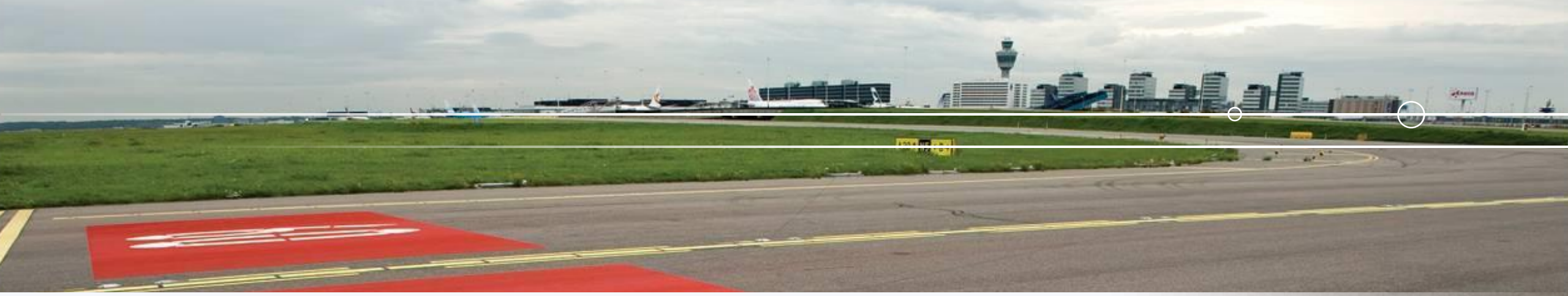

RFI Passenger Flow & Capacity

View on the platform

Version : 4 April 2018

Schiphol
Amsterdam Airport

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Scope of this document

This document contains Schiphol's view on the architecture and requirements for the passenger flow and capacity management platform. It describes the architecture we envision, what part of this solution we desire and what functionality we need in our view.

Please note that these are our initial thoughts and we want to elaborate, validate and develop them together with a protentional partner. Please view this document as a starting point for the discussion.

Organization:
Continuous improvement of processes, technology & people

1. Continuous Improvement Teams

We need to develop the capability/skills to continuously improve, move from traditional planning / execution towards process optimization, fact-based decision making and root cause analysis on disturbances

2. Partnerships

We need to partner with industry leaders that share our vision and have the drive, skills and tools to jointly achieve our business goals as expressed in our ambition and participate in the continuous improvement teams.

3. Platforms

Instead of purchasing turn key solutions, the IT systems in this area should not be set in stone, but be open and enable continuous improvements (platforms).

Agile development

- Mixed team (Schiphol & Partner)
- Within Value Stream for Planning & Forecasting

Process Groups

We identify five process groups:

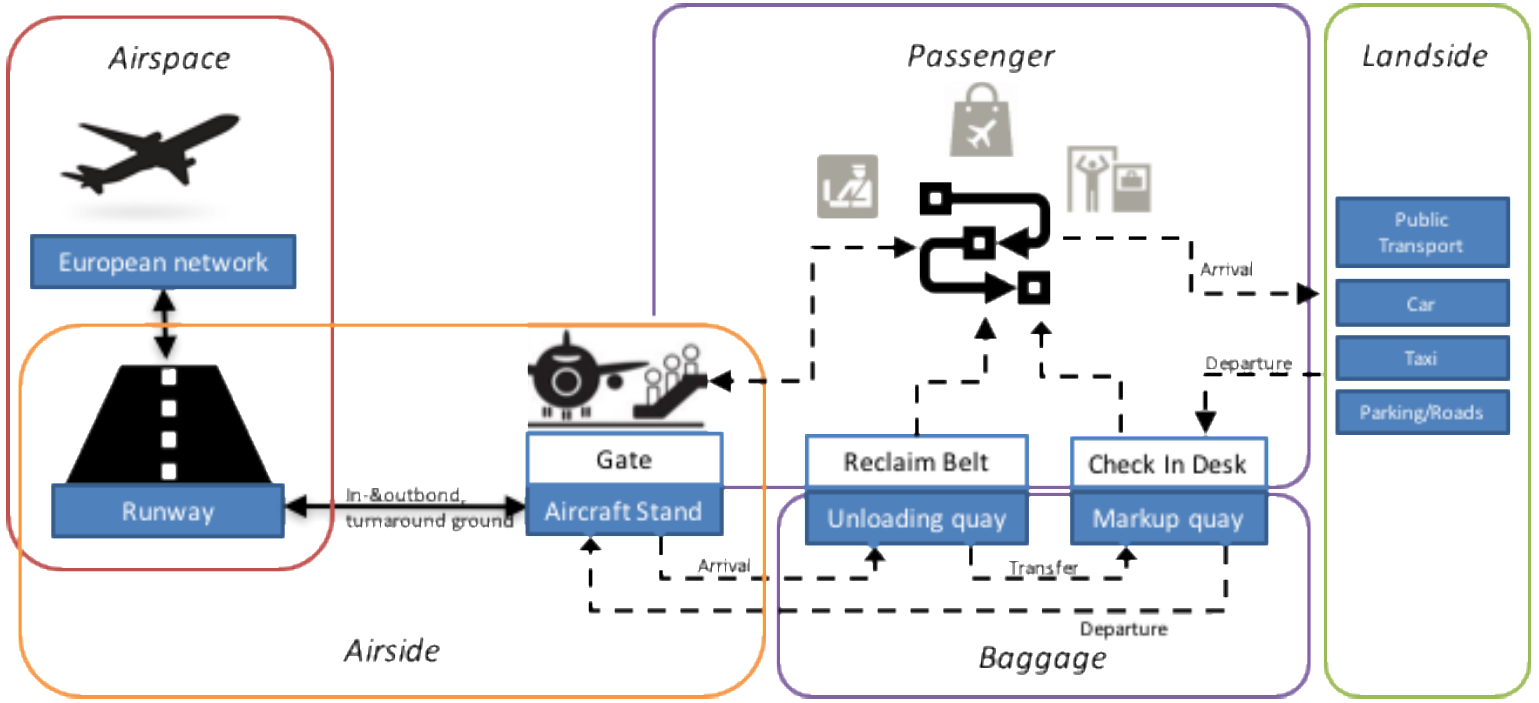
1. Airspace; all travel patterns/flows between the European airspace and runway

2. Airside; all travel patterns/flows between runway and aircraft stands including all other airside traffic.

3. Passenger; all travel patterns/flows between the gate and check-in desks, reclaim and other gated, including non standard processes e.g. PRM, VIP.

4. Baggage; All travel patterns/flows between the aircraft stands and markup/unloading quays.

5. Landside; All travel patters/flows between check-in desk and the various transport options.



Process groups are linked via a transfer point.
For example, the aircraft stands are linked to the gates. Check-in desks are linked with the markup quays.

The scope of this RFI is Passenger Flow & Capacity management

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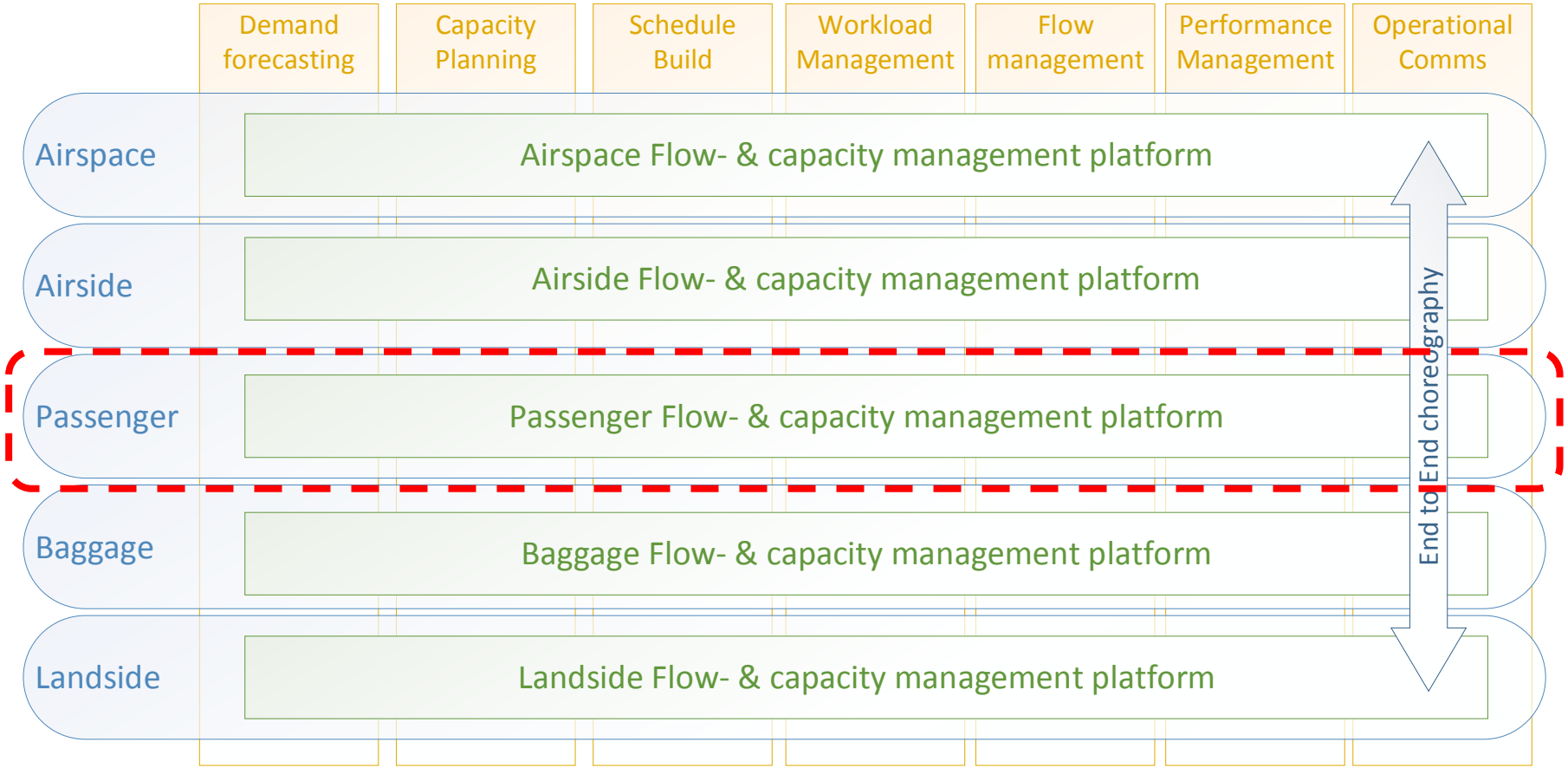
Flow & capacity domain architecture

- At a high level, each of the five process group (i.e. flow) needs similar capabilities[1] (top axis) within the flow & capacity domain.
- We need however to group the processes and supporting software in such way that that he solution space is more manageable and has clear transfer points.
- We expect a platform to have the functionality to support all capabilities needed to perform flow & capacity management for a specific process group/flow, e.g. for Passengers.
- This would be for all tactical and operational time horizons (5 years till day of operation).

  The platform will consist of a cohesive toolset supporting all capabilities.
- Finally there is a layer across all platforms for end to end choreography that ensures the principle of end to end optimization is met.



The scope of this RFI Passenger Flow & Capacity management

1. A description of the capabilities is available in the appendix
2. A overview of touchpoints in the passenger process is available in the appendix

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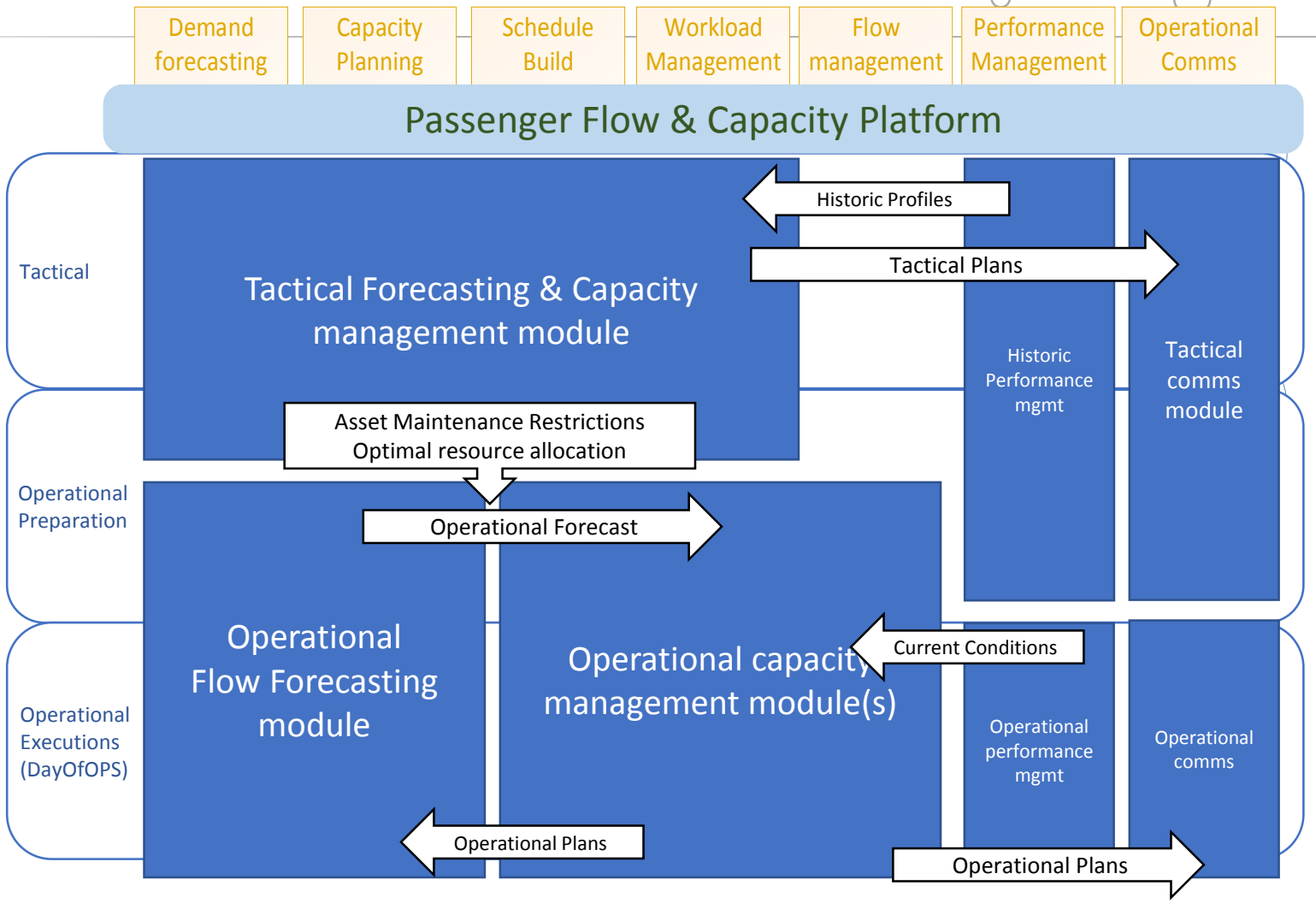
Passenger Flow and Capacity platform architecture

This picture depicts the logical modules we foresee for the Passenger flow & capacity platform.

- The modules should be loosely coupled and highly cohesive. The modules should be changeable and have clearly demarcated inputs and outputs.
- If a module does not perform or reaches the limits of complexity, but the others work fine, we need to be able to change the unfit module.
- This results into a solution space that for tactical planning all the processes can be forecasted and planned in one big cycle, while the operational forecasting and planning is an interaction between various stakeholders (internal and external) that act within an agreed mandate.
- This configuration fits the dynamics of the processes at Amsterdam Airport best. Execution at the day of operations is netcentric (choreography), while at tactical level it is command and control (orchestration).



Scope of the RFI for the Passenger flow & capacity platform

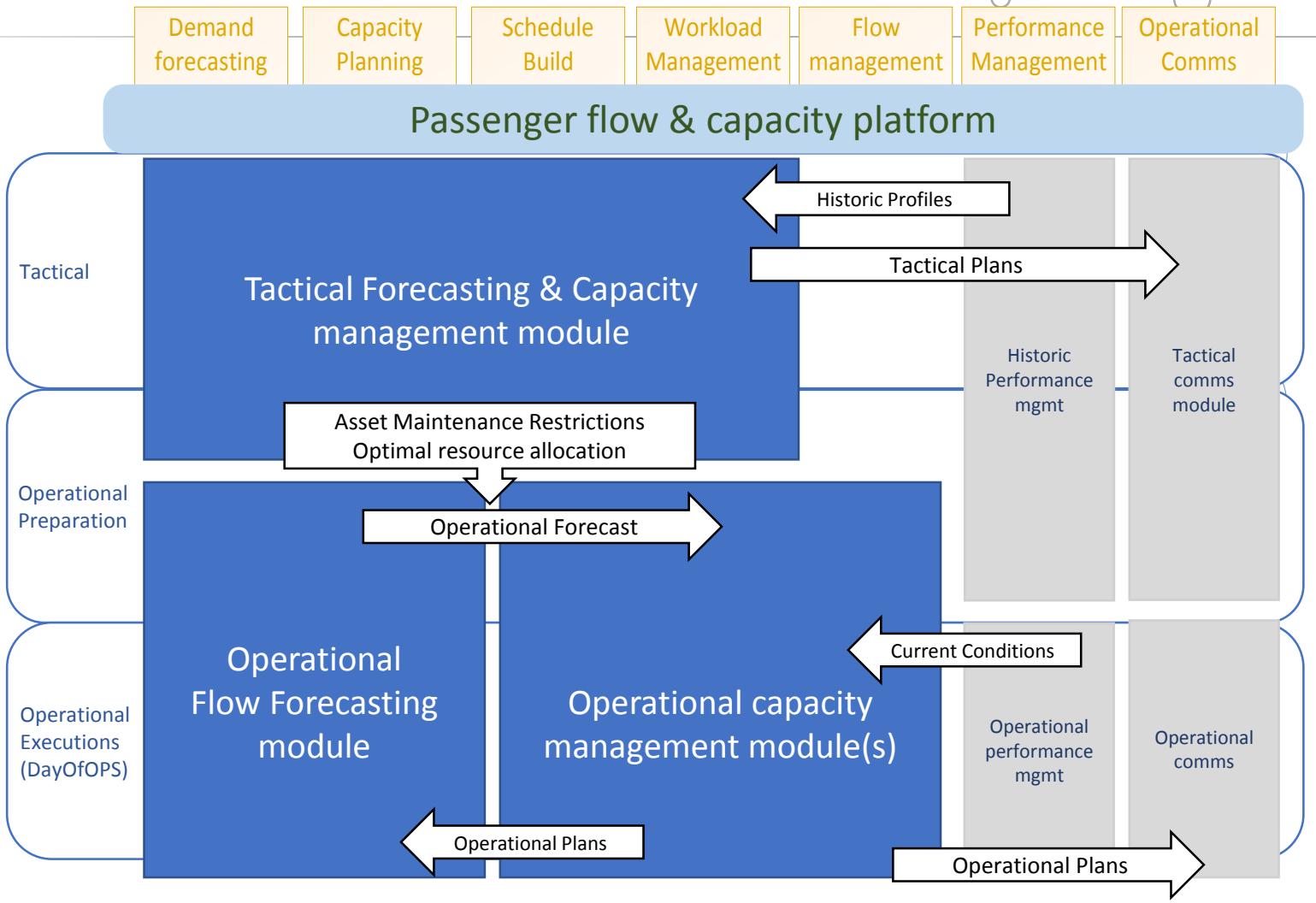
Schiphol is looking for a platform that can support the functionality defined for the modules as highlighted blue on the right:

- Tactical forecasting & capacity management
- Operational Flow Forecasting
- Operational Capacity management

For the modules highlighted grey, Schiphol already has systems in place, but we do want to learn what the vendor has to offer and its experiences with integration of these systems:

- Operational & historical performance management
- Tactical and operational communications

Our first views on desired functionality is included in the following slides.



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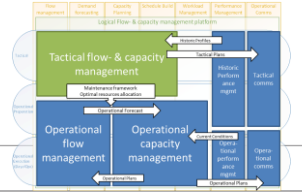
Key capabilities

The key capabilities of the platform are:

1. Agent based flow simulation (to forecast passengers at each location of the terminal)
2. Planning & optimisation functionality for capacity processes (Check-in, Security filters & border patrol)
3. Engine able to simulate full airport passenger flow within minutes
4. Able to include real-time realisation data during day of operation (e.g. boarding card scans before security/ crowd/ flow data)
5. Able to calculate scenario's/ what-ifs both during day of operation and longer term (till 5 years ahead)

The next slides elaborate more on the functionality that the platform should contain in our view.

Functionality for Tactical Forecasting & Capacity management



The Tactical Forecasting and Capacity management module supports the processes for forecasting of passenger volumes and planning of capacity to handle the passenger volumes for all passenger travel patterns and for a period of 5 years to the season ahead. For this period the demand and supply can still be influenced, for example by allowing more planes or building new terminal space. Incidentally tactical calculations are done in the current season to check if major flow changes will fit.

Functionality:

1. Define passenger flow models (travel patterns) including all the touchpoints, working units[1] in the flows and their productivity.
2. Agent based passenger volume demand forecast for all passenger flows.
3. Calculate needed capacity for all process points ('working units') based on demand forecast for all passenger flows.
4. Rapidly simulate, for a complete season, various scenario's, for example various flight schedules, terminal layouts and routes, productivity variants, based on Business rules.
5. Ability to score performance per segment of the airport process or possible solutions (e.g. score redesign variants of check-in process).
6. Ability to run simulations in batches for sensitivity analysis purposes.
7. Ability to implement a Plan/Do/Check/Act loop, based on historical performance profiles.
8. Create visualizations for various stakeholders, for example the capacity managers, but also senior management and directors (e.g. movies of flows).

Input:

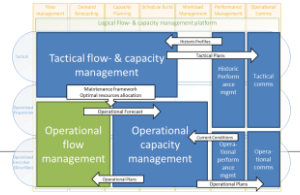
- Tactical flight forecasts containing flight schedules with gate allocation, load factors/ pax numbers and passenger categories.
- Historical performance/productivity and asset availability profiles. Historical pax flow figures (walking times, walking routes).
- Airport design parameters (terminal layout including check-in, security and reclaim layout, possible pax travel patterns/routes, walking distances etc.).
- Process quality performance indicators and norms (average waiting time at security lanes, minimum space per passengers).

Outputs:

- Expected passenger forecast at 15 minute intervals at detailed level: per working unit and per area, specified per flight and per passenger category.
- Planned/predicted performance figures, e.g. predicted waiting times.
- Capacity bottleneck analysis.
- Asset maintenance framework stating the optimal moments to perform maintenance.
- Optimal resource allocation for the working units (i.e.: asset with corresponding personnel).
- Daily dump of generated forecasts for quality analysis purposes.

1. We define a "Working Unit" as the combination of an asset and/or staff at a touchpoint within the passenger flow that is needed to process a certain workload. E.g. a security lane with security staff, or check-in desks with airline personnel or a reclaim belt. Both the capacity of the assets and staff need to be planned, scheduled and managed.

Functionality for Operational Flow Forecasting



Operational flow forecasting module supports the forecasting of passenger volumes for the season ahead and current season including a detailed day of operations forecast. This module also supports the day of operations and therefore should support real time operations and data updates (e.g. flight cancellations).
Major difference with tactical forecasting is that in the operational forecasting the terminal capacity and amount of flights are mostly set. Major terminal projects to increase capacity are not possible and via the slot process we agreed that airlines may arrive and depart from our airport.

Functionality:

1. Agent based passenger demand volume forecast, including a re-forecasting the daily forecast at the day of operations.
2. Ability to create new forecasts based on real-time data updates: actual flight data, gate-assignment and e.g. actual number of opened security lanes and check-in desks.
3. Taking into account real time and/or weighted historical adjustments based on measurements of actual show-up profiles, passenger flows and working unit productivity.
4. Simulate various scenario's, for example rerouting passenger from one security filter to another, changes in processing times or changes in passenger arrival patterns.
5. Ability to generate possible solutions based on historical scenario's.(for example using machine learning)
6. Visualization of flows for operational staff, for example heatmaps, graphs, etc.

Input:

- Seasonal flight forecasts containing flight schedule/gates and load factors and passenger categories.
- Operational Flight flight data and gate planning.
- Asset maintenance plans (availability).
- Optimal resource allocation from tactical level.
- Operational schedules from operational capacity management (within own platform or other platforms).
- Actual airport layout parameters (terminal layout, possible pax travel patterns/routes including temporary rerouting/blockages, walking distances etc.).
- Real-time measurements: e.g. actual actual passenger flows, walking times, process times and arrival patterns based on boarding pass scans and e.g. Bluetooth/WiFi measurements and actual operational asset availability.

Outputs:

- Expected passenger forecast in 5 minute intervals at detailed level: per working unit or per area, specified per flight and per passenger category.
- Expected performance per touchpoint in comparison to KPI's.
- Daily dump of generated forecasts for quality analysis purposes.

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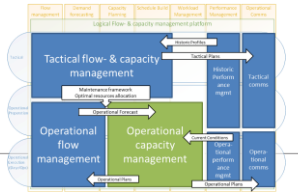
Functionality for Operational Capacity Management



Operational capacity management module(s) supports the capacity planning, schedule building and workload management for the season ahead and current season including a detailed day of operations planning. This module also supports the day of operations and therefore should support real time operations.

Compared to the tactical forecasting the schedule that is produced for the working units is more detailed. Also with workload management employees will receive their tasks based on the schedule, something that is not done at tactical level.

Operational Capacity Management may be implemented with one module or multiple modules. We expect that each touchpoint for the passenger flows has its own planning, which we view as a module. So there would be a module for planning the capacity of check-in, security, border control, etc.

Functionality:

1. Balance planned of capacity of working units with forecasted demands for all passenger flows.
2. Build and manage schedules for all working units (assent + personnel) in the passenger flows, for example check-in planning, security staff roster.
3. Assign tasks to staff based on the various business rules.
4. Define available capacity, performance norms, preferences.
5. Ability to recalculate/adjust planning, based on 'real-time' input of ’working unit' measurement data (asset availability, personnel availability, productivity, process times)
6. Simulate various scenario’s, for example different business rules for allocation, rerouting of passenger flows, lowered productivity or maintenance.
7. Scenario analysis to (automatically) find solutions to handle adverse conditions due to e.g. weather, traffic or calamities.
8. Visualize schedules and bottlenecks.

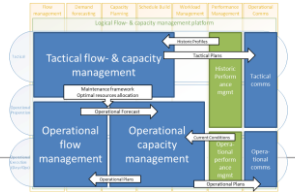
Input:

- Expected passenger flow forecast at detailed level, so per working unit, per flight, per passenger segment/category.
- Business rules for scheduling/planning assets and/or staff. E.g opening hours, break times, employee roles, planning preferences, staff/asset configurations.
- Asset availability/maintenance planning.
- Available staffing levels.

Outputs:

- Operational schedules with recommended staffing level for working units e.g. Check-in planning, security roster
- Task assignment e.g. role based lane assignments for security employees.
- Planned/predicted performance figures, e.g. capacity in pax/minute and predicted waiting times.
- Asset utilization i.e. availability for asset maintenance.
- Planned/actual staff and asset utilization information needed for billing and invoicing purposes between Schiphol and partners like Security companies and airlines (check-in desks)
- Historical performance per touchpoint in comparison to Key performance indicators.

Functionality for tactical & operational performance management



The Tactical / Operational performance management module supports the process of ensuring that that the operation executed within the agreed KPI's and the measurement of these KPI's. Schiphol has already systems in place for these modules, but the platform should provide interfaces to supply the information for this capability and use its (historical) data to improve the forecasting and planning capability.
Tactical and operational data are combined for conciseness.

Functionality:

1. Provide insight in performance Key Performance Indicators (KPI):
    - For historical purposes: this is implemented with a data warehouse reporting solution and is called Integral Process management Operations (IPO) and Security (IPS).
    - On the day of operations this is implemented in Wilbur (OPS and in future security). This environment is used to at least look 4 hours ahead.
2. Measure performance of the overall flow and the productivity of the individual working units in the flow. Realized performance and flow data should be fed back to the forecasting and capacity management modules both at operational and at tactical level. Historic patterns are built up by storing this data in a data warehouse/data lake.
    - Flow measurements are done with Bluetooth and Wi-Fi detection using Blip Systems.
    - Productivity measurements are done by the various working units themselves. For example for security many sensors are built in the security lane.
3. Perform integral root cause analysis to explain why performance is not being met for causes that lie beyond the scope of individual capacity planning modules.
   This is also used for operational incident management over different working units, each handling their own capacity management within their own mandate.

Input:

- Tactical / operational forecasts and schedules
- Maintenance schedules
- Realized flow and productivity measurements.

Outputs:

- Current conditions.
- Historic profiles.
- Recommendations based on historic scenario's.

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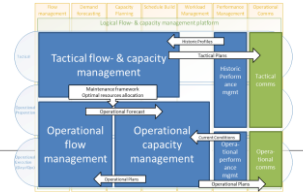
Functionality for tactical & operational communications



The Tactical / Operational communications module supports the communication of the forecasts and plans to other stakeholders. For example via an Airport Operations Plan, conforming the SESAR standards. Currently Schiphol had the CDM subset implemented, but as stated earlier in this document, Schiphol has the ambition to grow to Total Airport Management.

We view the operational communications as the linking pin between the platforms that support the defined process groups. Instead of all modules communicating with each other directly we think a central relay point will make communications more manageable and allows each process group to stay in control within their mandate and scope. So the airside platform would provide the flight forecast to the passenger platform via the operational communications modules.

Schiphol has already systems in place for these modules an the platform should be able to interface with these systems. Tactical and operational are combined for conciseness.

Functionality:

1. Distribute tactical / seasonal outlook and operational plan:
    - Currently implemented by sharing presentations and datasets.
    - On the day of operations this is implemented in Wilbur (OPS and in future security). This environment looks at least 4 hours ahead.
2. Distribute Airport Operations Plan (Season ahead up to day of operations):
    - Currently implemented in the AODB (CISS) for real-time distribution
    - Sharing with Sector is done via the CDM portal. Plans are to evolve the CDM portal to the AOP sector portal with the end goal of Total Airport Management
3. Provide operational briefings so people in the operation know what they can expect

Input:

- Operational planning and performance

Outputs:

- Airport Operations Plan.
- Tactical / Seasonal outlook.
- Operational briefings.

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Architecture: platform v.s. complete solution

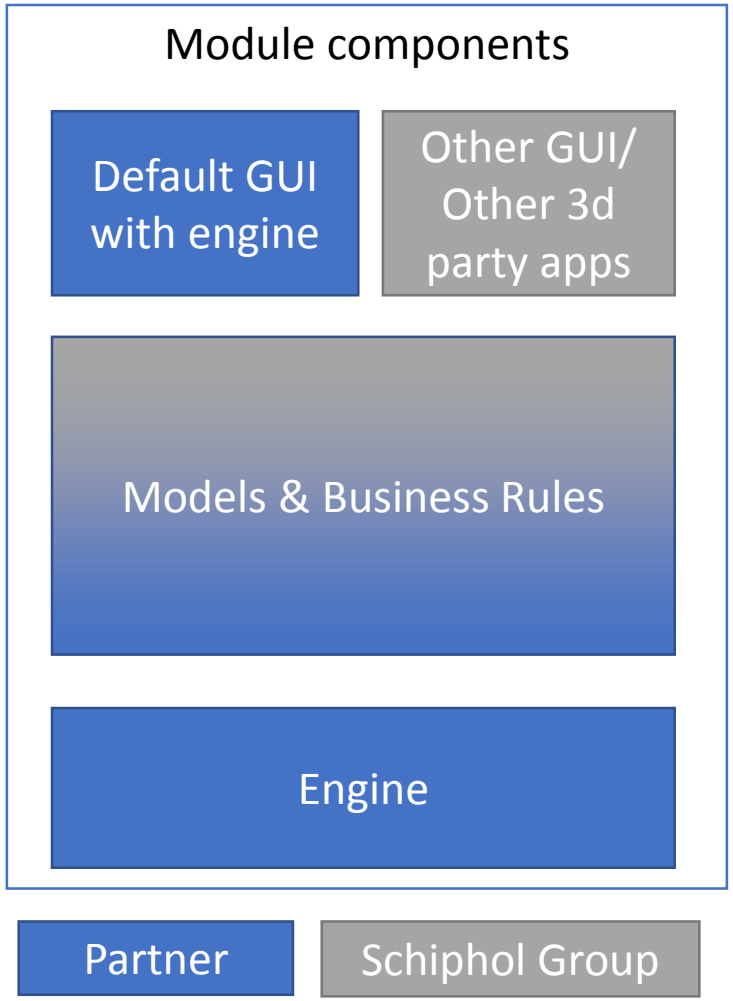
Commercial Off The Shelf products are not modular and flexible and limited in the possibility to adapt the models and business rules to fit the One Terminal concept of Schiphol with complex flows and the high traffic volumes.

A real open platform consists of a coherent toolset. For the flow and capacity capability in the platform we envision that this will be built on top of core engine(s). An engine provides the functionality to implement and continuously improve functionality like passenger volume forecasting on top of a stable platform. This allows us to avoid limitations in predefined products and develop the platform further with the partner.

The figure shows what components a typical platform consist of and where Schiphol must be able to have control:

- Schiphol does not want to develop its own engines for flow & capacity management, for example a forecasting or planning engine. Therefore this part will be supplied by the partner.
- To ensure knowledge retention and ability to continuously improve the solution, Schiphol wants to be able to develop and change models and business rules that are built on top of the engine. Schiphol also wants to leverage the knowledge, expertise and execution power of the partner to accelerate development. So this is a relationship with shared business outcomes.
- Engines typically have a default GUI. Schiphol does not want to recreate these. However for operations we need an integrated GUI with all information needed from different sources.
- Schiphol does want various applications and GUI's to be able to interact with the solution implemented on the engine. This requires a solution that is completely open and accessible.

It is of utmost importance that the platform exposes all functionality as services to other applications to ensure that we are able to create various specific applications based on one platform.



Support for industry standards and best practices

The platform should adhere to commonly accepted industry standards and best practices including but not limited to:

- An open architecture and usage of open standards like W3C, ISO, IETF, IP protocol, XML, RESTFull etc.
- Should fit in a Service Oriented Architecture (SOA) and Event Driven Architecture (EDA)
- All Schiphol employees should be able to have access to the platform via SNBV's standard desktop and mobile devices. This implies web based access or support for (Citrix) thin client applications, using SAML 2.0 or OAuth 2.0 and SCIM 2.0 for authentication.
- For maintenance and support industry best practice are used e.g. ITIL, ASL, BISL or its agile equivalent
- Adhere to ACI and IATA resolutions and best practices
- Non functional requirements (e.g. ISO/IEC 25010:2011) are properly balanced
- Information security policies and best practices are implemented, for example OWASP, or General Data Protection Regulation (GDPR).

Non functional requirements

- The platform should provide excellent user experience and visualizations; The primary factor in adoption of software is if the experience for the user is positive and the user can get the information they need.
- The performance must be excellent and the platform should be highly scalable. An operational reforecast for the entire terminal should be completed within a few minutes. The system should be able to handle both real-time events and be capable to do batch processing of large volumes of data e.g. for analysis.
- Availability: as an real-time operational system, the system must support high availability e.g. by supporting redundant core components.
- Modifiability: the platform should be highly flexible and modular so at any point in time we can choose which functionality we use from the platform or for which functionality we use other solutions; for example for check-in desk planning we only plan the assets, but for the security lane planning we want to perform role based scheduling. For border control we do not make the schedule, but want to use the external planning as input.
- Requirements & the IT landscape change continuously, therefore continuous integration & deployment should be supported
- Maintainability: the platform should support versioning of models and business rules; Terminal layout and business rules change over time. It should be possible to have various versions of models and business rules in the system and have user friendly management of these versions. The Terminal layout must be easily retrieved from the Schiphol Geo Information System.
- Publish or read data to/from other systems, like our data warehouse; we want to be able to store “Snapshots of the operation” from all viewpoints so we can perform root cause analysis and advanced analytics on our operations.
- Use the Schiphol Data Hub as input and or output; Big data platform exposing data services based on machine learning, AI and advanced analytics. We expect that the platform is able to incorporate these data service, for example advanced algorithms to determine real-time show-up patterns or determine the amount of trays used at security based on weather conditions.
- Integrate with the Airport Service Bus using standardized messaging; This Enterprise Service Bus of Schiphol that provides real time reliable messaging and exposes various systems like our AODB, Data Hub, Data Warehouse and planning systems real time. We expect the platform can both subscribe to information and publish information on the ASB and support interface technology like Message Queuing and Restfull API’s.