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SP06 - Understanding the Life Cycle and Concept Phase of the ADS-B Surveillance Process

The System Lifecycle Program as used for the Airways National ADS-B System

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- **The aim of this presentation is to introduce an Airways NZ System-of-Interest, with specific reference to the life-cycle of the National ADS-B system.**

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Presentation Outcomes

At the finish of this presentation, the attendees should have:

- A basic understanding of the Systems Engineering concepts as applied to the complex project that realised the National ADS-B system of New Zealand,

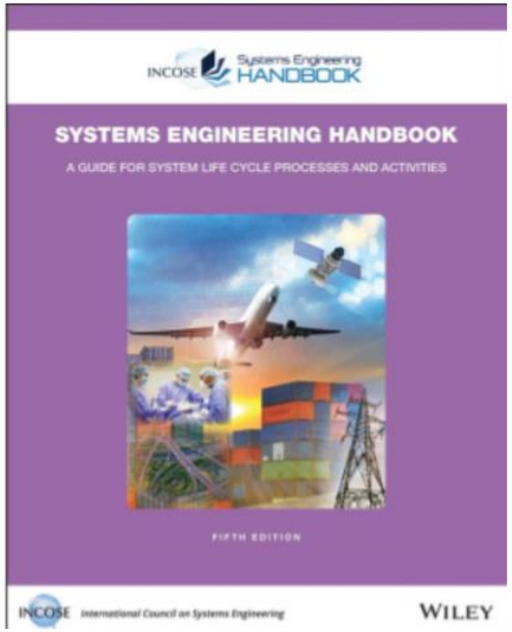
- Have knowledge of the various Processes and Stages that form the complete Life-Cycle of this Surveillance System.

- As mentioned, this presentation leads the ICAO Workshop through the System phases related to the **System Lifecycle Program** as implemented by Airways NZ.

- The **Systems Lifecycle** is a systems methodology aligned to the **INCOSE Systems Engineering Handbook***: A Guide for System Life Cycle Processes and Activities,

and makes use of:

- the Systems Engineering Body of Knowledge (SEBOK),
- the Systems Life Cycle Processes Standard ISO 15288.



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Systems Concepts and Life Cycle Models

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Systems Engineering

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Systems Engineering (SE) – a brief history of its development…

- 1937 A British **multidisciplinary** team set out to analyse the air defence system (eventually resulting in the famous Homechain radar), after the team had used their crude Air-to Surface (ASV) radar to detect the British **Home Fleet** in bad weather conditions.
- The term Systems Engineering can be traced back to **Bell Telephone Laboratories** in the 1940s.
- 1939–1945 Bell Labs supported **Project NIKE** missile project development
- 1951–1980 **SAGE** Air Defence system was defined
- 1954 Recommendation by the RAND Corporation to adopt the term “systems engineering”
- 1962 Publication of *A Methodology for Systems Engineering* by Hall
- 1995 **INCOSE** emerged from NCOSE to incorporate the international view.
- 2008 ISO, IEC, IEEE, INCOSE, PSM, and others fully harmonise SE concepts on ISO/IEC/IEEE 15288:2008

Systems Engineering – brief history - a large project….

- The **Semi-Automatic Ground Environment** (**SAGE**) was a system of large computers and associated networking equipment that coordinated data from many radar sites and processed it to produce a single unified image of the airspace over a wide area.[5] SAGE directed and controlled the NORAD response to a possible Soviet air attack, operating in this role from the late 1950s into the 1980s.
- Its enormous computers and huge displays remain a part of Cold War lore, and after decommissioning were common props in movies such as *Dr. Strangelove* and *Colossus*, and on science fiction TV series such as *The Time Tunnel*. (source Wikipedia).
- Impressive buildings - the 4-story SAGE blockhouses contained 3.5 acres (1.4 ha) of floor space and "were hardened [for] overpressures of" 5 psi (34 kPa).

(source Wikipedia)

Systems Engineering

What is Systems Engineering?

- Systems Engineering can be defined as a **methodical, multi-disciplinary approach** for the:
  - design,
  - realisation,
  - technical management,
  - operations,
  - and retirement of a system

Systems Engineering

What is Systems Engineering?

- It is the art and science of developing an operable system capable of meeting requirements within often opposing constraints,
- It is a discipline that concentrates on the design and application of the whole (system) as distinct from the parts,
- Systems Engineering includes both **technical** and **management** processes,
- and both processes depend upon **good decision making** (as explained in more detail in the INCOSE Handbook).

Systems Engineering

To summarise - What is Systems Engineering?

- Has history back to 1930's and evolved ever since
- Methodical and multidisciplinary
- Translates customer requirements to technical product or service
- Insights are gained as the processes unfold
- Contains many processes
- is considered a profession in its own right (the System Engineer)

Systems Engineer Role

What is the role of the Systems Engineer?

- The lead systems engineer ensures that the system technically fulfils the defined needs and requirements, and that a proper systems engineering approach is being followed.
- The Systems engineer is focused on the technical characteristics of decisions including technical, cost, and schedule, and on providing these to the project manager.
- For large projects, there may be one or more systems engineers.
- For small projects, the project manager may sometimes perform these practices.

Systems Engineer Role

What is the role of the Systems Engineer?

- Can change during a project, between projects – need to be adaptable
- Does the Systems Engineering Function – is not the project manager
- Documents many of the technical plans through to certification
- Important that the organisation has a clear understanding of the overlapping aspects between the Systems Engineer and other roles e.g. Project, Safety, Security, etc
- Team-work is essential

Systems of Interest, System of Systems and Enabling Systems

System of Interest (SOI)

- As defined in ISO/IEC/IEE 15288, the system-of-interest is the system that is the focus of the systems engineering effort. The system-of-interest contains system elements, system element interconnections, and the environment in which they are placed.
- The Airways ADS-B system will be the SOI in this presentation.

Systems of Interest, System of Systems and Enabling Systems

System of Systems is:

- “set or arrangement of systems that results when independent and useful systems are integrated into a larger system that delivers unique capabilities”.
- “the process of planning, analysing, organising, and integrating the capabilities of a mix of existing and new systems into a system-of-systems capability that is greater than the sum of the capabilities of the constituent parts”.

The ADS-B system is a good example of this:

It contains individual complex receiver systems (Ground station data processing computers) that each cover a portion of the airspace and are interconnected into a System of Systems (together with an Enabling System such as an ATM) that allows an air-traffic controller to look after a significantly larger airspace as well as a greater density of aircraft using surveillance technology.

Definitions and Terms

System Life Cycle Model

- The life cycle model is one of the key concepts of systems engineering (SE).
- Every system, whatever the kind or size, inherently evolves, from its initial conceptualisation through to its eventual retirement.

Some **key concept** of the Systems Engineering Life Cycle:

- Evolves from *Concept* through to *Retirement*
- Consists of a series of segmented stages to assist with decision making and planning.
- There can be life cycle phases **within** phases

(for example, at the utilisation and support phase, parts of the system could be replaced or modernised).

- The organisation sets the types of life cycles that will be used

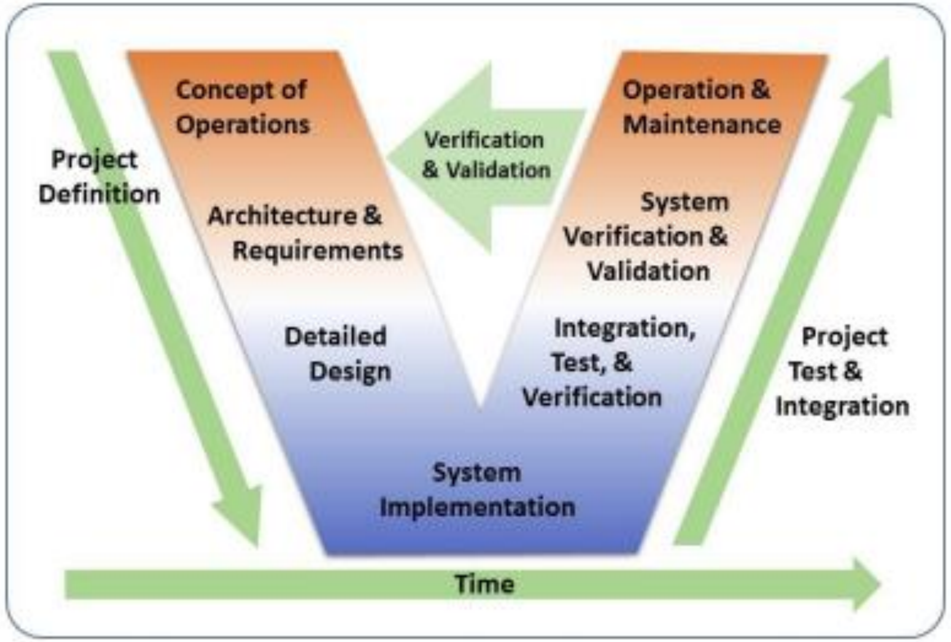
(In Airways in these initiatives are undertaken by a multi-disciplinary teams)

Approach

V Model Approach to Systems Engineering

- The V model is a common graphical representation of the systems engineering life cycle.
- The left side of the V represents concept development.
- The right side of the V represents integration of these entities (including appropriate testing to verify that they satisfy the requirements) and their ultimate transition into the field, where they are operated and maintained

System Life Cycle Models



System Life Cycle Models

The following are five common principles associated with a life cycle model:

- A system progresses through specific stages during its life;
- Enabling systems should be available for each stage in order to achieve the outcomes of the stage (an example of Enabling System is one that makes spare parts available, or caters for repairs);
- At specific life cycle stages, attributes, such as producibility, usability, supportability and disposability should be specified and designed into a system;
- Progression to another stage requires satisfaction of exit criteria of the current stage and possibly entrance criteria for the following stage or stages;
- Exit criteria are usually based on satisfactory outcomes of the stage being completed and may include demonstrable readiness to execute the processes in the subsequent stage or stages.

System Life Cycle Models

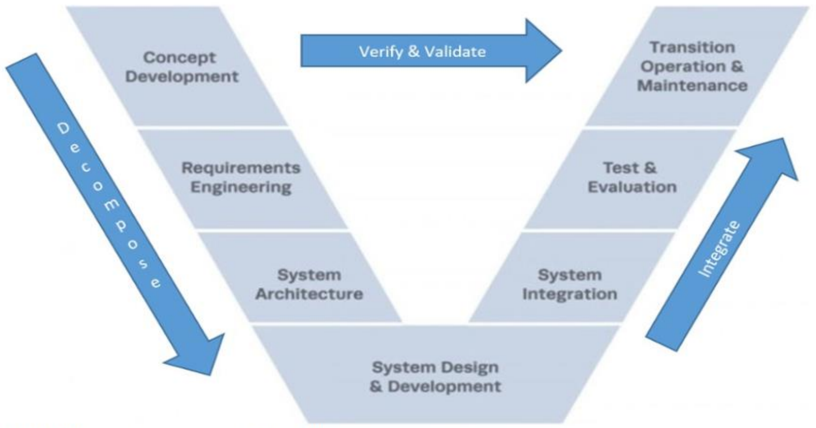
It is important to realise that:

- there is no one-size-fits-all **Life-Cycle** Model that works best for all complex system challenges.
- Many different systems engineering practices have evolved in response to this challenge, making use of **Lean, Agile**, iterative and evolutionary approaches to achieve life-cycle affordable systems.

System Life Cycle Processes

To summarise:

- Systems engineering models and processes are organised around the concept of a **life cycle**.
- System Engineering life cycle may differ, but they all share fundamental elements.
- ISO/IEC 15288 is an international systems engineering standard covering processes and life-cycle stages.
- The V Model is based on Validation and Verification activities
  - 1st half is the decomposition of user requirements to system elements
  - 2nd half is the integration to the final product or service
  - Validation builds the right product
  - Verification builds the product right



V Model Approach to Systems Engineering

AUTOMATIC DEPENDENT SURVEILLANCE – BROADCAST (ADS-B) SOI EXAMPLE

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This part of the presentation uses the installation of a National ADS-B (Automatic Dependent Surveillance – Broadcast) Surveillance System in NZ to link key processes throughout its life-cycle.

Its focus is to demonstrate a project with *conceptual* through to *retirement* processes.

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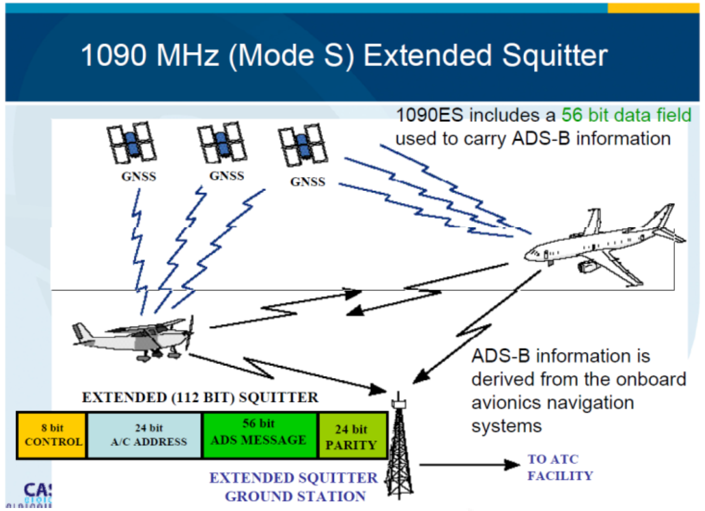
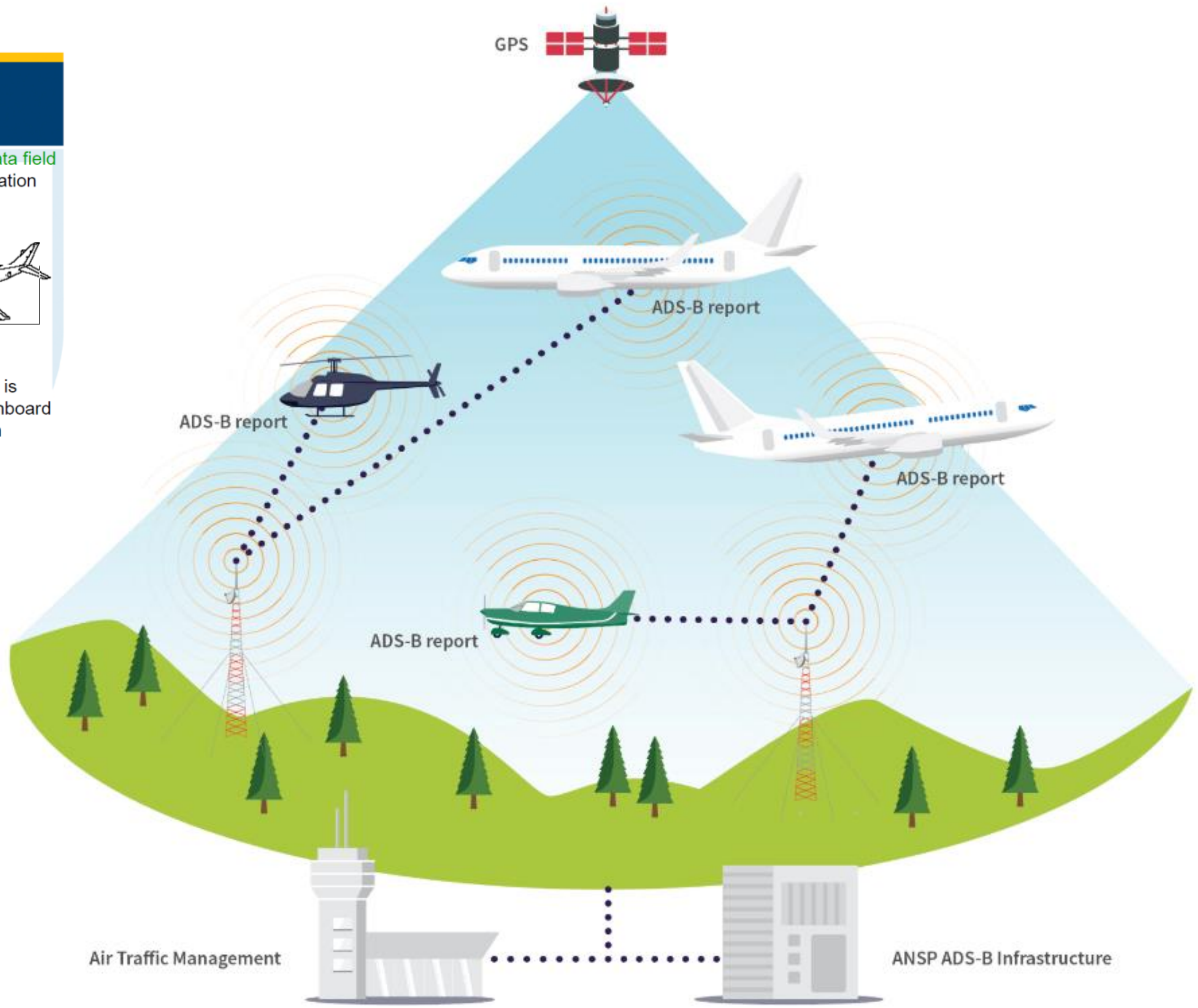
The following topics will be covered in the presentation:

- Background
- Lifecycle Phases:
  - Concept Phase
  - Development Phase
  - Production Phase
  - Utilisation Phase
  - Support Phase
  - Retirement Phase
- ***and Time for questions***

ADS-B = Automatic Dependent Surveillance - Broadcast





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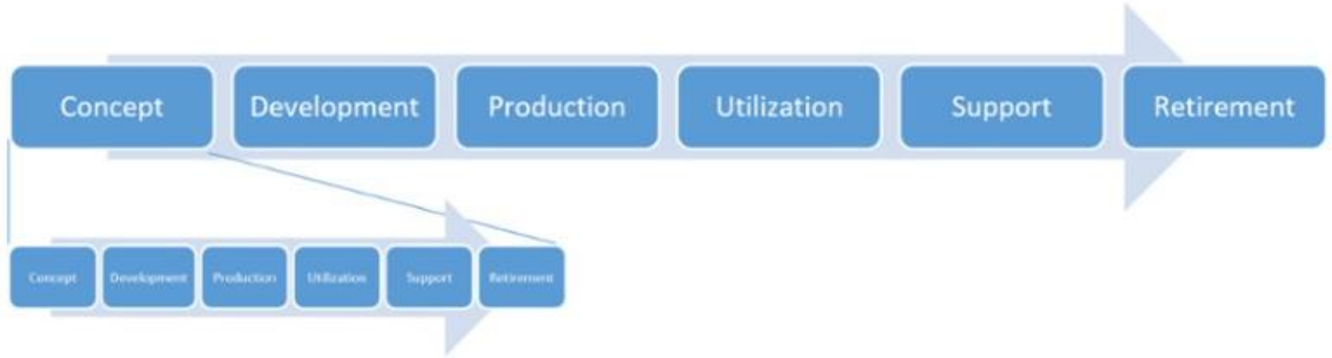
Background - installing ADS-B in NZ

- ADS-B was selected to replace the aging PSR/MSSR radars with new cost-effective surveillance technology.

- ADS-B is the now the primary source of airspace surveillance coverage in New Zealand since 2023.

- ADS-B offers improved Probability of Detection, higher target update rate and more comprehensive coverage (with increased receiving range and a greater number of receiver sites).



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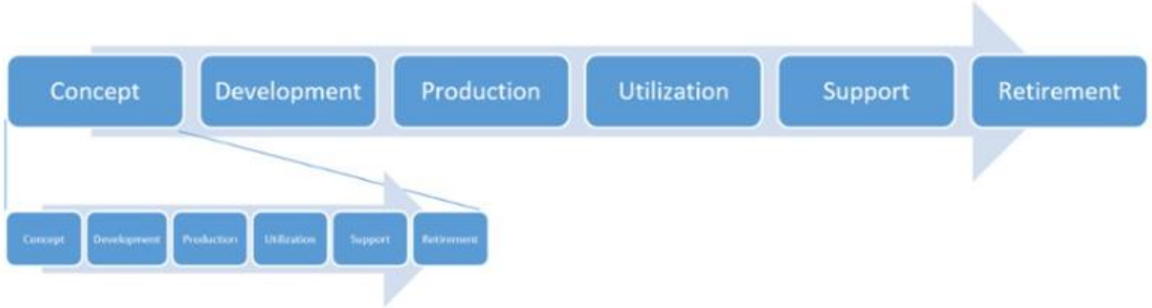
Background

- ADS-B uses satellite GPS systems, aircraft transmitters and a network of ground station receivers to follow aircraft with a higher level of accuracy.

- For NZ a network of 26 ground receivers are installed in nation-wide locations, sometimes remote.

- The system in NZ detects aircraft in places where there is limited or no radar coverage, such as behind mountains or in remote regions.



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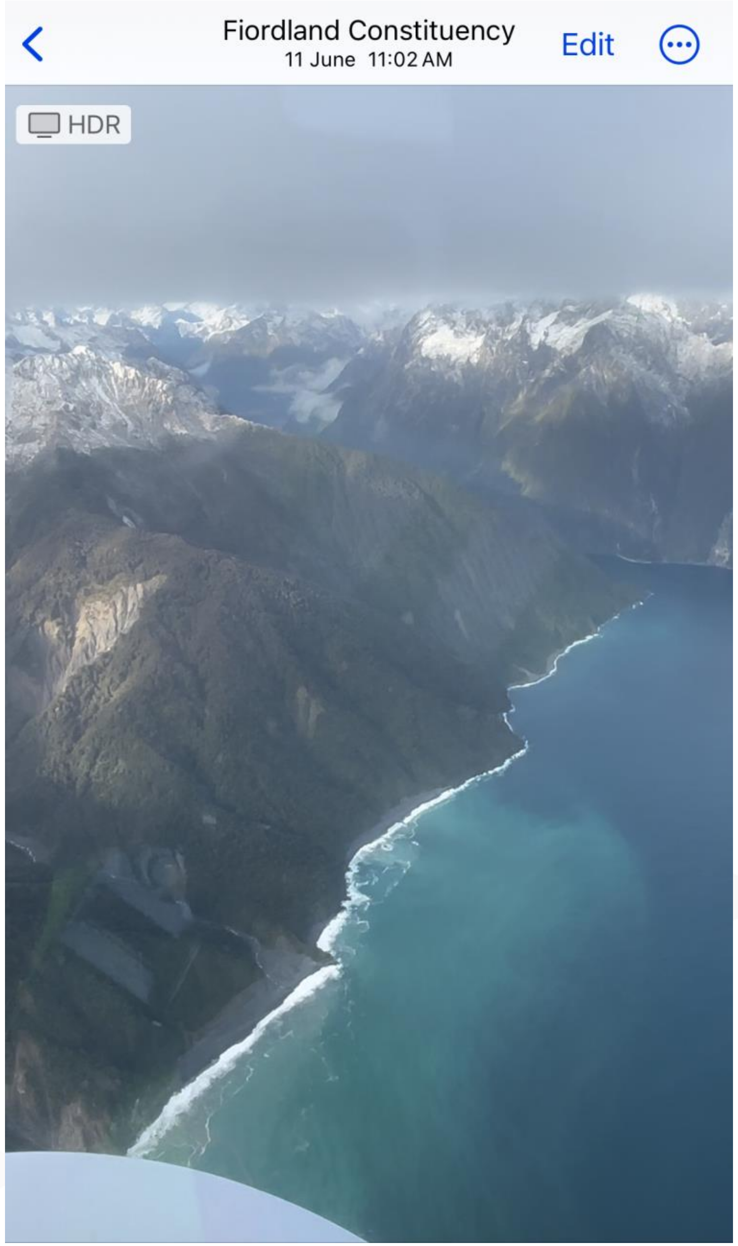
Background – examples of remote regions / sites



Background – examples of remote regions

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Background – examples of remote regions

Background – examples of remote sites

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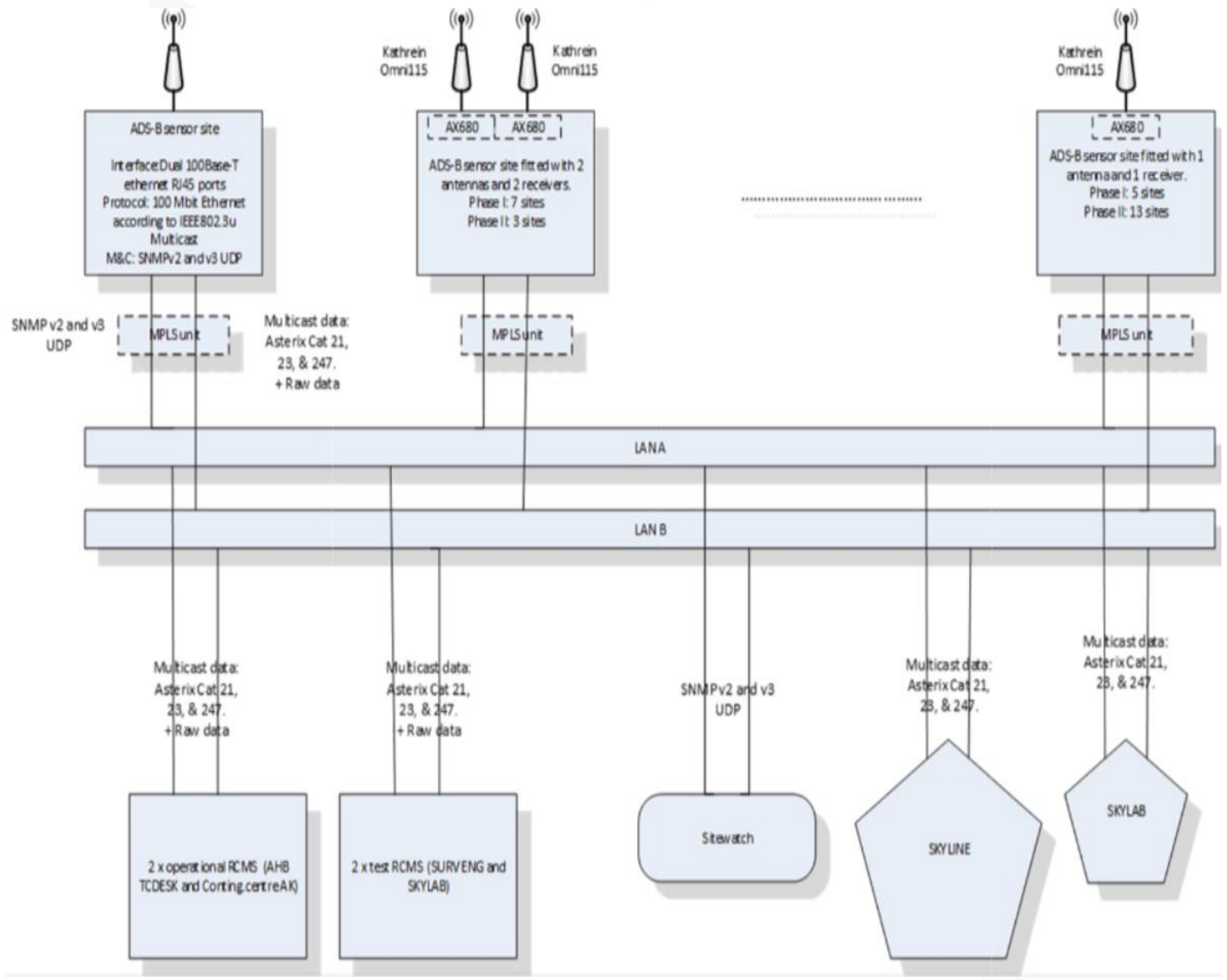
Background

Block diagram:

The Airways ADS-B system consists of:

- Antennas (GPS and ADS-B)
- Field Receivers (input from GPS and ADS-B Antennas)
- Communication - Wide Area Network linking the Field Receivers to the Central Processing and ATM servers
- Remote Monitoring systems
- Central Data Processing servers
- Software (residing on the receivers and the computer servers)



Background

- The ANSP awarded the contract to Thales (Germany) to provide ground equipment for the ADS-B network in 2016.
- Thales Headquarter in Ditzingen, Germany (recently changed to Thales Italy, in Gorgonzola near Milan)


Factory Acceptance Testing (FAT) at Thales, Germany

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Background and Lifecycle Phases Involved

Your Key takeaways?

- The retirement of one system (PSR/MSSR radar) can lead to a step change in new better technology (ADS-B) and cost savings
- Increasing use of Satellite Based ANSP Solutions (MLAT, ADSB, SBAS etc)
- How can you address the risk of Satellite Failures?
  - Non-GNSS Contingency Solutions

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Concept phase

For the ADS-B system a number of stakeholders were consulted for their needs:

- Key airline customers and the NZ Airforce
- ATC and flight service
- Technology engineers and maintenance staff
- Software staff (if in-house support)
- ICAO and regional air navigation plans
- Corporate strategic plan and finance
- Operations management and strategy

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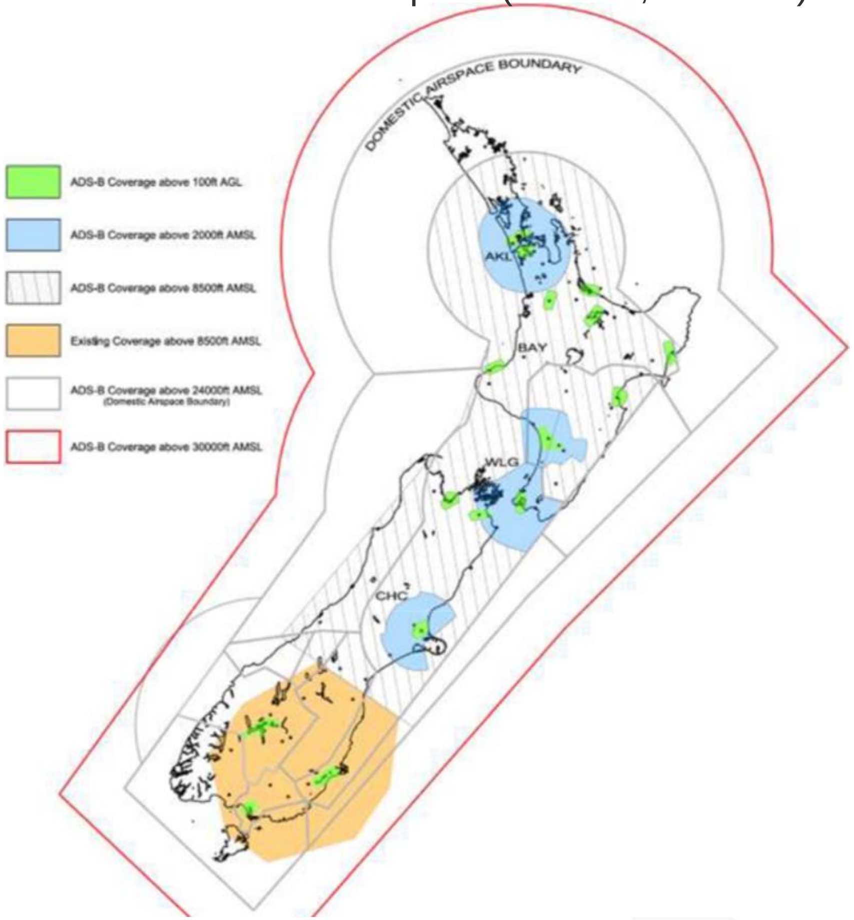
Concept phase

Scope of the Specification after stakeholder consultation:

In all cases, coverage should be equal or better than that provided by the current radar infrastructure.

ADS-B coverage to be provided in Controlled Airspace (Class A, C and D) as depicted in the picture below



ADS-B coverage requirements after stakeholder consultation

Concept Phase

Your Key takeaways?

- Business or Mission Analysis Process
  - Problem to address was to replace aging PSR/SSR and
  - an opportunity to implement a paradigm shift in surveillance capability
- The new ADS-B capability enabled other services for Towers not having this in the past, i.e. regional towers did not have radar coverage or local bypass.
  - How to manage this change
- Stakeholder Needs and Requirements Process
  - A large diverse group required consulting with
  - A large workforce required to implement the new Avionics (transponder fitment to the airframes)
  - Predicted surveillance coverage was required to be modelled to present benefits to stakeholders