Strategic Roadmap Update

Collaborative sector effort on Sustainable Taxiing

corendon · dnata · KLM Royal Dutch Airlines · LVNL · Schiphol Group · swissport · transavia · TUI · Viggo

Executive summary

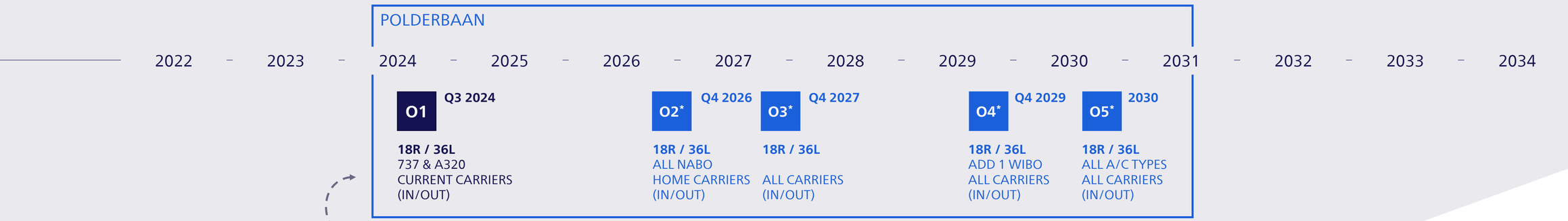
Starting by detailing Polderbaan operations first, while exploring all possibilities to mitigate emissions

As we updated the Roadmap, we have closely collaborated as a sector to start with what is possible. Considering the highest possible fuel savings, and corresponding reduction of green house emissions, applicable infrastructure and the ATC workload being able to better support taking up ST operations from tower west, we have started the update to the strategic Roadmap by detailing out a scale-up from and to the the Polderbaan first. Starting operations to/from the furthest runway allows us to further validate the technology under challenging conditions and obtain learnings that will support further scaling.

Following a stage-gate approach, we have scoped five milestones that represent not only significant operational achievements and scaling steps, but also are directly linked to decision gates.

Our ambitions partly overlap with other efforts, like those aimed at mitigating air pollutants. In parallel to taking up ST operations to and from the Polderbaan, we therefore align with other initiatives and investigate possible expansions of Sustainable Taxiing to other runways.

With successful passing of the TOPSAG in December 2023, we plan to kick off ST operations Q1 2024 by taking up trials that support a fast validation of ST and set the base for subsequent scaling steps, concluding with operational milestone O1 in Q3 2024. Reaching ST standard operations for Narrowbody Aircrafts of all consortium partners, we will next scale to all carriers and start adding Widebody Aircrafts until reaching a full roll-out to/from the Polderbaan with O5 in 2030.



In parallel, we investigate the possibilities to trial operations to other runways and align with related initiatives such as the Taskforce Optimal Future Ground Movements.

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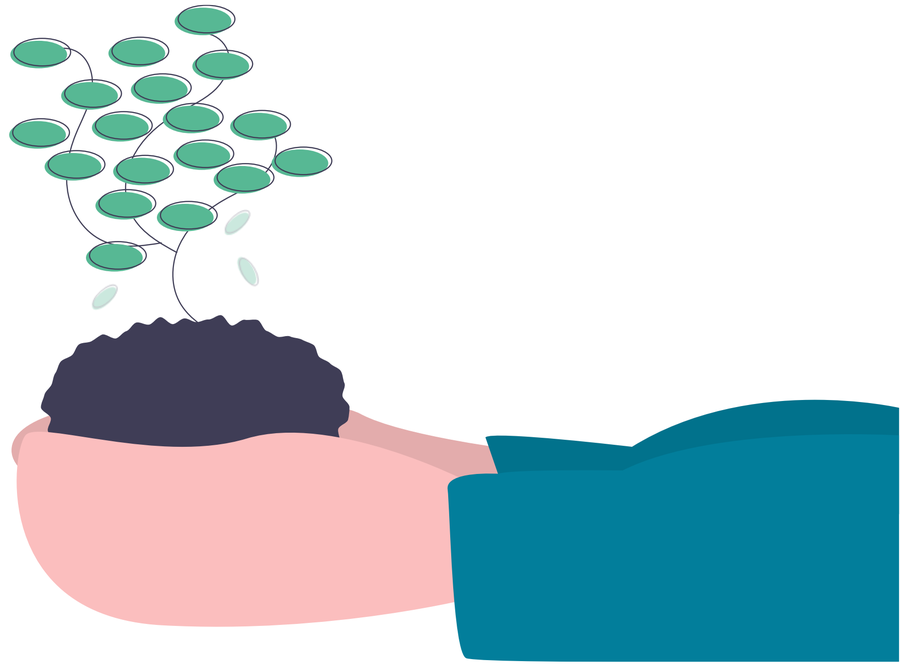
The mission remains the same: save fuel & emissions

The build-up over time must be adjusted based on our learnings and the world evolving around us

We, the sustainable taxiing taskforce, **realise aircraft ground movements where all avoidable emissions have been eliminated.** In close collaboration with the aviation ecosystem, we meet our own sustainability ambitions and societal & political demands for the benefit of airlines and our local community – now and in the future.



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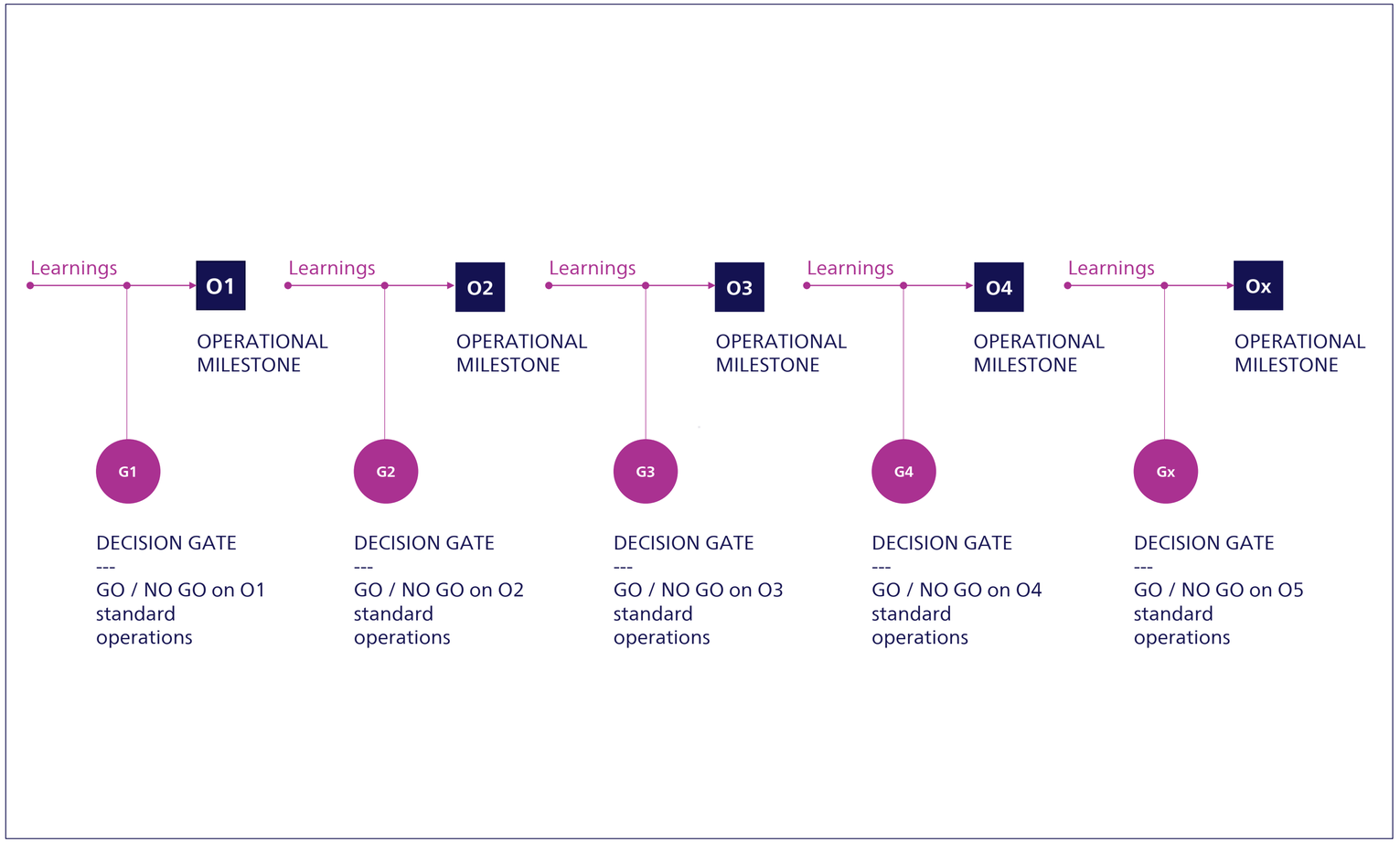
The Roadmap follows an iterative approach

For each milestone we have a decision gate, representing a GO / NO GO moment for implementation



Operational milestones
An operational milestone is a point in time in which we have standard Sustainable Taxiing operations in place at a certain scale. This means the consortium agrees we have learned enough about the process and are ready to 'just carry out' the operations like that continuously.

There will be a build-up of missions towards an operational milestone to gather learnings. These will be coordinated by the consortium core team and are as close to standard operations as possible.

GO / NO GO Decision Gates
Decision gates are part of the iterative approach we have built into this Roadmap to mitigate the risk of further exploration and step-by-step implementation. These GO / NO GO moments are linked to upcoming operational milestones.

Once the consortium members feel we have learned enough to start a new phase of standard operations, we plan a GO / NO GO session for the Executive Steering Board. Here, consortium members must judge if they are ready of standard operation. After attaining a GO, final steps are taken to implement the operational milestone (e.g. the required vehicle amount is purchased, or enough personnel is trained for scale-up and standardisation).

In parallel, efforts will continue to learn about for scaling and achieve the subsequent operational milestone.

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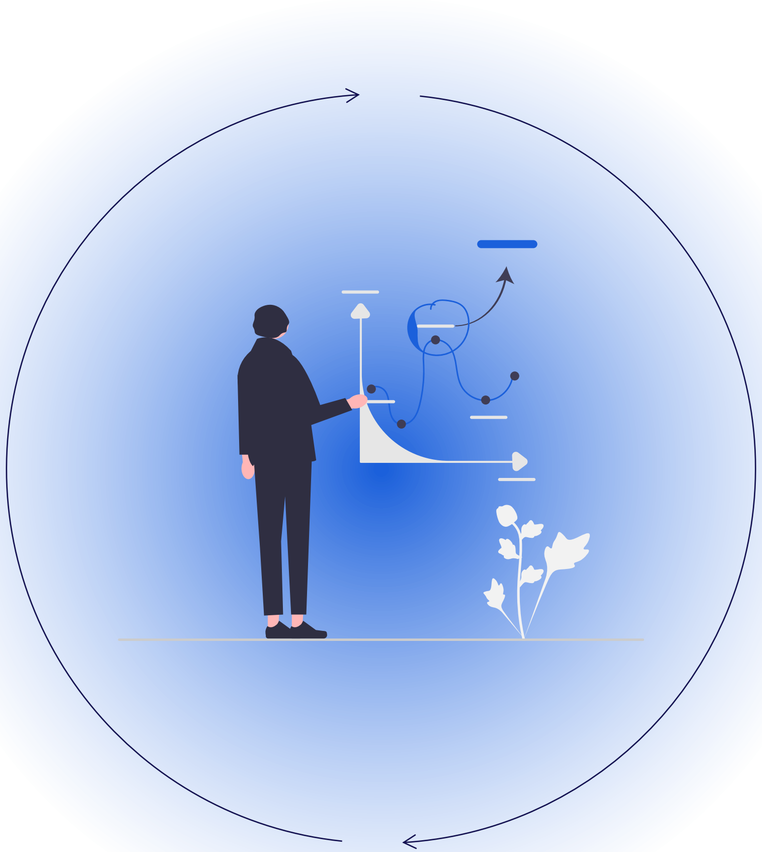
Our plans are subject to change

As we learn more and our circumstances change, plans must be updated to achieve our ambition ASAP

The Roadmap can and will change over time
The milestones as set out in this roadmap are an indication of the results necessary at a certain point in time, for the sector to realistically be able to achieve our shared ambition by 2030. They represent the most realistic roll-out strategy we can currently envision.

As a combination of our fixed ambition and ever-evolving knowledge on the subject, these milestones serve as guidelines towards the ambition, and markers for our shared GO / NO GO decisions. We do not intend to use them as markers to grade the sector and our efforts.

As we learn more by testing and implementing Sustainable Taxiing operations step-by-step, these milestones might change to better reflect knowledge developed over time.



The consortium can and will change over time
The more we learn about Sustainable Taxiing with a small group of forerunners, the closer we get to implementation and scale-up.

As we progress over time, the amount of partners in the consortium will need to grow. Scaling the operations will require more partners to adopt the procedures we develop, test and implement.

Other factors also have an influence on the build-up of our consortium. The regulated ground handling model, for example, will probably have an influence on the (amount of) handlers at Amsterdam Airport Schiphol and thus on Sustainable Taxiing.

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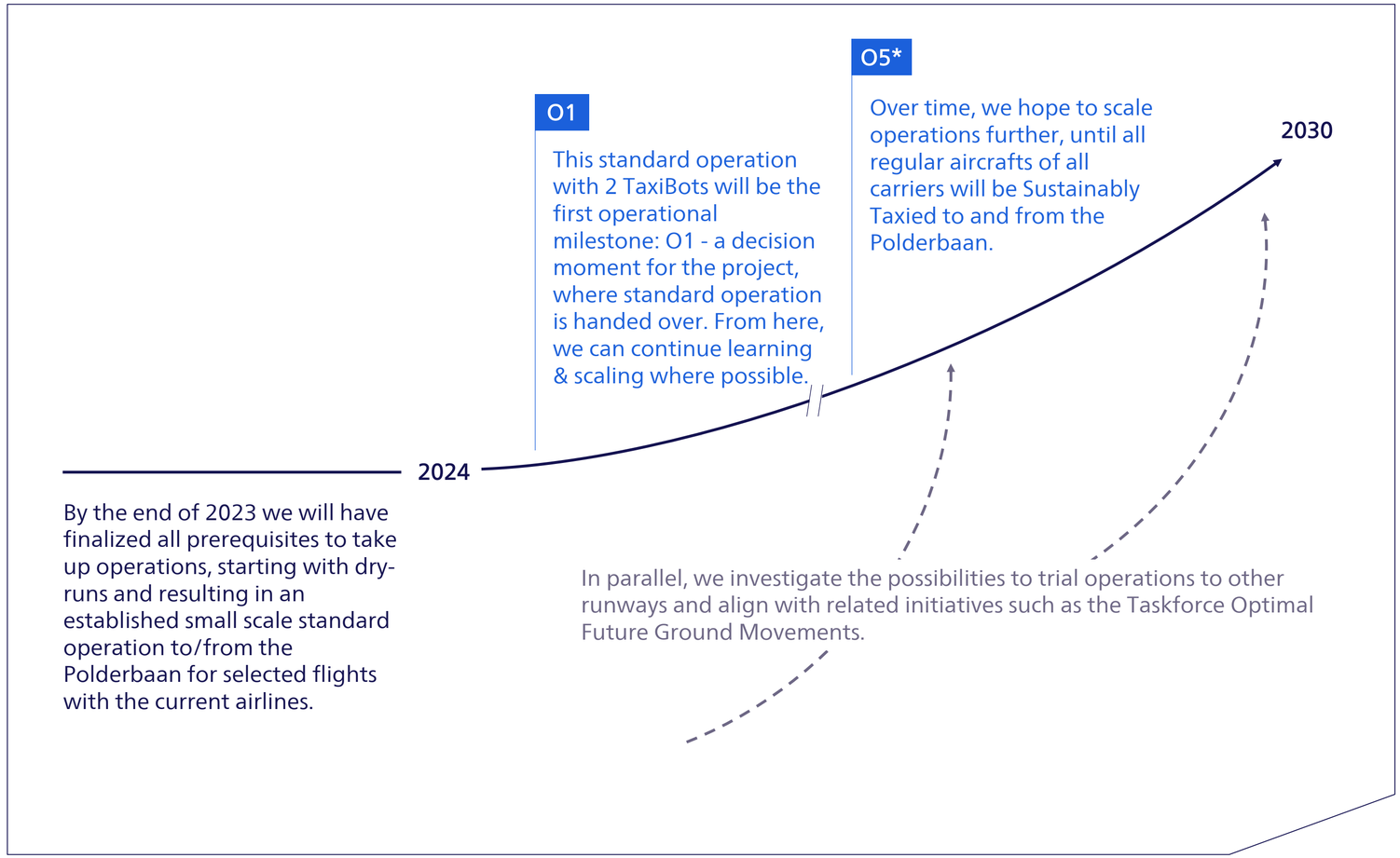
We start by detailing a feasible Polderbaan scale-up

At the same time, we keep exploring all possibilities to mitigate emissions & align with other initiatives

We have worked on defining a joint plan to take up small-scale standard operations as soon as possible and continue learning in live operations.

The updated Roadmap currently details our plans to implement standard operations to and from the Polderbaan.

In parallel, we align with other initiatives and investigate possible expansions of Sustainable Taxiing to other runways.



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We start with what's almost feasible right here, right now

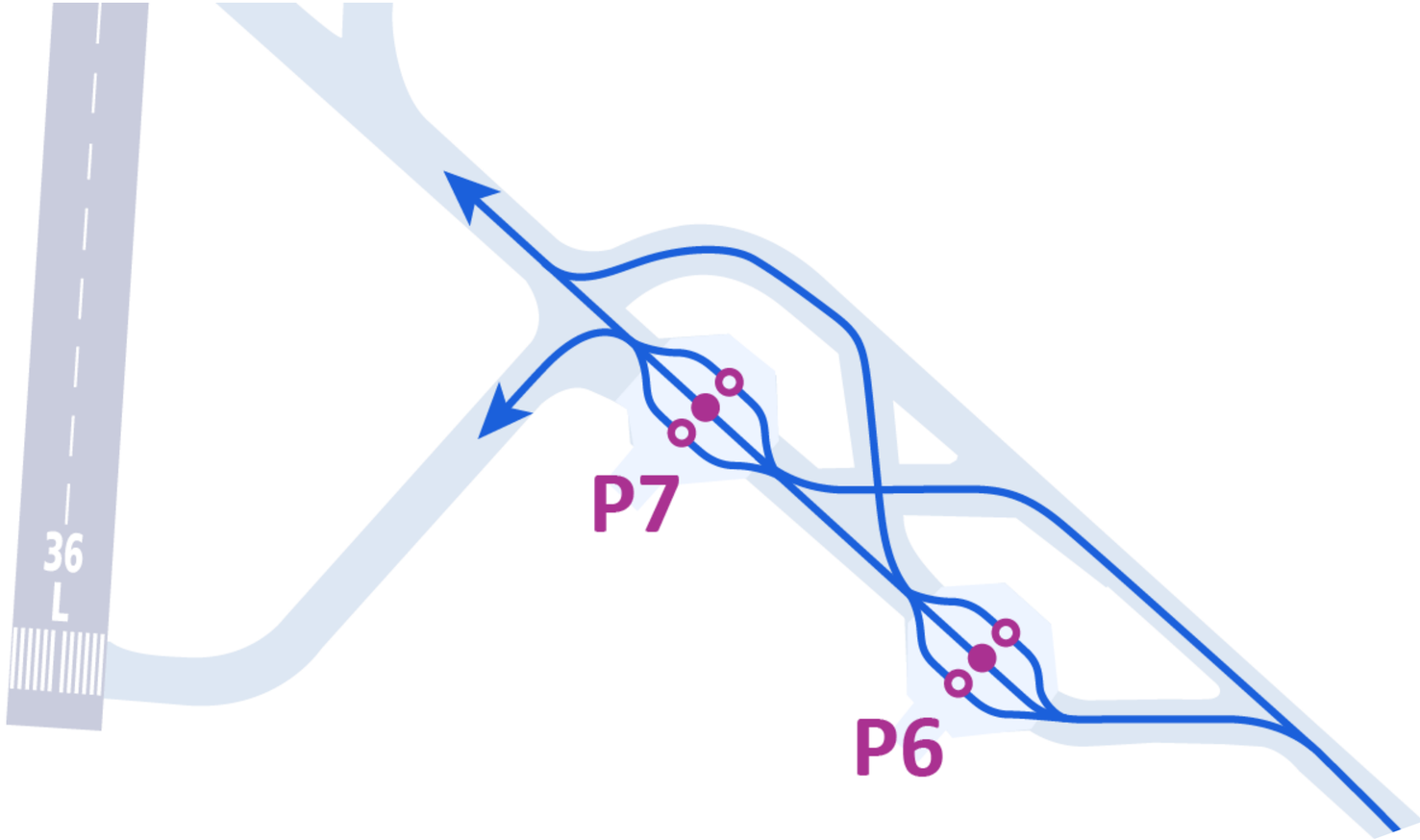
The Polderbaan remains the first logical step for operations and we aim to start trials in a few months

1 **Highest potential for fuel savings**
The Polderbaan is the furthest away runway, as well as the most preferential runway. Starting and scaling up here provides the biggest potential to mitigate green house gas emissions quickly.

2 **Existing infrastructure**
We have made most of the necessary adaptions to the infrastructure for our earlier trials; so we can take up operations quickly.

3 **Optimal ATC workload**
The Polderbaan has its own tower, with a lower Air Traffic Controller workload. This will make it easier to support the introduction of Sustainable Taxiing to/from the Polderbaan.

4 **Validation of the technology**
Starting operations to/from the furthest runway allows us to further validate the technology under challenging conditions and obtain learnings that will support further scaling.



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The update to our Strategic Roadmap

TaxiBots will be used to learn valuable lessons to reach O1 and inform further scaling steps

Previous Roadmap

18R / 36L
737 & A320
(IN/OUT)
O1

18R / 36L
737 & A320
(IN/OUT)
O2

18R / 36L
ADD 1 WIBO
(IN/OUT)
O3

18R / 36L
ALL A/C TYPES
(IN/OUT)
O4

36C ADDED
ALL A/C TYPES
(OUT)
O5

COMPLETE OPERATIONAL ROLL-OUT
Ox

2022 – 2023 – 2024 – 2025 – 2026 – 2027 – 2028 – 2029 – 2030 – 2031 – 2032 – 2033 – 2034

We plan to start using the TaxiBots by Q1 2024.

By O1 we aim to have an operating entity in place.

Q3 2024
O1

18R / 36L
737 & A320
CURRENT CARRIERS
(IN/OUT)

Roadmap Update

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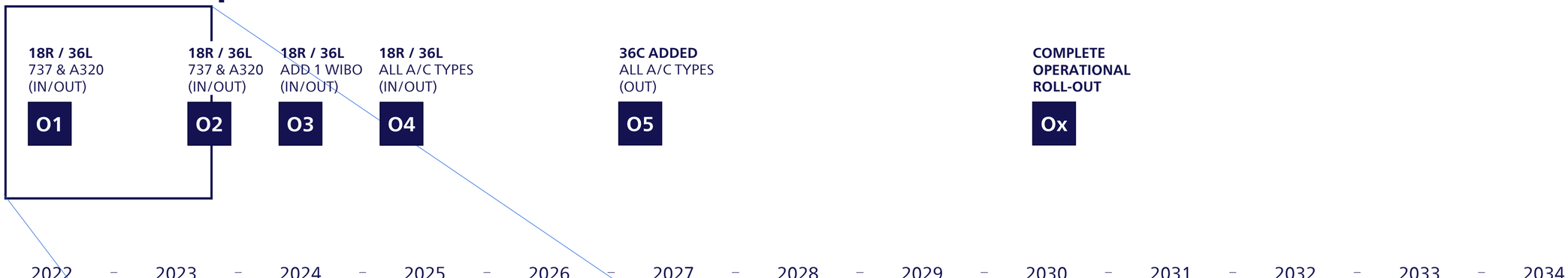
The update to our Strategic Roadmap

LVNL already supports a scale-up to all home carriers on NaBos[1], but we are dependent on more vehicles

Previous Roadmap



Roadmap Update

CURRENT SCOPE SET BY ATC

O1 **Q3 2024**

18R / 36L
737 & A320
CURRENT CARRIERS
(IN/OUT)

O2* **Q4 2026**

18R / 36L
ALL NABO
HOME CARRIERS
(IN/OUT)

While LVNL is committed to Sustainable Taxiing, the Roadmap commitment at this point in time can be given until O2, representing the Polderbaan NaBo[1] CONOPS[2] scope.

Achievable with current 2 TaxiBots

Requires more TaxiBots – amount will depend on capabilities of zero-emission driveline

*revised milestones. 1 | NaBo means Narrow Body – short haul planes like the Boeing 737, Airbus A320 and smaller regional planes like the Embraer 175/195. 2 | CONOPS = Concept of Operations, which is the design of the overall process.

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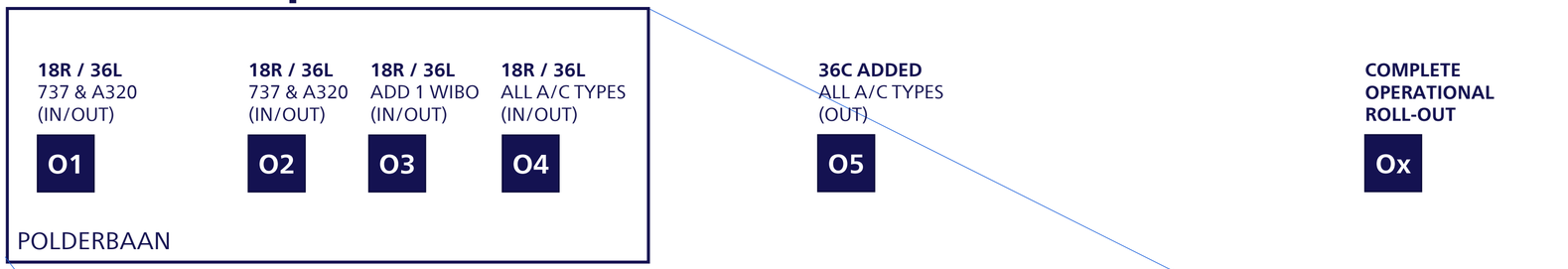
The update to our Strategic Roadmap

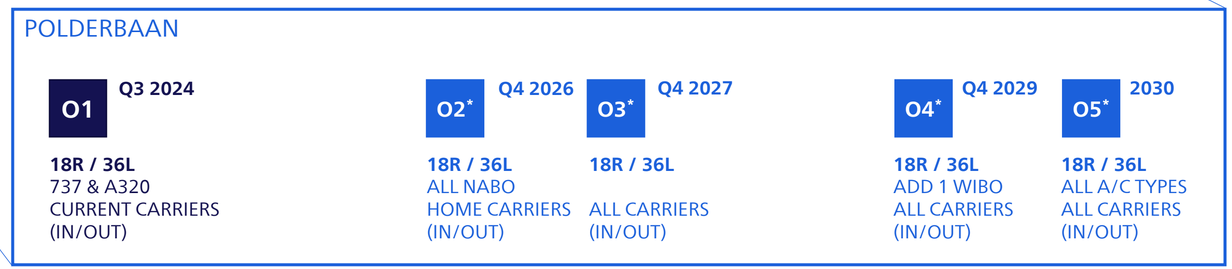
Over time, we aim to scale up to all flights to/from the Polderbaan

Previous Roadmap



2022 – 2023 – 2024 – 2025 – 2026 – 2027 – 2028 – 2029 – 2030 – 2031 – 2032 – 2033 – 2034

Roadmap Update



 *revised milestones

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Challenges to overcome

Achieving the Strategic Roadmap depends on addressing critical prerequisites & bottlenecks

Technology

To achieve a full scale-up to the Polderbaan, we will require more TaxiBots (or similar vehicles) than we have today.

These vehicles will need a zero-emission driveline (powered by electrify or hydrogen). Also, they will need to support (and be certified for) more aircraft types, include widebodies (like the Boeing 787 Dreamliner and the Airbus A350).

We are dependent on SAS/IAI or other manufacturers to take up these costly developments in time. A solid demand will help establish/accelerate this market.

Infrastructure

We have some infrastructure in place already, specifically for Sustainable Taxiing. This includes (un)load locations and bypass areas on service roads. Over time, we will probably need more of this supporting infrastructure – this will become as we scale up.

Sustainable Taxiing operations are dependent on the availability of clean energy on airside. We investigate electric as well as hydrogen vehicle options. Both require sufficient capacity and charging / refuelling facilities that aren't currently available on airside. Depending on the technology used, the availability of sufficient electrical capacity ('netcapaciteit') + charging facilities and/or a steady hydrogen supply + refuelling facilities will be critical. Here, we are dependent on other sectors and on new legislation.

Operations

An effective implementation and scale-up is only possible if certain operational prerequisites are in place.

A few examples are the development and implementation of procedural changes, clarity on the peak hour capacity we can support, securing enough capacity for all stakeholders, including ATC capacity and finding a way to operate under non-nominal conditions.

There are also challenges that will require a lot of collaboration with parties outside of our current consortium. For example, we are dependent on the support of many non-home carriers (airlines that don't have a base in The Netherlands) in order for pilots flying into Amsterdam to be trained to use ST operations.

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ST Roadmap Scale-Up and Acceleration

The Polderbaan approach is evident, will take time to accomplish and still faces many hurdles

2022 – 2023 – 2024 – 2025 – 2026 – 2027 – 2028 – 2029 – 2030 – 2031 – 2032 – 2033 – 2034

Roadmap Update

POLDERBAAN

O1 **Q3 2024**

18R / 36L
737 & A320
CURRENT CARRIERS
(IN/OUT)

O2* **Q4 2026**

18R / 36L
ALL NABO
HOME CARRIERS
(IN/OUT)

O3* **Q4 2027**

18R / 36L
ALL CARRIERS
(IN/OUT)

O4* **Q4 2029**

18R / 36L
ADD 1 WIBO
ALL CARRIERS
(IN/OUT)

O5* **2030**

18R / 36L
ALL A/C TYPES
ALL CARRIERS
(IN/OUT)

Options to accelerate

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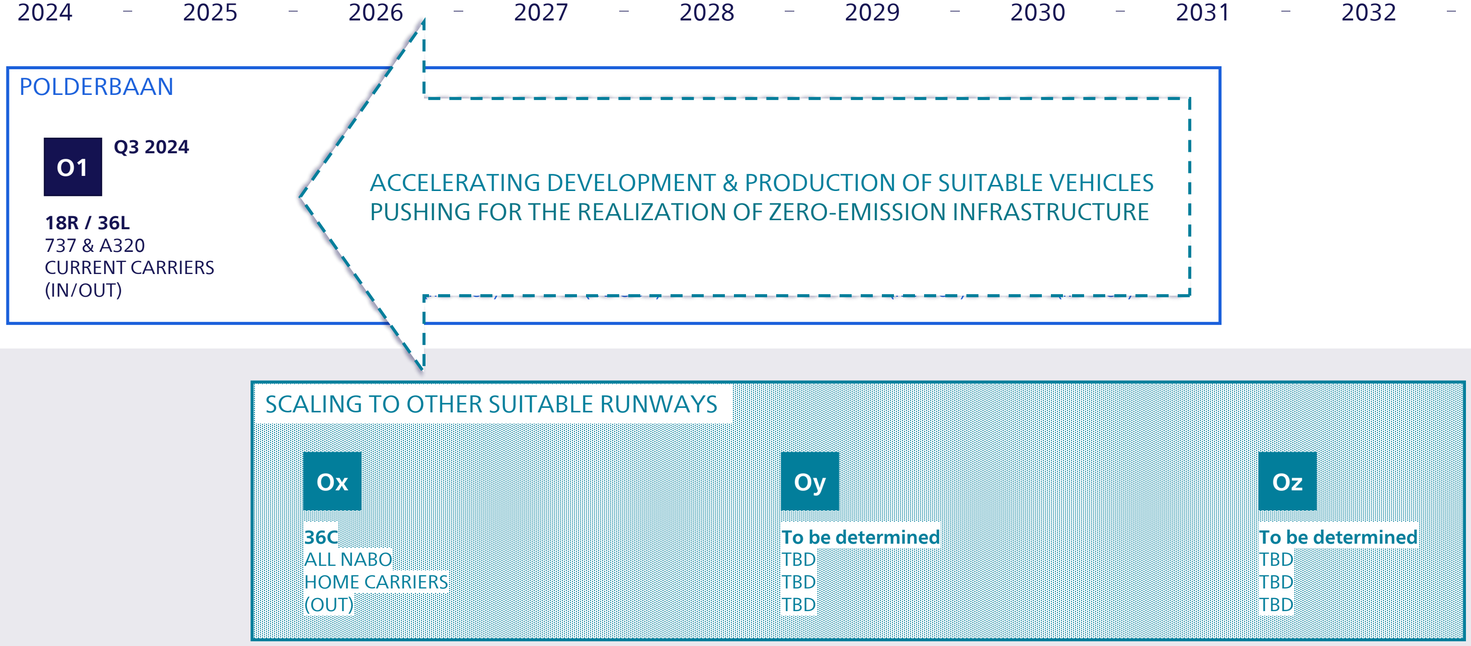
ST Roadmap Scale-Up and Acceleration

Building on Polderbaan learnings could help increase impact by scaling ST to other suitable runways

2022 – 2023 – 2024 – 2025 – 2026 – 2027 – 2028 – 2029 – 2030 – 2031 – 2032 – 2033 – 2034

Roadmap Update



Options to accelerate

ALIGNING WITH TASKFORCE OPTIMAL FUTURE GROUND MOVEMENTS

- **Elongated push-pulls**
- **Tug Release Points**
- **Outbound holding**
- **Unloading in-flow**
- ....

Aligning with the Taskforce Optimal Future Ground Movements can help expand our learnings and scope

 *revised milestones

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Acceleration takes more steep & costly commitment

New procedures and a flexible scale-up will only get us so far – investments in vehicles & infra are necessary

Zero-emission & wide-body vehicles

TaxiBot lead times were identified as a critical bottleneck as we scale up. This is an impediment that we can overcome by early commitment.

Other possibilities to speed up the availability of vehicles are outside of our control:

- Commitment at other airports
- TaxiBot competitors to step up

Infrastructure

Besides building the physical space to scale operations, Sustainable Taxiing operations are dependent on the availability of clean energy on airside.

We investigate electric as well as hydrogen vehicle options.

Both require sufficient capacity and charging / refuelling facilities that aren't currently available on airside.

Investing in scaling up necessary infrastructure now can be pivotal in catering for growing demand.

This will also require the right regulations to be in place quickly, for example for hydrogen-fuelling on airside.

Sphere of influence outside of the consortium

Scaling to other suitable Runways

It makes sense to investigate adding other Runways, such as 36C before a full-scale Polderbaan operation is underway.

This way, the large pool of vehicles required to support Polderbaan at peak capacity can also be used at other times.

While LVNL is committed to Sustainable Taxiing, the Roadmap commitment at this point in time can be given until O2, representing the Polderbaan NaBo1 CONOPS2 scope.

Broader alignment with Taskforce FGM

We want to further[1] align with the (upcoming) Taskforce Future Ground Movements, which will coordinate the redesign of departure & arrival procedures in response to the Arbeidsinspectie report in a Roadmap by 2024.

This way, all procedures that can contribute to more sustainable taxiing operations can complement each other, and the lessons learned can be shared between operational processes.

For example, regular tow tugs might provide the most optimal and sustainable form of taxiing for some short gate-runway combinations.

Sphere of influence within the consortium

1 | There is alignment already with the various initiatives currently in existence within partner organisations, such as the VDME programme within Schiphol, and its LVNL counterpart.

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Government support is critical for our ambition

Delivering on the innovations in this Roadmap hinges on Dutch / EU support on four key asks

Financial support

1 **Accelerate availability of zero-emission ST vehicles**
Incentives / targeted funds to develop zero-emission vehicles/solutions (for all aircraft types) required to implement the Roadmap.

2 **Ensure the installation of sufficient infrastructure**
Incentives / funding opportunities, including but not limited to Stikstofgelden to make sure sufficient (zero-emission) infrastructure required to implement the Roadmap.

The current (plans for) infrastructure at airside most likely won't cover the huge energy demand of a large fleet of ST vehicles.

Regulatory support

Such as licenses for hydrogen refuelling infrastructure, water directive issues, or achieving peak net capacity

3 **Support in addressing legislative hurdles**
We ask government to assist us with legislative hurdles and processes with long lead times that we will certainly face along the way, for example with regards to zero-emission energy infrastructure.

4 **Support in certification of technological solution**
Regarding MoC for operations, as well as assistance in acquiring certifications for additional aircraft types (narrow & wide body) – a lengthy process that may hinder roll-out.

Such as the certification of the 737-MAX

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