

Autonomous Networks: Works from ITU-T FG AN & TTC AN-AH

B5GPC – Autonomy WG

Feb 20th, 2024

Leon Wong

Autonomous Networks R&D



FG-AN: Overview

ITU-T **Focus Group on Autonomous Networks** was established by ITU-T Study Group 13 at its virtual meeting, 17 December 2020.

The Focus Group will draft **technical reports and specifications** for autonomous networks, including exploratory evolution in future networks, real-time responsive experimentation, dynamic adaptation to future environments, technologies, and use cases.

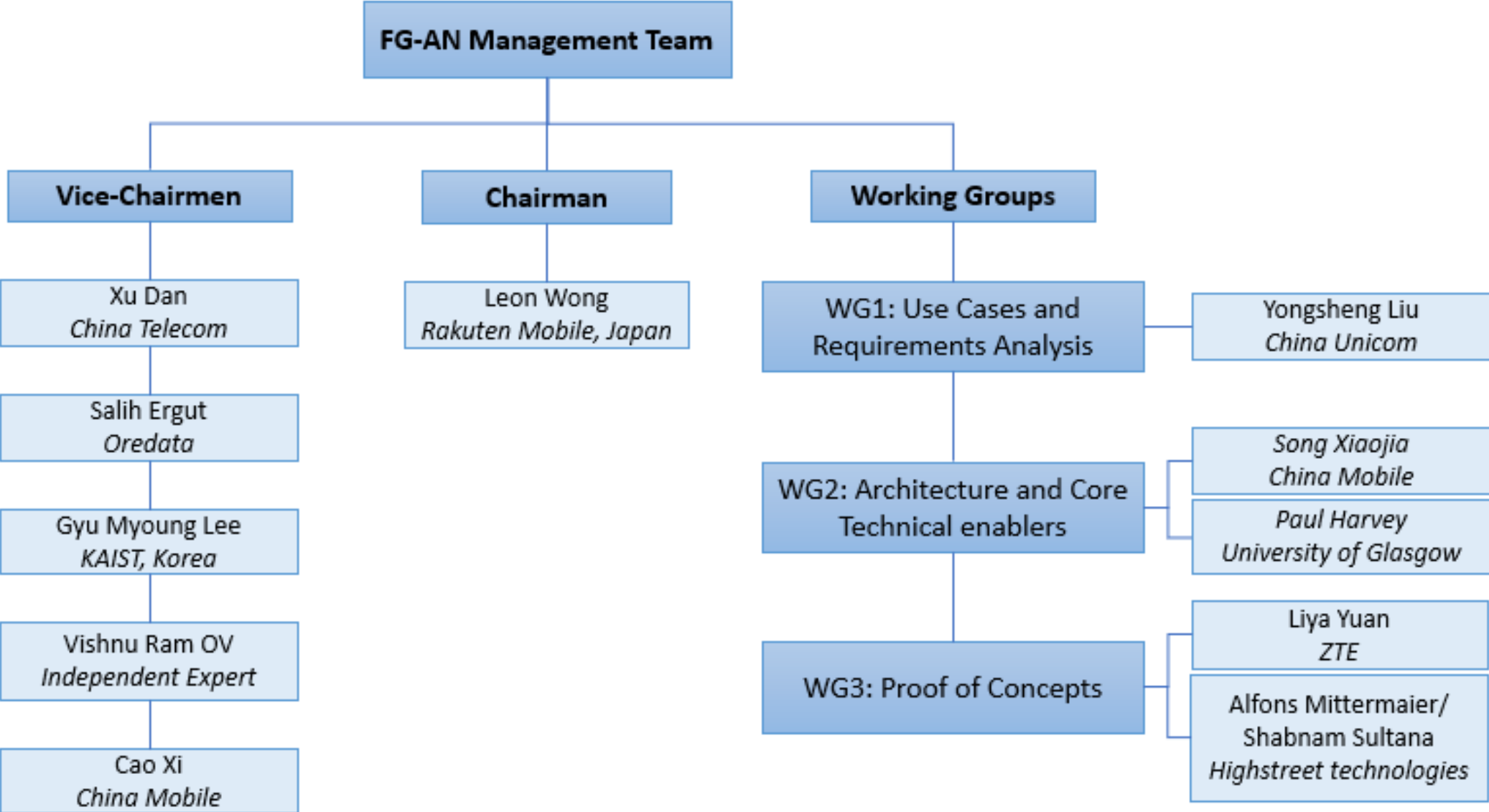
The Focus Group will also identify relevant gaps in the standardization of autonomous networks.

The primary objective of the Focus Group is to provide an open platform to perform pre-standards activities related to AN.

TTC AN-AH

TTC established **AN Ad-Hoc group** as a forum for Japan members for discussion and sharing related information of FG-AN

FG-AN: Structure



FG-AN: Activities

FG AN Meetings:

- 1st Virtual meeting, 2-4 Feb 2021
- 2nd Virtual meeting, 13-16 Apr 2021
- 3rd Virtual meeting, 15-17 Jun 2021
- 4th Virtual meeting, 1-3 Sept 2021
- 5th Virtual meeting, 3-5 Nov 2021
- 6th Virtual meeting, 26-28 Jan 2022
- 7th Virtual meeting, 30 Mar - 1 Apr 2022
- 8th Virtual meeting, 1-3 Jun 2022
- 9th Virtual meeting, 31 Aug – 2 Sep 2022
- 10th Virtual meeting, 1-2 Feb 2023
- 11th Virtual meeting, 19-22 Apr 2023
- 12th Virtual meeting, 13-15 Jul 2023
- 13th Virtual meeting, 28-29 Sep 2023
- 14th Virtual meeting, 18-19 Jan 2024

TTC AN-AH: Activities

TTC AN-AH Meetings:

- 1st meeting, 17 May 2021
- 2nd meeting, 2 Jun 2021
- 3rd meeting, 30 Jun 2021
- 4th meeting, 27 Aug 2021
- 5th meeting, 22 Sep 2021
- 6th meeting, 28 Oct 2021
- 7th meeting, 18 Jan 2022
- 8th meeting, 24 Mar 2022
- 9th meeting, 15 Apr 2022
- 10th meeting, 26 Aug 2022
- 11th meeting, 30 Sep 2022
- 12th meeting, 9 Dec 2022
- 13th meeting, 1 Jan 2023
- 14th meeting, 12 Apr 2023
- 15th meeting, 30 Jun 2023
- 16th meeting, 4 Sep 2023
- 17th meeting, 20 Oct 2023

FG-AN: Activities

Build-a-thon 2022:

Build-a-thon Workshop Kickoff, 3 Jun 2022

Build-a-thon Workshop 2.0, 2 Sep 2022

Build-a-thon Workshop 3.0, 7 Nov 2022

Build-a-thon 2023:

Build-a-thon Workshop Kickoff, 3 Feb 2023

Build-a-thon Workshop 2.0, 22 Apr 2023

Build-a-thon Workshop 3.0, 15 Jul 2023

Build-a-thon Workshop 4.0, 29 Sep 2023

Build-a-thon Workshop 5.0, 19 Jan 2024

ITU-T FG-AN Workshop:

ITU Workshop on “*Advances in Evolutionary Autonomous Networks: Use Cases, Architecture and PoC*”, 15 Nov 2022

ITU Workshop on “*Advances in Autonomous Networks: 2023 and beyond*”, 24 Oct 2023

FG-AN: Activities

Weekly Meeting every **Thursday 8:00 CET**

Weekly / Bi-Weekly **Editing sessions** for progressing deliverables

Meetings will cover:

Use cases document + use case requirements + mappings to other deliverables

- Architecture framework
- Trust in Autonomous Networks
- PoC
- Knowledge Management in Autonomous Networks
- Standards gap analysis
- Discussion with experts from industry & academia

FG-AN: Deliverables

Weekly e-Meetings: **122**

Input Documents: **369**

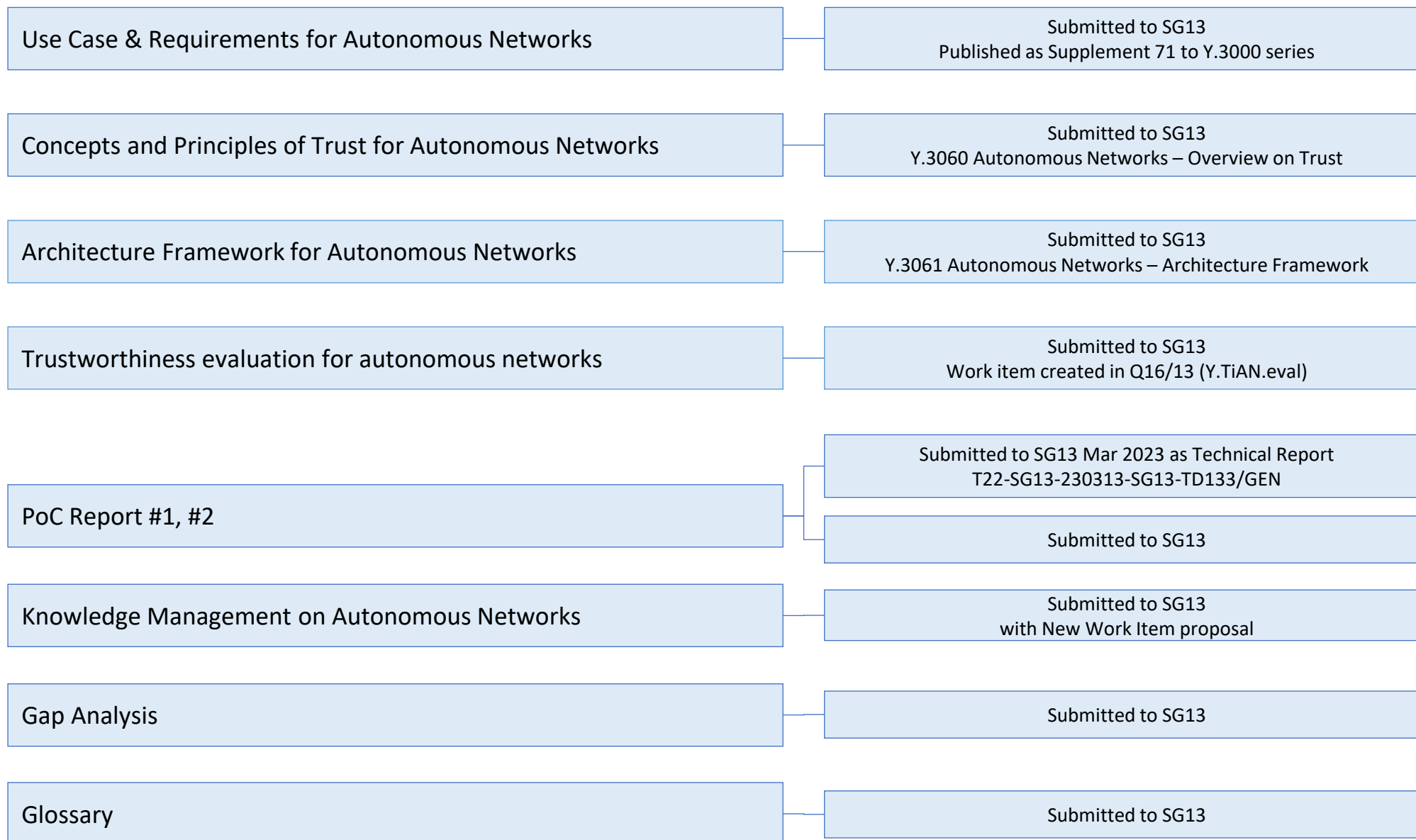
An Open Platform for AN, hosted:

Participants: >**300** unique individuals

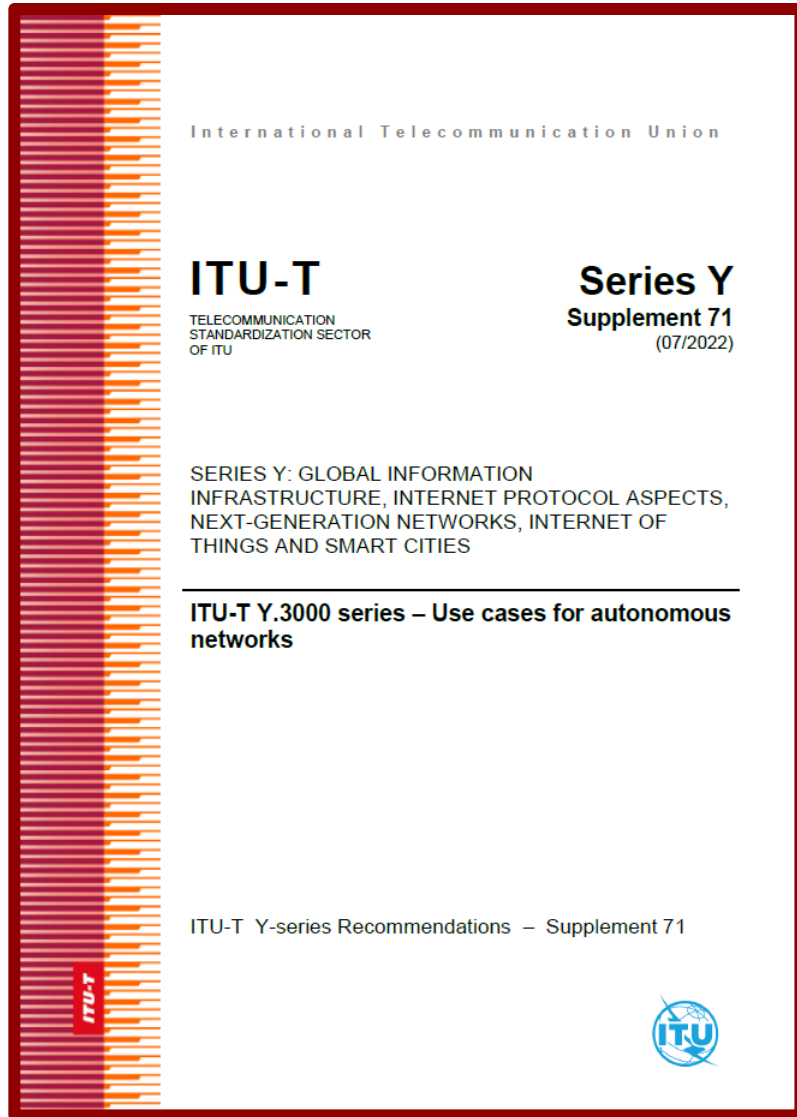
Countries: **38**

- **20** Members state
- **25** Recognized Operating Agencies (ROA)
- **50** Scientific or Industrial Organizations (SIO)
- **46** Universities/Academia

FG-AN: Deliverables



FG-AN: Deliverables



Use Cases for Autonomous Networks

FG-AN output document (FGAN-O-013-R1)

A collection of use cases presented and elaborated during FG-AN meetings.

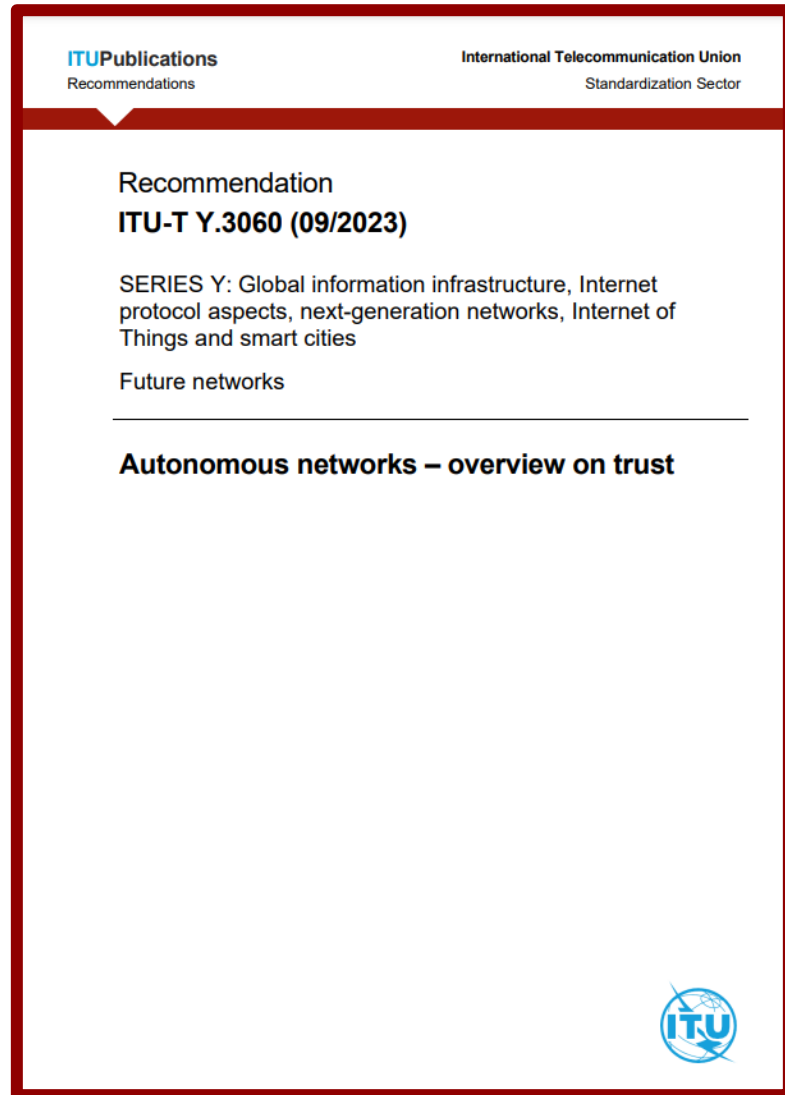
These use cases were published as a Technical Specification and a draft use case deliverable submitted to ITU-T SG13.

Approved during ITU-T SG13 July 2022 meeting as

Y.Supplement 71 : ITU-T Y.3000 series – Use cases for autonomous networks

<https://www.itu.int/rec/T-REC-Y.Sup71/en>

FG-AN: Deliverables



Concepts and Principles of Trust for Autonomous Networks

Based on FG-AN document (FGAN-I-179/218)

Provides an overview on trust for autonomous networks. It introduces the background and necessities of trust study in areas of network autonomy and network intelligence.

The technical specification derived from this work has been transmitted to parent ITU-T and now published as

ITU-T Y.3060 Autonomous Networks – Overview on Trust

<https://www.itu.int/rec/T-REC-Y.3060/en>

FG-AN: Deliverables

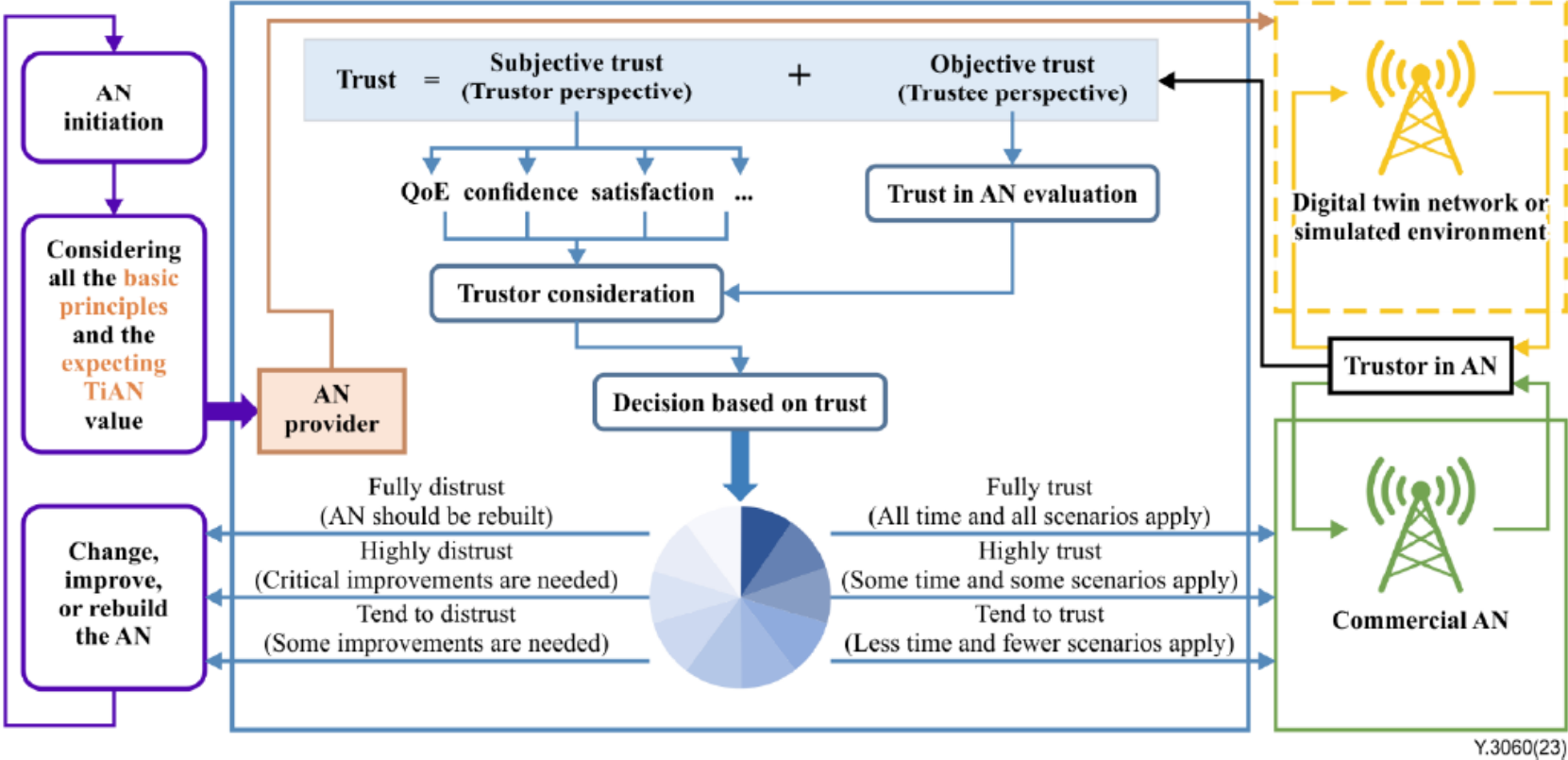
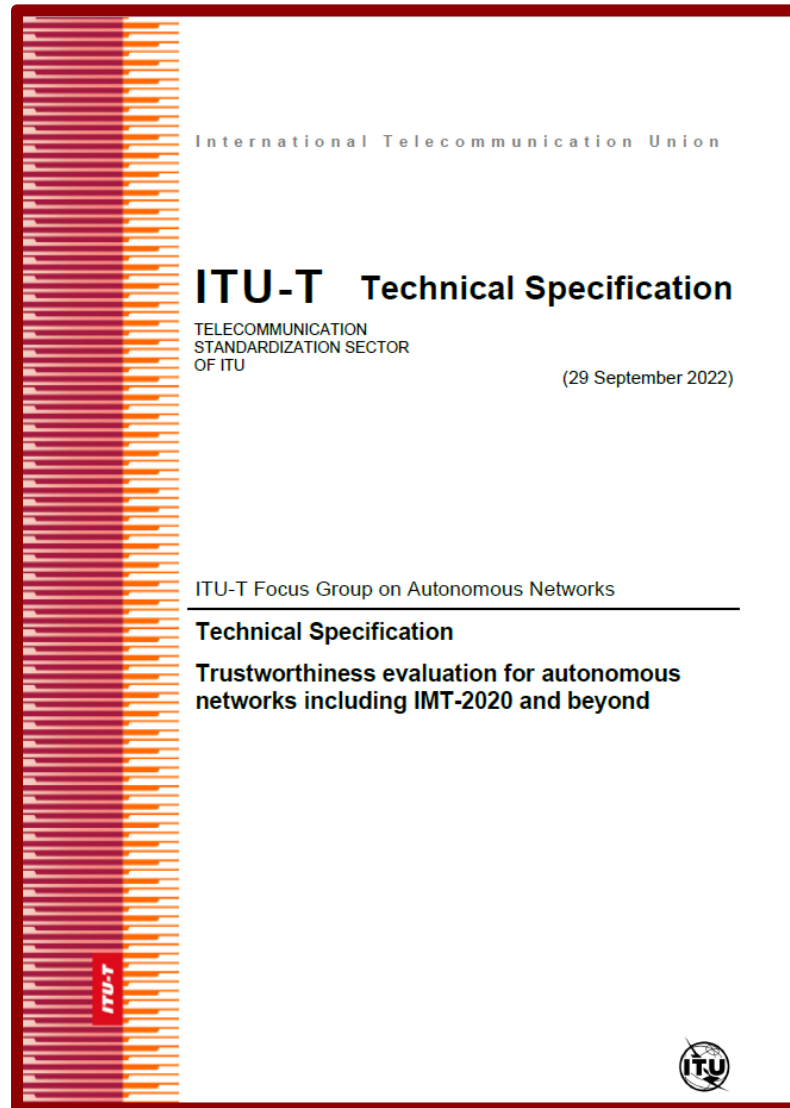


Figure 1 – An overall workflow model for trusted AN

FG-AN: Deliverables



Evaluation of Trustworthiness of Autonomous Networks

FG-AN output document (FGAN-O-024)

Provides the concepts, basic principles, metrics of evaluation, methodology for evaluation and evaluation models and use cases for trust in autonomous network.

The technical specification derived from this work has been transmitted to parent ITU-T SG13 as TD64/GEN:

<https://www.itu.int/md/T22-SG13-221114-TD-GEN-0064/en>

FG-AN: Deliverables

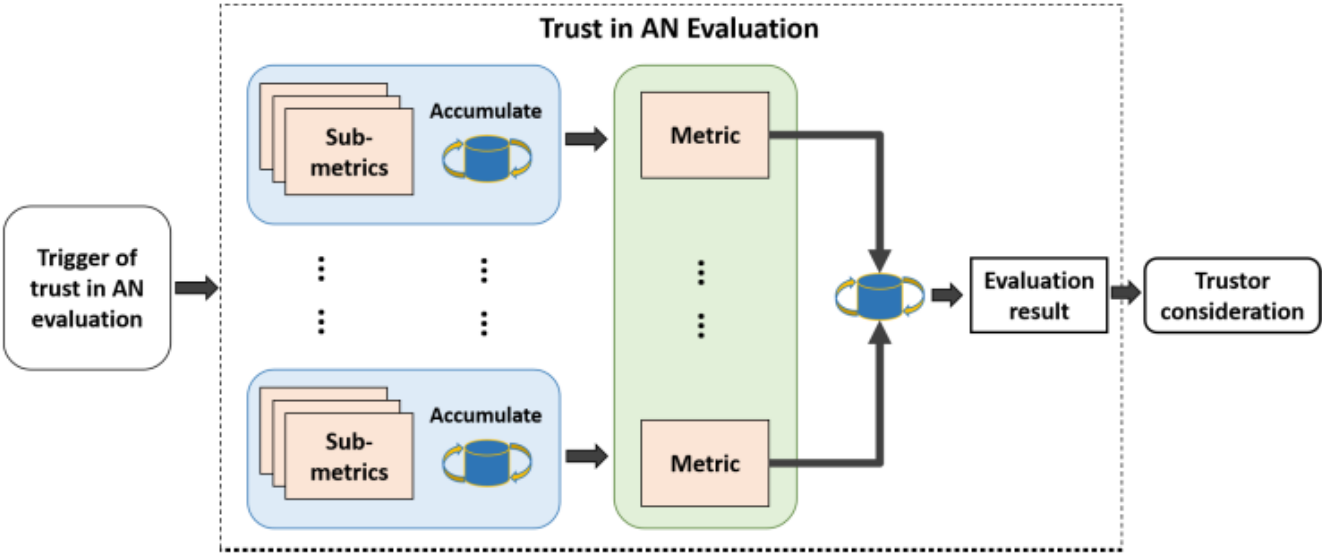


Figure 1 - General process of TiAN evaluation

Metric	Sub-metric	General Description of sub-metric
Accuracy	Reproducibility	Interactions in which the trustee reproduces the process of execution by trustee(s) across various interactions with the trustor, i.e. interactions which the trustee reproduces the same process and the same result(s)/action(s)/decision(s)/etc, using the same parameter(s)/input(s)/method(s)/algorithm(s)/knowledge/etc and other relevant conditions, in TiAN evaluation. $\frac{\text{num of the same reproduced results with executions}}{\text{num of all reproduced results}}$
	Precision	Interactions which the trustee produces precise result(s) during execution of the process(es)/step(s) by trustee(s), in TiAN evaluation. $\frac{\text{number of interactions with accurate results}}{\text{total number of interactions}}$
	Timeliness	Action(s)/reaction(s)/feedback(s)/decision(s) produced by the trustee within specific time duration for TiAN evaluation. $\frac{\text{num of action(s) within the specified time duration}}{\text{total number of actions produced in the whole evaluation}}$ <p><i>NOTE - above formula should be specified with evaluating time duration for evaluation.</i></p>

FG-AN: Deliverables

The image shows the cover page of an ITU-T Recommendation. At the top left, it says 'ITU Publications Recommendations'. At the top right, it says 'International Telecommunication Union Standardization Sector'. The main title is 'Recommendation ITU-T Y.3061 (12/2023)'. Below that, it says 'SERIES Y: Global information infrastructure, Internet protocol aspects, next-generation networks, Internet of Things and smart cities'. Underneath, it says 'Future networks'. The main title of the recommendation is 'Autonomous Networks - Architecture framework'. At the bottom, there is a 'CAUTION! PREPUBLISHED RECOMMENDATION' box with a warning that this is an unedited version and will be replaced by the published version. The ITU logo is at the bottom right.

Architecture Framework Autonomous Networks

FG-AN output document (FGAN-O-023)

Autonomous Networks (AN) architecture framework in relation to AN concepts.

The scope of this document includes:

- Requirements for the architecture
- Description of the architecture components
- Description of the architecture
- Sequence diagrams explaining the interactions between the architecture components

The technical specification derived from this work has been transmitted to parent ITU-T and now published as

ITU-T Y.3061 Autonomous Networks – Architecture Framework

<https://www.itu.int/rec/T-REC-Y.3061/en>

FG-AN: Deliverables

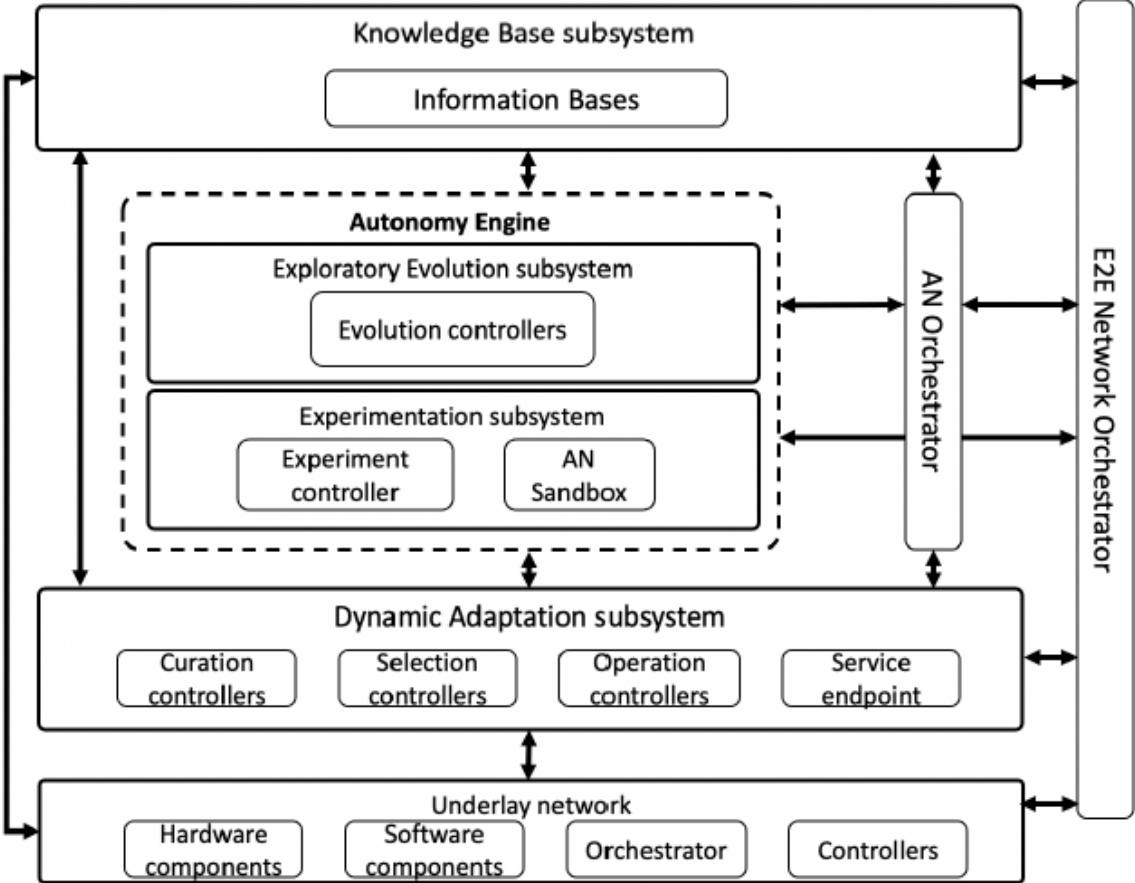
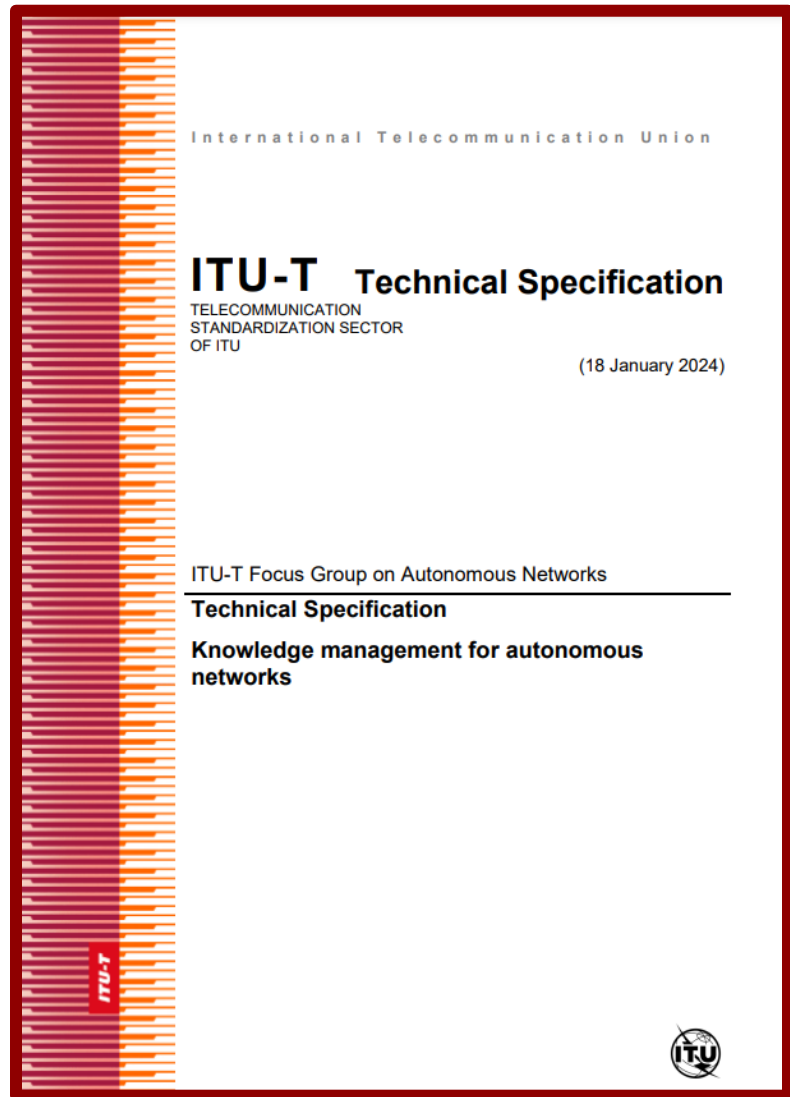


Figure 5: High-Level Framework for Autonomous Network

FG-AN: Deliverables



Knowledge Management for Autonomous Networks

FGAN output document (FGAN-O-036)

Provides studies and discussions on the background, necessity, and motivation of knowledge management in autonomous network

Submitted to ITU-T SG13 as as TD-WP1-0660 with A.1 Justification for new Work Item.

<https://www.itu.int/md/T22-SG13-240304-TD-WP1-0660/en>

FG-AN: Deliverables

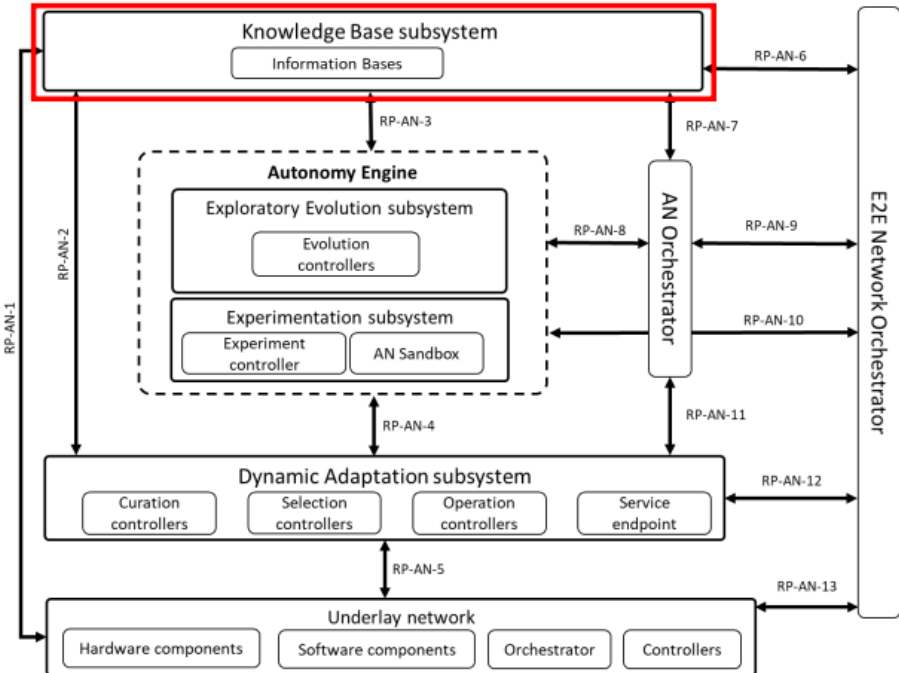


Figure 9-1 The position of knowledge management in AN architecture

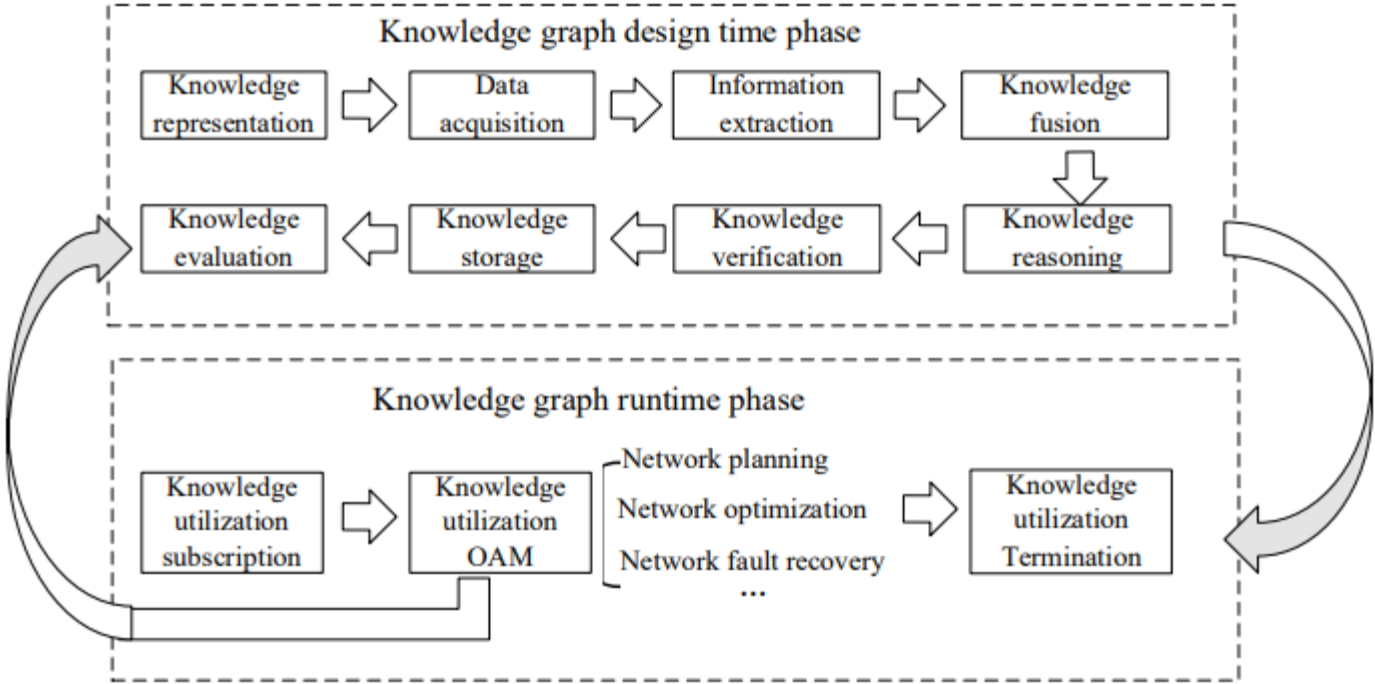
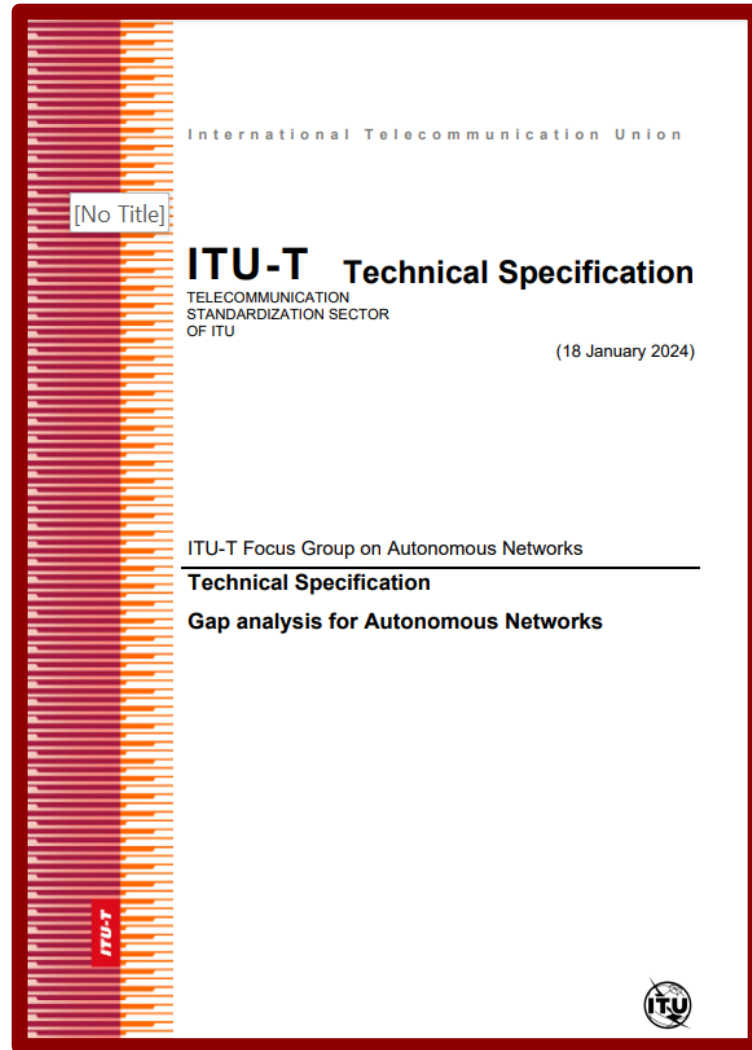


Figure 9-3 – A workflow of knowledge lifecycle management

FG-AN: Deliverables



Gap Analysis for Autonomous Networks

FGAN output document FGAN-O-037

Captures further steps and the gaps from the current state of the art in autonomous network

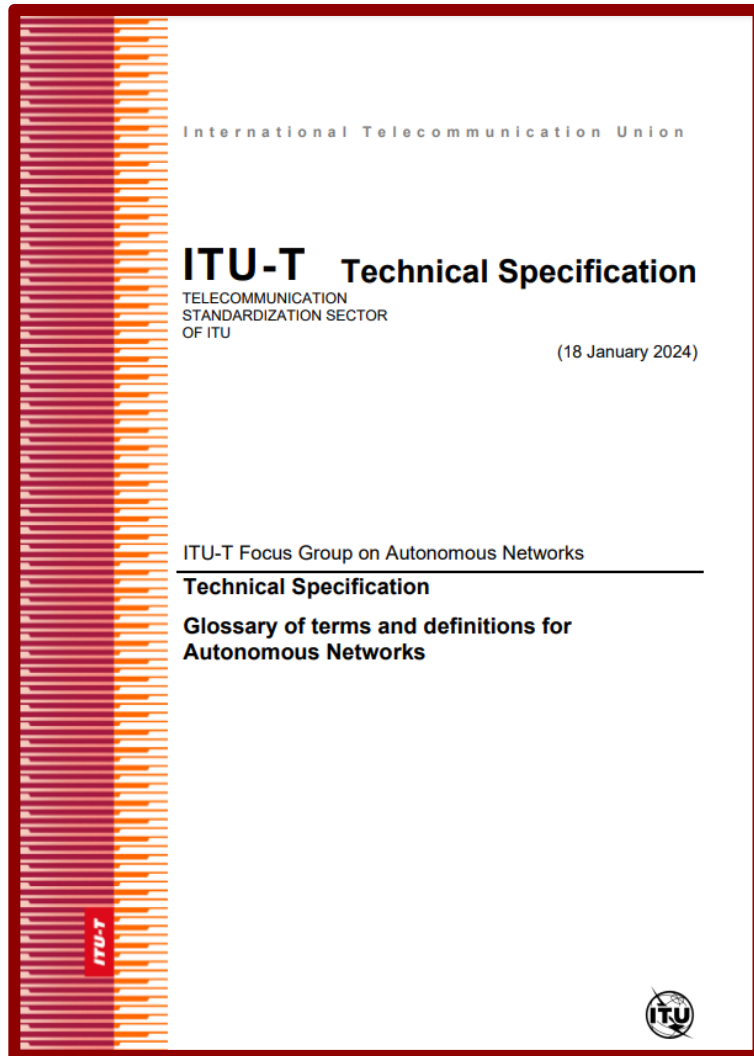
Submitted to ITU-T SG13 as TD-WP1-0661

<https://www.itu.int/md/T22-SG13-240304-TD-WP1-0661/en>

FG-AN: Deliverables

Gap Id	FGAN-GAP-001
Title	Representation mechanisms and transfer protocols for knowledge
Description	<p>Representation mechanisms and transfer protocols for knowledge need further study. The use case requirements pointed to the need for a knowledge base. The architecture framework [ITU-T Y.3061] specified the knowledge base.</p> <p>However, detailed specifications on the potential representation mechanisms and protocols for transfer of knowledge are beyond the scope of such a pre-standards study. It is possible that this requires a larger discussion, among various SDOs and industry bodies to identify potential alignment of various forms of knowledge representation suitable for various use cases and selection thereof.</p> <p>Interoperability of the knowledge base (KB) that allows storage, query, export, import and modification of knowledge using standard mechanisms as specified in [ITU-T Y.3061] needs to be specified in detail to prevent interoperability issues in future among various vendors providing this function.</p>
Reference	[FGAN-O-013-R1]
Future work	<p>Discuss the following in a global forum:</p> <ol style="list-style-type: none">1) comparison between existing forms of knowledge representations, and transformations, suitable for autonomous networks, as could be applicable to frameworks such as [ITU-T Y.3061].2) possible interoperability studies with various vendors in the context of the use cases specified in [ITU-T Supplement 71].

FG-AN: Deliverables



Glossary of terms and definitions for Autonomous Networks

FGAN output document FGAN-O-037

Provides a glossary of terms and definitions for Autonomous Networks

Submitted to ITU-T SG13 as TD-WP1-0662

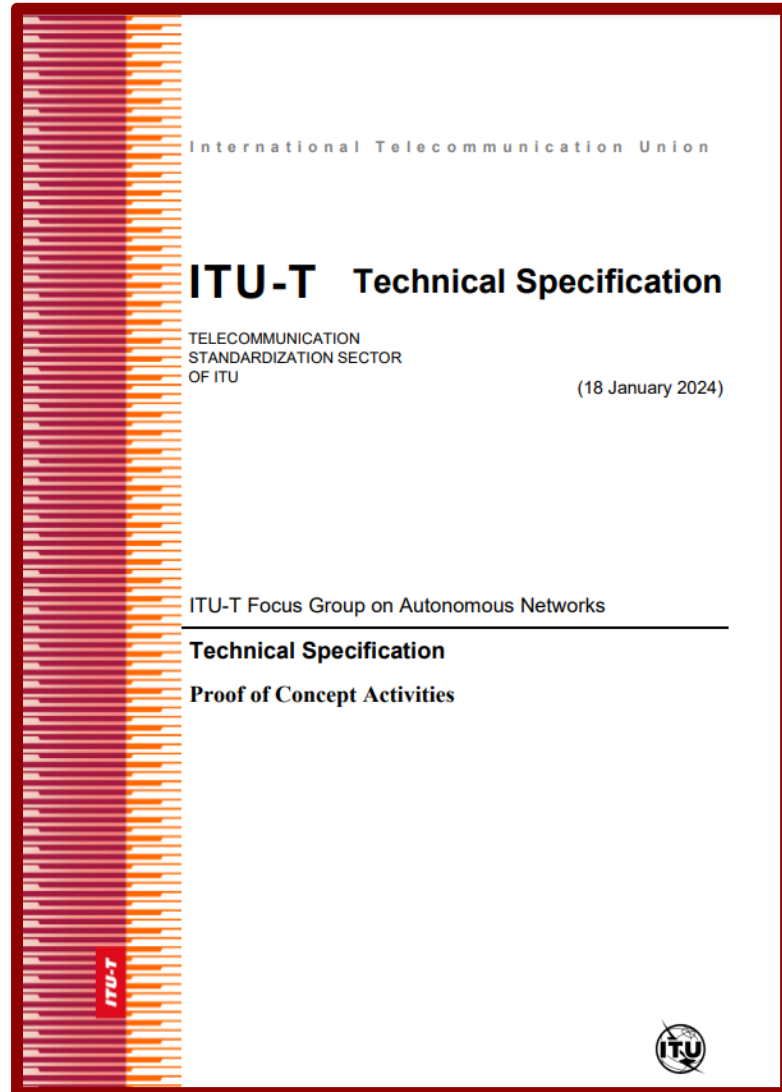
<https://www.itu.int/md/T22-SG13-240304-TD-WP1-0662/en>

FG-AN: Deliverables

Id	2
Title	AN sandbox
Definition or description	<p>An environment in which controllers can be deployed, experimentally validated with the help of models of underlay networks, and their effects upon an underlay network evaluated, without affecting the underlay network.</p> <p>NOTE - Domain specific models, if available, may be used in experimental validation of controllers. Examples of domain specific models are packet flow models for various types of applications such as video, chat, etc., and radio channel propagation models for various channel conditions.</p>
Reference	<i>ITU-T Y.3061</i>
NOTE	<p>Experimentation is the process that validates controllers using inputs from a combination of underlay network, simulators and/or testbeds. The process of experimentation ensures that the controller under experimentation satisfies the use case requirements and is compatible with deployment in the intended underlay.</p> <p>In addition to generating scenarios for experimentation, experimentation controller executes the scenarios in the AN Sandbox, collates and validates the results of the experimentation.</p>

Id	3
Title	autonomy engine
Definition or description	An environment where new controllers are autonomously generated and validated.
Reference	<i>ITU-T Y.3061</i>
NOTE	<p>Autonomy engine refers to the grouping of the Evolutionary Exploration subsystem and the Experimentation subsystem.</p> <p>Together, these architectural components enable the more general trial and error process where new candidate controllers are generated in the former and validated by the latter.</p>

FG-AN: Deliverables



Technical Report on Proof-of-Concept activities

FG-AN output document (FGAN-O-029 & FGAN-O-038)

Provides the technical report on the PoC activities conducted by ITU FG AN during the period.

Submitted to ITU-T SG13 as as TD-WP1-0663

<https://www.itu.int/md/T22-SG13-240304-TD-WP1-0663/en>

FG-AN: Deliverables

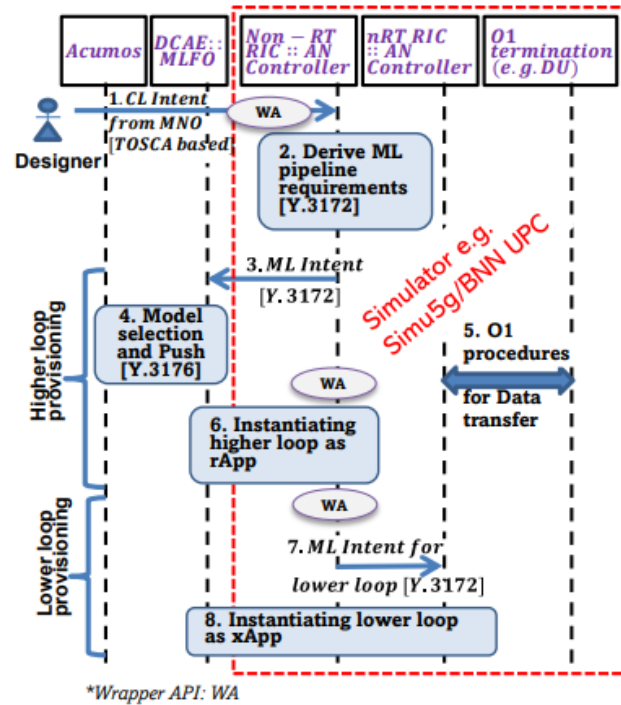


Fig. 30 – Simulator-based sequence for the integration of the activities.

10.1 Requirements for the PoC in 2023

This clause describes the requirements for the PoC.

NOTE- these are extensions to those described in [ITU-T FGAN-O-29]

Requirement	Description
Gen-Build-a-thon-PoC-001	It is critical that PoC development activity, a well-scoped, annotated knowledge base is created. NOTE- the scope of the knowledge base may be a subset of use cases.
Gen-Build-a-thon-PoC-002	It is critical that PoC development activity study the analysis of submitted use cases.
Gen-Build-a-thon-PoC-003	It is critical that the human experts are involved in the verification of the analysis
Gen-Build-a-thon-PoC-004	It is expected that the generation of new variations of use cases are generated using analytical techniques such as AI/ML.
2021-Build-a-thon-PoC-005	It is critical that demonstration of PoC is focussed on a unique scenario, in this case evolution of use cases.
2021-Build-a-thon-PoC-006	It is expected that the KB can be enhanced and validated by multiple regional experts.

FG-AN: Build-A-Thon PoC



ITU Events

Focus Group on Autonomous Networks BUILD-A-THON

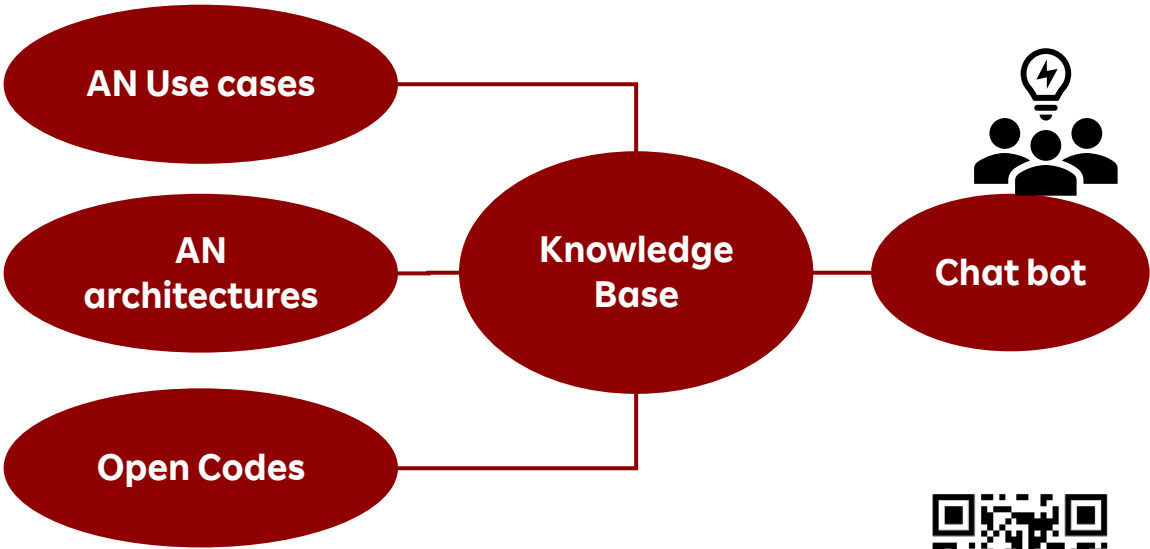
Workshop 5.0

Friday, 19 January 2024
12:00 - 16:30 Geneva (CEST)

itu.int/en/ITU-T/focusgroups/an/

The poster features a central graphic of a hexagonal grid with icons representing various network and AI concepts: a Wi-Fi signal, a cloud with an upload arrow, a USB drive, a padlock, a head with gears, and a magnifying glass over gears. The background is black with blue concentric circles and segments.

FG-AN Build-a-thon 2023: Problem Statement



<https://github.com/CrashingGuru/FGAN-Build-a-thon>



ITU J-FET publications: Academic participations

ITUJournal

*Future and evolving
technologies*

2022 paper based on Build-a-thon PoC

Network resource allocation for emergency management based on closed-loop analysis

Authors: Guda Blessed, Ibrahim Aliyu, James Agajo, Thiago Lima Sarmiento, Cleverson Veloso Nat Novoa, Rebecca Aben-Athar, Mariano Moura, Lucas Matni, Aldebaro Klautau, Deena Mukundan, Div Mehmet Karaca, Doruk Tayli, Özge Simay Demirci, V. Udaya Sankar, Sai Jnaneswar Juvvisetty, V.M. Abhishek Dandekar, Shabnam Sultana, Jinsul Kim, Vishnu Ram OV

Status: Final

Date of publication: 22 September 2022

Published in: ITU Journal on Future and Evolving Technologies, Volume 3 (2022), Issue 2, Pages 1

Article DOI : <https://doi.org/10.52953/HVPI8935>

ITUJournal

*Future and evolving
technologies*

2023 paper based on Build-a-thon PoC

Build your own closed loop: Graph-based proof of concept in closed loop for autonomous networks

Authors: Jaime Fúster de la Fuente, Álvaro Pendás Recondo, Paul Harvey, Tarek Mohamed, Chandan Singh, Vipul Sanap, Ayush Kumar, Sathish Venkateswaran, Sarvasuddi Balaganesh, Rajat Duggal, Sree Ganesh Lalitaditya Divakarla, Vaibhava Krishna Devulapali, Ebeledike Frank Chukwubuikem, Emmanuel Othniel Eggah, Abel Oche Moses, Nuhu Kontagora Bello, James Agajo, Wael Alron, Fathi Abdeldayem, Melanie Espinoza Hernández, Abigail Morales Retana, Jackeline García Alvarado, Nicolle Gamboa Mena, Juliana Morales Alvarado, Ericka Pérez Chinchilla, Amanda Calderón Campos, Derek Rodríguez Villalobos, Oscar Castillo Brenes, Kodandram Ranganath, Ayushi Khandal, Rakshesh P Bhatt, Kunal Mahajan, Prikshit CS, Ashok Kamaraj, Srinwaynti Samaddar, Sivaramakrishnan Swaminathan, M Sri Bhuvan, Nagaswaroop S N, Blessed Guda, Ibrahim Aliyu, Kim Jinsul, Vishnu Ram

Status: Final

Date of publication: 14 September 2023

Published in: ITU Journal on Future and Evolving Technologies, Volume 4 (2023), Issue 3, Pages 503-536

Article DOI : <https://doi.org/10.52953/OPDK5666>

What's Next?

- Continuation of standardization efforts
 - Gap Analysis
 - Existing Work Items
 - New Work Items
- New initiatives for wider/deeper collaboration
- Continuation for future state-of-the-art studies
 - Proposed Focus Group on AI Native for Future Networks (FG-AIFN)

Thank you for all the support

Happy to connect for questions / discussions about Autonomous Networks

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Rakuten

The Rakuten logo is centered on a solid red background. It consists of the word "Rakuten" in a bold, white, sans-serif font. A white, horizontal, slightly curved underline is positioned beneath the letters "a", "k", and "u".