General

ID[1]			
Use case name	Self-Driving Aircraft Towing Vehicle		
Context	Transportation		
Application domain	Self-driving vehicles		
Status	Prototype		
Contributor	Name	Affiliation	Contact
	Zielke	HSD, Germany	
Scope[2]	Self-Driving towing vehicle for aircrafts, operating on an airfield autonomously.		
Objective(s)	A towing vehicle that will, on command, autonomously navigate to an assigned aircraft, attach itself, tow the aircraft to an assigned location (a runway for departures, a gate for arrivals), autonomously detach itself, and navigate to an assigned location, either a staging area or to service another aircraft.		
Narrative	Short description (not more than 150 words)	Self-driving vehicle technology is applied to the problem of towing aircraft at busy airports from gate to runway and runway to gate. Autonomous aircraft towing can be supervised by human ramp controllers, by air traffic controllers (ATC), by pilots, or by ground crew. The controllers provide route information to the tugs, assisted by an automated route planning system. The planning system and tower and ground controllers work in conjunction with the tugs to make tactical decisions during operations to ensure safe and effective taxiing in a highly dynamic environment.	
	Complete description	Advances in self-driving automobiles make it technologically feasible to apply this technology for the purpose of taxiing planes to the runway from the terminal gate and vice-versa. Deploying self-driving vehicles for this purpose offers fewer technical challenges than deploying them on roadways and highways. Routes between gates to runways and runways to gates are typically pre-determined, with little or no possibility for alternatives. In addition, to ensure safety, constraints on taxiing operations are rigid and unambiguous. Rules such as separation constraints between taxiing aircraft and those governing right-of-way at intersection points are clearly documented and enforced by ramp and ATC controllers. These rules and procedures reduce the overall uncertainty in the operational environment and therefore potentially simplify the models that need to be employed by self-driving vehicles. Nominal autonomous operation of the towing vehicle (tug) is captured as the following sequence (for the case of departures): a tug sits at a tug depot, a designated area of the airport surface where tugs recharge and return when not in service. When the tug receives a message, describing time, route, and gate, it travels to the specified gate following the provided route. As the tug approaches the specified gate, it navigates to a designated ready position. Once the ground marshal attending the gate signals readiness for attachment, the tug assesses the environment to verify the surroundings are obstacle-free before moving to dock with the aircraft.	

		Once a taxi navigation plan is received from the centralized route planner and the aircraft crew and ground marshal both signal ready to push back, the tug pushes the aircraft away from the gate and begins navigation through its assigned route. When reaching a designated location in the takeoff queue near the runway, the tug autonomously detaches from the aircraft, moves to a safe position away from the aircraft, signals to the aircraft's crew through a cockpit display that it is detached, and navigates back to the depot along the route provided by the planner.		
Key performance indicators (KPIs)	ID	Name	Description	Reference to mentioned use case objectives
		Efficiency, environmental and economic benefits	Amount of delay in taxi time and maximizing throughput, reduced fuel emissions, reduced maintenance costs	Advantage of self-driving towing vehicle on busy airports
		Complexity of logistics	Complexity of logistics, primarily in the form of workload for flight crew, tower personnel or ground crew	Advantage of self-driving towing vehicle as to reduced workload for personnel
		Safety	Safety in the form of things like maintaining separation constraints and avoiding potentially dangerous events such as runway incursions	No compromises on safety by the autonomous operation
AI features	Taks(s)	Environment Perception, Path Planning, Obstacle Avoidance, Navigation, Fault Detection, Situational Awareness		
	Method(s)[3]	computer vision , logical decision making, pattern recognition, multimodal event detection, multi-agent planning and scheduling, probabilistic predictive modeling		
	Hardware[4]	host platform: AeroTech Expediter 600; positioning sensors, environment sensors (LIDAR, electro-optical cameras, infrared cameras)		
	Terms and concepts used[5]	autonomous vehicle guidance, environment perception, self perception, planning and scheduling		
Challenges and issues	Safe operations in the airfield environment, minimal changes to the airport infrastructure, minimal impact of their incorporation into normal operations			
Societal concerns	If labor replacements are involved, then the use of autonomy must provide an equivalent or greater benefit to some portion of the labor pool to offset the			

	potential job loss; furthermore, they must operate in a way that feels common and familiar to humans, and must be perceived as completely safe, simple and non-intimidating.

Data (optional)

Data characteristics	
Description	
Source[6]	
Type[7]	
Volume (size)	
Velocity (e.g. real time)[8]	
Variety (multiple datasets)[9]	
Variability (rate of change)[10]	
Quality[11]	

Process scenario (optional)

Scenario conditions					
No.	Scenario name	Scenario description	Triggering event	Pre-condition[12]	Post-condition[13]

Training (optional)

Scenario name	Training				
Step No.	Event[14]	Name of process/Activity[15]	Primary actor	Description of process/activity	Requirement
Specification of training data[16]					

Evaluation (optional)

Scenario name	Evaluation				
Step No.	Event[17]	Name of process/Activity[18]	Primary actor	Description of process/activity	Requirement
Input of evaluation[19]					
Output of evaluation[20]					

Execution (optional)

Scenario name	Execution				
Step No.	Event[21]	Name of process/Activity[22]	Primary actor	Description of process/activity	Requirement
Input of Execution[23]					
Output of Execution[24]					

Retraining (optional)

Scenario name	Retraining				
Step No.	Event[25]	Name of process/Activity[26]	Primary actor	Description of process/activity	Requirement
Specification of retraining data[27]					

References

References						
No.	Type	Reference	Status	Impact on use case	Originator/organization	Link
					NASA Ames Research Center	www.nasa.gov
					NASA Johnson Space Center	www.nasa.gov
					Lockheed Martin Advanced Technology Laboratories	www.lmco.com
					University of California-Santa Cruz Affiliated Research Center	www.ucsc.edu
					Carnegie Mellon University	www.cmu.edu

[1] R. Morris *et al.*, "Planning, Scheduling and Monitoring for Airport Surface Operations.," in *Workshop of the Thirtieth AAAI Conference on Artificial Intelligence: Planning for Hybrid Systems*, 2016 [Online]. Available: https://www.aaai.org/ocs/index.php/WS/AAAIW16/paper/download/12611/12430

[2] R. Morris *et al.*, "Self-Driving Aircraft Towing Vehicles: A Preliminary Report.," in *AAAI Workshop: AI for Transportation*, 2015.

[3] C. DiPrima and M. Fong, "TAXIING INTO AUTONOMY, 2018 IATA Competition Submission." 2018 [Online]. Available: https://www.iata.org/events/ighc/Documents/IGHC%20Innovator%202018/taxiing-into-autonomy.pdf

[4] E. V. Cross *et al.*, "SafeTug Semi-Autonomous Aircraft Towing Vehicles," NASA Aeronautics and Research Mission, Ames Research Center, 2015 [Online]. Available: https://www.researchgate.net/publication/311790811_SafeTug_Semi-Autonomous_Aircraft_Towing_Vehicles

Footnote

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1 Leave this cell blank.

2 The scope defines the limits of the use case.

3 AI method(s)/framework(s) used.

4 Hardware system used.

5 Terms and concepts listed here can be used to extend the work of WG 1 (AWI 22989 and AWI 23053) as necessary.

6 Origin of data, which could be from instruments, IoT, web, surveys, commercial activity, or from simulations.

7 Structured/unstructured Images, voices, text, gene sequences, and numerical. Composite: time-series, graph-structured

8 The rate of flow at which the data is created, stored, analysed, or visualized.

9 Data from a number of domains and a number of data types. The wider range of data formats, logical models, timescales, and semantics complicates the integration of the variety of data.

10 Changes in data rate, format/structure, semantics, and/or quality.

11 Completeness and accuracy of the data with respect to semantic content as well as syntactical of the data (such as presence of missing fields or incorrect values)

12 Describe which condition(s) should have been met before this scenario happens.

13 Describe which condition(s) should prevail after this scenario happens. The post-condition may also define "success" or "failure" conditions.

14 The event that triggers the step. This might be completion of the previous event.

15 Action verbs should be used when naming activity.

16 Training data can be further specified.

17 The event that triggers the step. This might be completion of the previous event.

18 Action verbs should be used when naming activity.

19 Specify input of evaluation.

20 Specify output of evaluation.

21 The event that triggers the step. This might be completion of the previous event.

22 Action verbs should be used when naming activity.

23 Specify input of evaluation.

24 Specify output of evaluation.

25 The event that triggers the step. This might be completion of the previous event.

26 Action verbs should be used when naming activity.

27 Retraining data can be further specified.

