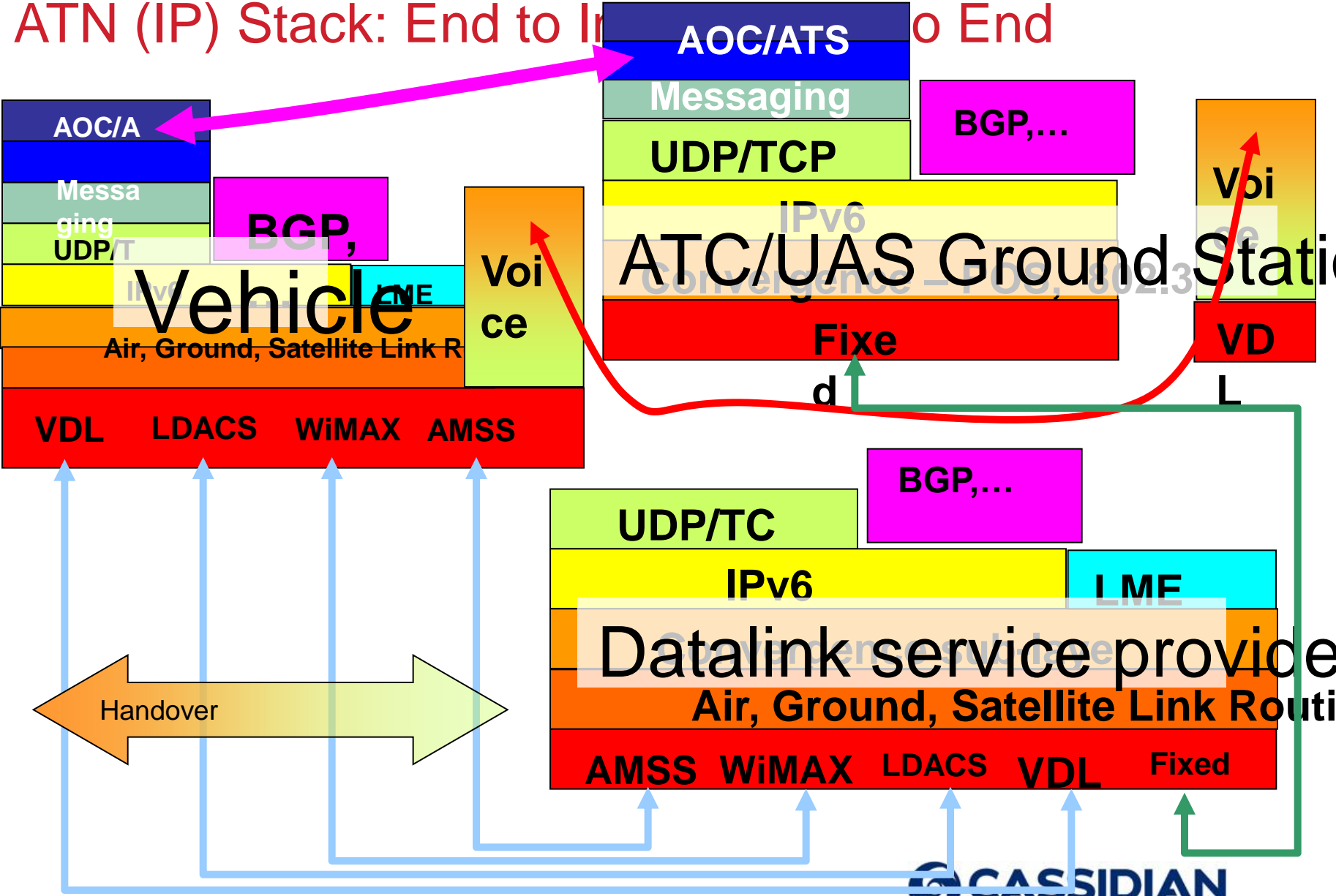
S-Mode air to ground?

ATN Stack: ATN/IP

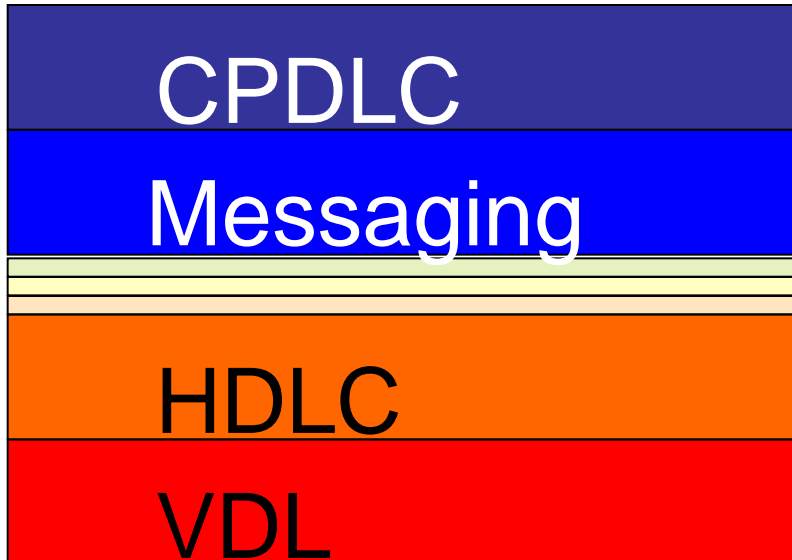
Security mechanisms present at each layer!



ATN (IP) Stack: End to End



Of course, it can be simpler...

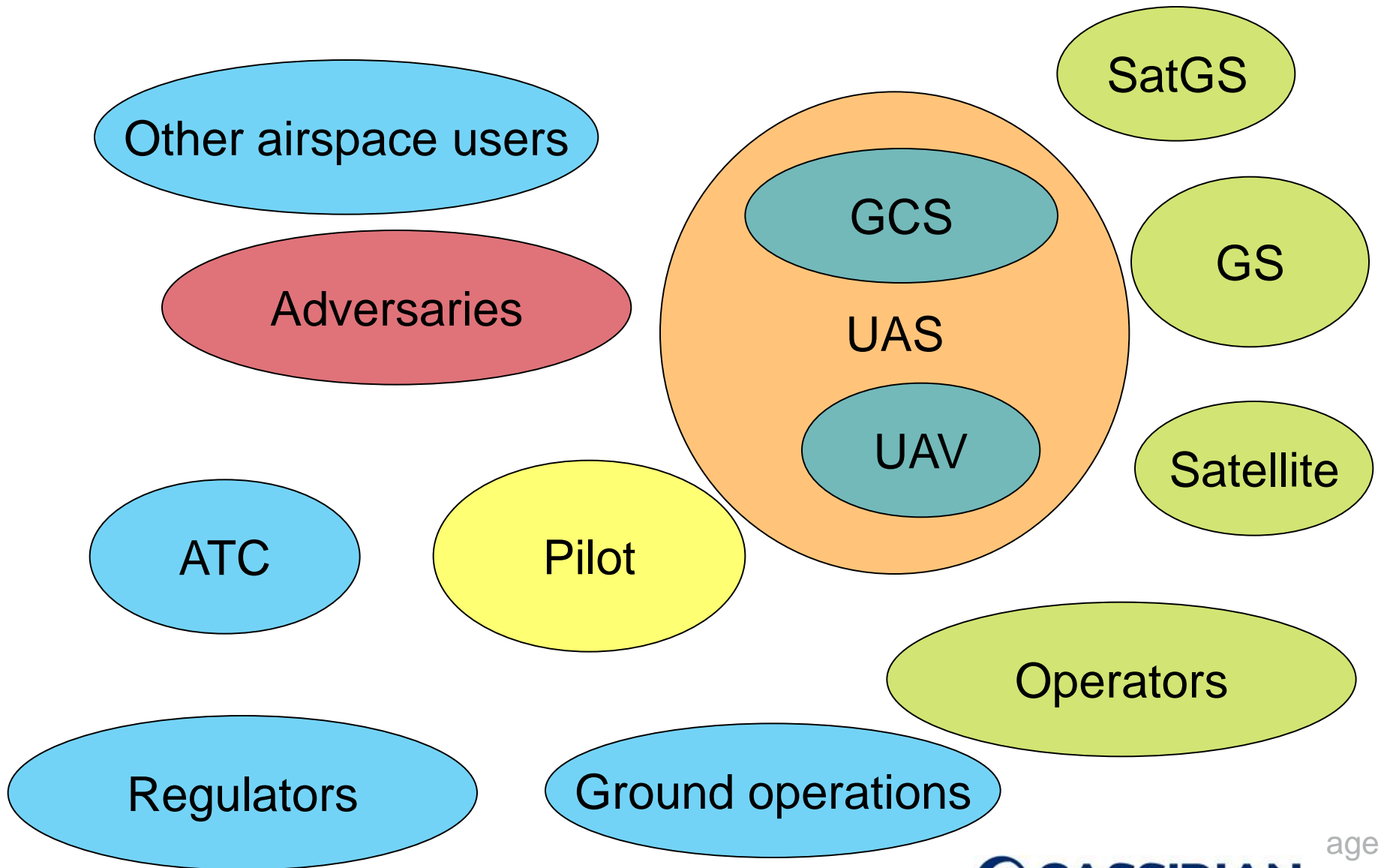


Dedicated circuit – no session (call set-up), internetwork routing

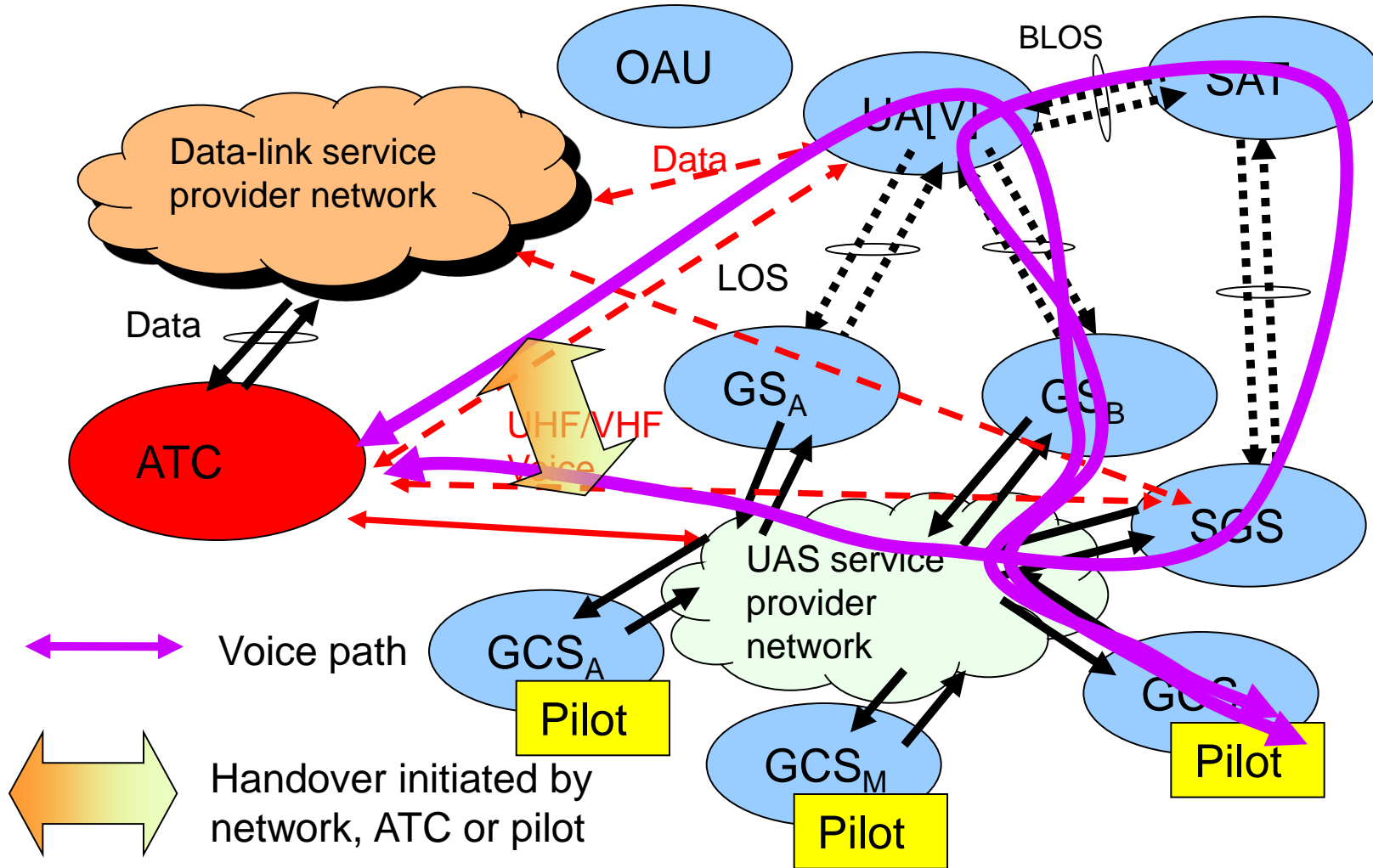
Link layer + messaging protocol provides transport service

But no security...

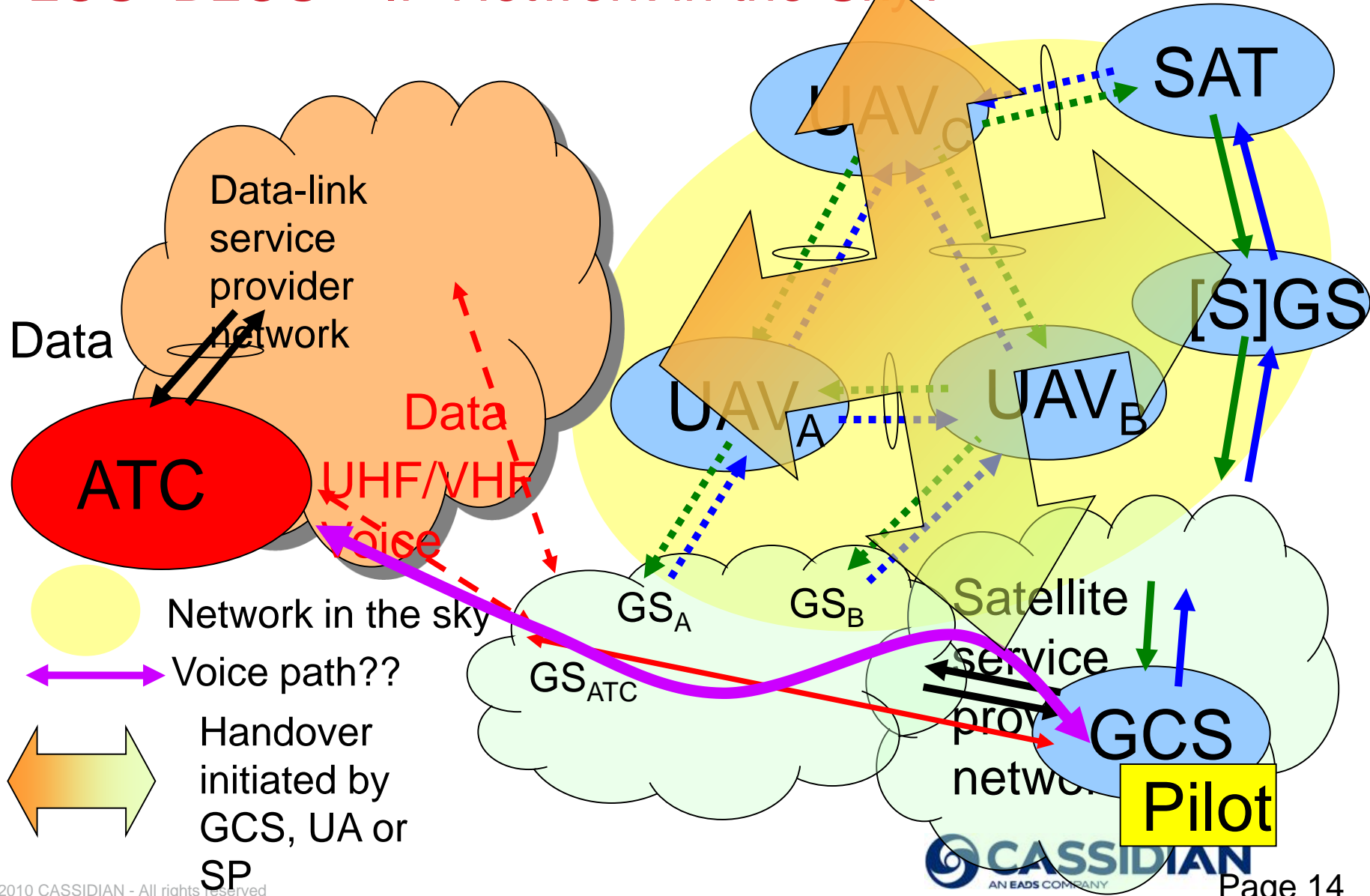
Top Down - the UAS Enterprise



Possible UAS Architecture

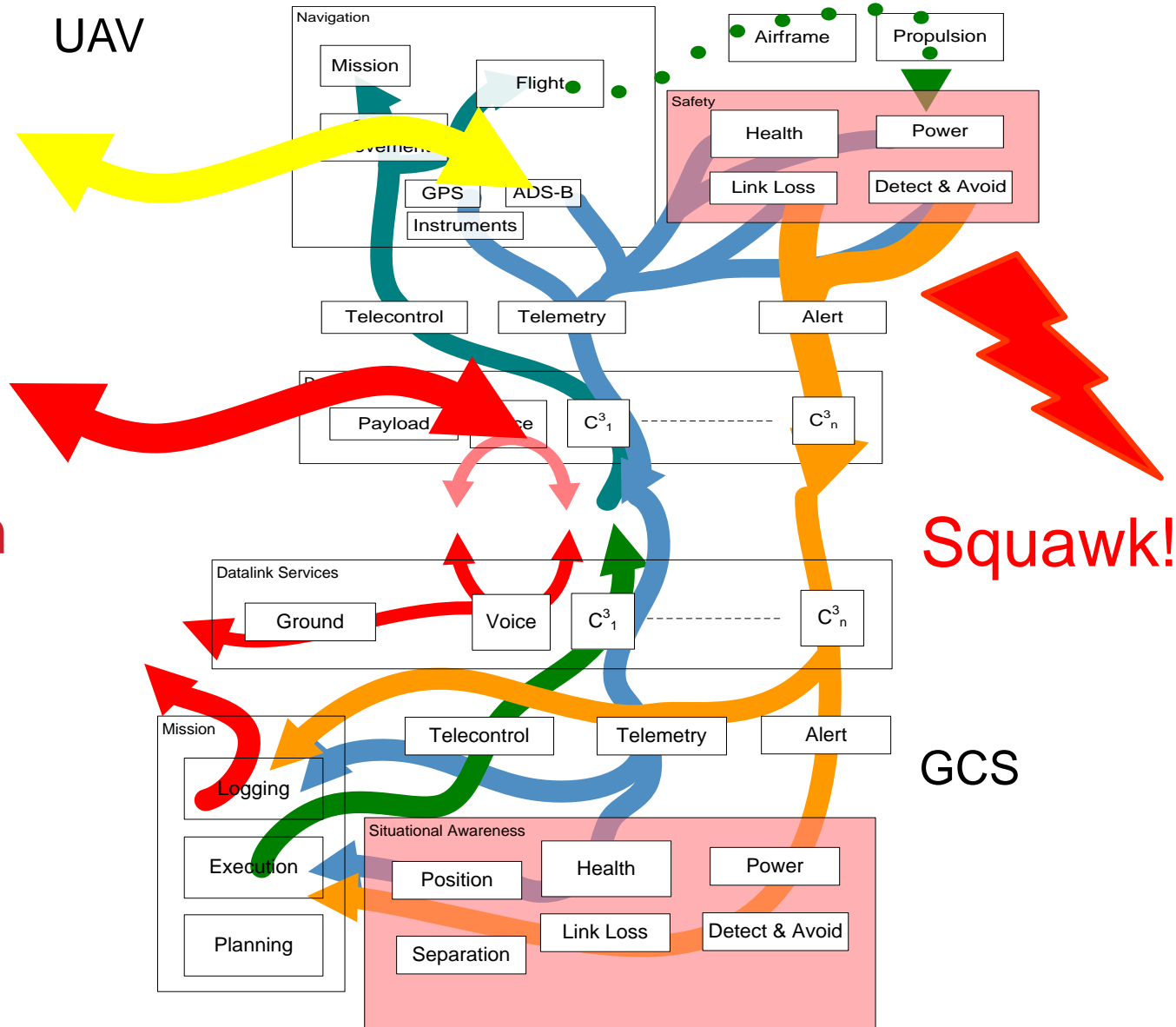


LOS+BLOS – IP Network in the Sky?



UAV

Elements of a UAS that require protection



Squawk!

GCS

Background: It Is All About Hazards

Policies, regulation

UAS Operations

Hazards!

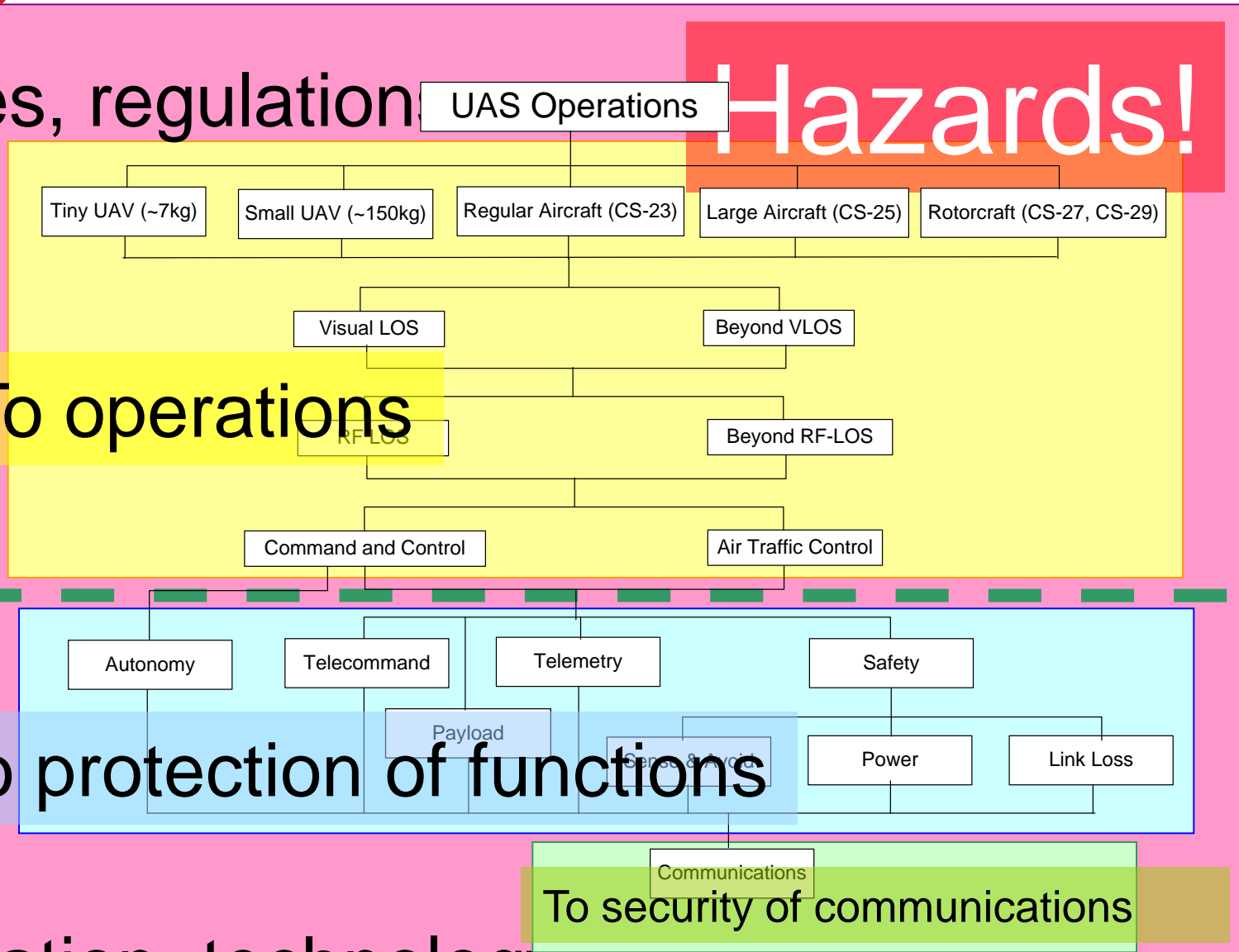
Mechanisms

To operations

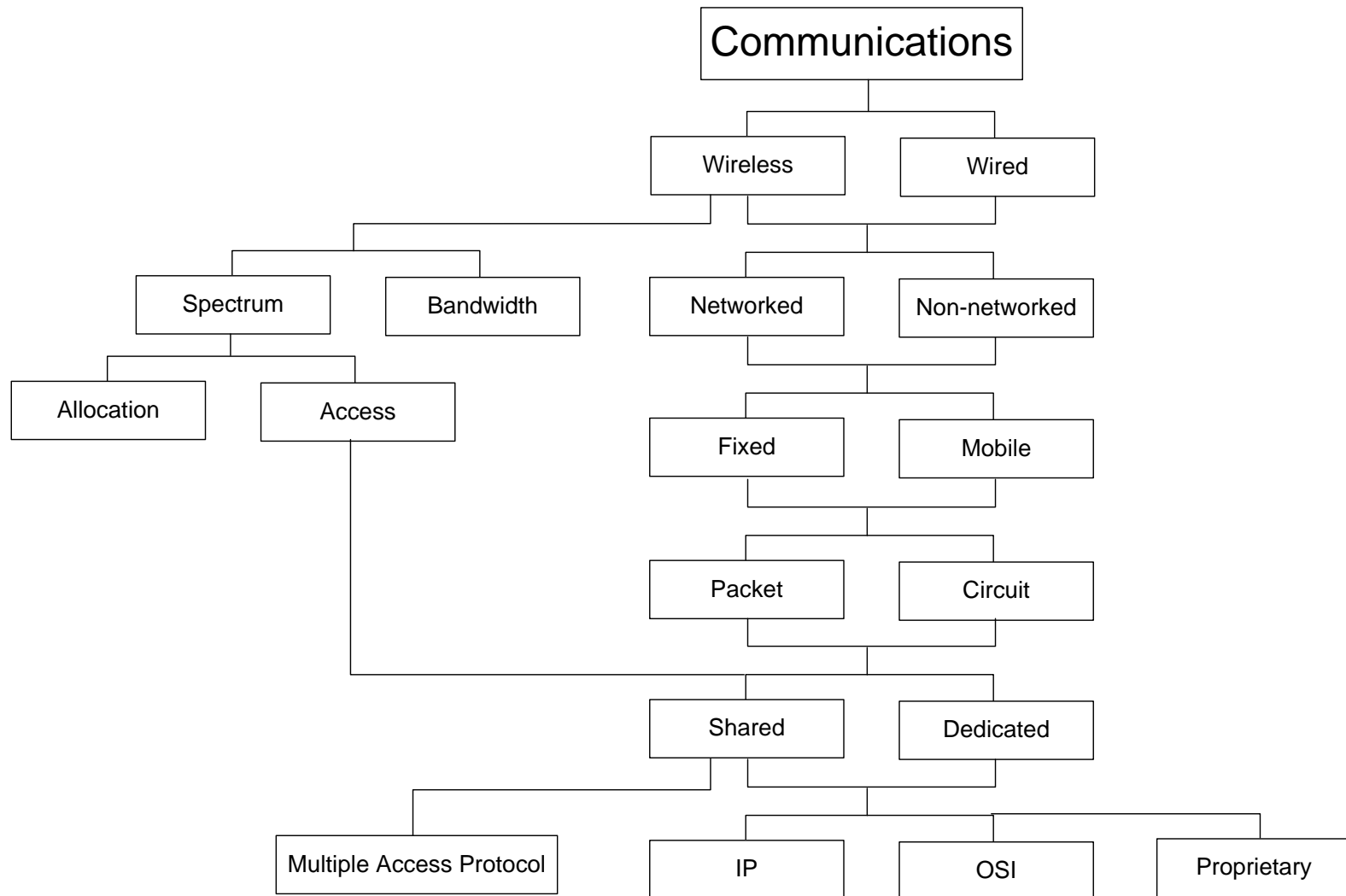
To protection of functions

To security of communications

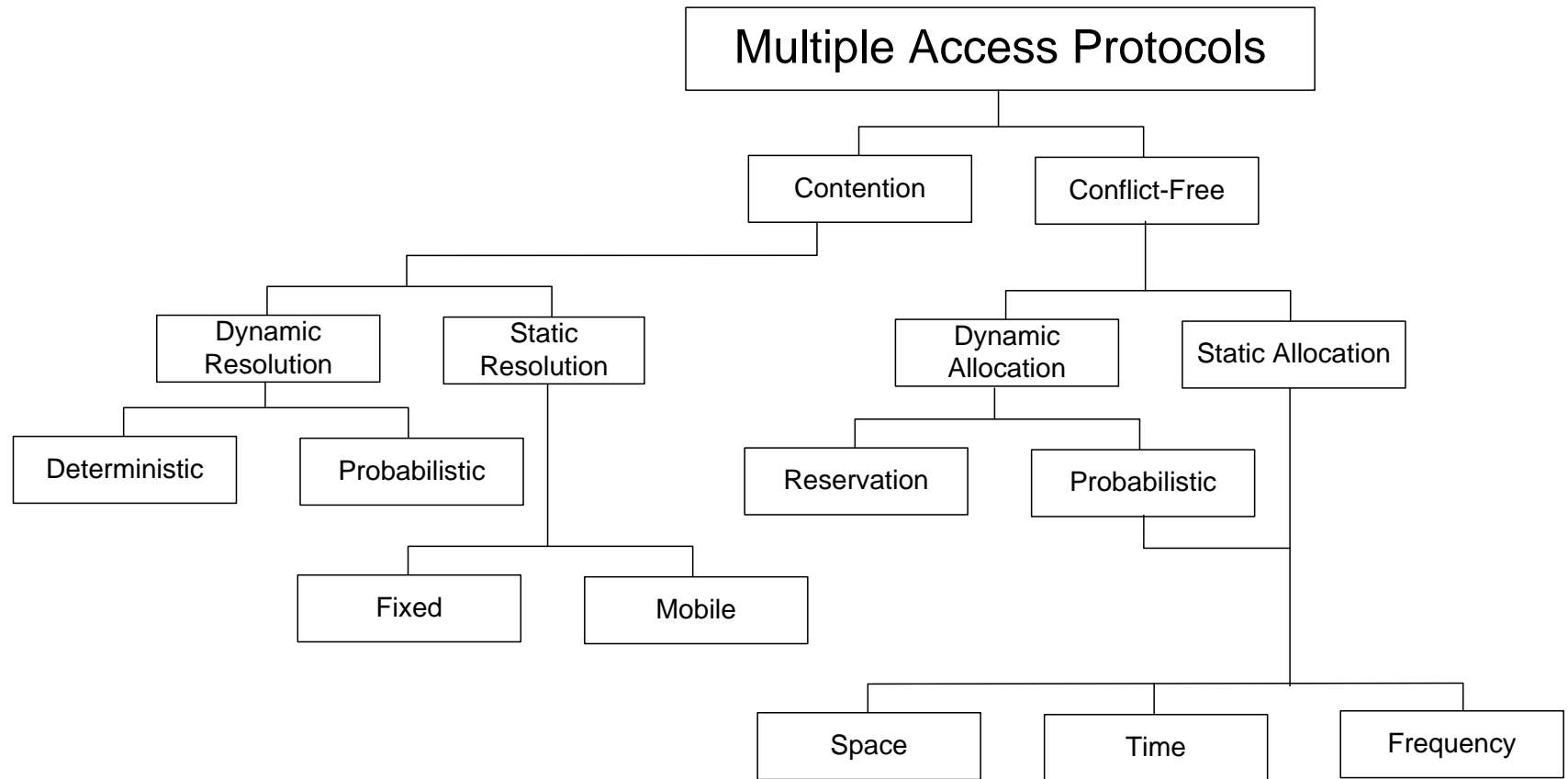
Information, technology, algorithms



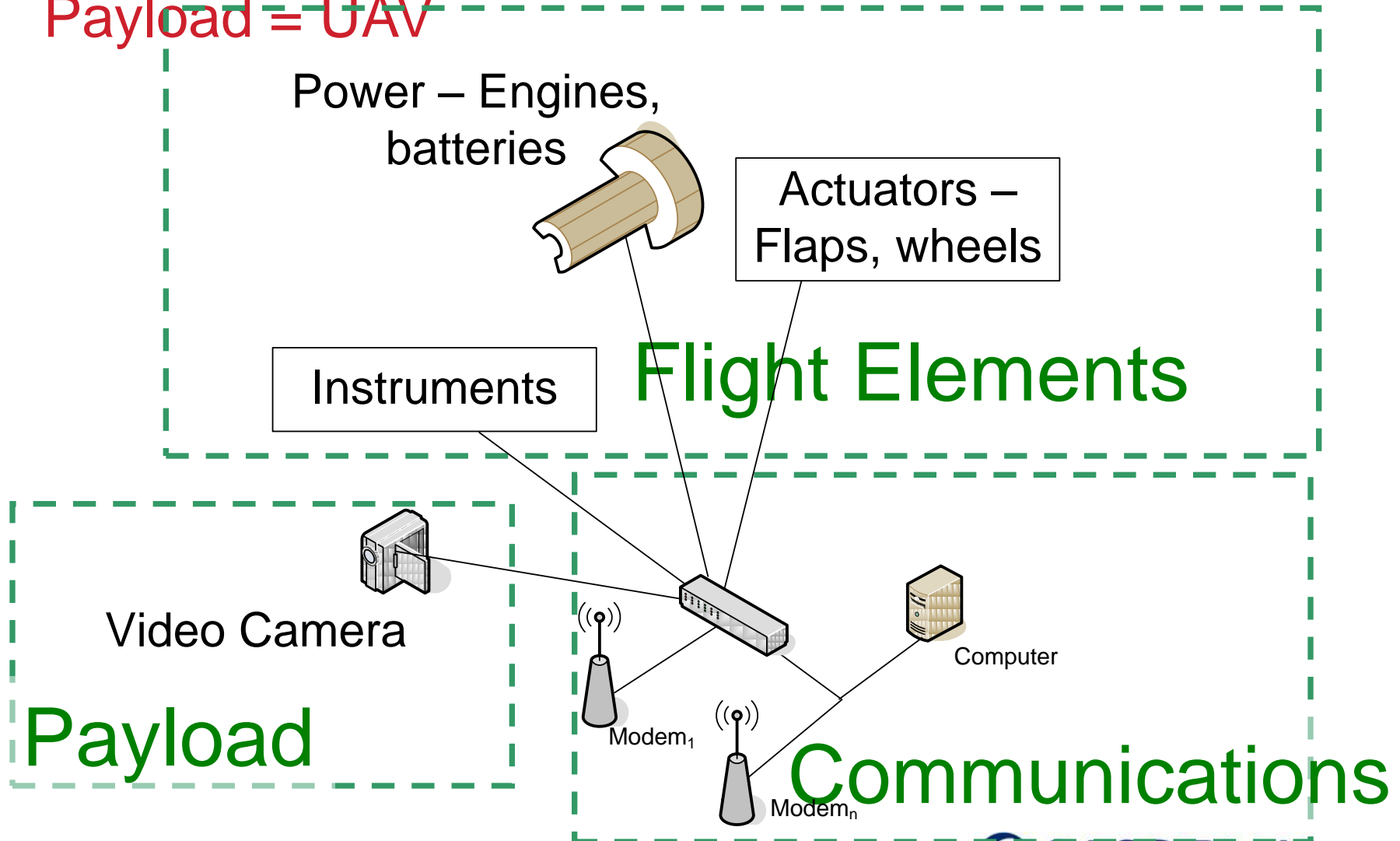
UAS Communications



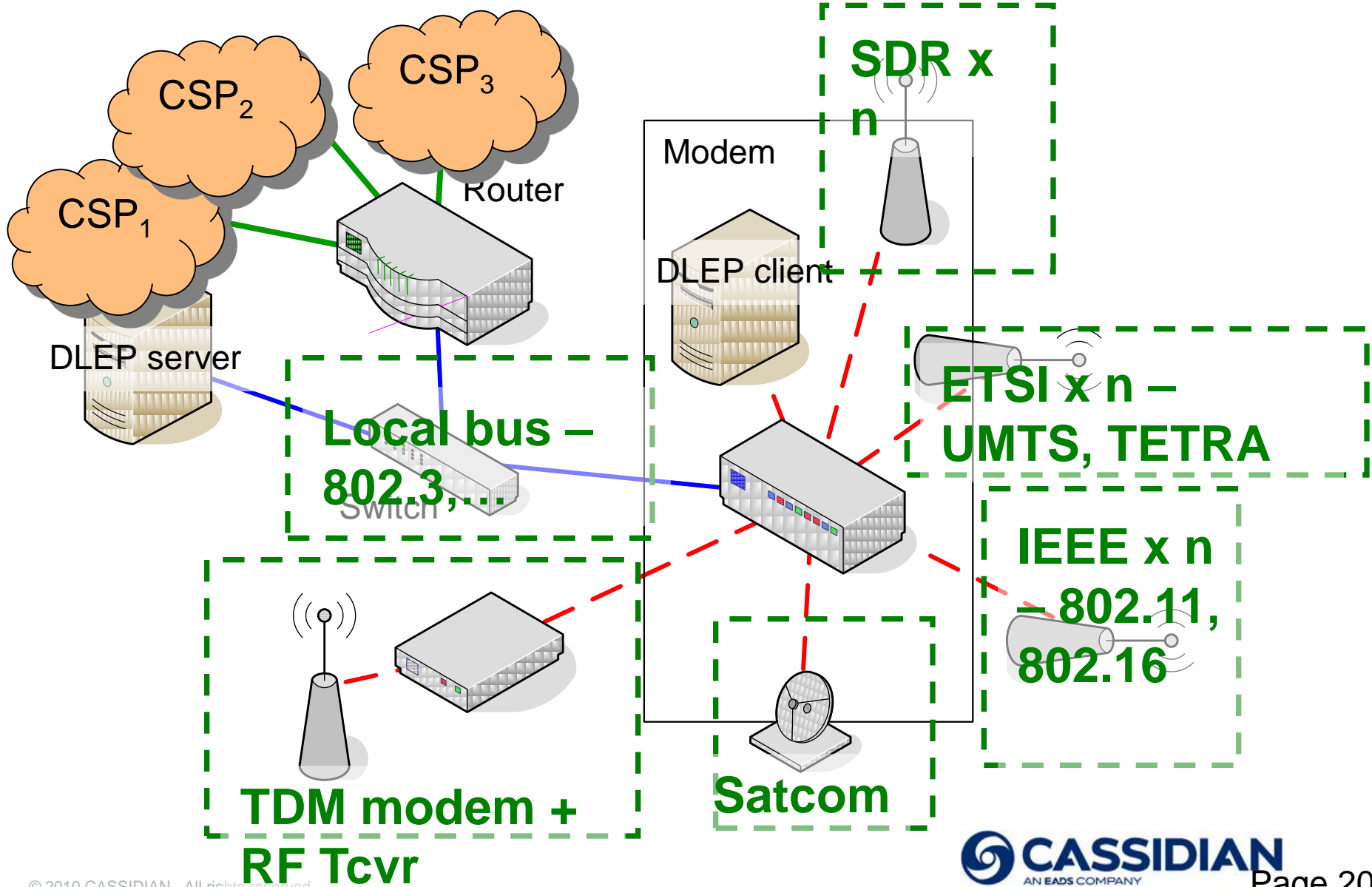
Multiple Access



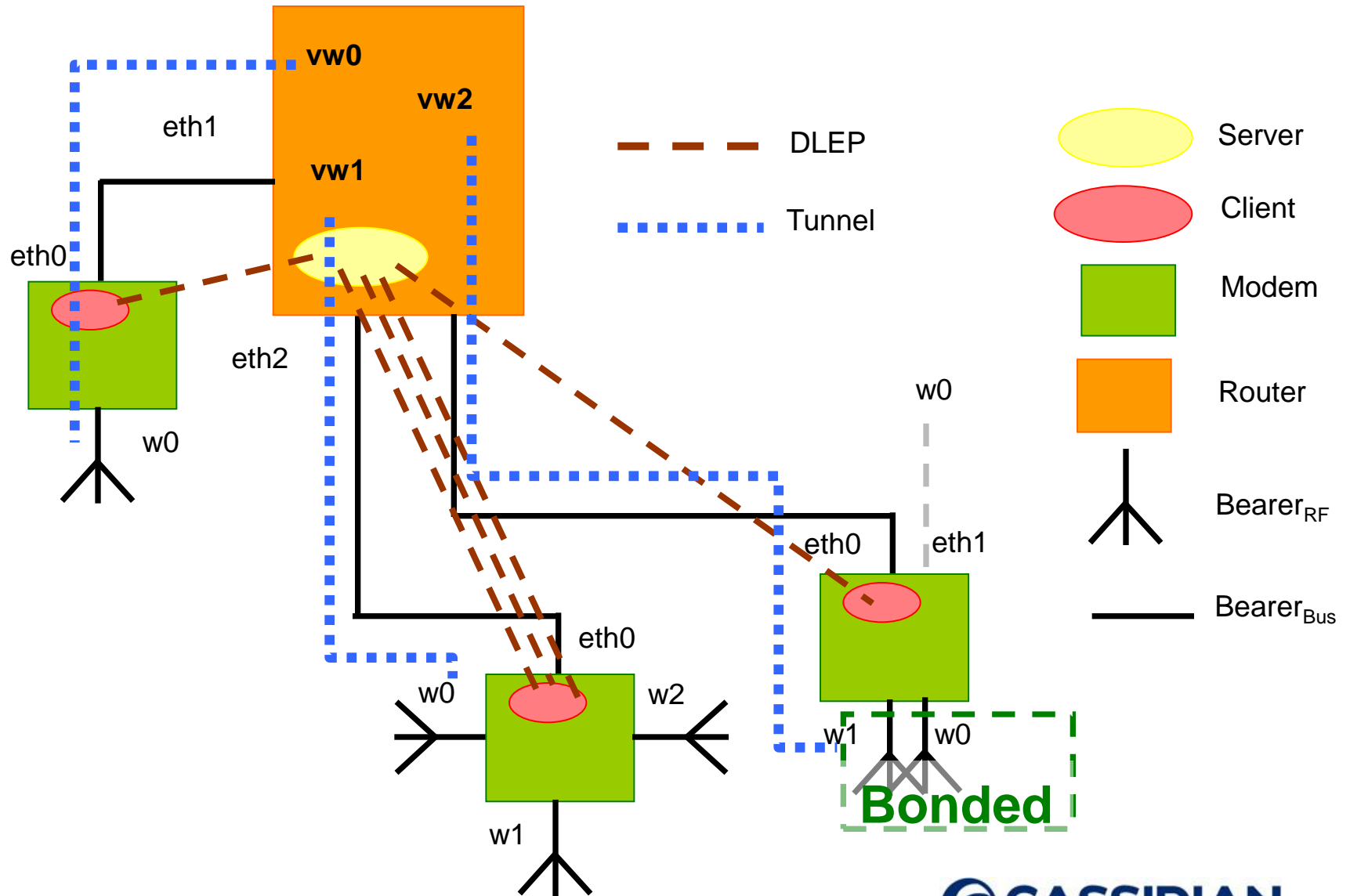
Reality: Communications + Flight Elements + Payload = UAV



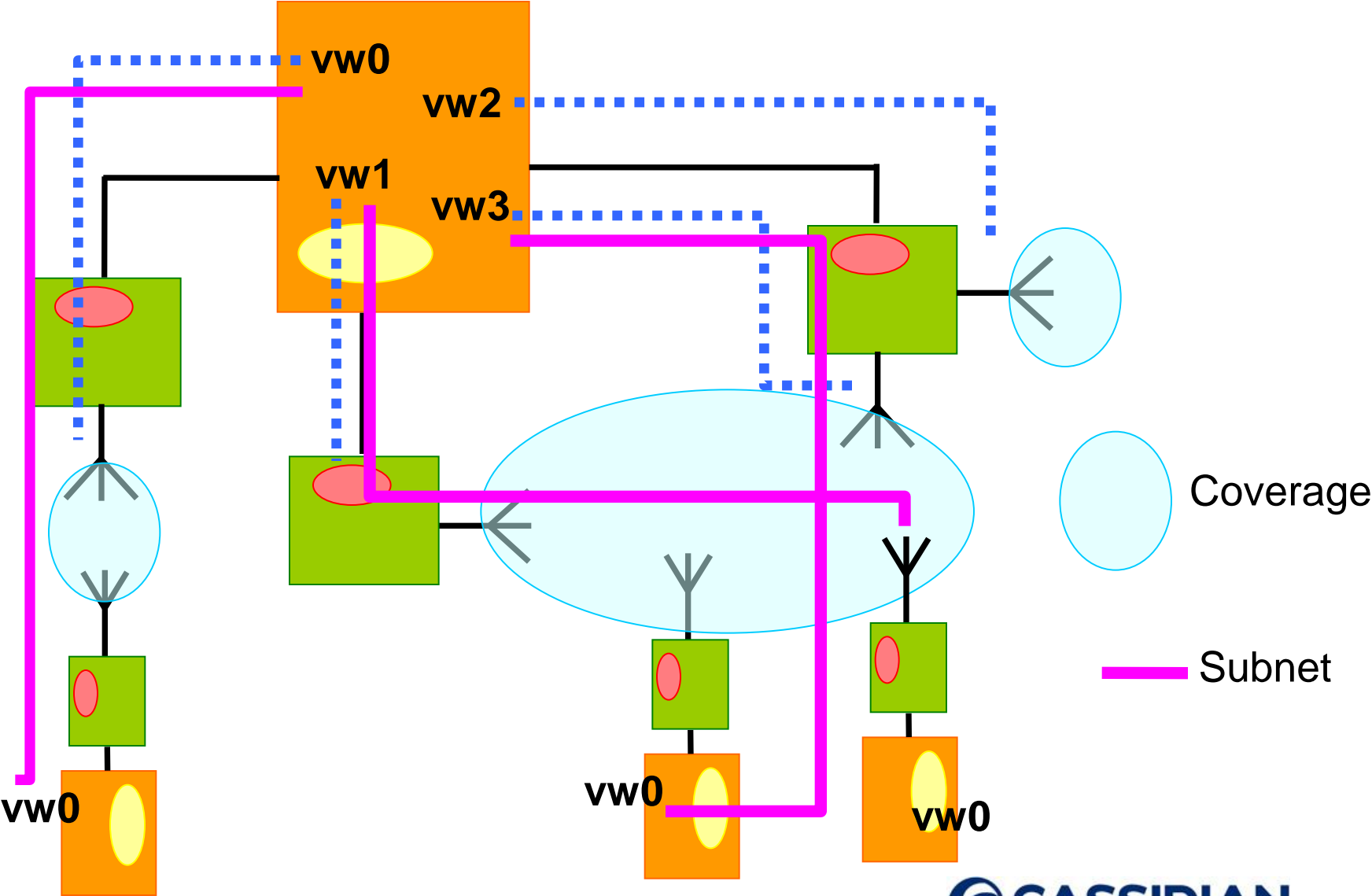
Platform Elements and Functions



DLEP Associations + L2 Tunnels



A Deployment



A Certification Process for UAS

- *Define the requirements on comms made by UAS functions*
- *Specify the initial solution, in terms of architecture, functions, and performance criteria, that will fulfil these requirements end-to-end and layer by layer*
- *Estimate the vulnerabilities, threats that expose them, and the level of risk that those threats turn into actual events*
- *Refine the initial solution, adding mitigating measures, reducing vulnerabilities, etc.*
- Develop and get approval by the Regulator (EASA) of a
 - Compliance Check List
 - A collection of Certification Review Items (the differences)
 - Acceptable Means of Compliance
- AND... specific to comms; political; economic...
 - Make sure that the resources and infrastructure are available to make UAS happen

What do we need?

- Formal design methods and methodologies for ontology and epistemology
- Theory of secure trusted cooperating objects – semantics, scalability, real-time, mobility and robustness, what is necessary, what is sufficient
- Information networking, not communications
- Tools for formal verification for dependability
- A sense of history – it has been done before and elsewhere
- A sense of future – our job is exploitation but we need visionaries and leadership

Thank you!
Questions?