The 4D Trajectory Data Link (4DTRAD) Service Closing the Loop for Air Traffic Control

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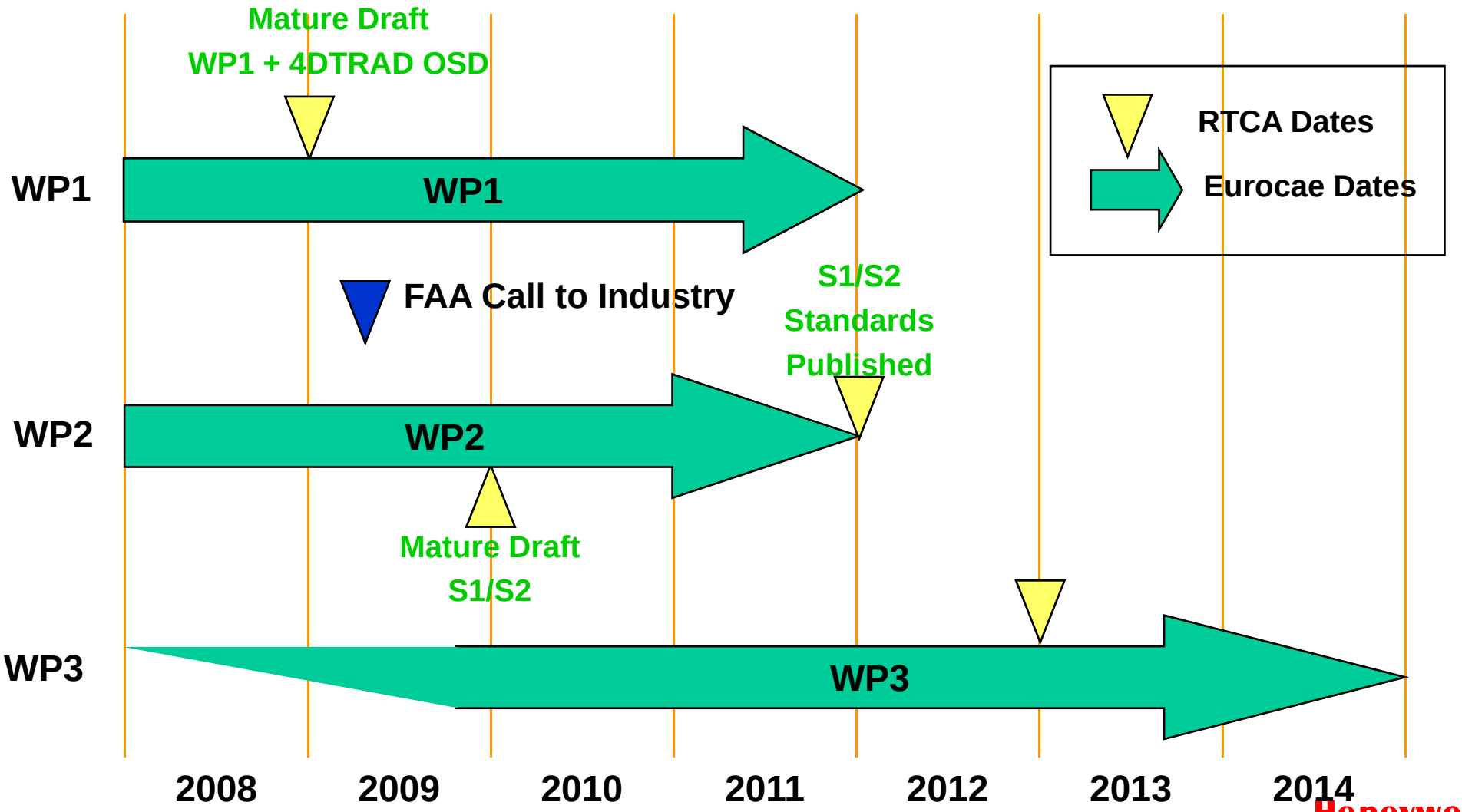
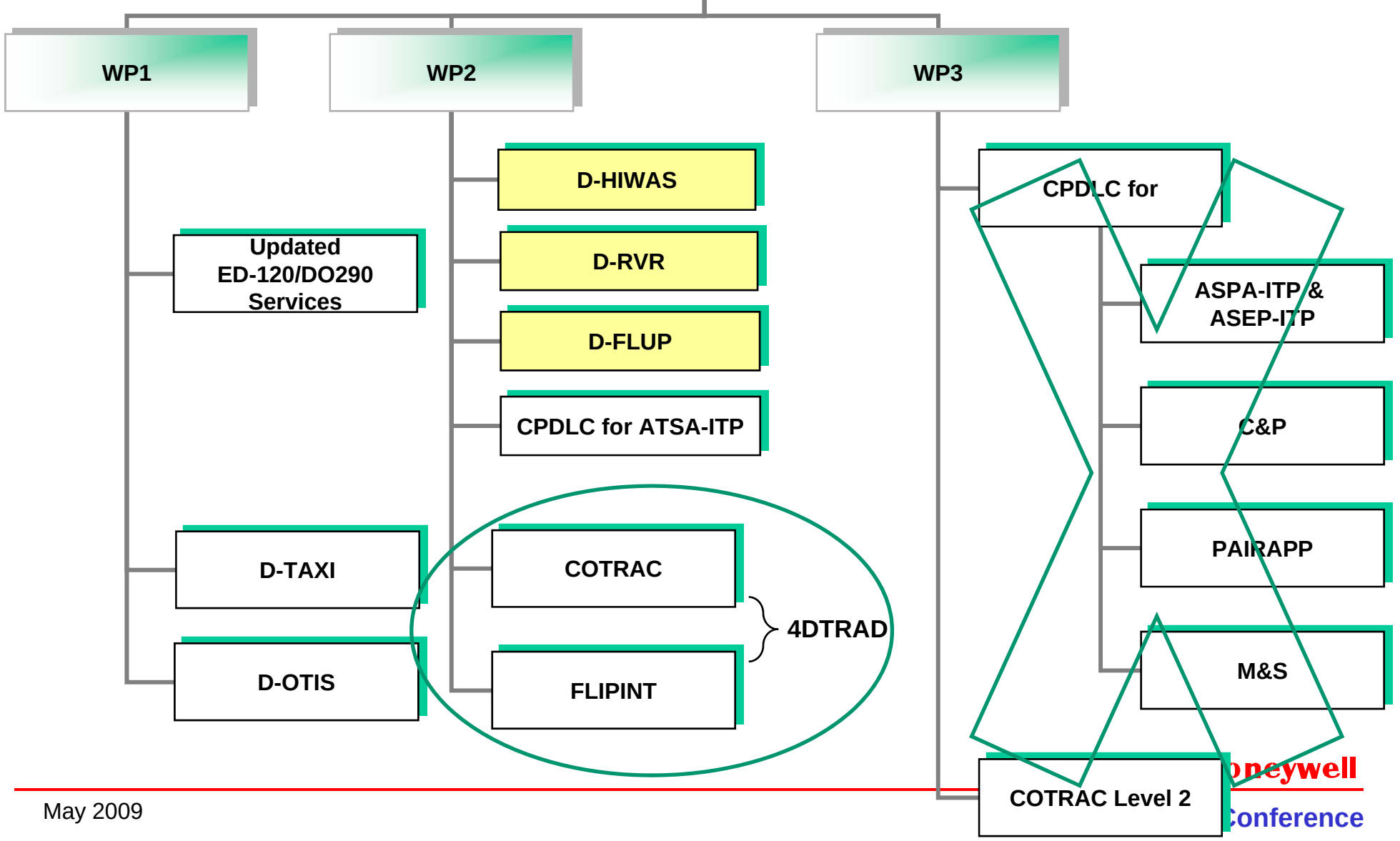
Background of RTCA SC214 / EUROCAE WG78

- **In plain terms:**
  - **Update of CPDLC (and ADS-C) specifications with new assumptions**
    - Interoperability of ATN, FANS, and ACARS
    - Primary means of communication – voice supplemental
    - Goal of worldwide applicability
    - Consider requirements of NexGen, SESAR, etc.
  - **These scope changes ripple through the definitions of services and data links.**
  - **Backwards compatibility is expected for portions of CPDLC that have already been implemented.**
- **These standards will drive the next generation of airborne capability.**

EUROCAE and RTCA Proposed Dates



SC-214/WG78 Scope

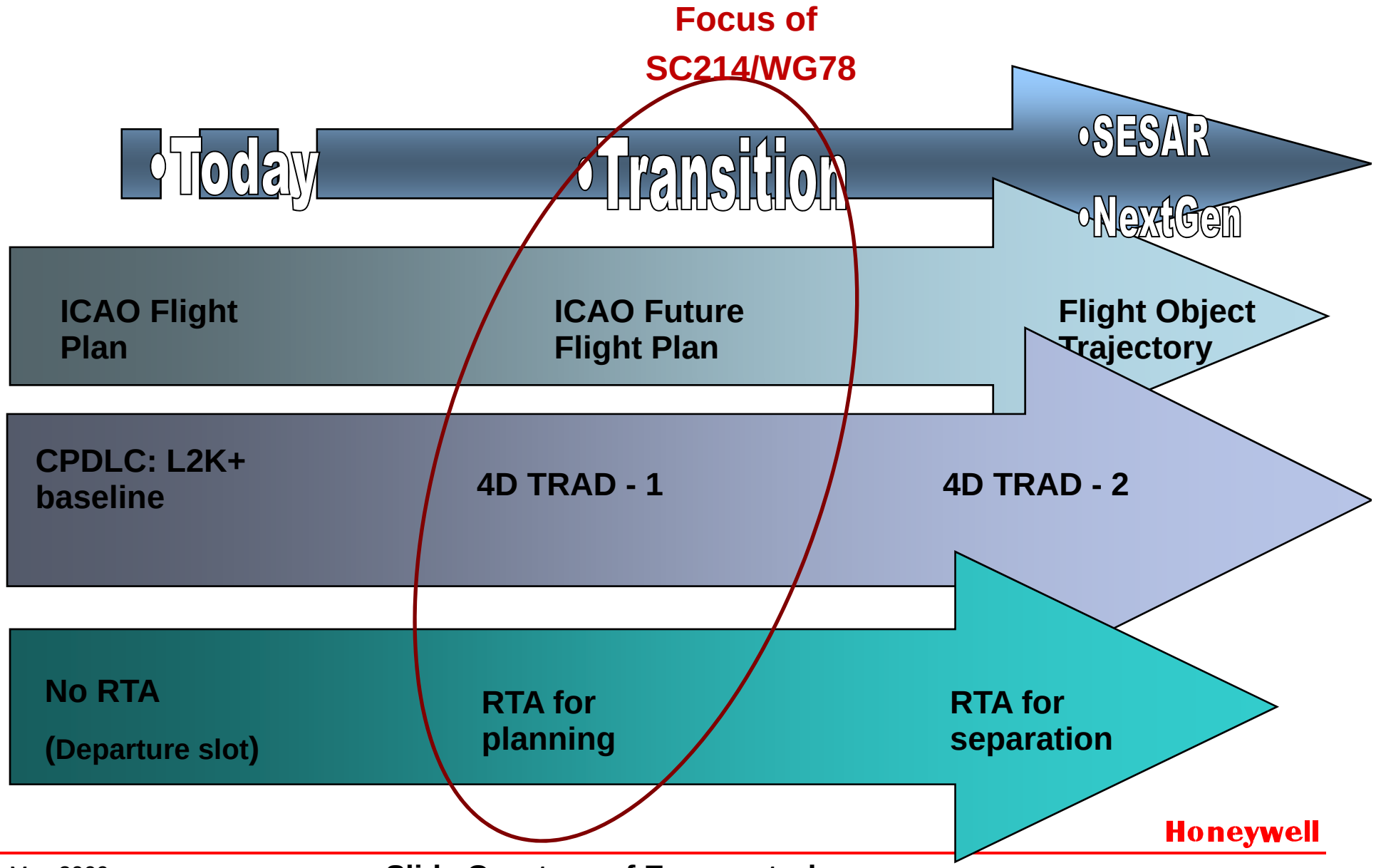


4D TRAD Service Description and Status

- **Service Description (OSD) includes**
  - **Controller-Pilot Data Link Communication (CPDLC) Application**
    - **3D+ Time or Speed**
  - **Flight Path Intent (FLIPINT) Service**
    - **Automatic Dependent Surveillance – Contract (ADS-C) Application could support**

- **Status**
  - **4DTRAD Environment included in larger Integrated Safety and Performance Requirements Draft**
  - **7 Operating Methods, 46 Operational Requirements, 3 Scenarios**
  - **OSD draft version 0.40 available on SC 214 website**
    - **http://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/techops/atc_comms_services/sc214/**
  - **4DTRAD Operational Safety Assessment (Env A/B CPDLC OSA) complete**
  - **4DTRAD Operational Performance Assessment (Env A/B CPDLC OPA) complete**

Trajectory Management and Communications Evolution



Environment Assumptions

- **Airborne perspective**
  - **Existing Environment** = existing capabilities in Traditional Airspace.
  - **Environment A** = upgraded capabilities in a mixed equipage situation requiring new safety and performance requirements.
  - **Environment B** = the strictest and most beneficial, full NextGen/SESAR capabilities in a 100% aircraft equipped High Performance Airspace.

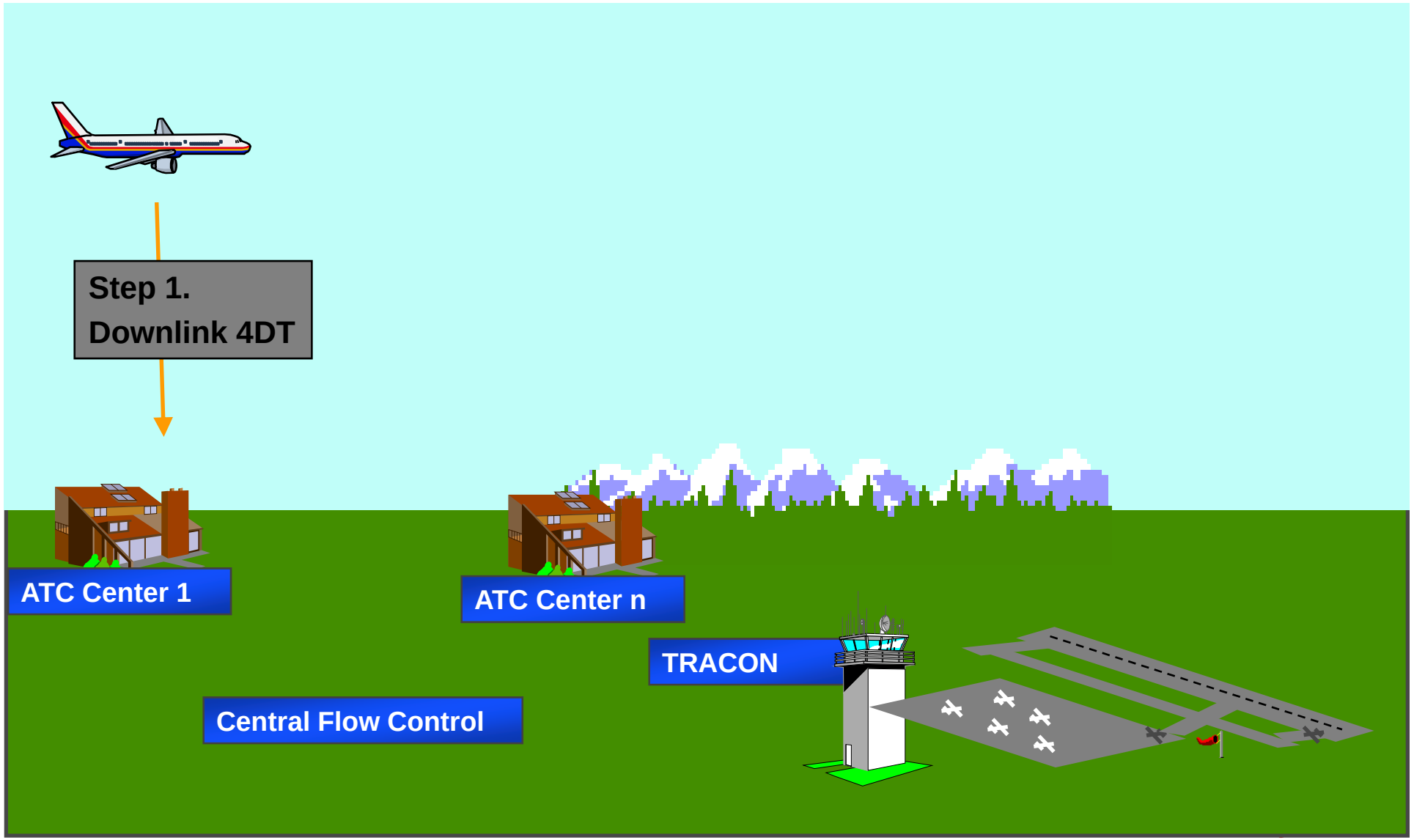
- **Ground perspective**
  - **Transitioning from Radar-based to trajectory based ATM**
  - **Decision support tools**
    - AMAN / TMA type tools for scheduling arrivals
    - En-route conflict probe and decisions support for controllers, e.g. EDA

Motivations for Data Link

- **NextGen and SESAR concepts use transmission of complex trajectory clearances, weather information and air traffic advisories.**

- **Difficulty in introducing CDAs / OPDs in high traffic density.**
  - **Lack of predictability in inter-aircraft compression**
  - **Lack of predictability in terminal area**
  - **Communication / coordination between airspace**

Operational Context of 4DTRAD

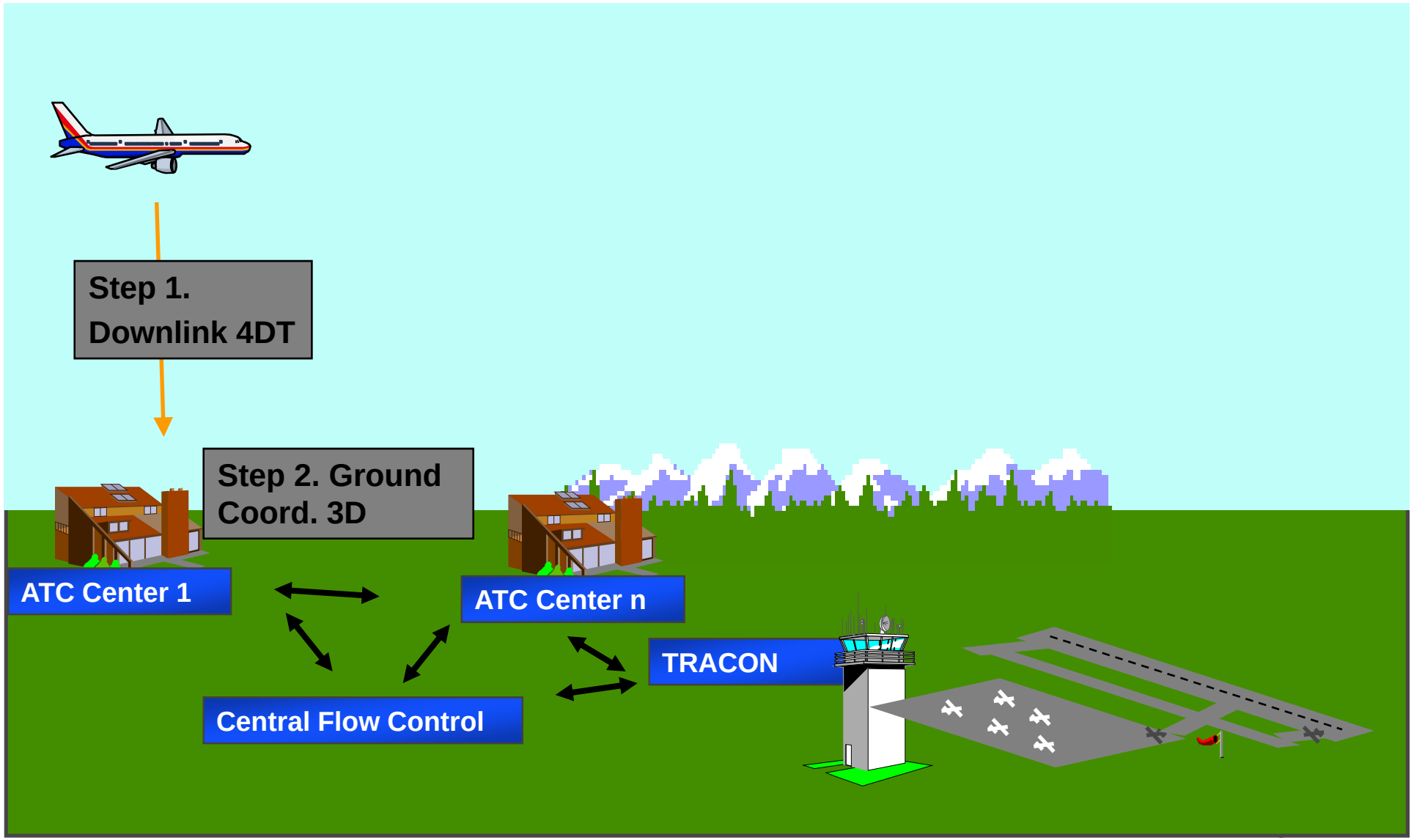


Step 1 – Downlink Current 4D Trajectory

- **Detailed user preferred trajectory**
  - **Waypoints** (lateral and vertical)
  - **Altitude, time, and speed predictions**
  - **Constraints in the flight plan** (altitude, speed, and time constraints)
  - **Gross weight**
  - **Min/Max ETA** at several waypoints specified by ATC.

- **ADS-C Extended Projected Profile (EPP)** is the expected means to transmit this information.
  - **ICAO 9694 draft 11**
  - **SC214/WG78 are proposing modifications to this draft**
  - **OPLINK panel expected to carry this forward.**

Operational Context of 4DTRAD



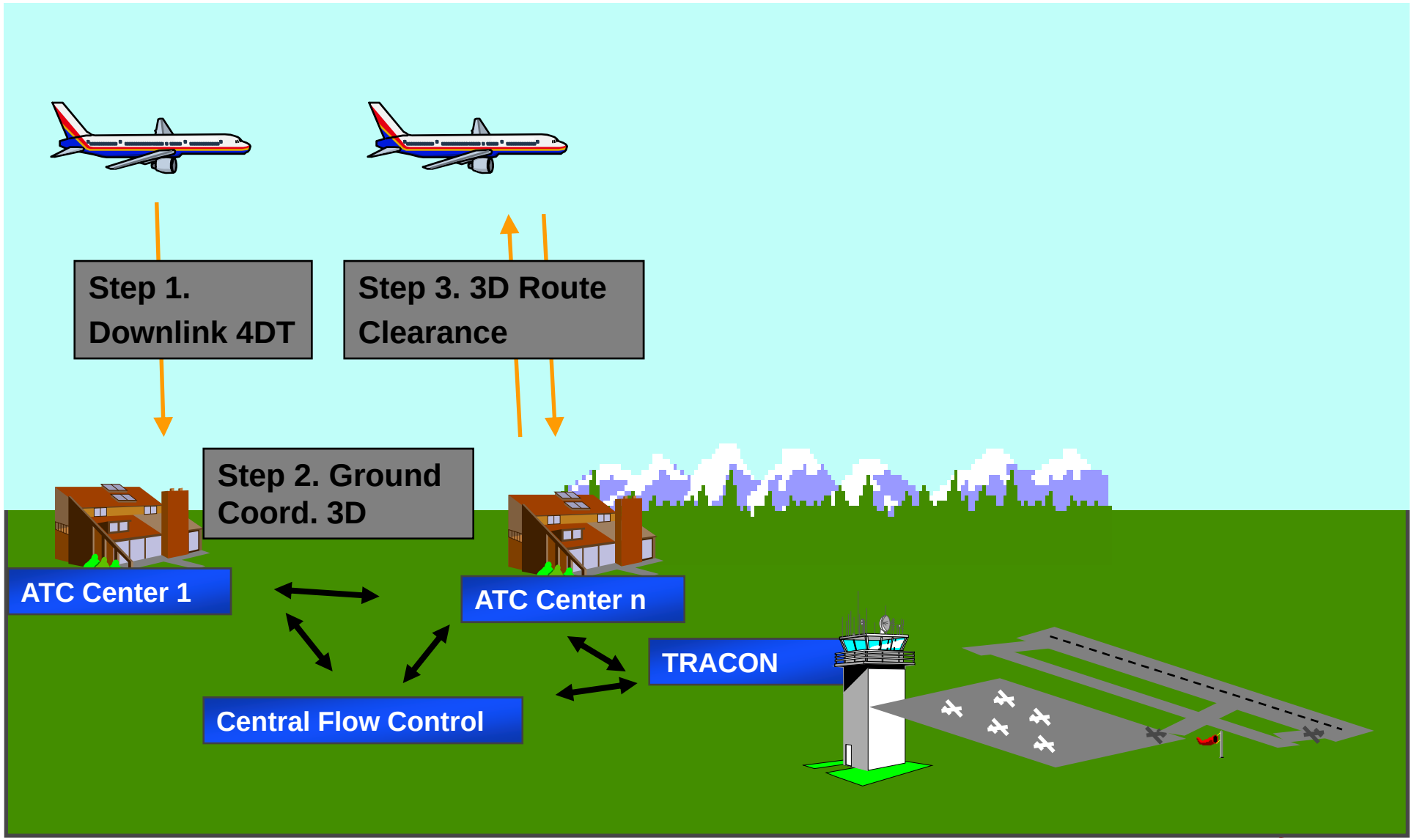
Step 2 – Ground-Ground Coordination – 3D

- **ATC ground system receives trajectory**
  - **Processes the 4DT in light of current airspace considerations**
  - **Develops a representation of the trajectory.**
  - **Evaluates user-preferred trajectory**
  - **Determines if trajectory modifications are required.**

- **Trajectory shared with all relevant ground systems**
  - **Discrepancies between ground systems need to be solved at this stage in order to propose to the aircraft a trajectory that can then be respected by all ground actors.**

For a majority of flights this evaluation and coordination will result in a reconfirmation of the planned trajectory.

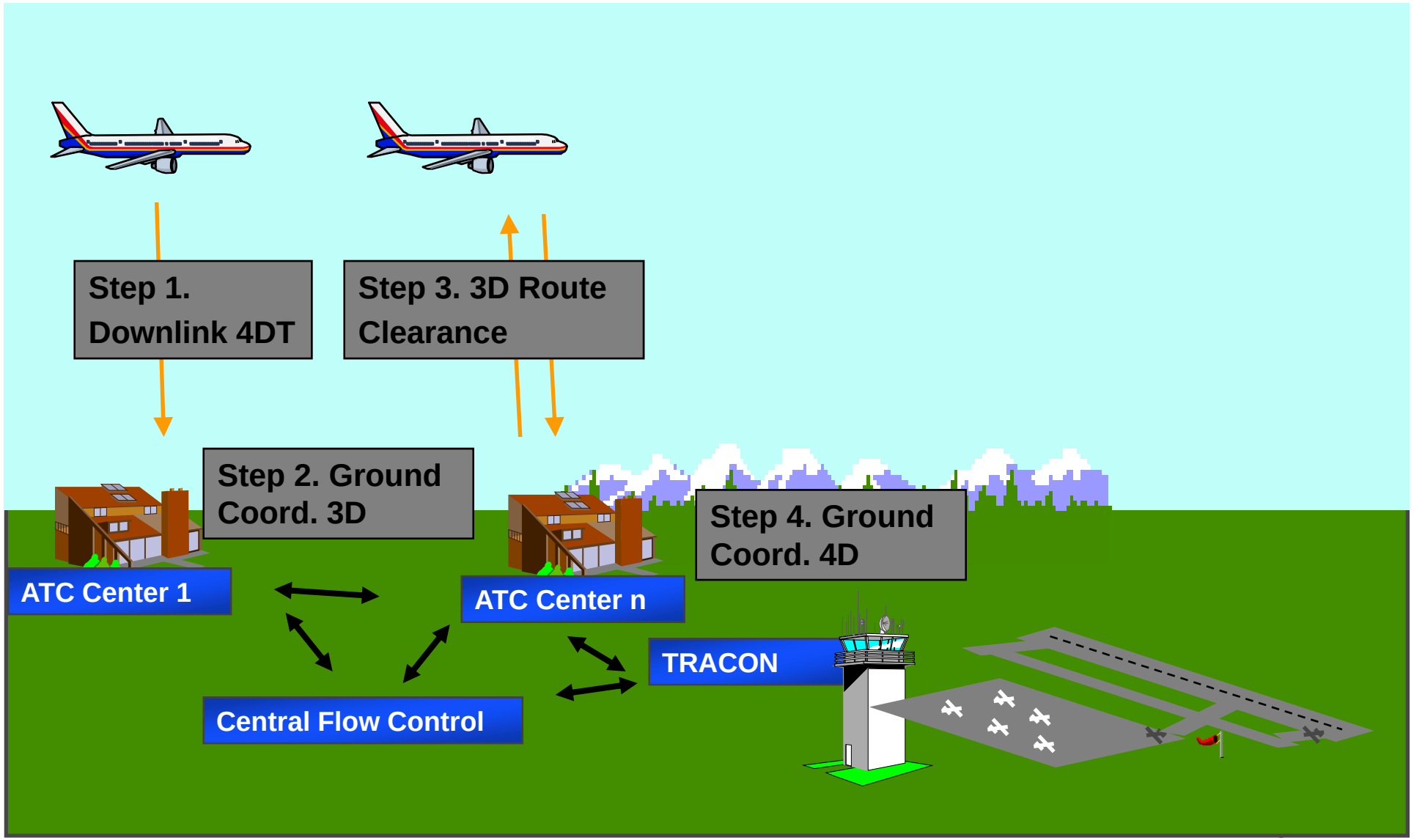
Operational Context of 4DTRAD



Step 3 – Uplink of 3D Route Clearance

- **If route change is necessary,**
  - **The ground coordinated route** (with any necessary altitude and speed constraints) **uplinked via CPDLC clearance.**
  - **Flight crew analyzes clearance**
    - If acceptable
      - activated in the FMS
      - CPDLC clearance is accepted
      - updated 4DT is downlinked to the ground
    - In case of a rejection
      - negotiation can switch to voice at any time
- **Flight crew loads updated meteorological data** for the modified route to ensure that the predicted times and speeds are accurate.
- **Aircraft trajectory downlink includes its preferred descent speed schedule for optimal operational and business needs.**
  - **ATC will attempt to effect deviations only to the extent needed to assure safety and capacity.**

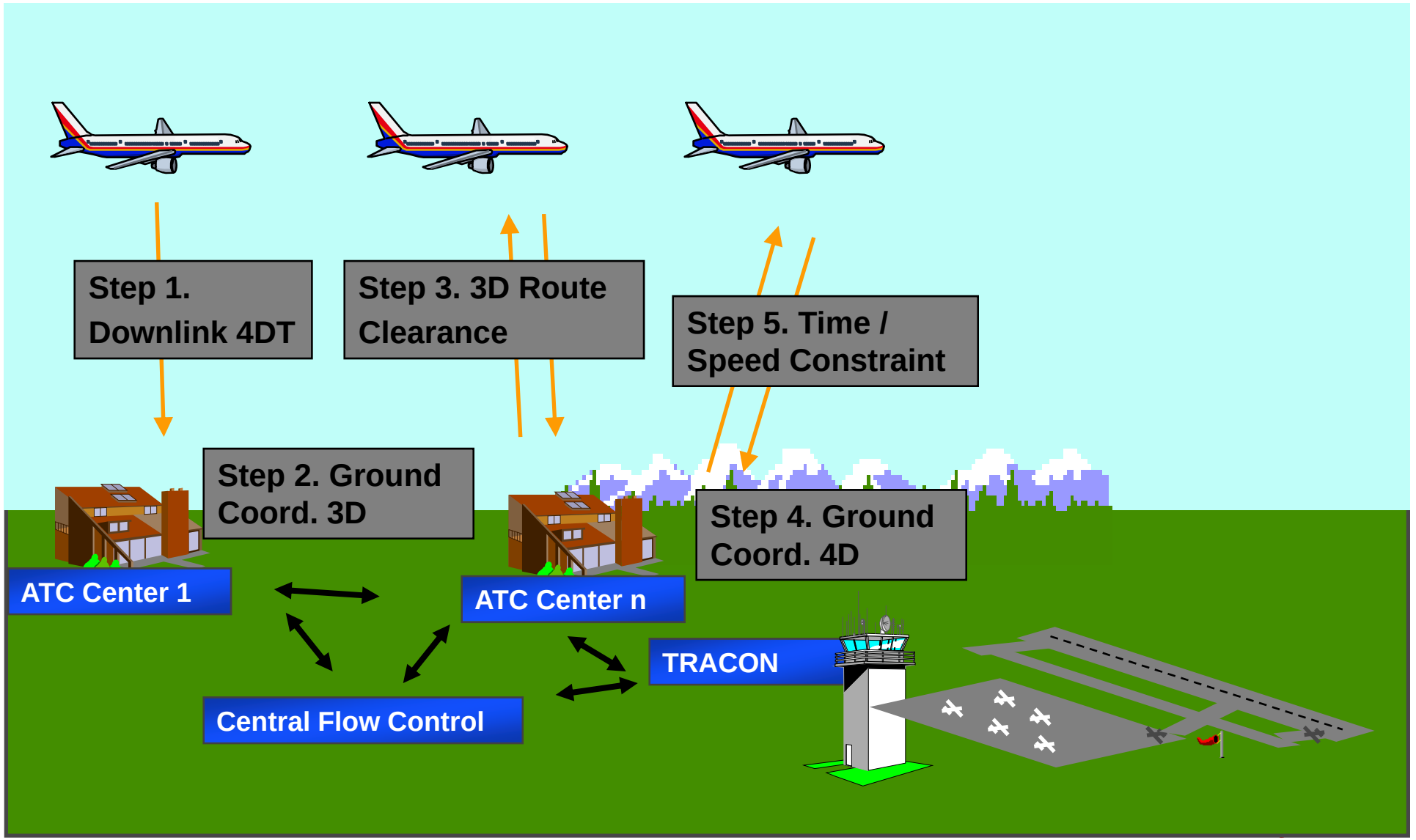
Operational Context of 4DTRAD



Step 4 – Time / Speed Constraint Determination

- **The 4th dimension (time / speed) may need to be adjusted**
  - **Ground system tools generate traffic sequence and schedules.**
  - **In light to medium density traffic, a simple speed assignment may suffice to prevent aircraft conflicts.**
  - **In higher density traffic, time or speed clearances can be used to improve the predictability of the aircraft arrival time at a metering fix.**
- **The location and value of the CTA agreed to by multiple ground systems via ground-ground coordination, if appropriate.**

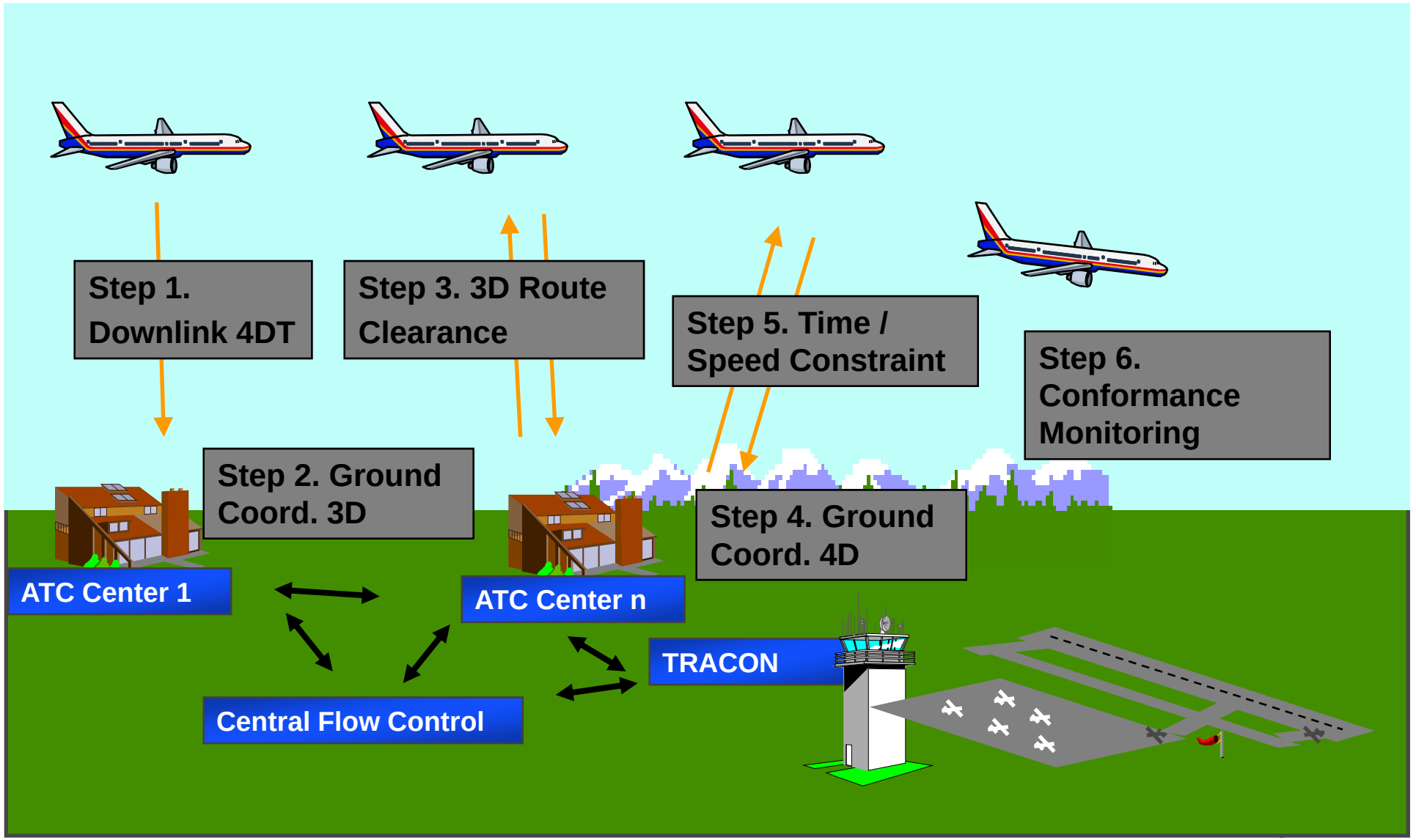
Operational Context of 4DTRAD



Step 5 – Air-Ground Negotiation of Time Constraint

- **If time or speed constraints are required,**
  - **the ground system controlling the aircraft issues the clearance to the aircraft.**
    - RTA used if how an aircraft meets the time constraint can be left up to the aircraft automation without impeding safety or capacity.
    - Speed schedule issued if ATC needs tighter control of the speed profile due to other traffic or control constraints.
- **Flight crew reviews the implications of the ground proposed time constraint and will either accept or reject it, similar to step 3.**
  - **For time constraints, the RTA function is engaged to track the time constraint using the speed profile.**

Operational Context of 4DTRAD



Step 6 – Conformance Monitoring

- **The flight continues its progression in accordance with the agreed route and constraints.**

- **Aircraft avionics monitor per the ADS-C contract**
  - **downlink updated 4DT as specified**
    - periodic updates
    - event-based updates (predicted speed, time, or altitude deviations)

- **ATC also monitors the aircraft progress for conformance**
  - **To the extent possible, ATC will limit tactical interventions of aircraft on 4D trajectories.**

Benefits of TBO

- **Improved accuracy and predictability of trajectories**
  - Early agreements of trajectories
  - Reduced tactical corrections
  - Increased fleet and aircrew utilization
- **Airspace capacity increase potential**
  - Reduced controller & pilot workload
  - Reduced frequency congestion
- **Improved Safety**
  - Reduction in pilot and controller errors
  - Additional means of communication
- **Helps enable Continuous Descent Approach / Optimized Profile Descent**
  - Reduced fuel burn and emissions
  - Reduced noise
  - Reduced flight time delay

Challenges to Trajectory Based Ops

- **Consensus on details of operational concept**
  - NexGen, SESAR, Boeing, Airbus, etc.
- **Critical mass of Users wanting to pursue TBO**
  - Belief that SESAR and NextGen is needed
  - Business case – the cost to build must be recouped by benefits within a reasonable time period.
- **Standards for the datalink communications**
  - RTCA, EUROCAE committee underway, ICAO also involved
- **Coordinated development of ground and airborne capability**
  - Neither air nor ground systems will be built without confidence in the other
  - Chicken & Egg problem: ATM system <> Airplane Capability <> Airline Investment …
- **Mixed equipage**
  - The system must be able to provide benefit with only a portion of aircraft equipped
- **Shared separation responsibility between ATM & pilot**
  - Requires ATM tools & culture shift

Thank you

Questions?

Comments?