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# Cyber Security Risk Assessment
# Fall 2016

*Lecture A – Case Study*

*Remotely Operated Virtual Tower*

*Fabio Massacci*



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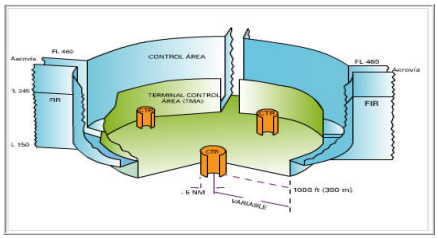
## Airspace Categories & Air Traffic Service Units




**CTA** – Control Area: Space large enough to contain airways, or part of them, in order to provide ATC service to aircrafts

**ACC** – Area Control Centre: ATC unit established to provide ATC service to controlled flights in CTAs under its jurisdiction

**TMA/CTR** – Terminal Control Area: When a CTA has heavy density of traffic and it is closed to a big airport, it is called TMA

**TMA/APP** – Terminal/Approach: ATC unit responsible for arriving and departing controlled flights

**ATZ** – An airspace of defined dimensions established around an aerodrome for the protection of aerodrome traffic

**TWR** – Control Tower: ATC Unit responsible for the airport traffic, landing, taxing and departing.

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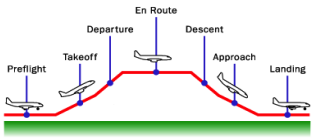
# The Area Control Centers

- ✓ Area Control Centers (ACC) manage Airpsace and Terminal Areas.
  - ✓ Complex web of automated equipment for
    - ✓ presentation of the air traffic (Radars)
    - ✓ traffic forecast (specific databases)
    - ✓ other information helpful for flight management (e.g. weather information)
  - ✓ Airspace is organised into adjacent volumes (Sectors).
  - ✓ Each Sector is operated by two Air Traffic Controllers,
- ✓ Each ACC is linked through dedicated radio frequencies to all aircrafts flying in its airspace and through dedicated point to point telephone line or radio link

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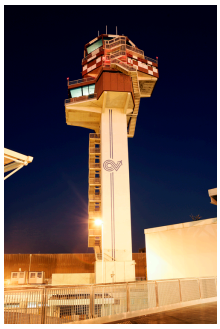
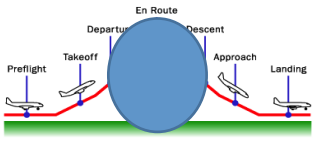
# The Air Traffic Control Tower

- ***The Tower (TWR) provides ATC service to aerodrome traffic (ICAO Doc. 4444)***
- ***TWR area of responsibility:***
  - Maneuvering Area
  - Airspace around the airport, within a 5 miles radius, up to 3000 feet altitude.
- ***TWR authorises movement inside the airport to prevent collisions of***
  - any person,
  - vehicle
  - or aircraft.
- ***TWR has a central position to observe and manage***
  - all flights
  - and depended operations on and around airport.





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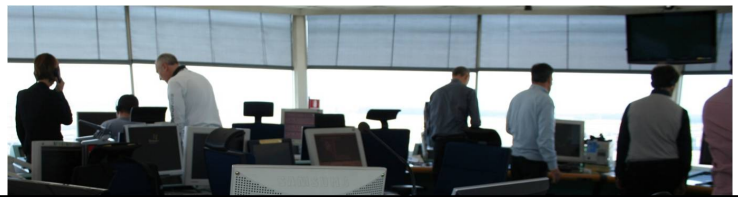
# Current Tower Operations (1/3)

- ***Small Control Tower could have 1 ATCOs and 1 MET operator, tower of bigger airports up to 10 ATCOs with different roles:***
  - **DELIVERY**: in charge of giving to the A/C the permission to start-up and the departure clearances
  - **GND CONTROLLER** is responsible for the safety of aircraft that are taxing from and/or to the RWY
  - **TWR CONTROLLER** is responsible to ensure that sufficient runway separation is kept between landing and departing aircraft
  - **COORDINATOR**: responsible for co-ordinate arrivals according to the decisions of the Approach Control Unit.
  - **SUPERVISOR**: supervises the operational team and the equipment



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# Current Tower Operations (2/3)

- ***Current Tower Operations are mainly based on the "out-the-window" (OTW) view:***
  - The OTW view is from a single viewpoint, typically high above the ground from the centre of the airport.
- ***All ATCOs "sensorial" experiences are relevant to detect potential safety problems:***
  - Airport sound like engine noise, birdsong, wind noises are directly available through ambient noise.

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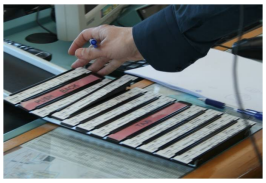
# Current Tower Operations (3/3)

- ***Additional systems that are needed to provide the service are:***
  - Voice communications;
  - Flight Plan and ATS message handling;
  - Manoeuvring of airport lights, navigation aids, ILS, alarm and other airport systems;
  - Binoculars, Signal Light Gun;
  - Paper Strips;
- ***Additional tools providing information gathered through specific sensors, e.g. ground radar information, meteo radar and meteo sensor information, ADS_B data, etc. can be used to facilitate surveillance, subject to coverage.***



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# Current Problems

- ***Cost : A main proportion of the ATS costs are associated with the building, maintenance and upkeep of the physical ATS facilities***
  - maintenance and upkeep of old Tower facilities can be inefficient and expensive
  - building new towers is very expensive, compared to “ordinary” buildings
- ***and the costs of personnel to provide the ATS.***
  - Minimum number of personnel can be costly for rarely used airports
- ***No standardization: systems, equipment, operating methods and procedures varies according to airport. This has an impact on***
  - cost (equipment, systems)
  - controller training (methods, equipment and procedures).
  - Variability and subsequent controller training (and geography) → many staff will only be valid/rated for one local airport
- ***Lack of space: There is often a lack of space to install new equipments and it is impossible to build completely new Towers.***

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# The Remote and Virtual Tower (1/3)

- ***The main objective of the Remote and Virtual Tower concept is to provide the air traffic services already provided by local aerodrome control Towers, but to do so from a remote location.***


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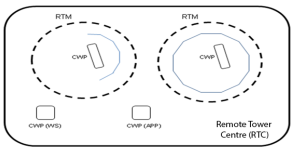
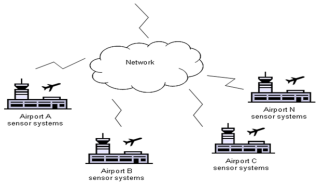
# Remotely Operated Virtual Tower (1/3)

- ***The main objective of the Remotely Operated Virtual Tower concept is to provide the air traffic services already provided by local aerodrome control Towers, but to do so from a remote location.***


# Remotely Operated Virtual Tower (2/3)

- ***ATCO no longer located at aerodrome***
  - re-located to a Remote Tower Centre (RTC).
- ***RTC contains many Remote Tower Modules (RTM),***
  - similar to Sector positions in ACC.
  - Each tower module remotely connected to 1+ airport
  - Each airport remotely connected to 1 or several RTM, dependent on size of airport.
- ***Visual surveillance provided by "reproduction" of the OTW view by***
  - Option 1: remotely provided through direct visual capture and visual reproduction by cameras
  - Option 2: remotely provided through computer generated images of the aerodrome, aircraft and vehicles, and terrain mapping and computer modelling to represent aerodromes.
  - Combination of the above.



# Remotely Operated Virtual Tower (3/3)

- ***Visual reproduction overlaid with information from additional sources***
  - surface movement radar, surveillance radar,
  - ADS-B,
  - multilateration or other positioning and surveillance implementations.
- ***Technology must enhance visual reproduction in all visibility conditions***
  - i.e. fog. bad weather
- ***Improve Situational Awareness***
  - Advanced Visual Features to aid in providing separations (from other aircraft or terrain)
  - audible background sounds could be captured and relayed in the RTM.

# RVT Deployment Scenarios

- ***A Remote Tower Centre will provide ATS for N>>1 aerodromes.***
  - staff resources and RTMs will be co-located in the RTC.
  - RTC may be located far from any airport or it may be an additional facility co-located with a local facility at a (big) aerodrome
- ***Remote Provision of ATS for a Single Aerodrome will be applied to***
  - low density aerodromes (where low density is determined as being mostly single operations, rarely exceeding two simultaneous movements)
  - medium density aerodromes (where more than two simultaneous movements can be expected).
  - small airports with occasionally more traffic density (for example tourist airports/remote airports during a particular event etc.)
  - NO big airports
- ***This scenario differ consistently from current operations: ATS are not currently provided to multiple aerodromes by a single ATCO.***

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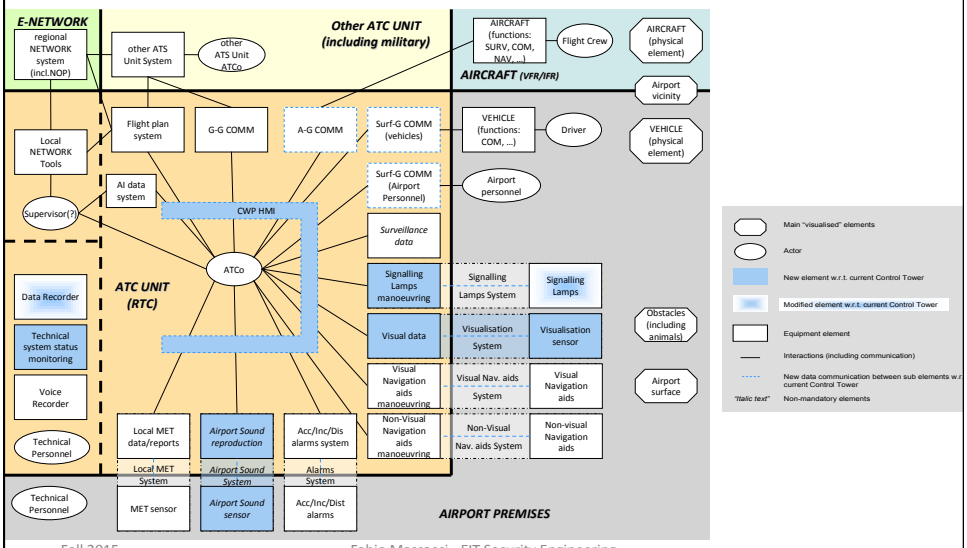
# RVT Technical Architecture



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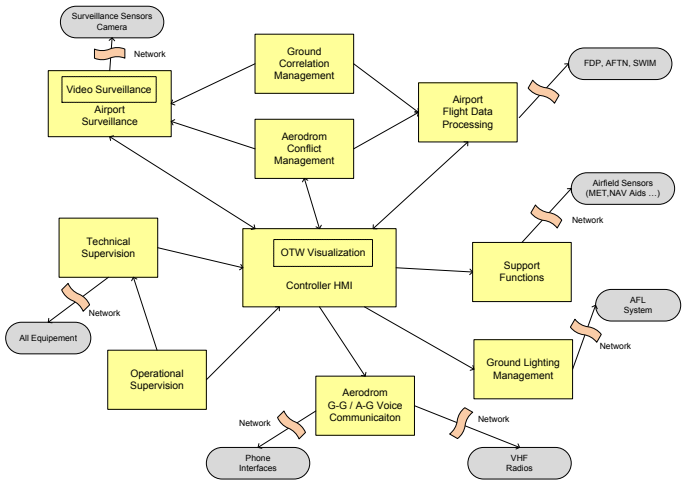
# RVT Functional View



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# What can go wrong?

- ***Tenerife: 1977***
  - two Boeing 747 crashed on the runaway→ 583 dead
  - Small airport suddenly crowded because of bomb alarm on nearby big airport
  - Fog plus "hurry" of captain to leave the airport
- ***Linate: 2001***
  - Boeing MD-87 crashed with Cessna 525-A → all occupants + 4 ground staff
  - Low visibility plus new radar not installed due to management/cost issues
  - Wrong structure of accountability → previous «almost incidents» ignored and little training of controlers
- ***Uberlingen: 2002***
  - Boeing 767 and Tupolov TU164M crashed mid-air → 71 dead
  - System was going over an upgrade
  - ATCO told pilots to ignore collision warnings from system plus 1 ATCO went to rest
  - Wrong structure of accountability again

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# More things to go wrong

- ***Nogales, 2006***
  - MQ-9 (Predator B) aircraft crashed at 18Km from Nogales International Airport at 4am.
  - Remotely piloted with two identical consoles: one lever controls "iris" (narrow → broad), another controls engine (full power→off)
  - Pilots take shifts every two hours.
  - At 3am, one console crashed, the pilot transfered controls to the other console without checking that the lever of the new console was in the right position → he cut off power and contact was lost
  - Drone are able to fly on autopilot but with power-off drone started to shed electric components to save batteries and cut off satellite emergency contact
- ***Sharana 2011***
  - A drone crashes into a Transport Aircraft Hercules C-130 landing on the airport at 700m of altitude
  - 2minutes later the plane landed with a left wing burning.
  - Most details are classified but it seems it was partly the fault of the air traffic controller
- ***Pennsylvania, April 2014***
  - A drone crashes 400 meters from an elementary school
- ***Federal Aviation Administration in the US is scheduled to issue rules by September 2015 that will begin the widespread integration of drones into civilian airspace.***

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# Most Likely Causes?

- ***Study of 114 major Accident in US and Canada till 2004***
  - By Cause = how many times the particular cause is mentioned over all reports
  - By report = how many reports mention the particular cause among one(s) responsible for the incident
- ***Category By Cause By Report***
  - Individuals … …
  - Organizations … …
  - Equipment … …
  - Other … …
- ***Guess: <10%, 20%, 40%, 60%, 80%***

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# Some Myths

- ***Personal Invulnerability:***
  - Accidents only happen to incompetent people, or to systems or equipment designed by incompetent people
    - "accidents only happen when someone messes up, and I will not mess up, so no accidents will happen to me or the systems with which I work."
  - Because few engineers consider themselves to be incompetent, they are inclined to think that accidents will not happen to them or to the systems with which they are involved.
- ***Causal Simplicity:***
  - making causal determinations for most accidents is a fairly simple thing to do
- ***Blaming an Individual:***
  - 75% [or some other high percentage] of accidents are blamed on human error

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# Most Likely Causes?

- ***Study of 114 major Accident in US and Canada***
  - By Cause = how many time the particular cause is mentioned over all reports
  - By report = how many reports mention the particular cause among the many responsible for the incident
- ***Category*** ***By Cause*** ***By Report***
  - Individuals 31% 62%
  - Organizations 50% 80%
  - Equipment 16% 43%
  - Other 3% 10%

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# RVT «Bad guys» scenarios?

- ***Global terrorist attack?***
  - Global attack style 9/11
  - Not necessarily on loss of life: «Syrian Cyber Army» might claim «We grounded all European planes»
- ***«Local» terrorist/organized crime attack***
  - Plane brought down to hit individual passengers
- ***Organized crime***
  - Drug smuggling?
- ***Disgruntled Employee***
- ***Other?***
  - Unmanned Aircrafts?

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# ROT Security Risk Assessment

- ***From SESAR's Security Case:***
- ***The ROT concept should encompass:***

✓ data continuous availability and integrity to ensure safety during landing/departure and taxing,

✓ data protection to ensure confidentiality and avoid malicious exploitation of traffic data,

✓ physical security issues, like the on-site protection of the remotely located cameras, sensors and surveillance radars in the aerodrome, etc.

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# Additional Reading

- ***RVT Case study Description***
- ***Incidents Report***
  - Nogales
    - http://www.ntsb.gov/aviationquery/brief2.aspx?ev_id=20060509X00531&ntsbno=CHI06MA121&akey=1
  - Sharana
    - http://www.washingtonpost.com/sf/investigative/2014/06/20/when-drones-fall-from-the-sky/
- ***See Chris Johnson's papers***
  - "Why System Safety Professionals Should Read Accident Reports"
  - http://www.dcs.gla.ac.uk/~johnson/papers/Linate/Chris_W_Johnson_Ueberlingen_Linate.pdf