NYSERDA TRANSPORTATION PROGRAM CASE STUDY:

Saab Sensis Advanced Airport Departure Manager

Final

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1. Executive Summary

This case study presents the results of a recent evaluation of the Saab Sensis Advanced Airport Departure Manager (DMAN) project that was funded by NYSERDA. From 2008 to 2010, the NYSERDA Transportation Program provided funding and support to Saab Sensis to assist them in developing a prototype advanced airport departure manager for use at the John F. Kennedy International Airport (JFK). The evaluation objectives for the Saab Sensis prototype DMAN were the following:

1. Investigate the extent of commercialization of DMAN after NYSERDA funding.
2. Investigate how many airports within and beyond NYS are using the commercialized product.
3. Assess the fossil fuel and emissions reductions.

ERS conducted five interviews with NYSERDA, Saab Sensis, JFK, and the Port Authority of New York and New Jersey (PANYNJ) staff to assess these objectives, along with secondary research into the fossil fuel and emissions reductions. The results of this research are summarized in the following subsections and detailed throughout this report.

Commercialization of DMAN software

From 2008 through 2010, NYSERDA supported Saab Sensis in their development and testing of DMAN. ERS's interviews revealed that in 2012, Saab Sensis procured a contract to perform advanced departure metering using DMAN at JFK. This contract is still in effect at JFK as of 2016. According to interviewees, NYSERDA helped to establish relationships between Saab Sensis, JFK, and the PANYNJ staff; without NYSERDA's networking and financial support, Saab Sensis would not have pursued the DMAN project.

Adoption of the DMAN System in New York State and Beyond

ERS's interviews and research revealed that candidates for DMAN require a high volume of air traffic, limiting candidate airports in New York State to JFK and LaGuardia. In addition to this volume requirement, in order to realize emissions and time savings due to departure metering, candidate airports require airline diversity, voluntary airline or FAA cooperation, and a large holding space for queuing flights. These are all requirements that were met by JFK, enabling DMAN's successful implementation at that airport. However, at the present time LaGuardia has lower airline diversity than JFK and limited holding space, making it a less attractive location for DMAN. No other airports in New York State are likely to benefit from DMAN, due in large part to their lower traffic volumes. Outside of New York State, DMAN has achieved some limited commercial success: it was used temporarily at the San Francisco International Airport while its runways were under construction and has been in use at the Dublin International Airport since 2015.

Fossil Fuel and Emissions Reductions

ERS reviewed independent research to verify the fossil fuel and emissions reductions achieved by the DMAN project. The primary source in this research was an MIT study that reported on the emissions and fuel savings achieved by DMAN's implementation at JFK. The MIT study and staff interviews established that, prior to the implementation of DMAN, JFK was operating with PASSUR's manual departure metering system, which is the basis for calculating the fossil fuel and emissions reductions associated with DMAN's use at JFK. Using this baseline, the MIT study found that DMAN was responsible for an emissions reduction of 10,000 tons of CO_2 and 3,000,000 kg of jet fuel per year at JFK.

2. Project Background

In 2013, New York State's transportation sector consumed more than 1,032 trillion Btus of energy, or 43% of the total energy consumed in the state. Approximately 92% of transportation energy consumption came from petroleum products. As a result of its reliance on the combustion of petroleum products, New York's transportation sector was responsible for 75 million metric tons of CO_2-equivalent emissions in 2013, or 42% of all fuel-borne greenhouse gas emissions in the state.[1]

Within this context, NYSERDA's Transportation Program has identified several objectives:

- Reduce and diversify the energy consumed by the transportation sector.
- Minimize greenhouse gas emissions.
- Create economic development opportunities in New York State.[2]

The current Transportation Program builds on decades of research conducted with state and federal funding. Beginning in 2016 with the transition to NYSERDA's Clean Energy Fund (CEF), the Transportation Program adopted three focus areas: electric vehicles, public transportation, and mobility management. The project described in this case study – Advanced Airport Departure Manager – aligns with the mobility management focus area.

2.1. Project Identification and Funding

Incorporated in the United States with its headquarters in Syracuse, New York, Saab Sensis provides solutions for the global air defense, air traffic control, and airline and airport operations markets. The Saab Sensis airport surface monitoring program, Aerobahn, is well established and used at airports across the world.

In 2008, NYSERDA contracted Saab Sensis to simulate and develop a prototype Advanced Departure Manager (DMAN) for use at JFK. The goal of DMAN was to reduce aircraft emissions. DMAN achieves this by assisting in continuous departure metering, which requires a combination of software (DMAN + Aerobahn), process management, and a manned operations center to create a "virtual departure queue" in which departures are "metered." Flights are held at the gate with the engines off, instead of queuing idle in an extended line waiting for departure, reducing fuel burn. Virtual queuing ensures that a flight's position in the departure lineup and its planned runway departure time are both preserved, even though the aircraft is not physically out on the active taxiway. JFK handles 92% of the total air cargo in New York State and is the third largest air cargo airport in the U.S. Due to insufficient gate and terminal resources and the high volume of flights, the airport often experiences excessive delays on the airport surface, including runways, ramps, movement areas, and gates. Saab Sensis developed DMAN to virtually queue departing flights, allowing planes to queue with the engines off at gates or ramps instead

[1] NYSERDA. 2015. Patterns and Trends – New York State Energy Profiles: 1999–2013. October 2015. Available at: http://www.nyserda.ny.gov/About/Publications/EA-Reports-and-Studies/Patterns-and-Trends.

[2] NYSERDA. 2015. Transportation Program: Product Development, Product Demonstration, and Product Deployment, Program Theory and Logic Model Report. August 2015.

of idling on the runways, thereby reducing fuel consumption. Airlines' compliance with the virtual queue generated by DMAN is entirely voluntary, as the Federal Aviation Administration (FAA), which regulates airlines' arrivals and departures on the runways, chose not to participate in enforcing the surface management at JFK. Exhibit 1 shows a conventional airport queue versus the DMAN virtual queue.

Exhibit 1. DMAN Virtual Queue

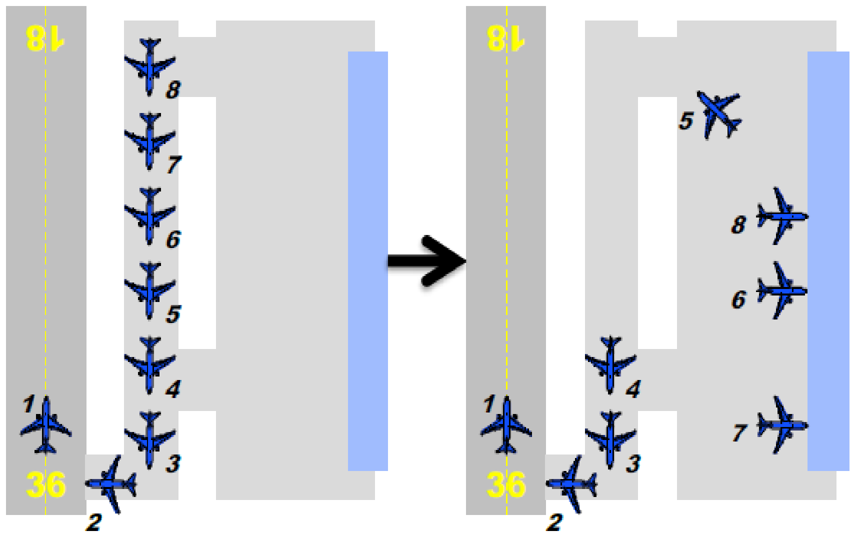

Figure 1. Instead of a long physical departure queue (left), DMAN maintains a virtual departure queue (right) in which aircraft take much of their delay at the gate or in the ramp.

From 2008 to 2010, NYSERDA provided $500,000 in funding to Saab Sensis for research and development of the prototype DMAN. Following the NYSERDA funding, Saab Sensis won the bid for a contract at JFK for continuous departure metering using DMAN, which is still ongoing as of 2016.

Exhibit 2 provides additional details on the focus of this case study. In particular, the primary intent is to understand the market, emissions, and energy impacts of the project, including commercialization to date and the potential for future replications and benefits from this software.[3]

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[3] This case study is part of a suite of six case studies with the following overall purpose: (1) highlighting important transportation research and development accomplishments in New York State; (2) understanding the role that the Transportation Program played in achieving those outcomes; and (3) informing Transportation Program strategy by identifying effective approaches that NYSERDA can build on and the remaining market barriers to address.

Exhibit 2. Evaluation Scope

Evaluation Question	Data Sources and Analytic Methods
1. To what extent was the product commercialized after NYSERDA's funding?	• Internet research to investigate the commercialized use of DMAN • In-depth interviews with PANYNJ/FAA, JFK, and Saab Sensis
2. How many airports within and beyond New York State are using the commercialized product?	• Internet research to investigate additional airports utilizing the commercialized DMAN • Interviews with Saab Sensis and PANYNJ/FAA
3. What were the fossil fuel and emissions reductions?	• Review of the Saab Sensis NYSERDA final report • Review of MIT study "Assessing the Impacts of the JFK Ground Management Program" • Review of independent departure metering reports

The following sections of this report discuss the evaluation questions, methods, and findings in detail. Section 3 summarizes the results of the case study analysis for each of the three evaluation questions listed in Exhibit 2. Section 4 then examines the strategic implications of those findings, including effective approaches that NYSERDA can build on to increase its benefit to New York State air transportation activities.

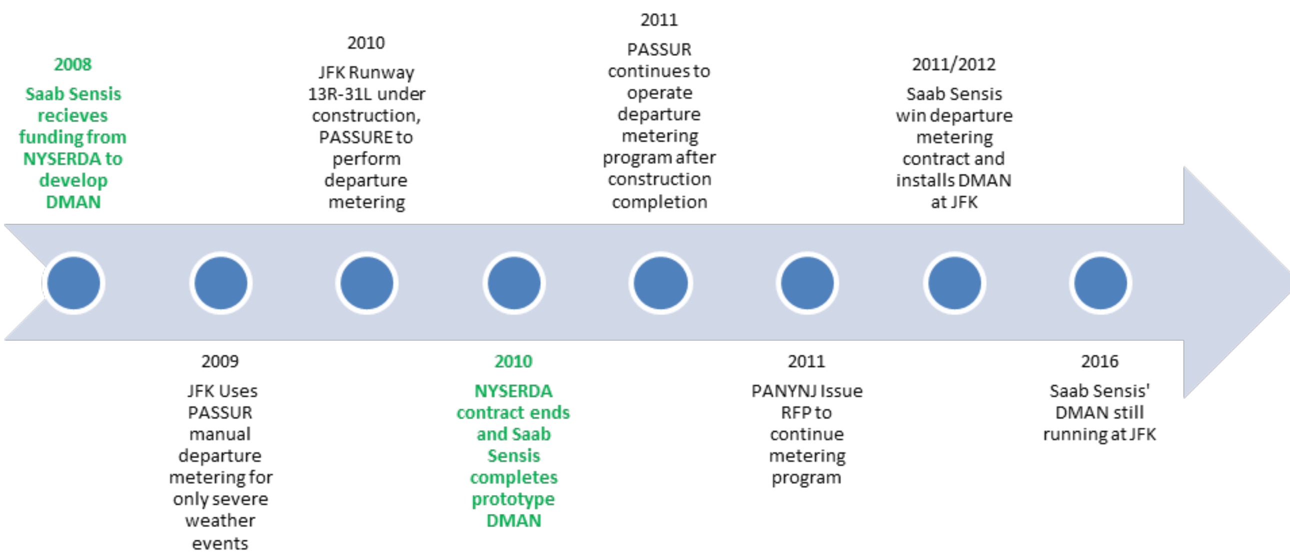
3. Project Outcomes

The following sections discuss each of the three evaluation questions in detail. First, Section 3.1 covers the extent of commercialization of DMAN after the completion of the NYSERDA contract. Section 3.2 discusses the replicability of the DMAN project and the limitations and requirements needed to implement DMAN at other airports in New York State and the U.S. Finally, Section 3.3 provides a detailed review of the fossil fuel and emissions impacts reported by NYSERDA.

3.1. Commercialization of DMAN Software

A central focus of this case study was the extent to which the DMAN prototype was commercialized both within New York State and the U.S. after the contract with NYSERDA concluded. Based on interviews with project engineers and managers at Saab Sensis and JFK, the ERS team established that after the conclusion of the DMAN prototyping project with NYSERDA, Saab Sensis was awarded the contract to implement DMAN at JFK, replacing an existing manual departure manager run by PASSUR. DMAN is a separate air surface management program that integrates with Saab Sensis's existing surface monitoring package, Aerobahn. Exhibit 3 provides a visual timeline of the development and commercialization of DMAN at JFK. Points in the timeline where NYSERDA was involved with the project are highlighted in green. The timing of departure management use at JFK is important when establishing the baseline departure strategy at JFK before DMAN was implemented – this will be covered in greater detail in Section 3.3.

Exhibit 3. Timeline of DMAN Development and Departure Management at JFK International Airport



3.2. Adoption of the DMAN System in New York State and Beyond

To date, DMAN has not been used at any other airports in New York State and has seen only limited use at other airports in the U.S. and Europe. In 2014, DMAN was used at the San Francisco International Airport (SFO) while its runway was under construction, but its use was discontinued upon the completion of construction. In 2015, DMAN was selected to be deployed at Ireland's Dublin International Airport and was integrated with the European departure management concepts and requirements. The ERS team's interviews with market actors and reviews of independent studies indicated that airports that are good candidates for DMAN require the following features:

- **High volume of air traffic** – Without a high volume of air traffic and a long queue at the departure ramp there is no need for a virtual departure queue.
- **Diversity of airlines** – Without a large diversity of airlines utilizing the airport, major airlines will have complete control of which flights have priority and hold flights at the gate on their own. Without competition for departure at the runway DMAN is redundant.
- **A large holding space for queuing flights –** The potential airport must have adequate space to maneuver and place aircraft that are ready for departure in addition to the aircraft gate area. If a departing aircraft cannot move to a holding area, they will block the gate for the arriving aircraft and prevent arriving flights from reaching their gate. Without adequate space for holding and maneuvering flights so that incoming flights can reach their gates on time it is impossible for an airport to benefit from DMAN.
- **Cooperation of all airlines or participation of the FAA** – Without cooperation of airlines in a voluntary program, or participation of the FAA in holding departing aircraft accountable to their virtual departure sequence, aircraft are able to bypass the virtual queue and skip their assigned position, departing ahead of others that are waiting.

Based on the first requirement alone, the only other candidate for DMAN in New York State is LaGuardia International Airport, but unfortunately LaGuardia lacks the required holding space and due to its design it is unlikely to benefit from a virtual queuing system without changes to airport policy and surface space. Newark International Airport, while in New Jersey, also serves the New York City metropolitan area and has sufficient air traffic volume, but with only 29 airlines, 6 of which comprise the majority of activity, it lacks the required airline diversity.

It is also important to note that the airline industry is a difficult market to change, as safety and security are priorities. The phrase "if it isn't broken, don't fix it" was used by airport-affiliated interviewees to represent the reluctance to involve a third party in airport surface management. This is likely one of the primary reasons that DMAN has not been adopted at other airports in the U.S., although this may change with the FAA nationwide modernization initiative, NextGen.[4]

The limited adoption of the DMAN software is somewhat surprising given how easily it can be integrated into Saab Sensis's more widely used Aerobahn package. The ERS team researched the capabilities of the Aerobahn package and found that it does not offer the same virtual queuing capabilities as DMAN, and interviews with former Saab Sensis employees indicated that there were no future plans to include DMAN into the more widely-established Aerobahn package.

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[4] The NextGen modernization of the U.S. air traffic system includes FAA streamlined approval processes for access to surface data through the new, secure National Airspace System (NAS) Enterprise Services Gateway. The gateway provides a secure connection between NAS and non-NAS systems that meets federal requirements, permitting external release of data while protecting internal systems.

3.3. Fossil Fuel and Emission Reductions

In order to assess the fossil fuel and emission impacts of developing and implementing DMAN, the ERS team reviewed the expected emission savings as estimated in Saab Sensis's final report, along with independent estimates of the emissions and fuel savings associated with the implementation of DMAN at JFK; these savings were developed by MIT based on in-service data provided by JFK.[5] In addition to the emissions savings, MIT also investigated the decrease in passenger wait time at JFK and the benefits associated with it. The MIT study found that the departure delays have been reduced by a total of 6,000 hours per year, decreasing the JFK air travel passenger wait time. The average taxi-in duration was also found to decrease, showing that holding departing aircraft at their gate did not negatively impact the waiting time of arriving flights. Exhibit 4 shows the respective emissions values for each of these case study sources.

Exhibit 4. Comparison of Emissions Savings Claims[6]

Metric	As Estimated in Saab Sensis Final Report	As Estimated in MIT Study
Unburned hydrocarbons	48 tons	No data
Jet fuel	17,000,000 kg	3,000,000 kg
CO_2	54,000 tons	10,000 tons
CO	329 tons	No data
NO_x	66 tons	No data

Data from the Saab Sensis final report was estimated by Saab Sensis at the completion of their contract with NYSERDA based on simulations of expected air traffic and use before DMAN was commercialized at JFK. The MIT study was completed within the Aeronautics & Astronautics department at MIT and included three months of data after DMAN had been operational at JFK. It is important to note that the MIT study calculated savings relative to the PASSUR manual departure metering system that was in place when JFK started using DMAN, while the Saab Sensis final report analysis calculated savings relative to using no departure metering at all (as was the case at JFK at the time of the Saab Sensis study).

The ERS team focused its verification of DMAN's fossil fuel and emissions reduction on the estimates in Saab Sensis's final project report and the independent study from MIT. While we largely found the calculations in both sources to be accurate, the MIT study generally relies on a longer period of data collection and more detailed calculations to arrive at the fossil fuel and emissions reductions and, as a result, provides the more accurate estimate of project impacts. The list below highlight some of the key differences between the fossil fuel and emissions savings reported in the Saab Sensis final report and MIT study:

[5] ERS verified the savings calculations in an independent analysis performed by MIT in its study "Assessing the Impacts of the JFK Ground Management Program."

[6] There is a third source of savings self-reported by Saab Sensis to NYSERDA each year. As there is no system of verification or requirement for formulas or validation for this reported data, it was unable to be verified and therefore was not used.

- **Differences in baseline** – Discrepancies in the baselines used in the Saab Sensis final report and MIT study are the primary reason for the different savings between the two reports. The savings in Saab Sensis's final report are relative to airport operations in 2009, when there was no departure management in use. The MIT study calculates and reports the fossil fuel and emissions savings relative to two different baselines: with no departure manager (similar to the Saab Sensis final report) and with PASSUR's airport departure manager system, which was installed at JFK starting in 2011, just before the deployment of DMAN in 2012.

- **Increased data collection** – The analysis in the final report is based on one day of actual data from the airport that is extrapolated to calculate annual savings. The MIT study includes data from two years prior to the DMAN installation and three months after the DMAN installation.

- **Normalization to annual operation** – MIT's annual savings estimation accounts for reduced traffic during non-peak days where the number of departures are smaller and the savings will be reduced; Saab Sensis's original analysis appeared to assume equal savings for every day across the entire year.

Exhibit 5 shows the CO_2 savings from Saab Sensis's final report relative to the MIT study with the two different baselines: (1) no departure manager to DMAN and (2) PASSUR manual departure manager to DMAN. The difference between the "no departure manager" and PASSUR baseline explains most of the difference in savings between the final report and the MIT study savings, while the increased data collection and more refined normalization methodology in the MIT report may explain the remaining discrepancies.

Exhibit 5. Saab Sensis and MIT Study CO_2 Savings

Source	Saab Sensis Final Report	MIT Study	
Baseline	No departure manager	No departure manager	PASSUR manual departure manager
CO_2 savings	54,000 tons	43,000 tons	10,000 tons
Explanation of differences in CO_2 savings	N/A	-11,000 ton delta in CO_2 savings relative to Saab Sensis report is due to differences in volume of data collection normalization method	-33,000 ton delta compared to no departure manager is due to differences in baseline

The CO_2 savings from Saab Sensis's final report are within 20% of the savings calculated in the MIT report with the "no departure manager" baseline. As noted before, there was no departure control strategy in place when the Saab Sensis final report was prepared. Prior to commercialization of the Saab Sensis DMAN software, JFK implemented the PASSUR baseline, and they likely would have continued operating the PASSUR system had they not decided to commercially adopt the DMAN package. The ERS team found that the Saab Sensis final report provided a reasonable and accurate estimate of the savings for the DMAN prototype, but we recommend that the MIT study with the PASSUR baseline be the basis for establishing the commercial savings for the DMAN software, as it better reflects the departure management strategy in place immediately prior to DMAN's commercialization at JFK.

3.4. Overall Results

The Saab Sensis DMAN project was successful in producing a prototype DMAN system that went on to be successfully implemented at JFK, reducing fuel burn and emissions. Exhibit 6 shows the progress and gaps in achievement for each of the three evaluation questions.

Exhibit 6. Results Summary

Progress Achieved	Gaps in Achievement
Evaluation Question 1: To what extent was the product commercialized after NYSERDA's funding?	
• DMAN was commercially implemented in 2012 and continues to operate at JFK. • The success and relationships resulting from the DMAN shadow testing at JFK that was funded by NYSERDA were a large factor in Saab Sensis winning the 2012 contract. Without NYSERDA's support, Saab Sensis would not have pursued this project.	• The R&D team at Saab Sensis that developed the tool has been decommissioned, limiting future product development.
Evaluation Question 2: How many airports within and beyond New York State are using the commercialized product?	
• No other airports in New York State are using DMAN, and without major changes to airport infrastructure, none are eligible for the benefits from advanced departure management. • San Francisco airport temporarily used DMAN while renovating runways; it was successful in managing the surface traffic, but the contract was not continued after the construction was completed. • Dublin International Airport contracted Saab Sensis for continuous departure metering using DMAN in 2015.	• The layout of airport and ability to maneuver outside of the FAA's jurisdiction on the surface dictates the feasibility of DMAN implementation. • Diversity and cooperation of airlines at other airports are a major factor in the functionality of DMAN.
Evaluation Question 3: What were the fossil fuel and emissions reductions?	
• Independently verified (MIT) emissions reduction of 10,000 tons of CO_2 per year. • MIT-verified savings are relative to the PASSUR system that was in place in 2011. NYSERDA savings were relative to no departure management in 2009.	• More cooperation and more information in real time from the FAA would allow DMAN to be more effective at saving time and fuel.

4. Strategic Implications

Through interviews with Saab Sensis, NYSERDA, JFK, and PANYNJ/FAA employees, the ERS team found that NYSERDA's support was crucial to the successful development and commercialization of the DMAN product. Without NYSERDA's financial support, Saab Sensis would not have pursued the project and the prototype DMAN would not have been developed. The ERS team's interviews also revealed that the interpersonal connections that NYSERDA provided at JFK were crucial in the development of a successful product. NYSERDA was able to open doors and build trust between PANYNJ and Saab Sensis, and NYSERDA's funding proved especially important to removing financial barriers from the relationship between Saab Sensis and the PANYNJ. Because NYSERDA was funding the DMAN prototype project, the PANYNJ was not restricted to traditional contracting requirements, making them more open to considering how DMAN could improve airport operations. Based on the interviews, the ERS team has the following recommendations for NYSERDA in their pursuit of similar mobility management and air transportation projects in the future:

- **Build a team of technical experts** – Having a team of technical experts available to assist in specific sectors/industries would help to ensure that NYSERDA can offer both financial and technical support to participants.
- **Gain further awareness of corporate structure** – In the case of Saab Sensis, the success of DMAN was largely due to a one-off collaboration between two internal groups at Saab Sensis. Prior to DMAN, the research and development team at Saab Sensis did not have a strong working relationship with the product development side of the company and largely worked as an independent entity. The DMAN software and NYSERDA's support of its development encouraged a somewhat unique collaboration between these two internal groups. Without this collaboration, the DMAN project would not have been a success. Working with companies to understand their internal structure could help NYSERDA encourage collaboration and bring projects to fruition that would not otherwise be possible. However, given the challenges associated with gathering the information on company structures needed to foster this kind of collaboration, this recommendation may only be applicable to a small portion of NYSERDA's customers.
- **Examine R&D team track records for commercialization** – Saab Sensis, while a large commercial company, did not have a strong connection between its R&D team and commercial products that it offered; completing background research into the dynamics of a larger company can help NYSERDA ensure that the research department has the support and resources needed to effectively commercialize promising R&D concepts.

4.1. Conclusions

The DMAN project was a success for the mobility management and air transportation sector of NYSERDA's transportation program, and this case study highlights NYSERDA's value beyond just financial support. Saab Sensis, a New York State based company, gained a new commercial market in departure management, and the project resulted in substantial emissions and fuel savings at JFK. Relationships within the air transportation network were developed, and developers and users of DMAN are very satisfied with the results of DMAN and their interactions with NYSERDA. In addition to saving fuel and emissions at JFK, DMAN is also saving time for JFK travelers.

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