efficient thrust reversing. Being a trijet, the MD-11 will, unlike twin-jets, offer unrestricted overwater operations, with lower fuel and maintenance costs than a four-jet aircraft, MDC argues.
Airlines are demanding greater flex-ibility for rapid cabin configuration changes, says MDC. Cabin-change features have been pre-engineered into the MD-11 design as much as possible, says Ornelas. These include variable toilet and galley locations, and passenger-address and lighting systems that can accommodate change. The air condi-tioning system allows three tempera-ture selections in each of three cabin areas. A complete cabin reconfiguration can be accomplished in 2| days, says MDC.

McDonnell Douglas emphasises the MD-ll's ability to carry underfloor cargo—50 per cent more than a 747-400, the company claims. The MD-11 can carry 18 LD3 containers forward of the wing and 14 aft. The extra cargo capacity makes MD-11 seat-mile costs more competitive with those of the 747, says Ornelas.

The aircraft makes its most significant advance over the DC-10 on the flightdeck. The MD-11 is a two-crew aircraft, and to achieve this without increasing crew workload, Douglas has introduced signifi-cant systems automation.
The company has elected to change aircraft systems only where it will reduce crew workload or improve maintain-ability, and to leave unchanged systems that have proved reliable and where no new technology has emerged. The reduction in MD-11 cockpit workload has therefore been achieved largely through automation.

Instead of displaying the corrective action which the pilot should take in the event of a system malfunction, the MD-11 automatically copes with the fail-ure by following a defined procedure based on MDC's long experience with the DC-10.

The company rejected systems using interactive checklists because these mimic current procedures and are more complex than actual automation, says MD-11 project pilot John Miller. With interactive checklists, problems must be dealt with in series according to a priority, and the pilot must be cued back to the correct action if he makes a mistake. This is time-consuming, says Miller.
Instead, MDC decided to automate systems operation along the same logic flow as the checklist, but to take the crew out of the flow diagram. Each system can then work in parallel without crew inter-vention, informing the pilot of the consequences of its automatic corrective action.

Five major systems—fuel, hydraulics, electrics, environmental control, and miscellaneous—each have two "flight engineers", computers which contain the logic and switching for system control and which interface with the overhead panel which takes the place of the flight engineer.
If one computer fails, then only one system is reduced to a single computer. If

that computer then fails, only one system reverts to manual control. The probability of a failure requiring pilot intervention is low, says Miller.
The advantage of this approach, says' Ornelas, is that it capitalises on more than 15 years of flight experience with some 400 DC-lOs and their systems. "We already have well-established procedures to deal with DC-10 failures. For the MD-11 we will simply mechanise that logic flow in a computer," he says.
Six 8in-square CRT displays are ranged across the MD-11 instrument panel. The outboard CRTs are primary flight displays, and inboard of them are the navi-gation displays. In the centre, flanking the prominent gear handle, are the engine (left) and system (right) displays. No compacted or unusual display formats are used in the event of a CRT failure. "The pilot doesn't want to see an unfamiliar display at a time of stress," says Miller.
The overhead panel is arranged hori-zontally by system type, with the most often used systems to the fore, and verti-cally by system number. Any system failure, although coped with auto-matically, will be flagged on the engine display and clearly marked if further pilot action is required. The pilot can then call up a system schematic on the display alongside to find out more about the failure and its consequences. "There is no need to look up at the panel," says Miller.

On the pedestal between the pilots are three multifunction control display units (MCDUs). The forward pair interface

with the dual flight management systems and provide backup radio management and inertial navigation capability. The third MCDU is used on the ground for maintenance, and in flight for the Acars airline datalink, via which flight-plans can be transmitted to the aircraft. The flight management and flight control systems are separate, but functionally integrated.
Sperry, now part of Honeywell, is McDonnell Douglas' partner on the MD-11, and is developing the flight management system, flight control system, electronic display system, and aircraft system control. Together these systems result in a reduction in lights, switches, and gauges from 1,000 in the three-crew DC-10 cockpit to around 300 in the two-crew MD-11, says MDC
As this article went to press, McDonnell Douglas had yet to launch the MD-11 formally, despite orders totalling $1,500 million for nine aircraft from British Caledonian and five from Japanese leas-ing company Mitsui. To protect the first flight date of January 1989, how-ever, engineering authority to proceed was given earlier this year. Certification and customer delivery is scheduled for 1990. Long-lead items for the first aircraft have been ordered, and a formal launch before the end of 1986 will enable MD-11 production to follow on from that of the DC-10 and KC-10 tanker/transport. This
will avoid heavy production start-up costs
and, coupled with the lower development
costs of a derivative, explains why
McDonnell Douglas will be able to launch
the MD-11 on only 20 firm orders.

The basic MD-11 fuselage is stretched by 18-6ft over the DC-10-30, increasing two-class seating capacity by 44, to 321 passengers

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MD-11

DC-10-30

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277 PSGfA \

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0 1,000 2,000 3,000 4,000 5,000 6,000 7,000 8,000 Range (n.m.)

MD-1 1

Max take-off weight

Max landing weight

Max zero-fuel weight

Fuel weight

Passengers
maximum

2-class

3-class

Range (321 pax)

273 3 tonnes

1 95 tonnes

181 -4 tonnes

117-5 tonnes

405

321

276

6,800 n,m.

FLIGHT INTERNATIONAL, 27 December 1986