

SAE 2006 Alternate Refrigerant System Symposium

**Energy Efficiency Improvement
of the MAC system with
the New Development Scroll Compressor**

Presented by

Hideto Noyama

Mitsubishi Heavy Industries, Ltd.

Kazumi Okinaka

Mitsubishi Motors Corporation

Contents

- 1. Background**
- 2. A/C system Specifications**
- 3. A/C System (Compressor) Control Strategy**
- 4. Bench Test Results**
- 5. Vehicle Fuel Consumption Test Results**
- 6. Summary**
- 7. Development Status**

1. Background

Recently, Fuel/Power saving mobile air-conditioning (MAC) systems are desired because of global warming issue and higher gas price.

SAE/EPA have been conducting I-MAC project. One of the I-MAC targets is 30% reduction on A/C power consumption.

We, Mitsubishi Heavy Industries (MHI) and Mitsubishi Motors Corporation (MMC), have been developing the MAC system with high efficiency brand-new scroll compressor and proper compressor cycling control to meet the I-MAC target.

2. A/C system Specifications

	Original system (for Mitsubishi 2.4L SUV '05MY "AirTrek")	Improved system 1 (for Mitsubishi 2.4L SUV '06MY "Outlander")	Improved system 2 (for next generation vehicles)
Compressor	MHI MSC90CA Fixed displacement scroll type (90cm ³ /rev.) Pulley ratio: 1.58	MHI MSC90CAS Fixed displacement scroll type with oil separator (90cm ³ /rev.) Pulley ratio: 1.52	MHI New scroll profile Fixed displacement prototype comp. (90cm ³ /rev.) Pulley ratio: 1.52
Condenser	Multi-flow type 16mm width Frontal area: 0.24m ²	Multi-flow type 16mm width Frontal area: 0.257m ²	Same as Improved system 1
Evaporator	Laminated Plate type 58mm width Frontal area: 0.056m ²	Laminated Plate type 38mm width Frontal area: 0.068m ²	Same as Improved system 1

2. A/C system Specifications – Test Vehicles



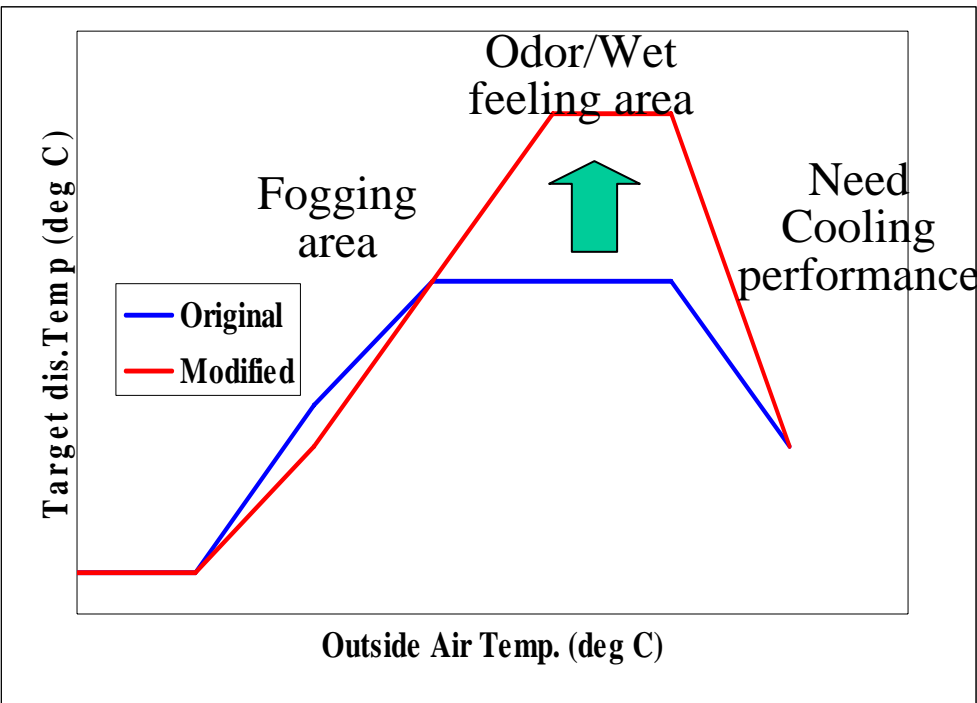
**Mitsubishi '05MY "AirTrek"
(Previous Generation Model in Japan)
with original system**



**Mitsubishi '06MY "Outlander"
(Latest Generation Model in Japan)
with improved system**

3. A/C System (Compressor) Control Strategy

- Basically, the system controls discharge air temp, which is the compressor cycling temp points, due to thermal load, for example outside air temp.
- The purpose is decreasing reheat, which is over cooling, during spring/autumn seasons.

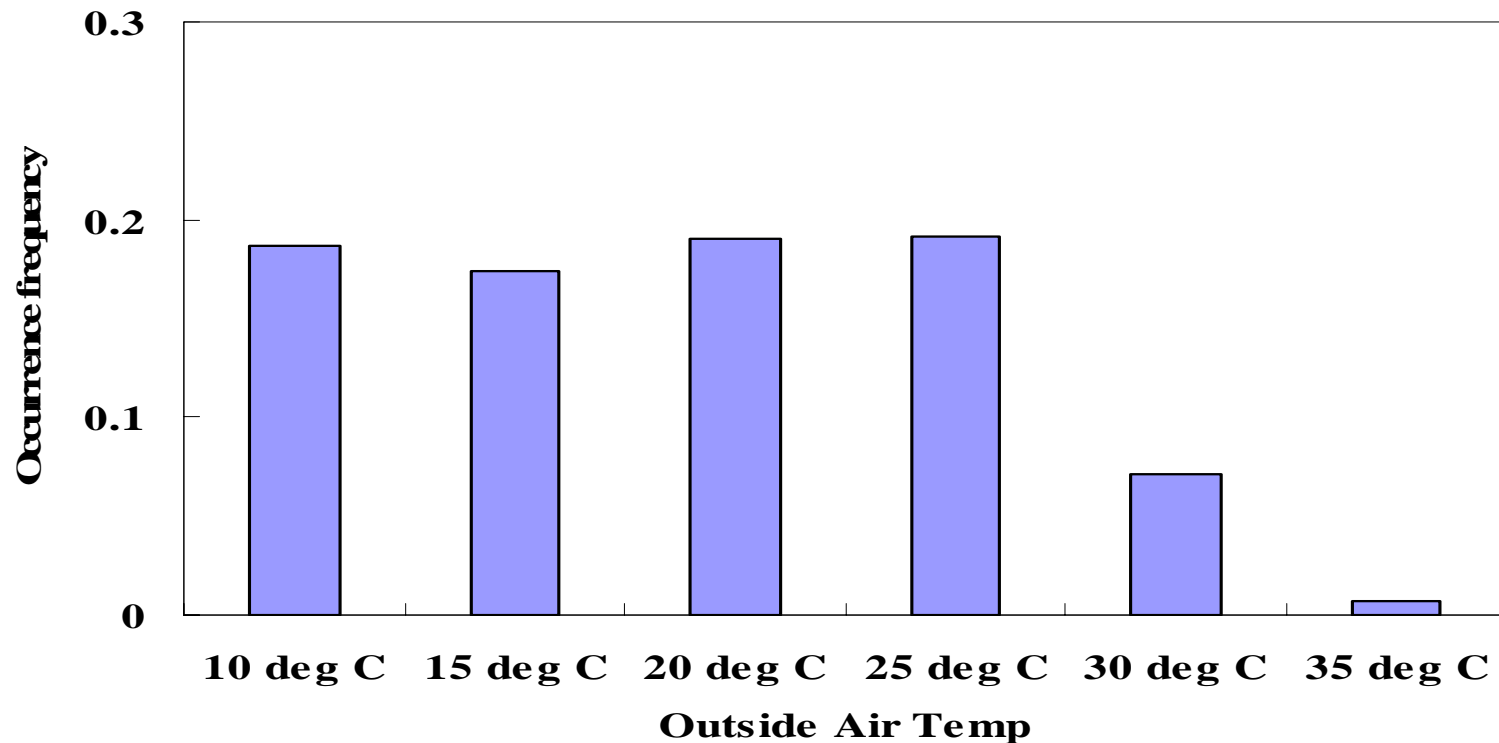


Comparison of Control characteristics

- The control characteristics depend on defog performance at lower temp, odor/wet feeling at mid temp, cooling performance at higher temp.
- We set the characteristics based on both performance test and subjective test results.

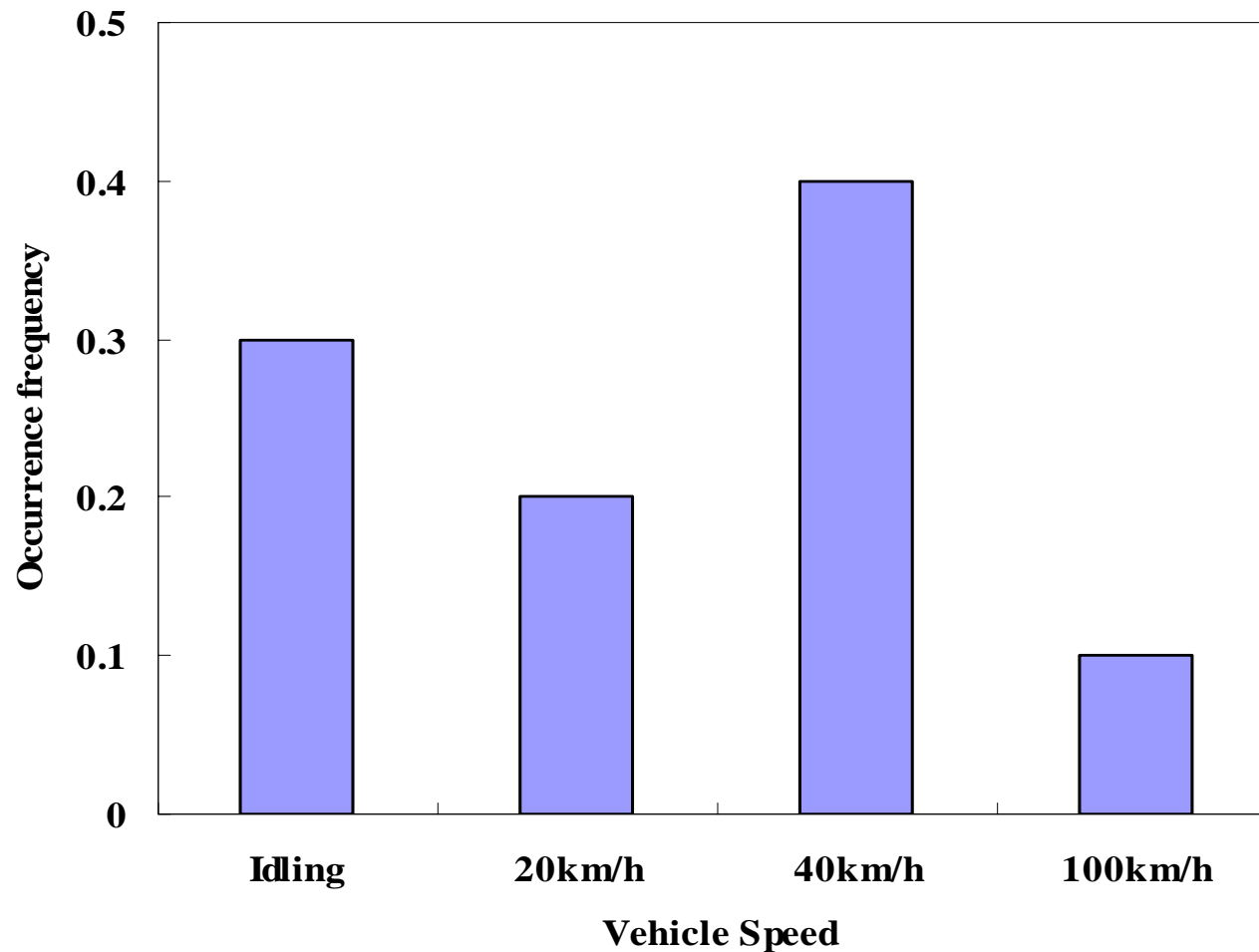
4. Bench Test Results - Conditions

- We calculated annual total MAC system power consumption based on occurrence frequencies of temperature and vehicle speed as follows;



**Occurrence frequency of Outside Air Temp.
(simulating weather conditions in Japan)**

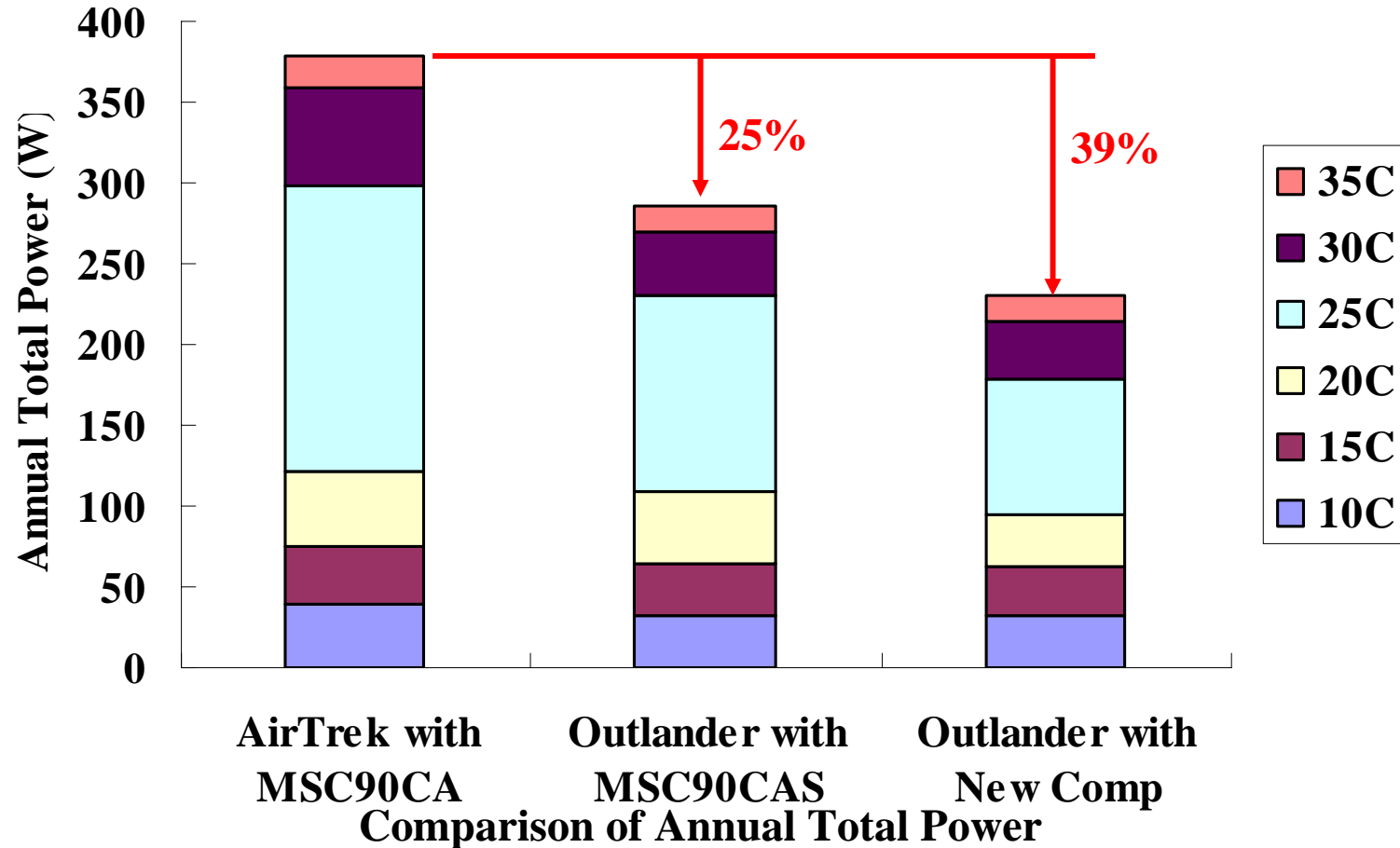
4. Bench Test Results - Conditions



**Occurrence frequency of Vehicle Speed
(simulating traffic conditions in Japan)**

4. Bench Test Results – Annual Total Power

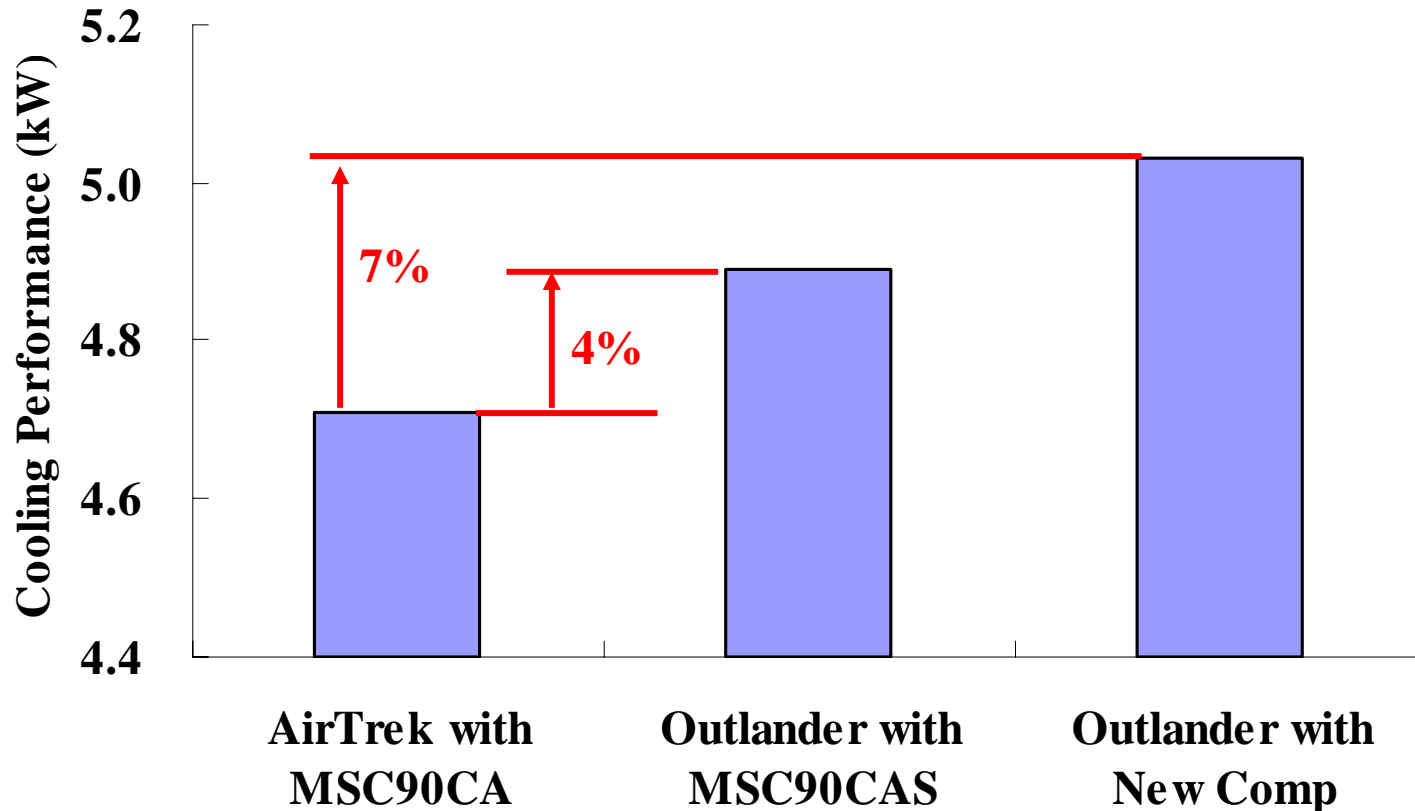
- “Outlander” system with the new compressor reduces 39% of the annual total power of “AirTrek” system with MSC90C (Original system). The system exceeds the I-MAC target (30%).



All values include both compressor power and all A/C electric power (cooling fan, blower, clutch).

4. Bench Test Results – Cooling Performance

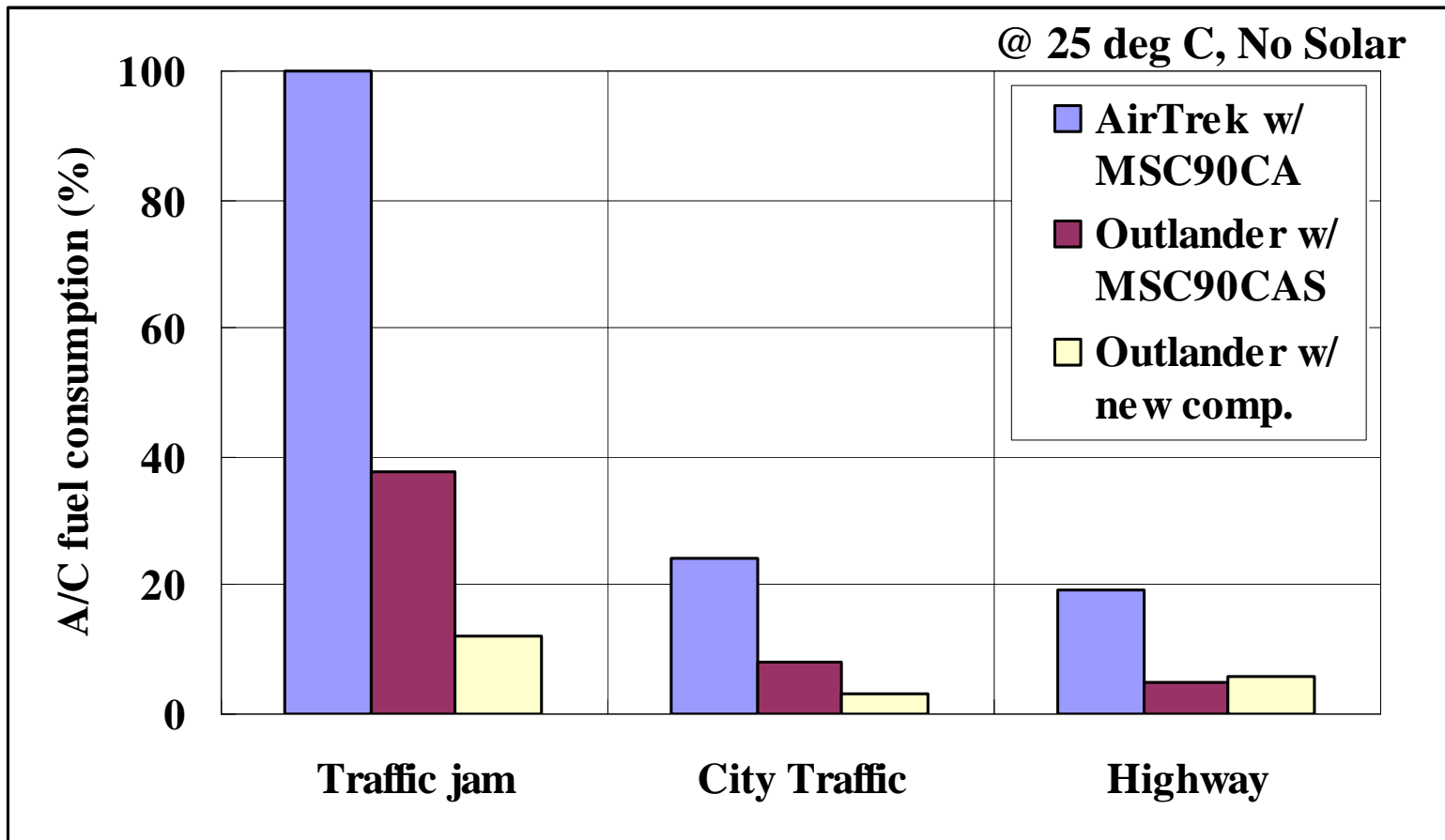
“Outlander” system with the new compressor increases 7% of the cooling performance of “AirTrek” system with MSC90C (Original system) in Full cooling condition.



Comparison of Cooling Performance
(@ 35 deg C, 40km/h, Blower Hi)

5. Vehicle Fuel Consumption Test Results

We verified A/C fuel consumption by the chassis dynamometer. The fuel consumption of “Outlander” with the new compressor system was decreased significantly.



All values are normalized based on “AirTrek” fuel consumption in Traffic jam condition.

6. Summary

- (1) '06MY “Outlander” AC system with our newly developed scroll compressor reduces 39% power consumption compared to '05MY “AirTrek” AC system (original system). The reduction value exceeds the I-MAC target 30%.**
- (2) The cooling performance of improved systems are better than the original system.**
- (3) We verified the effect on the fuel consumption of the improved system.**

7. Development Status

- **We are conducting**
 - **durability & reliability tests for the new compressor.**
 - **vehicle level feasibility tests.**
(drivability, actual fuel consumption, control feeling, etc.)
- **We expect that we can make a presentation on our new scroll compressor in detail by next year autumn.**
- **We, MMC and MHI, contribute to the reduction of fuel consumption with our MAC systems.**

Thank you for your attention.